

Enterprise COBOL for z/OS



Programming Guide

Version 3 Release 3

Enterprise COBOL for z/OS



Programming Guide

Version 3 Release 3

Note!

Before using this information and the product it supports, be sure to read the general information under “Notices” on page 725.

Third Edition (February 2004)

This edition applies to Version 3 Release 3 of IBM Enterprise COBOL for z/OS (program number 5655-G53) and to all subsequent releases and modifications until otherwise indicated in new editions. Make sure that you are using the correct edition for the level of the product.

You can order publications online at www.ibm.com/shop/publications/order/, or order by phone or fax. IBM Software Manufacturing Solutions takes publication orders between 8:30 a.m. and 7:00 p.m. Eastern Standard Time (EST). The phone number is (800)879-2755. The fax number is (800)445-9269.

You can also order publications through your IBM representative or the IBM branch office serving your locality.

© Copyright International Business Machines Corporation 1991, 2004. All rights reserved.

US Government Users Restricted Rights – Use, duplication or disclosure restricted by GSA ADP Schedule Contract with IBM Corp.

Contents

Tables xiii

About this document xv

Accessibility	xv
Using assistive technologies	xv
Keyboard navigation of the user interface	xv
Accessibility of this document	xv
How this document will help you	xvi
Abbreviated terms	xvi
Comparison of commonly used terms	xvii
How to read syntax diagrams	xvii
How examples are shown	xviii
Accessing softcopy documentation and support information	xix
Summary of changes	xix
Version 3 Release 3 (February 2004)	xix
Version 3 Release 2 (September 2002)	xix
Version 3 Release 1 (November 2001)	xx
How to send your comments	xxi

Part 1. Coding your program 1

Chapter 1. Structuring your program . . . 5

Identifying a program	5
Identifying a program as recursive	6
Marking a program as callable by containing programs	6
Setting a program to an initial state	6
Changing the header of a source listing	7
Describing the computing environment	7
Example: FILE-CONTROL entries	8
Specifying the collating sequence	8
Defining symbolic characters	10
Defining a user-defined class	10
Defining files to the operating system	10
Describing the data	12
Using data in input and output operations	13
Comparison of WORKING-STORAGE and LOCAL-STORAGE	15
Using data from another program	17
Processing the data	18
How logic is divided in the PROCEDURE DIVISION	18
Declaratives	22

Chapter 2. Using data 23

Using variables, structures, literals, and constants	23
Variables	23
Data structure: data items and group items	23
Literals	24
Constants	24
Figurative constants	25
Assigning values to data items	25
Examples: initializing data items	26

Initializing a structure (INITIALIZE)	27
Assigning values to elementary or group data items (MOVE)	27
Assigning arithmetic results (MOVE or COMPUTE)	28
Assigning input from a screen or file (ACCEPT)	29
Displaying values on a screen or in a file (DISPLAY)	30
Displaying data on the system logical output device	31
Using WITH NO ADVANCING	31
Using intrinsic functions (built-in functions)	32
Types of intrinsic functions	33
Nesting functions	33
Using tables (arrays) and pointers	33
Storage and its addressability	34
Settings for RMODE	35
Storage restrictions for passing data	35
Location of data areas	35
Storage for LOCAL-STORAGE data	35
Storage for external data	35
Storage for QSAM input-output buffers	36

Chapter 3. Working with numbers and arithmetic 37

Defining numeric data	37
Displaying numeric data	38
Controlling how numeric data is stored	39
Formats for numeric data	40
External decimal (DISPLAY) items	40
External floating-point (DISPLAY) items	40
Binary (COMP) items	41
Native binary (COMP-5) items	41
Packed-decimal (COMP-3) items	42
Floating-point (COMP-1 and COMP-2) items	42
Examples: numeric data and internal representation	42
Data format conversions	43
Conversions and precision	44
Sign representation and processing	45
NUMPROC(PFD)	45
NUMPROC(NOPFD)	45
NUMPROC(MIG)	46
Checking for incompatible data (numeric class test)	46
Performing arithmetic	47
COMPUTE and other arithmetic statements	47
Arithmetic expressions	48
Numeric intrinsic functions	48
Math and date Language Environment services	49
Examples: numeric intrinsic functions	51
Fixed-point versus floating-point arithmetic	53
Floating-point evaluations	54
Fixed-point evaluations	54
Arithmetic comparisons (relation conditions)	54
Examples: fixed-point and floating-point evaluations	55

Using currency signs	55
Example: multiple currency signs	56

Chapter 4. Handling tables 59

Defining a table (OCCURS)	59
Nesting tables	60
Subscripting	60
Indexing	61
Referring to an item in a table	61
Subscripting	62
Indexing	63
Putting values into a table	64
Loading a table dynamically.	64
Initializing a table (INITIALIZE)	64
Assigning values when you define a table (VALUE)	65
Example: PERFORM and subscripting	66
Example: PERFORM and indexing.	67
Creating variable-length tables (DEPENDING ON)	68
Loading a variable-length table.	69
Assigning values to a variable-length table	70
Searching a table	71
Doing a serial search (SEARCH)	71
Doing a binary search (SEARCH ALL)	72
Processing table items using intrinsic functions	73
Example: intrinsic functions	73

Chapter 5. Selecting and repeating program actions 75

Selecting program actions	75
Coding a choice of actions	75
Coding conditional expressions.	79
Repeating program actions	83
Choosing inline or out-of-line PERFORM	83
Coding a loop	84
Coding a loop through a table	85
Executing multiple paragraphs or sections	85

Chapter 6. Handling strings 87

Joining data items (STRING)	87
Example: STRING statement.	88
Splitting data items (UNSTRING)	89
Example: UNSTRING statement	89
Manipulating null-terminated strings.	91
Example: null-terminated strings	92
Referring to substrings of data items	93
Reference modifiers.	94
Example: arithmetic expressions as reference modifiers	94
Example: intrinsic functions as reference modifiers	95
Tallying and replacing data items (INSPECT)	95
Examples: INSPECT statement	96
Converting data items (intrinsic functions)	97
Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE).	97
Converting to reverse order (REVERSE)	97
Converting to numbers (NUMVAL, NUMVAL-C)	97
Converting from one code page to another	98
Evaluating data items (intrinsic functions)	99

Evaluating single characters for collating sequence	99
Finding the largest or smallest data item	99
Finding the length of data items	101
Finding the date of compilation	102

Chapter 7. Processing character data in an international environment 103

Unicode and encoding of language characters	105
Using national data (Unicode) in COBOL	106
National data items	106
National literals	106
National characters as figurative constants	106
Storage of national data	107
Converting national data	107
Converting alphanumeric and integer to national data (MOVE)	107
Converting alphanumeric to national data (NATIONAL-OF)	108
Converting national to alphanumeric data (DISPLAY-OF)	108
Conversion exceptions	108
Example: converting national data	109
Processing UTF-8 data	109
Processing Chinese GB 18030 data	110
Comparing national data items	111
Comparing national operands	111
Comparing national and numeric operands	111
Comparing national and alphabetic or alphanumeric operands	111
Comparing national and group operands	111
Processing alphanumeric data items that contain DBCS data	112

Chapter 8. Processing files 113

File organization and input-output devices	113
Choosing file organization and access mode	115
Format for coding input and output.	116
Allocating files	117
Checking for input or output errors	118

Chapter 9. Processing QSAM files 119

Defining QSAM files and records in COBOL	119
Establishing record formats.	120
Setting block sizes.	127
Coding input and output statements for QSAM files	129
Opening QSAM files	130
Dynamically creating QSAM files with CBLQDA.	130
Adding records to QSAM files.	131
Updating QSAM files	131
Writing QSAM files to a printer or spooled data set	131
Closing QSAM files	132
Handling errors in QSAM files	133
Working with QSAM files	133
Defining and allocating QSAM files	134
Retrieving QSAM files	136
Ensuring file attributes match your program	137

Using striped extended-format QSAM data sets	139
Accessing HFS files using QSAM.	140
Labels for QSAM files	141
Using trailer and header labels	141
Format of standard labels	143
Processing QSAM ASCII files on tape	144
Requesting the ASCII alphabet	144
Defining the record formats	144
Defining the ddname.	144
Processing ASCII file labels.	145

Chapter 10. Processing VSAM files 147

VSAM files	148
Defining VSAM file organization and records	149
Specifying sequential organization for VSAM files	150
Specifying indexed organization for VSAM files	150
Specifying relative organization for VSAM files	151
Specifying access modes for VSAM files	153
Defining record lengths for VSAM files.	154
Coding input and output statements for VSAM files	155
File position indicator	157
Opening a file (ESDS, KSDS, or RRDS)	158
Reading records from a VSAM file	160
Updating records in a VSAM file.	161
Adding records to a VSAM file	162
Replacing records in a VSAM file.	162
Deleting records from a VSAM file	163
Closing VSAM files	163
Handling errors in VSAM files	164
Protecting VSAM files with a password	164
Example: password protection for a VSAM indexed file	165
Working with VSAM data sets under z/OS and UNIX	165
Defining VSAM files	166
Creating alternate indexes	167
Allocating VSAM files	169
Sharing VSAM files through RLS.	170
Improving VSAM performance	171

Chapter 11. Processing line-sequential files 175

Defining line-sequential files and records in COBOL	175
Allowable control characters	176
Describing the structure of a line-sequential file	176
Defining and allocating line-sequential files	177
Coding input-output statements for line-sequential files	177
Opening line-sequential files	178
Reading records from line-sequential files	178
Adding records to line-sequential files	179
Closing line-sequential files.	179
Handling errors in line-sequential files	180

Chapter 12. Sorting and merging files 181

Sort and merge process	182
Describing the sort or merge file	182

Describing the input to sorting or merging	183
Example: describing sort and input files for SORT	183
Coding the input procedure	184
Describing the output from sorting or merging	185
Coding the output procedure	185
Coding considerations when using DFSORT	186
Example: coding the output procedure when using DFSORT	186
Restrictions on input and output procedures	187
Defining sort and merge data sets	187
Sorting variable-length records	188
Requesting the sort or merge	188
Setting sort or merge criteria	189
Example: sorting with input and output procedures	190
Choosing alternate collating sequences	190
Sorting on windowed date fields	191
Preserving the original sequence of records with equal keys	191
Determining whether the sort or merge was successful	192
Stopping a sort or merge operation prematurely	192
Improving sort performance with FASTSRT	193
FASTSRT requirements for JCL	193
FASTSRT requirements for sort input and output files	193
Checking for sort errors with NOFASTSRT	195
Controlling sort behavior	195
Sort special registers	196
Changing DFSORT defaults with control statements	197
Allocating storage for sort or merge operations	197
Allocating space for sort files	198
Using checkpoint/restart with DFSORT	198
Sorting under CICS	199
CICS SORT application restrictions	199

Chapter 13. Handling errors 201

Requesting dumps	201
Creating a formatted dump.	201
Creating a system dump	202
Handling errors in joining and splitting strings	202
Handling errors in arithmetic operations	203
Example: checking for division by zero.	203
Handling errors in input and output operations	203
Using the end-of-file condition (AT END)	206
Coding ERROR declaratives	207
Using file status keys.	208
Example: file status key	209
Using VSAM return codes (VSAM files only)	209
Example: checking VSAM status codes	210
Coding INVALID KEY phrases	212
Example: FILE STATUS and INVALID KEY	212
Handling errors when calling programs	213
Writing routines for handling errors.	213

Part 2. Compiling and debugging your program 215

Chapter 14. Compiling under z/OS 217

Compiling with JCL	217
Using a cataloged procedure	218
Writing JCL to compile programs.	228
Compiling under TSO	229
Example: ALLOCATE and CALL for compiling under TSO	230
Example: CLIST for compiling under TSO.	230
Starting the compiler from an assembler program	231
Defining compiler input and output.	232
Data sets used by the compiler under z/OS	233
Defining the source code data set (SYSIN).	235
Specifying source libraries (SYSLIB)	235
Defining the output data set (SYSPRINT)	236
Directing compiler messages to your terminal (SYSTEM)	236
Creating object code (SYSLIN or SYSPUNCH)	236
Creating an associated data file (SYSADATA)	237
Defining the output Java data set (SYSJAVA)	237
Defining the debug data set (SYSDEBUG)	237
Specifying compiler options under z/OS	238
Specifying compiler options with the PROCESS (CBL) statement	238
Example: specifying compiler options using JCL	239
Example: specifying compiler options under TSO	239
Compiler options and compiler output under z/OS	239
Compiling multiple programs (batch compilation)	241
Example: batch compilation	242
Specifying compiler options in a batch compilation	242
Example: precedence of options in a batch compilation	243
Example: LANGUAGE option in a batch compilation	244
Correcting errors in your source program	245
Generating a list of compiler error messages	246
Messages and listings for compiler-detected errors	246
Format of compiler error messages	246
Severity codes for compiler error messages	247

Chapter 15. Compiling under UNIX 249

Setting environment variables under UNIX	249
Specifying compiler options under UNIX	250
Compiling and linking with the cob2 command	251
Defining input and output	251
Creating a DLL.	252
Example: using cob2 to compile under UNIX	252
cob2	253
cob2 input and output files.	254
Compiling using scripts	255

Chapter 16. Compiling, linking, and running OO applications 257

Compiling, linking, and running OO applications under UNIX.	257
Compiling OO applications under UNIX	257
Preparing OO applications under UNIX	258

Example: compiling and linking a COBOL class definition under UNIX	259
Running OO applications under UNIX	259
Compiling, linking, and running OO applications using JCL or TSO/E	261
Compiling OO applications using JCL or TSO/E	261
Preparing and running OO applications using JCL or TSO/E	262
Example: compiling, linking, and running an OO application using JCL	263

Chapter 17. Compiler options 267

Option settings for COBOL 85 Standard conformance.	269
Conflicting compiler options	269
ADATA	270
ADV	271
ARITH	271
AWO	272
BUFSIZE	273
CICS	273
CODEPAGE	274
COMPILE	275
CURRENCY.	276
DATA	277
DATEPROC	278
DBCS	279
DECK	279
DIAGTRUNC	280
DLL	281
DUMP	281
DYNAM	282
EXIT	283
EXPORTALL	283
FASTSRT	284
FLAG	284
FLAGSTD	285
INTDATE	287
LANGUAGE	287
LIB	288
LINECOUNT	289
LIST	289
MAP	290
NAME	291
NSYMBOL	291
NUMBER	292
NUMPROC	293
OBJECT	294
OFFSET	294
OPTIMIZE	295
OUTDD	296
PGMNAME	297
PGMNAME(COMPAT)	297
PGMNAME(LONGUPPER).	298
PGMNAME(LONGMIXED)	298
QUOTE/APOST	299
RENT	299
RMODE	300
SEQUENCE	301
SIZE	302
SOURCE	302

SPACE	303
SQL	303
SSRANGE	304
TERMINAL	305
TEST	306
THREAD	309
TRUNC	310
TRUNC example 1	312
TRUNC example 2	312
VBREF	313
WORD	313
XREF	314
YEARWINDOW	315
ZWB	316

Chapter 18. Compiler-directing statements 317

Chapter 19. Debugging 321

Debugging with source language	322
Tracing program logic	322
Finding and handling input-output errors	323
Validating data	323
Finding uninitialized data	323
Generating information about procedures	324
Debugging using compiler options	325
Finding coding errors	326
Finding line sequence problems	327
Checking for valid ranges	327
Selecting the level of error to be diagnosed	328
Finding program entity definitions and references	329
Listing data items	330
Getting listings	331
Example: short listing	332
Example: SOURCE and NUMBER output	335
Example: embedded map summary	337
Terms used in MAP output	338
Symbols used in LIST and MAP output	338
Example: nested program map	340
Reading LIST output	340
Example: XREF output - data-name cross-references	352
Example: XREF output - program-name cross-references	353
Example: embedded cross-reference	353
Example: OFFSET compiler output	354
Example: VBREF compiler output	355
Preparing to use the debugger	355

Part 3. Targeting COBOL programs for certain environments 357

Chapter 20. Developing COBOL programs for CICS 359

Coding COBOL programs to run under CICS	359
Coding file input and output	360
Retrieving the system date and time	360
Displaying the contents of data items	361

Calling to or from COBOL programs	361
Coding nested programs	361
Coding a COBOL program to run above the 16-MB line	362
Determining the success of ECI calls	362
Compiling with the CICS option	362
Compiling a sequence of programs	363
Separating CICS suboptions	364
Integrated CICS translator	364
Using the separate CICS translator	365
CICS reserved-word table	366
Handling errors by using CICS HANDLE	367
Example: handling errors by using CICS HANDLE	368

Chapter 21. Programming for a DB2 environment 371

Coding SQL statements	371
Using SQL INCLUDE with the DB2 coprocessor	371
Using character data	372
Using binary items	373
Determining the success of SQL statements	373
Compiling with the SQL option	373
Compiling in batch	374
Separating DB2 suboptions	374
DB2 coprocessor	375

Chapter 22. Developing COBOL programs for IMS. 377

Compiling and linking COBOL programs for running under IMS	377
Using object-oriented COBOL and Java under IMS	378
Calling a COBOL method from an IMS Java application	378
Building a mixed COBOL and Java application that starts with COBOL	379
Writing mixed-language applications	380

Chapter 23. Running COBOL programs under UNIX. 383

Running in UNIX environments	383
Setting and accessing environment variables	384
Setting environment variables that affect execution	384
Resetting environment variables	385
Accessing environment variables	385
Example: accessing environment variables	385
Calling UNIX/POSIX APIs	386
fork(), exec(), and spawn()	386
Samples	387
Accessing main program parameters	388
Example: accessing main program parameters	388

Part 4. Structuring complex applications 391

Chapter 24. Using subprograms 393

Main programs, subprograms, and calls	394
---	-----

Ending and reentering main programs or subprograms	394
Transferring control to another program	396
Making static calls.	397
Making dynamic calls	397
AMODE switching	399
Performance considerations of static and dynamic calls	401
Making both static and dynamic calls	401
Examples: static and dynamic CALL statements	402
Calling nested COBOL programs	403
Making recursive calls	407
Calling to and from object-oriented programs	407
Using procedure and function pointers	407
Deciding which type of pointer to use	408
Calling a C function pointer	408
Calling to alternate entry points	409
Making programs reentrant	409

Chapter 25. Sharing data 411

Passing data.	411
Describing arguments in the calling program	413
Describing parameters in the called program	413
Testing for OMITTED arguments	414
Coding the LINKAGE SECTION	414
Coding the PROCEDURE DIVISION for passing arguments	415
Grouping data to be passed	415
Handling null-terminated strings	415
Using pointers to process a chained list	416
Passing return code information	419
Understanding the RETURN-CODE special register	419
Using PROCEDURE DIVISION RETURNING	420
Specifying CALL . . . RETURNING	420
Sharing data by using the EXTERNAL clause.	420
Sharing files between programs (external files)	421
Example: using external files	421

Chapter 26. Creating a DLL or a DLL application 425

Dynamic link libraries (DLLs)	425
Compiling programs to create DLLs.	426
Linking DLLs	427
Example: sample JCL for a procedural DLL application	428
Prelinking certain DLLs	429
Using CALL identifier with DLLs	429
Search order for DLLs in HFS	430
Using DLL linkage and dynamic calls together	430
Using procedure or function pointers with DLLs	431
Calling DLLs from non-DLLs	432
Example: calling DLLs from non-DLLs	432
Using COBOL DLLs with C/C++ programs	434
Using DLLs in OO COBOL applications	434

Chapter 27. Preparing COBOL programs for multithreading 437

Multithreading	437
--------------------------	-----

Choosing THREAD to support multithreading	439
Transferring control with multithreading	439
Using cancel with threaded programs	439
Ending a program.	439
Preinitializing the COBOL environment	440
Processing files with multithreading.	440
File definition storage	440
Recommended usage for file access	441
Example: usage patterns of file input and output with multithreading.	441
Handling COBOL limitations with multithreading	442

Part 5. Using XML and COBOL together 445

Chapter 28. Processing XML input 447

XML parser in COBOL	447
Accessing XML documents	449
Parsing XML documents	449
Processing XML events	450
Writing procedures to process XML	456
Understanding the encoding of XML documents	462
Coded character sets for XML documents	463
Code-page-sensitive characters in XML markup	464
Specifying the code page	464
Handling errors in parsing XML documents	465
Unhandled exceptions	467
Handling exceptions	468
Terminating XML parsing	468
Code-page conflict exception	469

Chapter 29. Producing XML output 471

Generating XML output	471
Example: generating XML	473
Enhancing XML output	476
Example: enhancing XML output.	477
Controlling the encoding of generated XML output	480
Handling errors in generating XML output	480

Part 6. Developing object-oriented programs 483

Chapter 30. Writing object-oriented programs 485

Example: accounts.	486
Subclasses	487
Defining a class	488
CLASS-ID paragraph for defining a class	490
REPOSITORY paragraph for defining a class	490
WORKING-STORAGE SECTION for defining class instance data.	492
Example: defining a class	493
Defining a class instance method.	493
METHOD-ID paragraph for defining a class instance method	494
INPUT-OUTPUT SECTION for defining a class instance method	495

DATA DIVISION for defining a class instance method	495
PROCEDURE DIVISION for defining a class instance method	496
Overriding an instance method	497
Overloading an instance method	498
Coding attribute (get and set) methods	499
Example: defining a method	500
Defining a client	502
REPOSITORY paragraph for defining a client	503
DATA DIVISION for defining a client	504
Comparing and setting object references	505
Invoking methods (INVOKE)	506
Creating and initializing instances of classes	508
Freeing instances of classes	509
Example: defining a client	510
Defining a subclass	510
CLASS-ID paragraph for defining a subclass	511
REPOSITORY paragraph for defining a subclass	512
WORKING-STORAGE SECTION for defining subclass instance data	512
Defining a subclass instance method	513
Example: defining a subclass (with methods)	513
Defining a factory section	514
WORKING-STORAGE SECTION for defining factory data	515
Defining a factory method	516
Example: defining a factory (with methods)	518
Wrapping procedure-oriented COBOL programs	523
Structuring OO applications	524
Examples: COBOL applications that you can run using the java command	524

Chapter 31. Communicating with Java methods 527

Accessing JNI services	527
Handling Java exceptions	528
Managing local and global references	530
Java access controls	531
Sharing data with Java	531
Coding interoperable data types in COBOL and Java	532
Declaring arrays and strings for Java	532
Manipulating Java arrays	534
Manipulating Java strings	536
Example: J2EE client written in COBOL	539
COBOL client (ConverterClient.cbl)	539
Java client (ConverterClient.java)	541

Part 7. Specialized processing . . 543

Chapter 32. Interrupts and checkpoint/restart 545

Setting checkpoints	545
Designing checkpoints	546
Testing for a successful checkpoint	546
DD statements for defining checkpoint data sets	547
Messages generated during checkpoint	548
Restarting programs	548
Requesting automatic restart	549

Requesting deferred restart	549
Formats for requesting deferred restart	550
Resubmitting jobs for restart	551
Example: restarting a job at a specific checkpoint step	551
Example: requesting a step restart	551
Example: resubmitting a job for a step restart	551
Example: resubmitting a job for a checkpoint restart	552

Chapter 33. Processing two-digit-year dates 553

Millennium language extensions (MLE)	554
Principles and objectives of these extensions	554
Resolving date-related logic problems	555
Using a century window	556
Using internal bridging	557
Moving to full field expansion	558
Using year-first, year-only, and year-last date fields	560
Compatible dates	561
Example: comparing year-first date fields	562
Using other date formats	562
Example: isolating the year	562
Manipulating literals as dates	563
Assumed century window	564
Treatment of nondates	565
Setting triggers and limits	565
Example: using limits	566
Using sign conditions	567
Sorting and merging by date	567
Example: sorting by date and time	568
Performing arithmetic on date fields	569
Allowing for overflow from windowed date fields	569
Specifying the order of evaluation	570
Controlling date processing explicitly	571
Using DATEVAL	571
Using UNDATE	571
Example: DATEVAL	572
Example: UNDATE	572
Analyzing and avoiding date-related diagnostic messages	572
Avoiding problems in processing dates	574
Avoiding problems with packed-decimal fields	574
Moving from expanded to windowed date fields	574

Part 8. Improving performance and productivity 577

Chapter 34. Tuning your program . . . 579

Using an optimal programming style	579
Using structured programming	580
Factoring expressions	580
Using symbolic constants	580
Grouping constant computations	580
Grouping duplicate computations	581
Choosing efficient data types	581
Computational data items	581
Consistent data types	582

Arithmetic expressions	582
Exponentiations	582
Handling tables efficiently	583
Optimization of table references	584
Optimizing your code	586
Optimization	586
Example: PERFORM procedure integration	588
Choosing compiler features to enhance performance.	588
Performance-related compiler options	589
Evaluating performance	592
Running efficiently with CICS, IMS, or VSAM	592
CICS	592
IMS	593
VSAM.	593

Chapter 35. Simplifying coding. 595

Eliminating repetitive coding	595
Example: using the COPY statement.	596
Using Language Environment callable services	597
Sample list of Language Environment callable services	598
Calling Language Environment services	599
Example: Language Environment callable services	600

Part 9. Appendixes 601

Appendix A. Intermediate results and arithmetic precision 603

Terminology used for intermediate results.	604
Example: calculation of intermediate results	605
Fixed-point data and intermediate results	605
Addition, subtraction, multiplication, and division	605
Exponentiation	606
Example: exponentiation in fixed-point arithmetic	607
Truncated intermediate results.	608
Binary data and intermediate results	608
Intrinsic functions evaluated in fixed-point arithmetic	608
Integer functions	608
Mixed functions	609
Floating-point data and intermediate results	610
Exponentiations evaluated in floating-point arithmetic	611
Intrinsic functions evaluated in floating-point arithmetic	611
Arithmetic expressions in nonarithmetic statements	611

Appendix B. Complex OCCURS DEPENDING ON 613

Example: complex ODO.	613
How length is calculated	614
Setting values of ODO objects	614
Effects of change in ODO object value	614
Preventing index errors when changing ODO object value	615

Preventing overlay when adding elements to a variable table	615
---	-----

Appendix C. Converting double-byte character set (DBCS) data 619

DBCS notation	619
Alphanumeric to DBCS data conversion (IGZCA2D)	619
IGZCA2D syntax	619
IGZCA2D return codes	620
Example: IGZCA2D	621
DBCS to alphanumeric data conversion (IGZCD2A)	622
IGZCD2A syntax	622
IGZCD2A return codes	623
Example: IGZCD2A	623

Appendix D. XML reference material 625

XML PARSE exceptions that allow continuation	625
XML PARSE exceptions that do not allow continuation.	628
XML conformance.	631
XML GENERATE exceptions	633

Appendix E. EXIT compiler option . . . 635

Using the user-exit work area	636
Calling from exit modules	637
Processing of INEXIT.	637
Parameter list for INEXIT	637
Processing of LIBEXIT	638
Processing of LIBEXIT with nested COPY statements	639
Parameter list for LIBEXIT	640
Processing of PRTEXTIT	641
Parameter list for PRTEXTIT.	641
Processing of ADEXIT	642
Parameter list for ADEXIT	643
Error handling for exit modules	644
Using the EXIT compiler option with CICS and SQL statements.	644
INEXIT	644
LIBEXIT	644
PRTEXTIT	645
ADEXIT	645
Example: INEXIT user exit	645

Appendix F. JNI.cpy 649

Appendix G. COBOL SYSADATA file contents 655

Existing compiler options affecting the SYSADATA file	655
SYSADATA record types	656
Example: SYSADATA	657
SYSADATA record descriptions	658
Common header section.	659
Job identification record - X'0000'.	660
ADATA identification record - X'0001'	661
Compilation unit start/end record - X'0002'	662
Options record - X'0010'.	662

External symbol record - X'0020'	672
Parse tree record - X'0024'	673
Token record - X'0030'	687
Source error record - X'0032'	687
Source record - X'0038'	688
COPY REPLACING record - X'0039'	688
Symbol record - X'0042'	689
Symbol cross-reference record - X'0044'	700
Nested program record - X'0046'	701
Library record - X'0060'	702
Statistics record - X'0090'	703
EVENTS record - X'0120'	703

Appendix H. Sample programs 705

IGYTCARA: batch application.	705
Input data for IGYTCARA	706
Report produced by IGYTCARA	707
Preparing to run IGYTCARA	708
IGYTCARB: interactive program	709

Preparing to run IGYTCARB	709
IGYTSALE: nested program application	711
Input data for IGYTSALE	713
Reports produced by IGYTSALE	715
Preparing to run IGYTSALE	719
Language elements and concepts that are illustrated	720

Notices 725

Trademarks	726
----------------------	-----

Glossary 727

List of resources 751

Enterprise COBOL for z/OS	751
Related publications	751

Index 753

Tables

1. FILE-CONTROL entries	8
2. FILE SECTION entries	14
3. Assignment to data items in a program	25
4. Effect of RMODE and RENT compiler options on the RMODE attribute	35
5. Ranges in value of COMP-5 data items	41
6. Internal representation of numeric items	42
7. NUMCLS(PRIM) and valid signs	46
8. NUMCLS(ALT) and valid signs	47
9. Order of evaluation of arithmetic operators	48
10. Numeric intrinsic functions	49
11. Compatibility of math intrinsic functions and callable services	50
12. INTDATE(ANSI) and compatibility of date intrinsic functions and callable services.	51
13. INTDATE(LILIAN) and compatibility of date intrinsic functions and callable services.	51
14. Hexadecimal values of the euro sign	56
15. COBOL statements and national data	103
16. Intrinsic functions and national data	104
17. Encoding and size of alphanumeric and national data	107
18. File organization, access mode, and record format	115
19. QSAM file allocation.	134
20. Maximum record length of QSAM files	137
21. Handling of QSAM user labels	142
22. Identifiers for standard tape labels	143
23. Comparison of VSAM data set types	149
24. VSAM file organization, access mode, and record format	150
25. Steps for using variable-length RRDS	152
26. Definition of VSAM fixed-length records	154
27. Definition of VSAM variable-length records	155
28. I/O statements for VSAM sequential files	156
29. I/O statements for VSAM relative and indexed files	156
30. Statements to load records into a VSAM file	159
31. Statements to update records in a VSAM file	161
32. Methods for improving VSAM performance	172
33. Methods for checking for sort errors with NOFASTSRT	195
34. Methods for controlling sort behavior	196
35. Compiler data sets	233
36. Block size of fixed-length compiler data sets	235
37. Block size of variable-length compiler data sets	235
38. Types of compiler output under z/OS	239
39. Severity codes for compiler error messages	247
40. Input files to the cob2 command.	254
41. Output files from the cob2 command	255
42. Commands for compiling and linking a class definition.	258
43. java command options for customizing the JVM	260
44. Compiler options	267
45. Mutually exclusive compiler options	270
46. Values of the LANGUAGE compiler option	288
47. Severity levels of compiler messages	328
48. Using compiler options to get listings	331
49. Terms used in MAP output	338
50. Symbols used in LIST and MAP output	338
51. Signature information bytes for compiler options	344
52. Signature information bytes for the DATA DIVISION	345
53. Signature information bytes for the ENVIRONMENT DIVISION	346
54. Signature information bytes for PROCEDURE DIVISION verbs	346
55. Signature information bytes for more PROCEDURE DIVISION items	348
56. Calls between COBOL and assembler under CICS	361
57. Compiler options required for the integrated CICS translator.	363
58. Compiler options required for the separate CICS translator.	366
59. TRUNC compiler options recommended for the separate CICS translator	366
60. Compiler options required with the DB2 coprocessor	374
61. Samples with POSIX function calls	387
62. Effects of termination statements.	394
63. Methods for passing data in the CALL statement.	412
64. Compiler options for DLL applications	426
65. Binder options for DLL applications	427
66. Special registers used by the XML parser	456
67. Supported EBCDIC code pages	463
68. Hexadecimal values of special characters for code page CCSIDs	464
69. Aliases for XML encoding declarations	465
70. Encoding of generated XML output.	480
71. Structure of class definitions	488
72. Structure of instance method definitions	493
73. Structure of COBOL clients	502
74. Structure of factory definitions	515
75. Structure of factory method definitions	516
76. JNI services for local and global references	531
77. Interoperable data types in COBOL and Java	532
78. Interoperable arrays and strings in COBOL and Java	532
79. Noninteroperable array types in COBOL and Java	533
80. JNI array services	534
81. Services that convert between jstring references and national data	536
82. Services that convert between jstring references and alphanumeric data	537

83. Advantages and disadvantages of Year 2000 solutions	556	100. ADEXIT processing	642
84. Performance-related compiler options	589	101. ADEXIT parameter list	643
85. Performance-tuning worksheet	592	102. SYSADATA record types	656
86. Language Environment callable services	598	103. SYSADATA common header section	659
87. IGZCA2D return codes	620	104. SYSADATA job identification record	661
88. IGZCD2A return codes	623	105. ADATA identification record	662
89. XML PARSE exceptions that allow continuation	625	106. SYSADATA compilation unit start/end record	662
90. XML PARSE exceptions that do not allow continuation	628	107. SYSADATA options record	662
91. XML GENERATE exceptions	633	108. SYSADATA external symbol record	672
92. INEXIT processing	637	109. SYSADATA parse tree record	673
93. INEXIT parameter list	638	110. SYSADATA token record	687
94. LIBEXIT processing	638	111. SYSADATA source error record	687
95. LIBEXIT processing with nonnested COPY statements	639	112. SYSADATA source record	688
96. LIBEXIT processing with nested COPY statements	640	113. SYSADATA COPY REPLACING record	688
97. LIBEXIT parameter list	640	114. SYSADATA symbol record	689
98. PRTEXIT processing	641	115. SYSADATA symbol cross-reference record	700
99. PRTEXIT parameter list	642	116. SYSADATA nested program record	701
		117. SYSADATA library record	702
		118. SYSADATA statistics record	703
		119. SYSADATA EVENTS record	703

About this document

Welcome to IBM Enterprise COBOL for z/OS, IBM's latest host COBOL compiler!

This version of IBM COBOL adds new COBOL function to help integrate COBOL business processes and Web-oriented business processes by:

- Simplifying the componentization of COBOL programs and enabling interoperability with Java components
- Promoting the exchange and use of data in standardized formats, including XML and Unicode

Accessibility

Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use software products successfully. The accessibility features in z/OS provide accessibility for Enterprise COBOL.

The major accessibility features in z/OS enable users to:

- Use assistive technology products such as screen readers and screen magnifier software.
- Operate specific or equivalent features by using only the keyboard.
- Customize display attributes such as color, contrast, and font size.

Using assistive technologies

Assistive technology products work with the user interfaces that are found in z/OS. For specific guidance information, consult the documentation for the assistive technology product that you use to access z/OS interfaces.

Keyboard navigation of the user interface

Users can access z/OS user interfaces by using TSO/E or ISPF. For information about accessing TSO/E and ISPF interfaces, refer to the following publications:

- *z/OS TSO/E Primer*
- *z/OS TSO/E User's Guide*
- *z/OS ISPF User's Guide Volume I*

These guides describe how to use TSO/E and ISPF, including the use of keyboard shortcuts or function keys (PF keys). Each guide includes the default settings for the PF keys and explains how to modify their functions.

Accessibility of this document

The English-language XHTML format of this document that is provided with WebSphere Studio Enterprise Developer is accessible to visually impaired individuals who use a screen reader.

To enable your screen reader to accurately read syntax diagrams, source code examples, and text that contains the period and comma PICTURE symbols, you must set the screen reader to speak all punctuation.

How this document will help you

This document will help you write and compile Enterprise COBOL programs. It will also help you define object-oriented classes and methods, invoke methods, and refer to objects in your programs.

This document assumes experience in developing application programs and some knowledge of COBOL. It focuses on using Enterprise COBOL to meet your programming objectives and not on the definition of the COBOL language. For complete information on COBOL syntax, see *IBM Enterprise COBOL Language Reference*.

For information on migrating programs to Enterprise COBOL, see *IBM Enterprise COBOL Compiler and Run-Time Migration Guide*.

IBM z/OS Language Environment provides the run-time environment and run-time services that are required to run your Enterprise COBOL programs. You will find information on link-editing and running programs in the *IBM z/OS Language Environment Programming Guide* and *IBM z/OS Language Environment Programming Reference*.

For a comparison of commonly used Enterprise COBOL and IBM z/OS Language Environment terms, see “Comparison of commonly used terms” on page xvii.

Abbreviated terms

Certain terms are used in a shortened form in this document. Abbreviations for the product names used most frequently are listed alphabetically in the following table:

Term used	Long form
CICS	CICS Transaction Server
Enterprise COBOL	IBM Enterprise COBOL for z/OS
Language Environment	IBM z/OS Language Environment
MVS	MVS/ESA
UNIX	z/OS UNIX System Services

OS/390 Version 2 Release 10 and z/OS Version 1 Release 1 and later are referred to collectively as “z/OS” throughout this document. The e-server zSeries and the S/390 hardware are referred to collectively as “zSeries.”

In addition to these abbreviated terms, the term “COBOL 85 Standard” is used to refer to the combination of the following standards:

- ISO 1989:1985, Programming languages - COBOL
- ISO/IEC 1989/AMD1:1992, Programming languages - COBOL - Intrinsic function module
- ISO/IEC 1989/AMD2:1994, Programming languages - COBOL - Correction and clarification amendment for COBOL
- ANSI INCITS 23-1985, Programming Languages - COBOL
- ANSI INCITS 23a-1989, Programming Languages - Intrinsic Function Module for COBOL

- ANSI INCITS 23b-1993, Programming Language - Correction Amendment for COBOL

The ISO standards are identical to the American National standards.

Other terms, if not commonly understood, are shown in *italics* the first time that they appear, and are listed in the glossary at the back of this document.

Comparison of commonly used terms

To better understand the terms used throughout the IBM z/OS Language Environment and IBM Enterprise COBOL for z/OS publications and what terms are meant to be equivalent, see the following table:

Language Environment term	Enterprise COBOL equivalent
Aggregate	Group item
Array	A table created using the OCCURS clause
Array element	Table element
Enclave	Run unit
External data	WORKING-STORAGE data defined with EXTERNAL clause
Local data	Any non-EXTERNAL data item
Pass parameters directly, by value	BY VALUE
Pass parameters indirectly, by reference	BY REFERENCE
Pass parameters indirectly, by value	BY CONTENT
Routine	Program
Scalar	Elementary item

How to read syntax diagrams

The following rules apply to syntax diagrams:

- Read the syntax diagrams from left to right, from top to bottom, following the path of the line.

The >>— symbol indicates the beginning of a syntax diagram.

The —> symbol indicates that the syntax diagram is continued on the next line.

The >— symbol indicates that the syntax diagram is continued from the previous line.

The —>< symbol indicates the end of a syntax diagram.

Diagrams of syntactical units other than complete statements start with the >— symbol and end with the —> symbol.

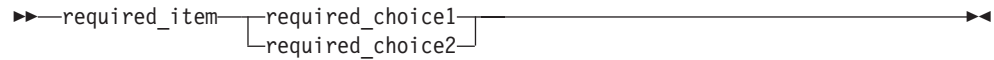
- Required items appear on the horizontal line (the main path):

>>—required_item—————><

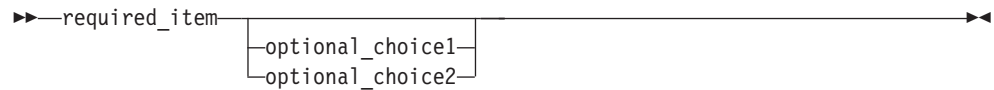
- Optional items appear below the main path:

>>—required_item—
 └optional_item┘—————><

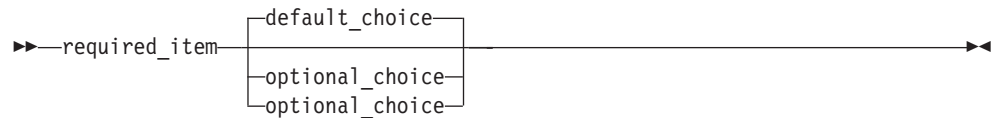
- If you can choose from two or more items, they appear vertically, in a stack. If you must choose one of the items, one item of the stack appears on the main path:



If choosing one of the items is optional, the entire stack appears below the main path:



If one of the items is the default, it appears above the main path and the remaining choices are shown below:



- An arrow returning to the left, above the main line, indicates an item that can be repeated:



If the repeat arrow contains a comma, you must separate repeated items with a comma:



- Keywords appear in uppercase (for example, FROM). They must be spelled exactly as shown. Variables appear in lowercase *italics* (for example, *column-name*). They represent user-supplied names or values.
- If punctuation marks, parentheses, arithmetic operators, or other such symbols are shown, you must enter them as part of the syntax.

How examples are shown

This document shows numerous examples of sample COBOL statements, program fragments, and small programs to illustrate the coding techniques being discussed. The examples of program code are written in lowercase, uppercase, or mixed case to demonstrate that you can write your programs in any of these ways.

To more clearly separate some examples from the explanatory text, they are presented in a monospace font.

COBOL keywords and compiler options that appear in text are generally shown in SMALL UPPERCASE. Other terms such as program variable names are sometimes shown in *an italic font* for clarity.

Accessing softcopy documentation and support information

IBM Enterprise COBOL for z/OS provides PDF and BookManager versions of the library on the product site at www.ibm.com/software/awdtools/cobol/zos/library/.

You can check that Web site for the latest editions of the documents. In the BookManager version of a document, the content of some tables and syntax diagrams might be aligned improperly due to variations in the display technology.

Support information is also available on the product site at www.ibm.com/software/awdtools/cobol/zos/support/.

Summary of changes

This section lists the key changes that have been made to Enterprise COBOL. The changes that are discussed in this document have an associated cross-reference for your convenience. The latest technical changes are marked by a revision bar in the left margin.

Version 3 Release 3 (February 2004)

- XML support has been enhanced. A new statement, XML GENERATE, converts the content of COBOL data records to XML format. XML GENERATE creates XML documents encoded in Unicode UTF-16 or in one of several single-byte EBCDIC code pages (Chapter 29, “Producing XML output,” on page 471).
- The XML PARSE statement supports XML files encoded in Unicode UTF-16 or any of several single-byte EBCDIC code pages. Support is not provided for ASCII code pages.
- There are new and improved features of Debug Tool:
 - Performance is improved when you use COBOL SYSDEBUG files.
 - You can more easily debug programs that use national data: When you display national data in a formatted dump or by using the Debug Tool LIST command, the data is automatically converted to EBCDIC representation using the code page specified by the CODEPAGE compiler option. You can use the Debug Tool MOVE command to assign values to national data items, and you can move national data items to or from group data items. You can use national data as a comparand in Debug Tool conditional commands such as IF and EVALUATE.
 - You can debug mixed COBOL-Java applications, COBOL class definitions, and COBOL programs that contain object-oriented syntax.

For further details about these enhancements to debugging support, see *Debug Tool User's Guide*.

- DB2 Version 8 SQL features are supported when you use the integrated DB2 coprocessor.
- The syntax for specifying options in the COBJVMINIOPTIONS environment variable has changed (“Running OO applications that start with a COBOL program” on page 260).

Version 3 Release 2 (September 2002)

- The compiler has been enhanced to support new features of Debug Tool, and features of Debug Tool Utilities and Advanced Functions:

- Playback support lets you record and replay application execution paths and data values.
- Automonitor support displays the values of variables that are referenced in the current statement during debugging.
- Programs that have been compiled with the OPTIMIZE and TEST(NONE,SYM,. . .) options are supported for debugging (“TEST” on page 306).
- The Debug Tool GOTO command is enabled for programs that have been compiled with the NOOPTIMIZE option and the TEST option with any of its suboptions (“TEST” on page 306). (In earlier releases, the GOTO command was not supported for programs compiled with TEST(NONE,. . .).)

For further details about these enhancements to debugging support, see *Debug Tool User's Guide*.

- Extending Java interoperability to IMS: Object-oriented COBOL programs can run in an IMS Java dependent region. The object-oriented COBOL and Java languages can be mixed in a single application (“Using object-oriented COBOL and Java under IMS” on page 378).
- Enhanced support for Java interoperability:
 - The OPTIMIZE compiler option is fully supported for programs that contain OO syntax for Java interoperability.
 - Object references of type `objectArray` are supported for interoperation between COBOL and Java (“Declaring arrays and strings for Java” on page 532).
 - OO applications that begin with a COBOL main factory method can be invoked with the `java` command (“Structuring OO applications” on page 524).
 - A new environment variable, `COBJVMINITOPTIONS`, is provided, enabling the user to specify options that will be used when COBOL initializes a Java virtual machine (JVM) (“Running OO applications under UNIX” on page 259).
 - OO applications that begin with a COBOL program can, with some limitations, be bound as modules in a PDSE and run using batch JCL (“Preparing and running OO applications using JCL or TSO/E” on page 262).
- Unicode enhancement for working with DB2: The code pages for host variables are handled implicitly when you use the DB2 integrated coprocessor. SQL DECLARE statements are necessary only for variables described with `USAGE DISPLAY` or `USAGE DISPLAY-1` when COBOL and DB2 code pages do not match (“Coding SQL statements” on page 371).

Version 3 Release 1 (November 2001)

- Interoperation of COBOL and Java by means of object-oriented syntax, permitting COBOL programs to instantiate Java classes, invoke methods on Java objects, and define Java classes that can be instantiated in Java or COBOL and whose methods can be invoked in Java or COBOL (Chapter 30, “Writing object-oriented programs,” on page 485)
- Ability to call services provided by the Java Native Interface (JNI) to obtain additional Java capabilities, with a copybook `JNI.cpy` and special register `JNIEnvPtr` to facilitate access (“Accessing JNI services” on page 527)
- XML support, including a high-speed XML parser that allows programs to consume inbound XML messages, verify that they are well formed, and transform their contents into COBOL data structures; with support for XML

documents encoded in Unicode UTF-16 or several single-byte EBCDIC or ASCII code pages (Chapter 28, “Processing XML input,” on page 447)

- Support for compilation of programs that contain CICS statements, without the need for a separate translation step (“Integrated CICS translator” on page 364)
 - Compiler option CICS, enabling integrated CICS translation and specification of CICS options (“CICS” on page 273)
- Support for Unicode provided by NATIONAL data type and national (N, NX) literals, intrinsic functions DISPLAY-OF and NATIONAL-OF for character conversions, and compiler options NSYMBOL and CODEPAGE (Chapter 7, “Processing character data in an international environment,” on page 103)
 - Compiler option CODEPAGE to specify the code page used for encoding national literals, and alphanumeric and DBCS data items and literals (“CODEPAGE” on page 274)
 - Compiler option NSYMBOL to control whether national or DBCS processing should be in effect for literals and data items that use the N symbol (“NSYMBOL” on page 291)
- Multithreading support: support of POSIX threads and asynchronous signals, permitting applications with COBOL programs to run on multiple threads within a process (Chapter 27, “Preparing COBOL programs for multithreading,” on page 437)
 - Compiler option THREAD, enabling programs to run in Language Environment enclaves with multiple POSIX threads or PL/I subtasks (“THREAD” on page 309)
- VALUE clauses for BINARY data items that permit numeric literals to have a value of magnitude up to the capacity of the native binary representation, rather than being limited to the value implied by the number of 9s in the PICTURE clause (“Formats for numeric data” on page 40)
- A 4-byte FUNCTION-POINTER data item that can contain the address of a COBOL or non-COBOL entry point, providing easier interoperability with C function pointers (“Using procedure and function pointers” on page 407)
- The following support is no longer provided (as documented in *Enterprise COBOL Compiler and Run-Time Migration Guide*):
 - SOM-based object-oriented syntax and services
 - Compiler options CMPR2, ANALYZE, FLAGMIG, TYPECHK, and IDLGEN
- Changed default values for the following compiler options: DBCS (“DBCS” on page 279), FLAG(I,I) (“FLAG” on page 284), RENT (“RENT” on page 299), and XREF(FULL) (“XREF” on page 314)

For a history of changes to previous COBOL compilers, see *Enterprise COBOL Compiler and Run-Time Migration Guide*.

How to send your comments

Your feedback is important in helping us to provide accurate, high-quality information. If you have comments about this document or any other Enterprise COBOL documentation, contact us in one of these ways:

- Fill out the Readers’ Comment Form at the back of this document, and return it by mail or give it to an IBM representative. If the form has been removed, address your comments to:

IBM Corporation
H150/090

555 Bailey Avenue
San Jose, CA 95141-1003
USA

- Fax your comments to this U.S. number: (800)426-7773.
- Use the Online Readers' Comment Form at www.ibm.com/software/awdtools/rcf/.

Be sure to include the name of the document, the publication number of the document, the version of Enterprise COBOL, and, if applicable, the specific location (for example, page number) of the text that you are commenting on.

When you send information to IBM, you grant IBM a nonexclusive right to use or distribute the information in any way it believes appropriate without incurring any obligation to you.

Part 1. Coding your program

Chapter 1. Structuring your program 5

Identifying a program	5
Identifying a program as recursive	6
Marking a program as callable by containing programs	6
Setting a program to an initial state.	6
Changing the header of a source listing	7
Describing the computing environment	7
Example: FILE-CONTROL entries	8
Specifying the collating sequence	8
Example: specifying the collating sequence	9
Defining symbolic characters	10
Defining a user-defined class	10
Defining files to the operating system	10
Varying the input or output file at run time	11
Optimizing buffer and device space	12
Describing the data.	12
Using data in input and output operations	13
FILE SECTION entries.	14
Comparison of WORKING-STORAGE and LOCAL-STORAGE	15
Example: storage sections.	15
Using data from another program	17
Sharing data in separately compiled programs	17
Sharing data in nested programs	17
Sharing data in recursive or multithreaded programs	17
Processing the data.	18
How logic is divided in the PROCEDURE DIVISION	18
Imperative statements	19
Conditional statements	19
Compiler-directing statements	20
Scope terminators	21
Declaratives	22

Chapter 2. Using data 23

Using variables, structures, literals, and constants	23
Variables	23
Data structure: data items and group items.	23
Literals	24
Constants	24
Figurative constants	25
Assigning values to data items	25
Examples: initializing data items	26
Initializing a structure (INITIALIZE)	27
Assigning values to elementary or group data items (MOVE)	27
Assigning arithmetic results (MOVE or COMPUTE)	28
Assigning input from a screen or file (ACCEPT)	29
Displaying values on a screen or in a file (DISPLAY)	30
Displaying data on the system logical output device	31
Using WITH NO ADVANCING	31
Using intrinsic functions (built-in functions)	32

Types of intrinsic functions	33
Nesting functions	33
Using tables (arrays) and pointers	33
Storage and its addressability	34
Settings for RMODE	35
Storage restrictions for passing data	35
Location of data areas	35
Storage for LOCAL-STORAGE data	35
Storage for external data	35
Storage for QSAM input-output buffers	36

Chapter 3. Working with numbers and arithmetic 37

Defining numeric data.	37
Displaying numeric data	38
Controlling how numeric data is stored	39
Formats for numeric data.	40
External decimal (DISPLAY) items	40
External floating-point (DISPLAY) items	40
Binary (COMP) items	41
Native binary (COMP-5) items	41
Packed-decimal (COMP-3) items	42
Floating-point (COMP-1 and COMP-2) items	42
Examples: numeric data and internal representation	42
Data format conversions	43
Conversions and precision	44
Conversions that preserve precision	44
Conversions that result in rounding	44
Sign representation and processing	45
NUMPROC(PFD)	45
NUMPROC(NOPFD)	45
NUMPROC(MIG)	46
Checking for incompatible data (numeric class test)	46
Performing arithmetic	47
COMPUTE and other arithmetic statements	47
Arithmetic expressions	48
Numeric intrinsic functions	48
Nesting functions and arithmetic expressions	49
ALL subscripting and special registers	49
Math and date Language Environment services	49
Math-oriented callable services	50
Date callable services	51
Examples: numeric intrinsic functions	51
General number handling	51
Date and time	52
Finance.	52
Mathematics	53
Statistics	53
Fixed-point versus floating-point arithmetic	53
Floating-point evaluations	54
Fixed-point evaluations	54
Arithmetic comparisons (relation conditions)	54
Examples: fixed-point and floating-point evaluations	55
Using currency signs	55
Example: multiple currency signs	56

Chapter 4. Handling tables.	59
Defining a table (OCCURS)	59
Nesting tables	60
Subscripting	60
Indexing	61
Referring to an item in a table	61
Subscripting	62
Indexing	63
Putting values into a table	64
Loading a table dynamically.	64
Initializing a table (INITIALIZE)	64
Assigning values when you define a table (VALUE)	65
Initializing each table item individually	65
Initializing a table at the 01 level	65
Initializing all occurrences of a table element	65
Example: PERFORM and subscripting	66
Example: PERFORM and indexing.	67
Creating variable-length tables (DEPENDING ON)	68
Loading a variable-length table.	69
Assigning values to a variable-length table.	70
Searching a table	71
Doing a serial search (SEARCH)	71
Example: serial search	71
Doing a binary search (SEARCH ALL)	72
Example: binary search	72
Processing table items using intrinsic functions	73
Example: intrinsic functions	73
Chapter 5. Selecting and repeating program actions	75
Selecting program actions	75
Coding a choice of actions	75
Using nested IF statements	76
Using the EVALUATE statement	77
Coding conditional expressions.	79
Switches and flags	80
Defining switches and flags	80
Example: switches	81
Example: flags	81
Resetting switches and flags.	81
Example: set switch on	82
Example: set switch off	82
Repeating program actions	83
Choosing inline or out-of-line PERFORM	83
Example: inline PERFORM statement.	84
Coding a loop	84
Coding a loop through a table	85
Executing multiple paragraphs or sections	85
Chapter 6. Handling strings	87
Joining data items (STRING)	87
Example: STRING statement.	88
STRING program results	88
Splitting data items (UNSTRING)	89
Example: UNSTRING statement	89
UNSTRING program results.	91
Manipulating null-terminated strings.	91
Example: null-terminated strings	92
Referring to substrings of data items	93
Reference modifiers.	94

Example: arithmetic expressions as reference modifiers	94
Example: intrinsic functions as reference modifiers	95
Tallying and replacing data items (INSPECT)	95
Examples: INSPECT statement	96
Converting data items (intrinsic functions)	97
Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE).	97
Converting to reverse order (REVERSE)	97
Converting to numbers (NUMVAL, NUMVAL-C)	97
Converting from one code page to another	98
Evaluating data items (intrinsic functions)	99
Evaluating single characters for collating sequence	99
Finding the largest or smallest data item	99
MAX and MIN	100
ORD-MAX and ORD-MIN	100
Returning variable-length results with alphanumeric functions	100
Finding the length of data items	101
Finding the date of compilation	102

Chapter 7. Processing character data in an international environment	103
Unicode and encoding of language characters	105
Using national data (Unicode) in COBOL	106
National data items	106
National literals	106
National characters as figurative constants	106
Storage of national data	107
Converting national data	107
Converting alphanumeric and integer to national data (MOVE)	107
Converting alphanumeric to national data (NATIONAL-OF)	108
Converting national to alphanumeric data (DISPLAY-OF)	108
Overriding the default code page.	108
Conversion exceptions	108
Example: converting national data	109
Processing UTF-8 data	109
Processing Chinese GB 18030 data	110
Comparing national data items	111
Comparing national operands	111
Comparing national and numeric operands	111
Comparing national and alphabetic or alphanumeric operands	111
Comparing national and group operands	111
Processing alphanumeric data items that contain DBCS data	112

Chapter 8. Processing files	113
File organization and input-output devices	113
Choosing file organization and access mode	115
Format for coding input and output.	116
Allocating files	117
Checking for input or output errors	118

Chapter 9. Processing QSAM files	119
Defining QSAM files and records in COBOL	119

Establishing record formats.	120	Specifying relative organization for VSAM files	151
Logical records	120	Fixed-length and variable-length RRDS.	152
Requesting fixed-length format	121	Simulating variable-length RRDS.	152
Requesting variable-length format	122	Specifying access modes for VSAM files	153
Requesting spanned format.	124	Example: using dynamic access with VSAM	
Requesting undefined format	126	files	154
Setting block sizes.	127	Defining record lengths for VSAM files.	154
Letting z/OS determine block size	127	Defining fixed-length records	154
Setting block size explicitly.	127	Defining variable-length records	155
Taking advantage of LBI.	128	Coding input and output statements for VSAM	
Block size and the DCB RECFM		files	155
subparameter	129	File position indicator	157
Coding input and output statements for QSAM		Opening a file (ESDS, KSDS, or RRDS).	158
files	129	Opening an empty file	158
Opening QSAM files	130	Statements to load records into a VSAM file	159
Dynamically creating QSAM files with		Opening a loaded file (a file with records)	160
CBLQDA.	130	Reading records from a VSAM file	160
Adding records to QSAM files.	131	Updating records in a VSAM file.	161
Updating QSAM files	131	Adding records to a VSAM file	162
Writing QSAM files to a printer or spooled data		Adding records sequentially	162
set	131	Adding records randomly or dynamically	162
Controlling the page size	132	Replacing records in a VSAM file.	162
Controlling the vertical positioning of records	132	Deleting records from a VSAM file	163
Closing QSAM files	132	Closing VSAM files	163
Handling errors in QSAM files	133	Handling errors in VSAM files	164
Working with QSAM files	133	Protecting VSAM files with a password	164
Defining and allocating QSAM files	134	Example: password protection for a VSAM	
Parameters for creating QSAM files	135	indexed file	165
Retrieving QSAM files	136	Working with VSAM data sets under z/OS and	
Parameters for retrieving QSAM files	136	UNIX	165
Ensuring file attributes match your program	137	Defining VSAM files	166
Processing existing files	137	Creating alternate indexes	167
Defining variable-length (format-V) records	138	Example: entries for alternate indexes	168
Defining format-U records	138	Allocating VSAM files	169
Defining fixed-length records	138	Sharing VSAM files through RLS.	170
Processing new files	138	Preventing update problems with VSAM files	
Processing files dynamically created by		in RLS mode	170
COBOL	139	Restrictions when using RLS	171
Using striped extended-format QSAM data sets	139	Handling errors in VSAM files in RLS mode	171
Allocation of buffers for QSAM files.	140	Improving VSAM performance	171
Accessing HFS files using QSAM.	140		
Labels for QSAM files	141	Chapter 11. Processing line-sequential files	175
Using trailer and header labels	141	Defining line-sequential files and records in	
Getting a user-label track	142	COBOL	175
Handling user labels	142	Allowable control characters	176
Format of standard labels	143	Describing the structure of a line-sequential file	176
Standard user labels	143	Defining and allocating line-sequential files	177
Processing QSAM ASCII files on tape	144	Coding input-output statements for line-sequential	
Requesting the ASCII alphabet	144	files	177
Defining the record formats	144	Opening line-sequential files	178
Defining the ddname.	144	Reading records from line-sequential files	178
Processing ASCII file labels.	145	Adding records to line-sequential files	179
		Closing line-sequential files.	179
Chapter 10. Processing VSAM files	147	Handling errors in line-sequential files	180
VSAM files	148		
Defining VSAM file organization and records	149	Chapter 12. Sorting and merging files	181
Specifying sequential organization for VSAM		Sort and merge process	182
files	150	Describing the sort or merge file	182
Specifying indexed organization for VSAM files	150	Describing the input to sorting or merging	183
Alternate keys	151	Example: describing sort and input files for	
Alternate index.	151	SORT	183

Coding the input procedure	184
Describing the output from sorting or merging . . .	185
Coding the output procedure	185
Coding considerations when using DFSORT . . .	186
Example: coding the output procedure when using DFSORT	186
Restrictions on input and output procedures . . .	187
Defining sort and merge data sets	187
Sorting variable-length records	188
Requesting the sort or merge	188
Setting sort or merge criteria	189
Example: sorting with input and output procedures	190
Choosing alternate collating sequences	190
Sorting on windowed date fields	191
Preserving the original sequence of records with equal keys	191
Determining whether the sort or merge was successful	192
Stopping a sort or merge operation prematurely . .	192
Improving sort performance with FASTSRT	193
FASTSRT requirements for JCL	193
FASTSRT requirements for sort input and output files	193
QSAM requirements	194
VSAM requirements	195
Checking for sort errors with NOFASTSRT	195
Controlling sort behavior	195
Sort special registers	196
Changing DFSORT defaults with control statements	197
Default characteristics of the IGZSRTCD data set	197
Allocating storage for sort or merge operations .	197
Allocating space for sort files	198
Using checkpoint/restart with DFSORT	198
Sorting under CICS	199
CICS SORT application restrictions	199
 Chapter 13. Handling errors	 201
Requesting dumps	201
Creating a formatted dump.	201
Creating a system dump	202
Handling errors in joining and splitting strings . .	202
Handling errors in arithmetic operations	203
Example: checking for division by zero. . . .	203
Handling errors in input and output operations . .	203
Using the end-of-file condition (AT END) . . .	206
Coding ERROR declaratives	207
Using file status keys.	208
Example: file status key	209
Using VSAM return codes (VSAM files only) .	209
Example: checking VSAM status codes	210
Coding INVALID KEY phrases	212
INVALID KEY and ERROR declaratives . . .	212
NOT INVALID KEY	212
Example: FILE STATUS and INVALID KEY	212
Handling errors when calling programs	213
Writing routines for handling errors.	213

Chapter 1. Structuring your program

A COBOL program consists of four divisions, each with a specific logical function:

- IDENTIFICATION DIVISION
- ENVIRONMENT DIVISION
- DATA DIVISION
- PROCEDURE DIVISION

Only the IDENTIFICATION DIVISION is required.

To define a COBOL class or method, you need to define some divisions differently than you do for a program.

RELATED TASKS

“Identifying a program”

“Describing the computing environment” on page 7

“Describing the data” on page 12

“Processing the data” on page 18

“Defining a class” on page 488

“Defining a class instance method” on page 493

“Structuring OO applications” on page 524

Identifying a program

Use the IDENTIFICATION DIVISION to name your program and, if you want, give other identifying information.

You can use the optional AUTHOR, INSTALLATION, DATE-WRITTEN, and DATE-COMPILED paragraphs for descriptive information about your program. The data you enter on the DATE-COMPILED paragraph is replaced with the latest compilation date.

IDENTIFICATION DIVISION.

Program-ID. Helloprog.

Author. A. Programmer.

Installation. Computing Laboratories.

Date-Written. 08/21/2003.

Date-Compiled. 02/27/2004.

Use the PROGRAM-ID paragraph to name your program. The program name that you assign is used in these ways:

- Other programs use the name to call your program.
- The name appears in the header on each page, except the first page, of the program listing generated when the program is compiled.
- If you use the NAME compiler option, the name is placed on the NAME linkage-editor or binder control statement to identify the object module created by the compilation.

Tip: Do not use program names that start with prefixes used by IBM products. If you try to use programs whose names start with any of the following, your CALL statements might resolve to IBM library or compiler routines rather than to your intended program:

AFB

AFH

CBC

CEE

EDC

Tip: When the program name is case sensitive, avoid mismatches with the name the compiler is looking for. Verify that the appropriate setting of the PGMNAME compiler option is used.

RELATED TASKS

“Changing the header of a source listing” on page 7

“Identifying a program as recursive”

“Marking a program as callable by containing programs”

“Setting a program to an initial state”

RELATED REFERENCES

Compiler limits (*Enterprise COBOL Language Reference*)

Conventions for program names (*Enterprise COBOL Language Reference*)

Identifying a program as recursive

Code the RECURSIVE attribute on the PROGRAM-ID clause to specify that your program can be recursively reentered while a previous invocation is still active.

You can code RECURSIVE only on the outermost program of a compilation unit. Neither nested subprograms nor programs that contain nested subprograms can be recursive. You must code RECURSIVE for programs that you compile with the THREAD option.

RELATED TASKS

“Sharing data in recursive or multithreaded programs” on page 17

“Making recursive calls” on page 407

Marking a program as callable by containing programs

Use the COMMON attribute on the PROGRAM-ID clause to specify that your program can be called by the containing program or by any program in the containing program. The COMMON program cannot be called by any program contained in itself.

Only contained programs can have the COMMON attribute.

RELATED CONCEPTS

“Nested programs” on page 404

Setting a program to an initial state

Use the INITIAL attribute to specify that whenever a program is called, it is placed in its initial state. If the program contains programs, these are also placed in their initial states.

A program is in its initial state when the following has occurred:

- Data items having VALUE clauses are set to the specified value.
- Changed GO TO statements and PERFORM statements are set to their initial states.
- Non-EXTERNAL files are closed.

Changing the header of a source listing

The header on the first page of your source statement listing contains the identification of the compiler and the current release level, plus the date and time of compilation and the page number. For example:

PP 5655-G53 IBM Enterprise COBOL for z/OS 3.3.0 Date 02/27/2004 Time 15:05:19 Page 1

You can customize the header on succeeding pages of the listing with the compiler-directing TITLE statement.

RELATED REFERENCES

TITLE statement (*Enterprise COBOL Language Reference*)

Describing the computing environment

In the ENVIRONMENT DIVISION you describe the aspects of your program that depend on the computing environment.

Use the CONFIGURATION SECTION to specify the following items:

- Computer for compiling your program (in the SOURCE-COMPUTER paragraph)
- Computer for running your program (in the OBJECT-COMPUTER paragraph)
- Special items such as the currency sign and symbolic characters (in the SPECIAL-NAMES paragraph)
- User-defined classes (in the REPOSITORY paragraph)

Use the FILE-CONTROL and I-O-CONTROL paragraphs of the INPUT-OUTPUT SECTION to do the following:

- Identify and describe the characteristics of your program files.
- Associate your files with the external QSAM, VSAM, or HFS (hierarchical file system) data sets where they physically reside.

The terms *file*, in COBOL terminology, and *data set* or *HFS file*, in operating system terminology, have essentially the same meaning and are used interchangeably in this documentation.

For Customer Information Control System (CICS) and online Information Management System (IMS) message processing programs (MPP), code only the ENVIRONMENT DIVISION header and, optionally, the CONFIGURATION SECTION. CICS does not allow COBOL definition of files. IMS allows COBOL definition of files only for batch programs.

- Provide information to control efficient transmission of the data records between your program and the external medium.

“Example: FILE-CONTROL entries” on page 8

RELATED TASKS

“Specifying the collating sequence” on page 8

“Defining symbolic characters” on page 10

“Defining a user-defined class” on page 10

“Defining files to the operating system” on page 10

RELATED REFERENCES

Sections and paragraphs (*Enterprise COBOL Language Reference*)

Example: FILE-CONTROL entries

The following table shows FILE-CONTROL entries for a QSAM sequential file, a VSAM indexed file, and a line-sequential file.

Table 1. FILE-CONTROL entries

QSAM file	VSAM file	Line-sequential file
SELECT PRINTFILE ¹ ASSIGN TO UPDPRINT ² ORGANIZATION IS SEQUENTIAL ³ ACCESS IS SEQUENTIAL. ⁴	SELECT COMMUTER-FILE ¹ ASSIGN TO COMMUTER ² ORGANIZATION IS INDEXED ³ ACCESS IS RANDOM ⁴ RECORD KEY IS COMMUTER-KEY ⁵ FILE STATUS IS ⁵ COMMUTER-FILE-STATUS COMMUTER-VSAM-STATUS.	SELECT PRINTFILE ¹ ASSIGN TO UPDPRINT ² ORGANIZATION IS LINE SEQUENTIAL ³ ACCESS IS SEQUENTIAL. ⁴
<ol style="list-style-type: none">1. The SELECT clause chooses a file in the COBOL program to be associated with an external data set.2. The ASSIGN clause associates the program's name for the file with the external name for the actual data file. You can define the external name with a DD statement or an environment variable.3. The ORGANIZATION clause describes the file's organization. For QSAM files, the ORGANIZATION clause is optional.4. The ACCESS MODE clause defines the manner in which the records are made available for processing: sequential, random, or dynamic. For QSAM and line-sequential files, the ACCESS MODE clause is optional. These files always have sequential organization.5. For VSAM files, you might have additional statements in the FILE-CONTROL paragraph depending on the type of VSAM file you use.		

RELATED TASKS

Chapter 9, "Processing QSAM files," on page 119

Chapter 10, "Processing VSAM files," on page 147

Chapter 11, "Processing line-sequential files," on page 175

"Describing the computing environment" on page 7

Specifying the collating sequence

You can use the PROGRAM COLLATING SEQUENCE clause and the ALPHABET clause of the SPECIAL-NAMES paragraph to establish the collating sequence used in the following operations on alphanumeric items:

- Nonnumeric comparisons explicitly specified in relation conditions and condition-name conditions
- HIGH-VALUE and LOW-VALUE settings
- SEARCH ALL
- SORT and MERGE unless overridden by a COLLATING SEQUENCE phrase on the SORT or MERGE statement

"Example: specifying the collating sequence" on page 9

The sequence that you use can be based on one of these alphabets:

- EBCDIC: references the collating sequence associated with the EBCDIC character set
- NATIVE: references the same collating sequence as EBCDIC
- STANDARD-1: references the collating sequence associated with the ASCII character set defined by *ANSI INCITS X3.4, Coded Character Sets - 7-bit American National Standard Code for Information Interchange (7-bit ASCII)*

- STANDARD-2: references the collating sequence associated with the character set defined by *ISO/IEC 646 — Information technology — ISO 7-bit coded character set for information interchange, International Reference Version*
- An alteration of the EBCDIC sequence that you define in the SPECIAL-NAMES paragraph

The PROGRAM COLLATING SEQUENCE clause does not affect comparisons that involve national operands.

RELATED TASKS

“Choosing alternate collating sequences” on page 190

“Comparing national data items” on page 111

Example: specifying the collating sequence

The following example shows the ENVIRONMENT DIVISION coding used to specify a collating sequence where uppercase and lowercase letters are similarly handled for comparisons and for sorting or merging. When you change the EBCDIC sequence in the SPECIAL-NAMES paragraph, the overall collating sequence is affected, not just the collating sequence of the characters included in the SPECIAL-NAMES paragraph.

IDENTIFICATION DIVISION.

. . .

ENVIRONMENT DIVISION.

CONFIGURATION SECTION.

Source-Computer. IBM-390.

Object-Computer. IBM-390.

Program Collating Sequence Special-Sequence.

Special-Names.

Alphabet Special-Sequence Is

"A" Also "a"
 "B" Also "b"
 "C" Also "c"
 "D" Also "d"
 "E" Also "e"
 "F" Also "f"
 "G" Also "g"
 "H" Also "h"
 "I" Also "i"
 "J" Also "j"
 "K" Also "k"
 "L" Also "l"
 "M" Also "m"
 "N" Also "n"
 "O" Also "o"
 "P" Also "p"
 "Q" Also "q"
 "R" Also "r"
 "S" Also "s"
 "T" Also "t"
 "U" Also "u"
 "V" Also "v"
 "W" Also "w"
 "X" Also "x"
 "Y" Also "y"
 "Z" Also "z".

RELATED TASKS

“Specifying the collating sequence” on page 8

Defining symbolic characters

Use the SYMBOLIC CHARACTERS clause to give symbolic names to any character of the specified alphabet. Use ordinal position to identify the character. Position 1 corresponds to character X'00'.

For example, to give a name to the backspace character (X'16' in the EBCDIC alphabet), code:

```
SYMBOLIC CHARACTERS BACKSPACE IS 23
```

Defining a user-defined class

Use the CLASS clause to give a name to a set of characters listed in the clause. For example, name the set of digits by using this code:

```
CLASS DIGIT IS "0" THROUGH "9"
```

The class-name can be referenced only in a class condition. This user-defined class is not the same as an object-oriented class.

Defining files to the operating system

For all files that you process in your COBOL program, you need to define the files to the operating system with an appropriate system data definition:

- DD statement for z/OS JCL.
- ALLOCATE command under TSO.
- Environment variable for z/OS or UNIX. The contents can define either an MVS data set or a file in the HFS (hierarchical file system).

The following shows the relationship of a FILE-CONTROL entry to the system data definition and to the FD entry in the FILE SECTION.

- JCL DD statement:

```
(1)
//OUTFILE DD DSN=MY.OUT171,UNIT=SYSDA,SPACE=(TRK,(50,5)),
//          DCB=(BLKSIZE=400)
/*
. . .
```

- Environment variable (export command):

```
(1)
export OUTFILE=DSN(MY.OUT171),UNIT(SYSDA),SPACE(TRK,(50,5))
. . .
```

- COBOL code:

```
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT CARPOOL
        ASSIGN TO OUTFILE (1)
        ORGANIZATION IS SEQUENTIAL.
. . .
DATA DIVISION.
FILE SECTION.
FD CARPOOL (2)
    LABEL RECORD STANDARD
    BLOCK CONTAINS 0 CHARACTERS
    RECORD CONTAINS 80 CHARACTERS
```

- (1) The *ddname* in the DD statement or the environment variable name in the export command, corresponds to the *assignment-name* in the ASSIGN clause:

- //OUTFILE DD DSN=OUT171 . . ., or

- export OUTFILE= . . .

This *assignment-name* points to the *ddname* OUTFILE in the DD statement or the environment variable name OUTFILE in the export command:

```
ASSIGN TO OUTFILE
```

- (2) When you specify a file in a COBOL FILE-CONTROL entry, you must describe the file in an FD entry for *file-name*.

```
SELECT CARPOOL
```

```
..  
FD CARPOOL
```

RELATED TASKS

“Optimizing buffer and device space” on page 12

Varying the input or output file at run time

The *file-name* you code in your SELECT clause is used as a constant throughout your COBOL program, but you can associate the name of the file on the DD statement or export command with a different file at run time.

Changing a *file-name* in your COBOL program requires changing the input statements and output statements and recompiling the program. Alternatively, you can change the *dsname* in the DD statement or the *dsname path-name* in your export command.

Rules for using different files: The name you use in the *assignment-name* of the ASSIGN clause must be the same as the *ddname* in the DD statement or the environment variable in the export command. You can change the actual file by using the *DSNAME* in the DD statement or the *DSNAME* or path name in the environment variable.

The *file-name* that you use with the SELECT clause (such as SELECT MASTER) must be the same as in the FD *file-name* entry.

Two files should not use the same *ddname* or environment variable name in their SELECT clauses; otherwise, results could be unpredictable. For example, if DISPLAY is directed to SYSOUT, do not use SYSOUT as the *ddname* or environment variable name on the SELECT clause for a file.

“Example: using different input files”

Example: using different input files: Consider a COBOL program that is used in exactly the same way for several different master files. It contains this SELECT clause:

```
SELECT MASTER  
  ASSIGN TO DA-3330-S-MASTERA
```

Assume the three possible input files are MASTER1, MASTER2, and MASTER3. You must code one of the following DD statements in the job step that calls for program execution, or issue one of the following export commands from the same shell from which you run the program, prior to running the program:

```
//MASTERA DD DSNAME=MY.MASTER1,..  
export MASTERA=DSN(MY.MASTER1),..
```

```
//MASTERA DD DSNAME=MY.MASTER2,..
```

```
export MASTERA=DSN(MY.MASTER2),. . .  
  
//MASTERA      DD  DSN=MY.MASTER3,. . .  
export MASTERA=DSN(MY.MASTER3),. . .
```

Any reference in the program to MASTERA will therefore be a reference to the file currently assigned to ddname or environment variable name MASTERA.

Notice that in this example, you cannot use the *PATH(path)* form of the export command to reference a line-sequential file in the HFS, because you cannot specify an organization field (S- or AS-) with a line-sequential file.

Optimizing buffer and device space

Use the APPLY WRITE-ONLY clause to make optimum use of buffer and device space when creating a sequential file with blocked variable-length records. With APPLY WRITE-ONLY specified, a buffer is truncated only when the next record does not fit in the unused portion of the buffer. Without APPLY WRITE-ONLY specified, a buffer is truncated when it does not have enough space for a maximum-size record.

The APPLY WRITE-ONLY clause has meaning only for sequential files that have variable-length records and are blocked.

The AWO compiler option applies an implicit APPLY WRITE-ONLY clause to all eligible files. The NOAWO compiler option has no effect on files that have the APPLY WRITE-ONLY clause specified. The APPLY WRITE-ONLY clause takes precedence over the NOAWO compiler option.

The APPLY-WRITE ONLY clause can cause input files to use a record area rather than process the data in the buffer. This use might affect the processing of both input files and output files.

RELATED REFERENCES

“AWO” on page 272

Describing the data

Define the characteristics of your data and group your data definitions into one of the sections in the DATA DIVISION:

- Define data used in input-output operations (FILE SECTION).
- Define data developed for internal processing:
 - To have storage be statically allocated and exist for the life of the *run unit* (WORKING-STORAGE SECTION).
 - To have storage be allocated each time a program is entered, and deallocated on return from the program (LOCAL-STORAGE SECTION).
- Describe data from another program (LINKAGE SECTION).

The Enterprise COBOL compiler limits the maximum size of DATA DIVISION elements.

RELATED CONCEPTS

“Comparison of WORKING-STORAGE and LOCAL-STORAGE” on page 15

RELATED TASKS

“Using data in input and output operations” on page 13

“Using data from another program” on page 17

Using data in input and output operations

Define the data you use in input and output operations in the FILE SECTION:

- Name the input and output files your program will use. Use the FD entry to give names to your files that the input-output statements in the PROCEDURE DIVISION can refer to.

Data items defined in the FILE SECTION are not available to PROCEDURE DIVISION statements until the file has been successfully opened.

- In the record description following the FD entry, describe the fields of the records in the file:
 - You can code a level-01 description of the entire record, and then in the WORKING-STORAGE SECTION code a working copy that describes the fields of the record in more detail. Use the READ INTO statement to bring the records into WORKING-STORAGE. Processing occurs on the copy of data in WORKING-STORAGE. A WRITE FROM statement then writes processed data into the record area defined in the FILE SECTION.
 - The record-name established is the object of WRITE and REWRITE statements.
 - For QSAM files only, you can set the record format in the RECORDING MODE clause. If you omit the RECORDING MODE clause, the compiler determines the record format based on the RECORD clause and on the level-01 record descriptions.
 - For QSAM files, you can set a blocking factor for the file in the BLOCK CONTAINS clause. If you omit the BLOCK CONTAINS clause, the file defaults to unblocked. However, you can override this with z/OS data management facilities (including a DD file job control statement).
 - For line-sequential files, you can set a blocking factor for the file in the BLOCK CONTAINS clause. When you code BLOCK CONTAINS 1 RECORDS, or BLOCK CONTAINS *n* CHARACTERS, where *n* is the length of one logical record, WRITE statements result in the record being transferred immediately to the file, rather than being buffered. This technique is useful when you want each record written immediately, such as to an error log.

Programs in the same run unit can share, or have access to, common files. The method for doing this depends on whether the programs are part of a nested (contained) structure or are separately compiled (including programs compiled as part of a batch sequence).

You can use the EXTERNAL clause for separately compiled programs. A file that is defined as EXTERNAL can be referenced by any program in the run unit that describes the file.

You can use the GLOBAL clause for programs in a nested, or contained, structure. If a program contains another program (directly or indirectly), both programs can access a common file by referencing a GLOBAL file name.

RELATED CONCEPTS

“Nested programs” on page 404

RELATED TASKS

“Sharing files between programs (external files)” on page 421

RELATED REFERENCES
 “FILE SECTION entries”

FILE SECTION entries

Entries in the FILE SECTION are summarized in the table below.

Table 2. FILE SECTION entries

Clause	To define	Notes
FD	The <i>file-name</i> to be referred to in PROCEDURE DIVISION input-output statements (OPEN, CLOSE, READ, also START and DELETE for VSAM)	Must match <i>file-name</i> in the SELECT clause. <i>file-name</i> is associated with a <i>ddname</i> through the <i>assignment-name</i> .
BLOCK CONTAINS	Size of physical record	<p>QSAM: If provided, must match information on JCL or data set label. If not provided, the system determines the optimal block size for you.</p> <p>Line sequential: Can be specified to control buffering for WRITE statements.</p> <p>VSAM: Handled as comments.</p>
RECORD CONTAINS <i>n</i>	Size of logical records (fixed length)	If provided, must match information on JCL or data set label. If <i>n</i> is equal to 0, LRECL must be coded on JCL or data set label.
RECORD IS VARYING	Size of logical records (variable length)	If provided, must match information on JCL or data set label; compiler checks match with record descriptions.
RECORD CONTAINS <i>n</i> TO <i>m</i>	Size of logical records (variable length)	If provided, must match information on JCL or data set label; compiler checks match with record descriptions.
LABEL RECORDS	Labels for QSAM files	VSAM: Handled as comments
STANDARD	Labels exist	QSAM: Handled as comments
OMITTED	Labels do not exist	QSAM: Handled as comments
<i>data-name</i>	Labels defined by the user	QSAM: Allowed for (optional) tape or disk
VALUE OF	An item in the label records associated with file	Comments only
DATA RECORDS	Names of records associated with file	Comments only
LINAGE	Depth of logical page	QSAM only
CODE-SET	ASCII or EBCDIC files	<p>QSAM only.</p> <p>When an ASCII file is identified with the CODE-SET clause, the corresponding DD statement might need to have DCB=(OPTCD=Q. . .) or DCB=(RECFM=D. . .) coded if the file was not created using VS COBOL II, COBOL for OS/390 & VM, or IBM Enterprise COBOL for z/OS.</p>
RECORDING MODE	Physical record description	QSAM only

Comparison of WORKING-STORAGE and LOCAL-STORAGE

WORKING-STORAGE for programs is allocated at the start of the run unit. Any data items with VALUE clauses are initialized to the appropriate value at that time. For the duration of the run unit, WORKING-STORAGE items persist in their last-used state. Exceptions are:

- A program with INITIAL specified in the PROGRAM-ID paragraph
In this case, WORKING-STORAGE data items are reinitialized each time that the program is entered.
- A subprogram that is dynamically called and then canceled
In this case, WORKING-STORAGE data items are reinitialized on the first reentry into the program following the CANCEL.

WORKING-STORAGE is deallocated at the termination of the run unit.

See the related tasks for information about WORKING-STORAGE in COBOL class definitions.

A separate copy of LOCAL-STORAGE data is allocated for each call of a program or invocation of a method, and is freed on return from the program or method. If you specify a VALUE clause on a LOCAL-STORAGE item, the item is initialized to that value on each call or invocation. If a VALUE clause is not specified, the initial value of the item is undefined.

Threading: Each invocation of a program that runs simultaneously on multiple threads shares access to a single copy of WORKING-STORAGE data. Each invocation has a separate copy of LOCAL-STORAGE data.

“Example: storage sections”

RELATED TASKS

“WORKING-STORAGE SECTION for defining class instance data” on page 492
Chapter 27, “Preparing COBOL programs for multithreading,” on page 437
“Ending and reentering main programs or subprograms” on page 394

RELATED REFERENCES

Working-storage section (*Enterprise COBOL Language Reference*)
Local-storage section (*Enterprise COBOL Language Reference*)

Example: storage sections

The following is an example of a recursive program that uses both WORKING-STORAGE and LOCAL-STORAGE.

```
CBL pgmn(1u)
*****
* Recursive Program - Factorials
*****
IDENTIFICATION DIVISION.
Program-Id. factorial recursive.
ENVIRONMENT DIVISION.
DATA DIVISION.
Working-Storage Section.
01 numb pic 9(4) value 5.
01 fact pic 9(8) value 0.
Local-Storage Section.
```

```

01 num pic 9(4).
PROCEDURE DIVISION.
    move numb to num.

    if numb = 0
        move 1 to fact
    else
        subtract 1 from numb
        call 'factorial'
        multiply num by fact
    end-if.

    display num '! = ' fact.
    goback.
End Program factorial.

```

The program produces the following output:

```

0000! = 00000001
0001! = 00000001
0002! = 00000002
0003! = 00000006
0004! = 00000024
0005! = 00000120

```

The following tables show the changing values of the data items in LOCAL-STORAGE and WORKING-STORAGE in the successive recursive calls of the program, and in the ensuing gobacks. During the gobacks, fact progressively accumulates the value of 5! (five factorial).

Recursive calls	Value for num in LOCAL-STORAGE	Value for numb in WORKING-STORAGE	Value for fact in WORKING-STORAGE
Main	5	5	0
1	4	4	0
2	3	3	0
3	2	2	0
4	1	1	0
5	0	0	0

Gobacks	Value for num in LOCAL-STORAGE	Value for numb in WORKING-STORAGE	Value for fact in WORKING-STORAGE
5	0	0	1
4	1	0	1
3	2	0	2
2	3	0	6
1	4	0	24
Main	5	0	120

RELATED CONCEPTS

“Comparison of WORKING-STORAGE and LOCAL-STORAGE” on page 15

Using data from another program

How you share data depends on the type of program. You share data differently in programs that are separately compiled than you do for programs that are nested or for programs that are recursive or multithreaded.

RELATED TASKS

“Sharing data in separately compiled programs”

“Sharing data in nested programs”

“Sharing data in recursive or multithreaded programs”

Sharing data in separately compiled programs

Many applications consist of separately compiled programs that call and pass data to one another. Use the LINKAGE SECTION in the called program to describe the data passed from another program. In the calling program, use a CALL . . . USING or INVOKE . . . USING statement to pass the data.

RELATED TASKS

“Passing data” on page 411

Sharing data in nested programs

Some applications consist of nested programs, that is, programs that are contained in other programs. Level-01 data items can include the GLOBAL attribute. This attribute allows any nested program that includes the declarations to access these data items.

A nested program can also access data items in a sibling program (one at the same nesting level in the same containing program) that is declared with the COMMON attribute.

RELATED CONCEPTS

“Nested programs” on page 404

Sharing data in recursive or multithreaded programs

If your program has the RECURSIVE attribute or is compiled with the THREAD compiler option, data that is defined in the LINKAGE SECTION is not accessible on subsequent invocations of the program.

To address a record in the LINKAGE SECTION, use either of these techniques:

- Pass an argument to the program and specify the record in an appropriate position in the USING phrase in the program.
- Use the format-5 SET statement.

If your program has the RECURSIVE attribute or is compiled with the THREAD compiler option, the address of the record is valid for a particular instance of the program invocation. The address of the record in another execution instance of the same program must be reestablished for that execution instance. Unpredictable results will occur if you refer to a data item for which the address has not been established.

RELATED CONCEPTS

“Multithreading” on page 437

RELATED TASKS

“Making recursive calls” on page 407

“Processing files with multithreading” on page 440

RELATED REFERENCES

SET statement (*Enterprise COBOL Language Reference*)
"THREAD" on page 309

Processing the data

In the PROCEDURE DIVISION of a program, you code the executable statements that process the data you have defined in the other divisions. The PROCEDURE DIVISION contains one or two headers and the logic of your program.

The PROCEDURE DIVISION begins with the division header and a procedure-name header. The division header for a program can simply be:

```
PROCEDURE DIVISION.
```

You can code your division header to receive parameters with the USING phrase or to return a value with the RETURNING phrase.

To receive an argument that was passed by reference (the default) or by content, code the division header for a program in either of these ways:

```
PROCEDURE DIVISION USING dataname  
PROCEDURE DIVISION USING BY REFERENCE dataname
```

Be sure to define *dataname* in the LINKAGE SECTION of the DATA DIVISION.

To receive a parameter that was passed by value, code the division header for a program as follows:

```
PROCEDURE DIVISION USING BY VALUE dataname
```

To return a value as a result, code the division header as follows:

```
PROCEDURE DIVISION RETURNING dataname2
```

You can also combine USING and RETURNING in a PROCEDURE DIVISION header:

```
PROCEDURE DIVISION USING dataname RETURNING dataname2
```

Be sure to define *dataname* and *dataname2* in the LINKAGE SECTION of the DATA DIVISION.

RELATED CONCEPTS

"How logic is divided in the PROCEDURE DIVISION"

RELATED TASKS

"Eliminating repetitive coding" on page 595

How logic is divided in the PROCEDURE DIVISION

The PROCEDURE DIVISION of a program is divided into sections and paragraphs, which contain sentences and statements:

Section

Logical subdivision of your processing logic.

A section has a section header and is optionally followed by one or more paragraphs.

A section can be the subject of a PERFORM statement. One type of section is for declaratives.

Paragraph

Subdivision of a section, procedure, or program.

A paragraph has a name followed by a period and zero or more sentences.

A paragraph can be the subject of a statement.

Sentence

Series of one or more COBOL statements ending with a period.

Statement

Performs a defined step of COBOL processing, such as adding two numbers.

A statement is a valid combination of words, beginning with a COBOL verb. Statements are imperative (indicating unconditional action), conditional, or compiler-directing. Using explicit scope terminators instead of periods to show the logical end of a statement is preferred.

Phrase

A subdivision of a statement.

RELATED CONCEPTS

"Compiler-directing statements" on page 20

"Scope terminators" on page 21

"Imperative statements"

"Conditional statements"

"Declaratives" on page 22

RELATED REFERENCES

PROCEDURE DIVISION structure (*Enterprise COBOL Language Reference*)

Imperative statements

An imperative statement indicates an unconditional action to be taken (such as ADD, MOVE, INVOKE, or CLOSE).

An imperative statement can be ended with an implicit or explicit scope terminator.

A conditional statement that ends with an explicit scope terminator becomes an imperative statement called a *delimited scope statement*. Only imperative statements (or delimited scope statements) can be nested.

RELATED CONCEPTS

"Conditional statements"

"Scope terminators" on page 21

Conditional statements

A conditional statement is either a simple conditional statement (IF, EVALUATE, SEARCH) or a conditional statement made up of an imperative statement that includes a conditional phrase or option.

You can end a conditional statement with an implicit or explicit scope terminator. If you end a conditional statement explicitly, it becomes a delimited scope statement (which is an imperative statement).

You can use a delimited scope statement in these ways:

- To delimit the range of operation for a COBOL conditional statement and to explicitly show the levels of nesting

For example, use an END-IF statement instead of a period to end the scope of an IF statement within a nested IF.

- To code a conditional statement where the COBOL syntax calls for an imperative statement

For example, code a conditional statement as the object of an inline PERFORM:

```
PERFORM UNTIL TRANSACTION-EOF
  PERFORM 200-EDIT-UPDATE-TRANSACTION
  IF NO-ERRORS
    PERFORM 300-UPDATE-COMMUTER-RECORD
  ELSE
    PERFORM 400-PRINT-TRANSACTION-ERRORS
  END-IF
  READ UPDATE-TRANSACTION-FILE INTO WS-TRANSACTION-RECORD
  AT END
    SET TRANSACTION-EOF TO TRUE
  END-READ
END-PERFORM
```

An explicit scope terminator is required for the inline PERFORM statement, but it is not valid for the out-of-line PERFORM statement.

For additional program control, you can use the NOT phrase with conditional statements. For example, you can provide instructions to be performed when a particular exception does not occur, such as NOT ON SIZE ERROR. The NOT phrase cannot be used with the ON OVERFLOW phrase of the CALL statement, but it can be used with the ON EXCEPTION phrase.

Do not nest conditional statements. Nested statements must be imperative statements (or delimited scope statements) and must follow the rules for imperative statements.

The following statements are examples of conditional statements if they are coded without scope terminators:

- Arithmetic statement with ON SIZE ERROR
- Data-manipulation statements with ON OVERFLOW
- CALL statements with ON OVERFLOW
- I/O statements with INVALID KEY, AT END, or AT END-OF-PAGE
- RETURN with AT END

RELATED CONCEPTS

“Imperative statements” on page 19

“Scope terminators” on page 21

RELATED TASKS

“Selecting program actions” on page 75

RELATED REFERENCES

Conditional statements (*Enterprise COBOL Language Reference*)

Compiler-directing statements

A compiler-directing statement is not part of the program logic. A compiler-directing statement causes the compiler to take specific action about the program structure, COPY processing, listing control, or control flow.

RELATED REFERENCES

Chapter 18, “Compiler-directing statements,” on page 317

Compiler-directing statements (*Enterprise COBOL Language Reference*)

Scope terminators

Scope terminators can be explicit or implicit. Explicit scope terminators end a verb without ending a sentence. They consist of END followed by a hyphen and the name of the verb being terminated, such as END-IF. An implicit scope terminator is a period (.) that ends the scope of all previous statements not yet ended.

Each of the two periods in the following program fragment ends an IF statement, making the code equivalent to the code after it that instead uses explicit scope terminators:

```
IF ITEM = "A"
    DISPLAY "THE VALUE OF ITEM IS " ITEM
    ADD 1 TO TOTAL
    MOVE "C" TO ITEM
    DISPLAY "THE VALUE OF ITEM IS NOW " ITEM.
IF ITEM = "B"
    ADD 2 TO TOTAL.
IF ITEM = "A"
    DISPLAY "THE VALUE OF ITEM IS " ITEM
    ADD 1 TO TOTAL
    MOVE "C" TO ITEM
    DISPLAY "THE VALUE OF ITEM IS NOW " ITEM
END-IF
IF ITEM = "B"
    ADD 2 TO TOTAL
END-IF
```

If you use implicit terminators, the end of statements can be unclear. As a result, you might end statements unintentionally, changing your program's logic. Explicit scope terminators make a program easier to understand and prevent unintentional ending of statements. For example, in the program fragment below, changing the location of the first period in the first implicit scope example changes the meaning of the code:

```
IF ITEM = "A"
    DISPLAY "VALUE OF ITEM IS " ITEM
    ADD 1 TO TOTAL.
    MOVE "C" TO ITEM
    DISPLAY " VALUE OF ITEM IS NOW " ITEM
IF ITEM = "B"
    ADD 2 TO TOTAL.
```

The MOVE statement and the DISPLAY statement after it are performed regardless of the value of ITEM, despite what the indentation indicates, because the first period terminates the IF statement.

For improved program clarity and to avoid unintentional ending of statements, use explicit scope terminators, especially within paragraphs. Use implicit scope terminators only at the end of a paragraph or the end of a program.

Be careful when coding an explicit scope terminator for an imperative statement that is nested within a conditional statement. Ensure that the scope terminator is paired with the statement for which it was intended. In the following example, the scope terminator will be paired with the second READ statement, though the programmer intended it to be paired with the first.

```
READ FILE1
    AT END
        MOVE A TO B
        READ FILE2
END-READ
```

To ensure that the explicit scope terminator is paired with the intended statement, the preceding example can be recoded in this way:

```
READ FILE1
  AT END
    MOVE A TO B
    READ FILE2
  END-READ
END-READ
```

RELATED CONCEPTS

“Conditional statements” on page 19

“Imperative statements” on page 19

Declaratives

Declaratives provide one or more special-purpose sections that are executed when an exception condition occurs.

Start each declarative section with a USE statement that identifies the function of the section; in the procedures, specify the actions to be taken when the condition occurs.

RELATED TASKS

“Finding and handling input-output errors” on page 323

RELATED REFERENCES

Declaratives (*Enterprise COBOL Language Reference*)

Chapter 2. Using data

This information is intended to help non-COBOL programmers relate terms used in other programming languages to COBOL terms for data. It introduces COBOL fundamentals for:

- Variables, structures, literals, and constants
- Assigning and displaying values
- Intrinsic (built-in) functions
- Tables (arrays) and pointers

RELATED CONCEPTS

“Storage and its addressability” on page 34

RELATED TASKS

“Using variables, structures, literals, and constants”

“Assigning values to data items” on page 25

“Displaying values on a screen or in a file (DISPLAY)” on page 30

“Using intrinsic functions (built-in functions)” on page 32

“Using tables (arrays) and pointers” on page 33

Chapter 7, “Processing character data in an international environment,” on page 103

Using variables, structures, literals, and constants

Most high-level programming languages share the concept of data being represented as variables, structures, literals, and constants. The data in a COBOL program can be alphabetic, alphanumeric, national, or numeric. You can also define index data items, and data items described with `USAGE POINTER`, `USAGE FUNCTION-POINTER`, `USAGE PROCEDURE-POINTER`, or `USAGE OBJECT REFERENCE`. You place all data definitions in the `DATA DIVISION` of your program.

Variables

A *variable* is a data item; its value can change during a program. The values are restricted, however, to the data type that you define when you give the data item a name and a length. For example, if a customer name is a data item in your program, you could code:

Data Division.

```
. . .  
01 Customer-Name           Pic X(20).  
01 Original-Customer-Name  Pic X(20).  
. . .
```

Procedure Division.

```
. . .  
    Move Customer-Name to Original-Customer-Name  
. . .
```

Data structure: data items and group items

Related data items can be parts of a hierarchical data structure. A data item that does not have any subordinate items is called an *elementary* data item. A data item that is composed of subordinated data items is called a *group* item. A record can be either an elementary data item or a group of data items.

In this example, Customer-Record is a group item composed of two group items (Customer-Name and Part-Order), each of which contains elementary data items. You can refer to the entire group item or to parts of the group item as shown in the MOVE statements in the PROCEDURE DIVISION.

```
Data Division.
File Section.
FD Customer-File
   Record Contains 45 Characters.
01 Customer-Record.
   05 Customer-Name.
      10 Last-Name          Pic x(17).
      10 Filler             Pic x.
      10 Initials           Pic xx.
   05 Part-Order.
      10 Part-Name          Pic x(15).
      10 Part-Color         Pic x(10).
Working-Storage Section.
01 Orig-Customer-Name.
   05 Surname              Pic x(17).
   05 Initials             Pic x(3).
01 Inventory-Part-Name     Pic x(15).
. . .
Procedure Division.
. . .
   Move Customer-Name to Orig-Customer-Name
   Move Part-Name to Inventory-Part-Name
. . .
```

Literals

A *literal* is a character string whose value is given by the characters themselves. When you know the value you want to use for a data item, use a literal representation of the data value in the PROCEDURE DIVISION. You do not need to define it or refer to a data-name. For example, you can prepare an error message for an output file this way:

```
Move "Name is not valid" To Customer-Name
```

You can compare a data item to a certain number this way:

```
01 Part-number          Pic 9(5).
. . .
   If Part-number = 03519 then display "Part number was found"
```

In these examples, "Name is not valid" is an alphanumeric literal, and 03519 is a numeric literal.

Constants

A *constant* is a data item that has only one value. COBOL does not define a construct specifically for constants. However, most COBOL programmers define a data item with an initial VALUE (as opposed to initializing a data item by using the INITIALIZE statement). For example:

```
Data Division.
. . .
01 Report-Header        pic x(50) value "Company Sales Report".
. . .
01 Interest             pic 9v9999 value 1.0265.
```

Figurative constants

Certain commonly used constants and literals are provided as reserved words called *figurative constants*: ZERO, SPACE, HIGH-VALUE, LOW-VALUE, QUOTE, NULL, and ALL. Because they represent fixed values, figurative constants do not require a data definition. For example:

Move Spaces To Report-Header

RELATED REFERENCES

Classes and categories of data (*Enterprise COBOL Language Reference*)

PICTURE clause (*Enterprise COBOL Language Reference*)

Literals (*Enterprise COBOL Language Reference*)

Figurative constants (*Enterprise COBOL Language Reference*)

Assigning values to data items

After you have defined a data item, you can assign a value to it at any time. Assignment takes many forms in COBOL, depending on what you want to do.

Table 3. Assignment to data items in a program

What you want to do	How to do it
To assign values to a data item or large data area	Use one of these ways: <ul style="list-style-type: none">• INITIALIZE statement• MOVE statement• STRING or UNSTRING statement• VALUE clause (to set data items to the values you want them to have when the program is in its initial state)
To assign the results of arithmetic	Use the COMPUTE statement.
To replace characters or groups of characters in a data item	Use the INSPECT statement.
To receive values from a file	Use the READ (or READ INTO) statement.
To receive values from a system input device or a file	Use the ACCEPT statement.
To establish a constant	Use the VALUE clause in the definition of the data item, and do not use the data item as a receiver in the program. Such an item gives the equivalent of a constant even though the compiler does not enforce read-only constants.
To place a value associated with a table element in an index To set the status of an external switch to ON or OFF To move data to a condition-name to make the condition true To set a POINTER, PROCEDURE-POINTER, or FUNCTION-POINTER data item to an address To associate an OBJECT REFERENCE data item with an object instance	Use the SET statement.

“Examples: initializing data items” on page 26

RELATED TASKS

“Initializing a structure (INITIALIZE)” on page 27

“Assigning values to elementary or group data items (MOVE)” on page 27

“Joining data items (STRING)” on page 87

“Splitting data items (UNSTRING)” on page 89

“Assigning arithmetic results (MOVE or COMPUTE)” on page 28
 “Tallying and replacing data items (INSPECT)” on page 95
 “Assigning input from a screen or file (ACCEPT)” on page 29
 Chapter 7, “Processing character data in an international environment,” on page 103

RELATED REFERENCES
Enterprise COBOL Language Reference

Examples: initializing data items

Initializing a data item to blanks or zeros:

INITIALIZE *identifier-1*

IDENTIFIER-1 PICTURE	IDENTIFIER-1 before	IDENTIFIER-1 after
9(5)	12345	00000
X(5)	AB123	bbbb ¹
99XX9	12AB3	bbbb ¹
XXBX/XX	ABbC/DE	bbbb/bb ¹
**99.9CR	1234.5CR	**00.0bb ¹
A(5)	ABCDE	bbbb ¹
+99.99E+99	+12.34E+02	+00.00E+00
1. The symbol <i>b</i> represents a blank space.		

Initializing a right-justified field:

```

01 ANJUST          PIC X(8)  JUSTIFIED RIGHT.
01 ALPHABETIC-1    PIC A(4)  VALUE "ABCD".
. . .
  INITIALIZE ANJUST
    REPLACING ALPHANUMERIC DATA BY ALPHABETIC-1
  
```

ALPHABETIC-1	ANJUST before	ANJUST after
ABCD	bbbbbb ¹	bbbbABCD ¹
1. The symbol <i>b</i> represents a blank space.		

Initializing an alphanumeric data item:

```

01 ALPHANUMERIC-1  PIC X.
01 ALPHANUMERIC-3  PIC X(1) VALUE "A".
. . .
  INITIALIZE ALPHANUMERIC-1
    REPLACING ALPHANUMERIC DATA BY ALPHANUMERIC-3
  
```

ALPHANUMERIC-3	ALPHANUMERIC-1 before	ALPHANUMERIC-1 after
A	y	A

Initializing a numeric data item:

```

01 NUMERIC-1        PIC 9(8).
01 NUM-INT-CMPT-3   PIC 9(7) COMP VALUE 1234567.
. . .
  INITIALIZE NUMERIC-1
    REPLACING NUMERIC DATA BY NUM-INT-CMPT-3
  
```


NUM-INT-CMPT-3	NUMERIC-1 before	NUMERIC-1 after
1234567	98765432	01234567

Initializing an edited alphanumeric data item:

```
01 ALPHANUM-EDIT-1      PIC XXBX/XXX.
01 ALPHANUM-EDIT-3      PIC X/BB VALUE "M/bbb".
```

...

```
    INITIALIZE ALPHANUM-EDIT-1
      REPLACING ALPHANUMERIC-EDITED DATA BY ALPHANUM-EDIT-3
```

ALPHANUM-EDIT-3	ALPHANUM-EDIT-1 before	ALPHANUM-EDIT-1 after
M/bb ¹	ABbC/DEF ¹	M/bb/bbb ¹

1. The symbol *b* represents a blank space.

RELATED TASKS

“Initializing a structure (INITIALIZE)”

Initializing a structure (INITIALIZE)

You can reset the values of all subordinate data items in a group item by applying the INITIALIZE statement to the group item. However, it is inefficient to initialize an entire group unless you really need all the items in the group initialized.

The following example shows how you can reset fields in a transaction record produced by a program to spaces and zeros. The fields are not identical in each record produced.

```
01 TRANSACTION-OUT.
   05 TRANSACTION-CODE      PIC X.
   05 PART-NUMBER           PIC 9(6).
   05 TRANSACTION-QUANTITY  PIC 9(5).
   05 PRICE-FIELDS.
      10 UNIT-PRICE         PIC 9(5)V9(2).
      10 DISCOUNT          PIC V9(2).
      10 SALES-PRICE        PIC 9(5)V9(2).
   ...
   INITIALIZE TRANSACTION-OUT
```

Record	TRANSACTION-OUT before	TRANSACTION-OUT after
1	R0013830002400000000000000000	b000000000000000000000000000 ¹
2	R0013900004800000000000000000	b000000000000000000000000000 ¹
3	S0014100001200000000000000000	b000000000000000000000000000 ¹
4	C001383000000000425000000000	b000000000000000000000000000 ¹
5	C002010000000000000010000000	b000000000000000000000000000 ¹

1. The symbol *b* represents a blank space.

Assigning values to elementary or group data items (MOVE)

Use the MOVE statement to assign values to elementary data items or group data items.

For example, the following statement assigns the contents of the data item Customer-Name to the data item Orig-Customer-Name:

```
Move Customer-Name to Orig-Customer-Name
```

If Customer-Name were longer than Orig-Customer-Name, truncation would occur on the right. If it were shorter, the extra character positions on the right would be filled with spaces.

When you move a group item to another group item, be sure that the subordinate data descriptions are compatible. The compiler performs all MOVE statements regardless of whether the items fit, even if a destructive overlap could occur at run time.

For data items that contain numbers, moves can be more complicated because there are several ways numbers are represented. In general, the algebraic values of numbers are moved if possible (as opposed to the digit-by-digit move performed with character data):

```
01 Item-x          Pic 999v9.
. . .
    Move 3.06 to Item-x
```

This move would result in Item-x containing the value 3.0, represented by 0030.

You can move an alphanumeric item or an integer item to a national data item; the item is converted. You can move a national data item only to another national data item. In either case padding or truncation might occur, and you must ensure that truncation does not occur within a character.

The following example shows a data item in the Greek language that moves into a national data item:

```
CBL CODEPAGE(00875)
. . .
01 Data-in-Unicode Pic N(100) usage national.
01 Data-in-Greek   Pic X(100).
. . .
    Read Greek-file into Data-in-Greek
    Move Data-in-Greek to Data-in-Unicode
```

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

RELATED REFERENCES

MOVE statement (*Enterprise COBOL Language Reference*)

“CODEPAGE” on page 274

“Converting national data” on page 107

Assigning arithmetic results (MOVE or COMPUTE)

When assigning a number to a data item, consider using the COMPUTE statement instead of the MOVE statement. For example, the following two statements accomplish the same thing in most cases:

```
Move w to z
Compute z = w
```

The MOVE statement carries out the assignment with truncation. You can, however, specify the DIAGTRUNC compiler option to request that the compiler issue a warning diagnostic for MOVE statements that might truncate numeric receivers.

When significant left-order digits would be lost in execution, the COMPUTE statement can detect the condition and allow you to handle it.

When you use the ON SIZE ERROR phrase of the COMPUTE statement, the compiler generates code to detect a size-overflow condition. If the condition occurs, the code in the ON SIZE ERROR phrase is performed, and the content of z remains unchanged. If the ON SIZE ERROR phrase is not specified, the assignment is carried out with truncation. There is no ON SIZE ERROR support for the MOVE statement.

You can also use the COMPUTE statement to assign the result of an arithmetic expression (or intrinsic function) to a data item. For example:

```
Compute z = y + (x ** 3)
Compute x = Function Max(x y z)
```

Results of date, time, and mathematical calculations, as well as other operations, can be assigned to data items using Language Environment callable services. These Language Environment services are available through a standard COBOL CALL statement, and the values they return are passed in the parameters in the CALL statement. For example, you can call the Language Environment service CEESIABS to find the absolute value of a data item by coding the statement:

```
Call 'CEESIABS' Using Arg, Feedback-code, Result.
```

As a result of this call, the data item Result is assigned to be the absolute value of the value that is in the data item Arg; the data item Feedback-code contains the return code indicating whether the service completed successfully. You have to define all the data items in the DATA DIVISION using the correct descriptions according to the requirements of the particular callable service you are using. For the example above, the data items could be defined like this:

```
77 Arg                Pic s9(9)  Binary.
77 Feedback-code      Pic x(12)  Display.
77 Result              Pic s9(9)  Binary.
```

RELATED REFERENCES

"DIAGTRUNC" on page 280

Intrinsic functions (*Enterprise COBOL Language Reference*)

Callable services (*Language Environment Programming Reference*)

Assigning input from a screen or file (ACCEPT)

One way to assign a value to a data item is to read the value from a screen or a file. To enter data from the screen, first associate the monitor with a mnemonic-name in the SPECIAL-NAMES paragraph. Then use ACCEPT to assign the line of input entered at the screen to a data item.

For example:

```
Environment Division.
Configuration Section.
Special-Names.
    Console is Names-Input.
. . .
    Accept Customer-Name From Names-Input
```

To read from a file instead of the screen, make the following change:

- Change Console to *device*, where *device* is any valid system device (for example, SYSIN). For example:

```
SYSIN is Names-Input
```

Note that *device* can be a ddname that references a hierarchical file system (HFS) path. If this DD is not defined and your program is running in a UNIX

environment, `stdin` is the input source. If this DD is not defined and your program is not running in a UNIX environment, the `ACCEPT` statement fails.

When you assign a value to a national data item, input data from the console is converted from EBCDIC to Unicode representation (UTF-16), based on the value of the `CODEPAGE` option. This is the only situation where conversion of national data is done when you use the `ACCEPT` statement, because the input is known to be coming from a screen.

If you want conversion done when the input data is from any other device, use the `NATIONAL-OF` intrinsic function.

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

RELATED TASKS

RELATED REFERENCES

“`CODEPAGE`” on page 274

`SPECIAL-NAMES` paragraph (*Enterprise COBOL Language Reference*)

Displaying values on a screen or in a file (DISPLAY)

You can display the value of a data item on a screen or write it to a file by using the `DISPLAY` statement. For example:

```
Display "No entry for surname '" Customer-Name  
      "' found in the file."
```

If the content of the data item `Customer-Name` is `JOHNSON`, then the statement above displays the following message on the system logical output device:

```
No entry for surname 'JOHNSON' found in the file.
```

To write data to a destination other than the system logical output device, use the `UPON` clause with a destination other than `SYSOUT`. For example, the following statement writes to the file specified in the `SYSPUNCH` DD statement:

```
Display "Hello" upon syspunch.
```

You can specify a file in the hierarchical file system (HFS) with this ddname. For example, with the following definition, your `DISPLAY` output is written to the HFS file `/u/userid/cobol/demo.lst`:

```
//SYSPUNCH DD PATH='/u/userid/cobol/demo.lst',  
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),PATHMODE=SIRWXU,  
// FILEDATA=TEXT
```

The following statement writes to the job log or console and to the TSO screen if you are running under TSO:

```
Display "Hello" upon console.
```

When you display the value of a national data item to the console, it is converted from Unicode representation (UTF-16) to EBCDIC, based on the value of the `CODEPAGE` option. This is the only situation where conversion of national data is done when you use the `DISPLAY` statement, because the output is known to be directed to a screen.

If you want a national data item to be converted when you direct output to a different device, use the `DISPLAY-OF` intrinsic function, such as in this example:

```
01 Data-in-Unicode pic N(10) usage national.
. . .
Display function Display-of(Data-in-Unicode, 00037)
```

Displaying data on the system logical output device

To write data to the system logical output device, either omit the UPON clause or use the UPON clause with destination SYSOUT. For example:

```
Display "Hello" upon sysout.
```

The output is directed to the ddname that you specify in the OUTDD compiler option. You can specify a file in the hierarchical file system (HFS) with this ddname.

If the OUTDD ddname is not allocated and you are not running in a UNIX environment, a default DD of SYSOUT=* is allocated.

If the OUTDD ddname is not allocated and you are running in a UNIX environment, the _IGZ_SYSOUT environment variable is used as follows:

Undefined or set to stdout

Output is routed to stdout (file descriptor 1).

Set to stderr

Output is routed to stderr (file descriptor 2).

Otherwise (set to something other than stdout or stderr)

The DISPLAY statement fails; a severity-3 Language Environment condition is raised.

When DISPLAY output is routed to stdout or stderr, the output is not subdivided into records; rather the output is written as a single stream of characters without line breaks.

If OUTDD and the Language Environment run-time option MSGFILE both specify the same ddname, DISPLAY output and Language Environment run-time diagnostics are both routed to the Language Environment message file.

Using WITH NO ADVANCING

If you specify the WITH NO ADVANCING phrase and the output is going to a ddname, the printer control character + (plus) is placed into the first output position from the *next* DISPLAY statement. + is the ANSI-defined printer control character that suppresses line spacing before a record is printed.

If you specify the WITH NO ADVANCING phrase and the output is going to stdout or stderr, a new-line character is not appended to the end of the stream. A subsequent DISPLAY statement might add additional characters to the end of the stream.

If you do not specify WITH NO ADVANCING and the output is going to a ddname, the printer control character ' ' (space) is placed into the first output position from the next DISPLAY statement, indicating single-spaced output.

For example:

```
DISPLAY "ABC"
DISPLAY "CDEF" WITH NO ADVANCING
DISPLAY "GHIJK" WITH NO ADVANCING
DISPLAY "LMNOPQ"
DISPLAY "RSTUVWX"
```

If you use the statements above, the result sent to the output device is:

```
ABC
CDEF
+GHIJK
+LMNOPQ
RSTUVMX
```

The output printed depends on how the output device interprets printer control characters.

If you do not specify the `WITH NO ADVANCING` phrase and the output is going to `stdout` or `stderr`, a new-line character is appended to the end of the stream.

RELATED CONCEPTS

"Unicode and encoding of language characters" on page 105

RELATED TASKS

"Setting and accessing environment variables" on page 384

"Coding COBOL programs to run under CICS" on page 359

"Converting national data" on page 107

RELATED REFERENCES

`DISPLAY` statement (*Enterprise COBOL Language Reference*)

"OUTDD" on page 296

"CODEPAGE" on page 274

Using intrinsic functions (built-in functions)

Some high-level programming languages have built-in functions that you can reference in your program as if they were variables that have defined attributes and a predetermined value. In COBOL, these functions are called *intrinsic functions*. They provide capabilities for manipulating strings and numbers.

Because the value of an intrinsic function is derived automatically at the time of reference, you do not need to define functions in the `DATA DIVISION`. Define only the nonliteral data items that you use as arguments. Figurative constants are not allowed as arguments.

A *function-identifier* is the combination of the COBOL reserved word `FUNCTION` followed by a function name (such as `Max`), followed by any arguments to be used in the evaluation of the function (such as `x, y, z`).

The groups of highlighted words in the following examples are referred to as *function-identifiers*.

```
Unstring Function Upper-case(Name) Delimited By Space Into Fname Lname
Compute A = 1 + Function Log10(x)
Compute M = Function Max(x y z)
```

A function-identifier represents both the invocation of the function and the data value returned by the function. Because it actually represents a data item, you can use a function-identifier in most places in the `PROCEDURE DIVISION` where a data item having the attributes of the returned value can be used.

The COBOL word `function` is a reserved word, but the function-names are not reserved. You can use them in other contexts, such as for the name of a data item. For example, you could use `Sqrt` to invoke an intrinsic function and to name a data item in your program:

```

Working-Storage Section.
01  x                      Pic 99  value 2.
01  y                      Pic 99  value 4.
01  z                      Pic 99  value 0.
01  Sqrt                   Pic 99  value 0.
. . .
    Compute Sqrt = 16 ** .5
    Compute z = x + Function Sqrt(y)
. . .

```

Types of intrinsic functions

A function-identifier represents a value that is of one of these types: alphanumeric, national, numeric, or integer. You can include a substring specification (reference modifier) in a function-identifier for alphanumeric or national functions. Numeric intrinsic functions are further classified according to the type of numbers they return.

The functions MAX, MIN, DATEVAL, and UNDATE can return either type of value depending on the type of arguments you supply.

The functions DATEVAL, UNDATE, and YEARWINDOW are provided with the millennium language extensions to assist with manipulating and converting windowed date fields.

Nesting functions

Functions can reference other functions as arguments as long as the results of the nested functions meet the requirements for the arguments of the outer function.

For example:

```
Compute x = Function Max((Function Sqrt(5)) 2.5 3.5)
```

In this case, Function Sqrt(5) returns a numeric value. Thus, the three arguments to the MAX function are all numeric, which is an allowable argument type for this function.

RELATED TASKS

“Processing table items using intrinsic functions” on page 73

“Converting data items (intrinsic functions)” on page 97

“Evaluating data items (intrinsic functions)” on page 99

Using tables (arrays) and pointers

In COBOL, arrays are called tables. A table is a set of logically consecutive data items that you define in the DATA DIVISION by using the OCCURS clause.

Pointers are data items that contain virtual storage addresses. You define them explicitly with the USAGE IS POINTER clause in the DATA DIVISION or implicitly as ADDRESS OF special registers.

You can perform the following operations on pointer data items:

- Pass them between programs by using the CALL . . . BY REFERENCE statement
- Move them to other pointers by using the SET statement
- Compare them to other pointers for equality by using a relation condition
- Initialize them to contain an address that is not valid by using VALUE IS NULL

Use pointer data items to:

- Accomplish limited base addressing, particularly if you want to pass and receive addresses of a record area that is defined with OCCURS DEPENDING ON and is therefore variably located.
- Handle a chained list.

RELATED TASKS

“Defining a table (OCCURS)” on page 59

“Using procedure and function pointers” on page 407

Storage and its addressability

When you run your COBOL programs, the programs and the data that they use reside in virtual storage. Storage that you use with COBOL can be either below the 16-MB line or above the 16-MB line but below the 2-GB bar. Two modes of addressing are available to address this storage: 24-bit and 31-bit.

You can address storage below (but not above) the 16-MB line with 24-bit addressing. You can address storage either above or below the 16-MB line with 31-bit addressing. *Unrestricted storage* is addressable by 31-bit addressing and therefore encompasses all the storage available to your program, both above and below the 16-MB line.

Enterprise COBOL does not directly exploit the 64-bit virtual addressing capability of z/OS, however COBOL applications running in 31-bit or 24-bit addressing mode are fully supported on 64-bit z/OS systems.

Addressing mode (AMODE) is the attribute that tells which hardware addressing mode is supported by your program: 24-bit addressing, 31-bit addressing, or either 24-bit or 31-bit addressing. This attribute is AMODE 24, AMODE 31, or AMODE ANY, respectively. The object program, the load module, and the executing program each has an AMODE attribute. All Enterprise COBOL object programs are AMODE ANY.

Residency mode (RMODE) is the attribute of a program load module that identifies where in virtual storage the program will reside: below the 16-MB line, or either below or above. This attribute is RMODE 24 or RMODE ANY.

Enterprise COBOL uses Language Environment services to control the storage used at run time. Thus COBOL compiler options and Language Environment run-time options influence the AMODE and RMODE attributes of your program and data, alone and in combination:

DATA	Compiler option that influences the location of storage for WORKING-STORAGE data, I-O buffers, and parameter lists for programs compiled with RENT.
RMODE	Compiler option that influences the residency mode and also influences the location of storage for WORKING-STORAGE data, I-O buffers, and parameter lists for programs compiled with NORENT.
RENT	Compiler option to generate a reentrant program.
HEAP	Run-time option that controls storage for the run-time heap. For example, COBOL WORKING-STORAGE is allocated from heap storage.
STACK	Run-time option that controls storage for the run-time stack. For example, COBOL LOCAL-STORAGE is allocated from stack storage.
ALL31	Run-time option that specifies whether an application can run entirely in AMODE 31.

Settings for RMODE

The RMODE and RENT options determine the RMODE attribute of your program:

Table 4. Effect of RMODE and RENT compiler options on the RMODE attribute

RMODE compiler option	RENT compiler option	RMODE attribute
RMODE(AUTO)	NORENT	RMODE 24
RMODE(AUTO)	RENT	RMODE ANY
RMODE(24)	RENT or NORENT	RMODE 24
RMODE(ANY)	RENT or NORENT	RMODE ANY

Storage restrictions for passing data

Do not pass parameters that are allocated in storage above the 16-MB line to AMODE 24 subprograms. Force the WORKING-STORAGE data and parameter lists below the line for programs that run in 31-bit addressing mode and pass data to programs that run in AMODE 24:

- Compile reentrant programs (RENT) with DATA(24).
- Compile nonreentrant programs (NORENT) with RMODE(24) or RMODE(AUTO).
- Nonreentrant programs (NORENT) compiled with RMODE(ANY) must be link-edited with RMODE 24. The data areas for NORENT programs are above the 16-MB line or below the 16-MB line depending on where the program is loaded, even if the program was compiled with DATA(24). The DATA option does not affect programs compiled with NORENT.

Location of data areas

For reentrant programs, the DATA compiler option and the HEAP run-time option control whether storage for data areas such as WORKING-STORAGE SECTION and FD record areas is obtained from below the 16-MB line or from unrestricted storage. Compile programs with RENT or RMODE(ANY) if they will be run with 31-bit addressing in virtual storage addresses above the 16-MB line. The DATA option does not affect programs compiled with NORENT.

When you specify the run-time option HEAP(, ,BELOW), the DATA compiler option has no effect; the storage for WORKING-STORAGE SECTION data areas is allocated from below the 16-MB line. However, with HEAP(, ,ANYWHERE) as the run-time option, storage for data areas is allocated from below the 16-MB line if you compiled the program with the DATA(24) compiler option, or from unrestricted storage if you compiled with the DATA(31) compiler option.

Storage for LOCAL-STORAGE data

The location of LOCAL-STORAGE data items is controlled by the STACK run-time option and the AMODE of the program. LOCAL-STORAGE data items are acquired in unrestricted storage when the STACK(, ,ANYWHERE) run-time option is in effect and the program is running in AMODE 31. Otherwise LOCAL-STORAGE is acquired below the 16-MB line. The DATA compiler option does not influence the location of LOCAL-STORAGE data.

Storage for external data

In addition to affecting how storage is obtained for dynamic data areas (WORKING-STORAGE, FD record areas, and parameter lists), the DATA compiler option

can also influence where storage for EXTERNAL data is obtained. Storage required for EXTERNAL data is obtained from unrestricted storage if the following conditions are met:

- The program is compiled with the DATA(31) and RENT compiler options or the RMODE(ANY) and NORENT compiler options.
- The HEAP(,,ANYWHERE) run-time option is in effect.
- The ALL31(ON) run-time option is in effect.

In all other cases, the storage for EXTERNAL data is obtained from below the 16-MB line. When you specify the ALL31(ON) run-time option, all the programs in the run unit must be capable of running in 31-bit addressing mode.

Storage for QSAM input-output buffers

The DATA compiler option can also influence where input-output buffers for QSAM files are obtained. See the related references below for information about allocation of buffers for QSAM files and the DATA compiler option.

RELATED CONCEPTS

AMODE considerations for heap storage (*Language Environment Programming Guide*)
“AMODE switching” on page 399

RELATED TASKS

Chapter 24, “Using subprograms,” on page 393
Chapter 25, “Sharing data,” on page 411

RELATED REFERENCES

“Allocation of buffers for QSAM files” on page 140
“DATA” on page 277
“RENT” on page 299
“RMODE” on page 300
“Performance-related compiler options” on page 589
HEAP (*Language Environment Programming Reference*)
STACK (*Language Environment Programming Reference*)
ALL31 (*Language Environment Programming Reference*)
z/OS DFSMS: Program Management

Chapter 3. Working with numbers and arithmetic

In general, you can view COBOL numeric data as a series of decimal digit positions. However, numeric items can also have special properties such as an arithmetic sign or a currency sign.

This section describes how to define, display, and store numeric data so that you can perform arithmetic operations efficiently:

- Use the PICTURE clause and the characters 9, +, -, P, S, and V to define numeric data.
- Use the PICTURE clause and editing characters (such as Z, comma, and period) along with MOVE and DISPLAY statements to display numeric data.
- Use the USAGE clause with various formats to control how numeric data is stored.
- Use the numeric class test to validate that data values are appropriate.
- Use ADD, SUBTRACT, MULTIPLY, DIVIDE, and COMPUTE statements to perform arithmetic.
- Use the CURRENCY SIGN clause and appropriate PICTURE characters to designate the currency you want.

RELATED TASKS

"Defining numeric data"

"Displaying numeric data" on page 38

"Controlling how numeric data is stored" on page 39

"Checking for incompatible data (numeric class test)" on page 46

"Performing arithmetic" on page 47

"Using currency signs" on page 55

Defining numeric data

Define numeric items by using the PICTURE clause with the character 9 in the data description to represent the decimal digits of the number. Do not use an X, which is for alphanumeric items:

```
05 Count-y          Pic 9(4)   Value 25.
05 Customer-name    Pic X(20)  Value "Johnson".
```

You can code up to 18 digits in the PICTURE clause when you compile using the default compiler option ARITH(COMPAT) (referred to as *compatibility mode*). When you compile using ARITH(EXTEND) (referred to as *extended mode*), you can code up to 31 digits in the PICTURE clause.

Other characters of special significance that you can code are:

- P** Indicates leading or trailing zeroes
- S** Indicates a sign, positive or negative
- V** Implies a decimal point

The s in the following example means that the value is signed:

```
05 Price            Pic s99v99.
```

The field can therefore hold a positive or a negative value. The v indicates the position of an implied decimal point, but does not contribute to the size of the

item because it does not require a storage position. An s usually does not contribute to the size of a numeric item, because by default it does not require a storage position.

However, if you plan to port your program or data to a different machine, you might want to code the sign as a separate position in storage. In this case, the sign takes 1 byte:

```
05 Price          Pic s99V99  Sign Is Leading, Separate.
```

This coding ensures that the convention your machine uses for storing a nonseparate sign will not cause unexpected results on a machine that uses a different convention.

Separate signs are also preferable for data items that will be printed or displayed.

You cannot use the PICTURE clause with internal floating-point data (COMP-1 or COMP-2). However, you can use the VALUE clause to provide an initial value for a floating-point literal:

```
05 Compute-result Usage Comp-2  Value 06.23E-24.
```

“Examples: numeric data and internal representation” on page 42

RELATED CONCEPTS

Appendix A, “Intermediate results and arithmetic precision,” on page 603

RELATED TASKS

“Displaying numeric data”

“Controlling how numeric data is stored” on page 39

“Performing arithmetic” on page 47

RELATED REFERENCES

“Sign representation and processing” on page 45

“ARITH” on page 271

“NUMPROC” on page 293

Displaying numeric data

You can define numeric items with certain editing symbols (such as decimal points, commas, dollar signs, and debit or credit signs) to make the data easier to read and understand when you display it or print it. For example, in the code below, Edited-price is a numeric-edited item:

```
05 Price          Pic 9(5)V99.
05 Edited-price   Pic $$z,zz9.99.
. . .
Move Price To Edited-price
Display Edited-price
```

If the contents of Price are 0150099 (representing the value 1,500.99), then \$ 1,500.99 is displayed when you run the code. The z in the PICTURE clause of Edited-price indicates the suppression of leading zeros.

You cannot use numeric-edited items as operands in arithmetic expressions or in ADD, SUBTRACT, MULTIPLY, DIVIDE, or COMPUTE statements. You use numeric-edited items primarily for displaying or printing numeric data. (You can specify the clause USAGE IS DISPLAY for numeric-edited items; however, it is implied. It means that the items are stored in character format.)

You can move numeric-edited items to numeric or numeric-edited items. In the following example, the value of the numeric-edited item is moved to the numeric item:

```
Move Edited-price to Price  
Display Price
```

If these two statements immediately followed the statements in the previous example, then Price would be displayed as 0150099, representing the value 1,500.99.

“Examples: numeric data and internal representation” on page 42

RELATED TASKS

“Controlling how numeric data is stored”

“Defining numeric data” on page 37

“Performing arithmetic” on page 47

RELATED REFERENCES

MOVE statement (*Enterprise COBOL Language Reference*)

Controlling how numeric data is stored

You can control how the computer stores numeric data items by coding the USAGE clause in your data description entries. You might want to control the format for any of several reasons such as these:

- Arithmetic on computational data types is more efficient than on USAGE DISPLAY data types.
- Packed-decimal format requires less storage per digit than USAGE DISPLAY data types.
- Packed-decimal format converts to and from DISPLAY format more efficiently than binary format does.
- Floating-point format is well suited for arithmetic operands and results with widely varying scale, while maintaining the maximal number of significant digits.
- You might need to preserve data formats when you move data from one machine to another.

The numeric data you use in your program will have one of the following formats available with COBOL:

- External decimal (USAGE DISPLAY)
- External floating point (USAGE DISPLAY)
- Internal decimal (USAGE PACKED-DECIMAL)
- Binary (USAGE BINARY)
- Native binary (USAGE COMP-5)
- Internal floating point (USAGE COMP-1, USAGE COMP-2)

COMP and COMP-4 are synonymous with BINARY, and COMP-3 is synonymous with PACKED-DECIMAL.

The compiler converts displayable numbers to the internal representation of their numeric values before using them in arithmetic operations. Therefore it is often more efficient if you define data items as BINARY or PACKED-DECIMAL rather than as DISPLAY. For example:

```
05 Initial-count Pic S9(4) Usage Binary Value 1000.
```

Regardless of which USAGE clause you use to control the internal representation of a value, you use the same PICTURE clause conventions and decimal value in the VALUE clause (except for floating-point data, for which you cannot use a PICTURE clause).

“Examples: numeric data and internal representation” on page 42

RELATED CONCEPTS

“Formats for numeric data”

“Data format conversions” on page 43

Appendix A, “Intermediate results and arithmetic precision,” on page 603

RELATED TASKS

“Defining numeric data” on page 37

“Displaying numeric data” on page 38

“Performing arithmetic” on page 47

RELATED REFERENCES

“Conversions and precision” on page 44

“Sign representation and processing” on page 45

Formats for numeric data

The following are the available formats for numeric data.

External decimal (DISPLAY) items

When USAGE DISPLAY is in effect for a data item (either because you have coded it, or by default), each position (byte) of storage contains one decimal digit. This means the items are stored in displayable form.

External decimal (also known as *zoned decimal*) items are primarily intended for receiving and sending numbers between your program and files, terminals, or printers. You can also use external decimal items as operands and receivers in arithmetic processing. However, if your program performs a lot of intensive arithmetic and efficiency is a high priority, COBOL’s computational numeric types might be a better choice for the data items used in the arithmetic.

External floating-point (DISPLAY) items

Displayable numbers coded in a floating-point format are called *external floating-point items*. As with external decimal items, you define external floating-point items explicitly by coding USAGE DISPLAY or implicitly by omitting the USAGE clause. You cannot use the VALUE clause for external floating-point items.

In the following example, Compute-Result is implicitly defined as an external floating-point item. Each byte of storage contains one of the characters (except for the v).

```
05 Compute-Result Pic -9v9(9)E-99.
```

The minus signs (-) do not mean that the mantissa and exponent must necessarily be negative numbers. Instead, they mean that when the number is displayed, the sign appears as a blank for positive numbers or a minus sign for negative numbers. If you instead code a plus sign (+), the sign appears as a plus sign for positive numbers or a minus sign for negative numbers.

As with external decimal numbers, external floating-point numbers have to be converted (by the compiler) to an internal representation of their numeric value before they can be used in arithmetic operations. If you compile with the default option `ARITH (COMPAT)`, external floating-point numbers are converted to long (64-bit) floating-point format. If you compile with `ARITH (EXTEND)`, they are instead converted to extended-precision (128-bit) floating-point format.

Binary (COMP) items

`BINARY`, `COMP`, and `COMP-4` are synonyms. Binary-format numbers occupy 2, 4, or 8 bytes of storage. If the `PICTURE` clause specifies that an item is signed, the leftmost bit is used as the operational sign.

A binary number with a `PICTURE` description of four or fewer decimal digits occupies 2 bytes; five to nine decimal digits, 4 bytes; and 10 to 18 decimal digits, 8 bytes. Binary items with nine or more digits require more handling by the compiler. Testing them for the `SIZE ERROR` condition and rounding is more cumbersome than with other types.

You can use binary items, for example, for indexes, subscripts, switches, and arithmetic operands or results.

Use the `TRUNC(STD|OPT|BIN)` compiler option to indicate how binary data (`BINARY`, `COMP`, or `COMP-4`) is to be truncated.

Native binary (COMP-5) items

Data items that you declare as `USAGE COMP-5` are represented in storage as binary data. However, unlike `USAGE COMP` items, they can contain values of magnitude up to the capacity of the native binary representation (2, 4, or 8 bytes) rather than being limited to the value implied by the number of 9s in the `PICTURE` clause.

When you move or store numeric data into a `COMP-5` item, truncation occurs at the binary field size rather than at the COBOL `PICTURE` size limit. When you reference a `COMP-5` item, the full binary field size is used in the operation.

`COMP-5` is thus particularly useful for binary data items originating in non-COBOL programs where the data might not conform to a COBOL `PICTURE` clause.

The table below shows the ranges of values possible for `COMP-5` data items.

Table 5. Ranges in value of COMP-5 data items

PICTURE	Storage representation	Numeric values
S9(1) through S9(4)	Binary halfword (2 bytes)	-32768 through +32767
S9(5) through S9(9)	Binary fullword (4 bytes)	-2,147,483,648 through +2,147,483,647
S9(10) through S9(18)	Binary doubleword (8 bytes)	-9,223,372,036,854,775,808 through +9,223,372,036,854,775,807
9(1) through 9(4)	Binary halfword (2 bytes)	0 through 65535
9(5) through 9(9)	Binary fullword (4 bytes)	0 through 4,294,967,295
9(10) through 9(18)	Binary doubleword (8 bytes)	0 through 18,446,744,073,709,551,615

You can specify scaling (that is, decimal positions or implied integer positions) in the `PICTURE` clause of `COMP-5` items. If you do so, you must appropriately scale the

maximal capacities listed above. For example, a data item you describe as PICTURE S99V99 COMP-5 is represented in storage as a binary halfword, and supports a range of values from -327.68 through +327.67.

Large literals in VALUE clauses: Literals specified in VALUE clauses for COMP-5 items can, with a few exceptions, contain values of magnitude up to the capacity of the native binary representation. See *Enterprise COBOL Language Reference* for the exceptions.

Regardless of the setting of the TRUNC compiler option, COMP-5 data items behave like binary data does in programs compiled with TRUNC(BIN).

Packed-decimal (COMP-3) items

PACKED-DECIMAL and COMP-3 are synonyms. Packed-decimal items occupy 1 byte of storage for every two decimal digits you code in the PICTURE description, except that the rightmost byte contains only one digit and the sign. This format is most efficient when you code an odd number of digits in the PICTURE description, so that the leftmost byte is fully used. Packed-decimal items are handled as fixed-point numbers for arithmetic purposes.

Floating-point (COMP-1 and COMP-2) items

COMP-1 refers to short floating-point format and COMP-2 refers to long floating-point format, which occupy 4 and 8 bytes of storage, respectively. The leftmost bit contains the sign and the next 7 bits contain the exponent; the remaining 3 or 7 bytes contain the mantissa.

COMP-1 and COMP-2 data items are stored in zSeries hexadecimal format.

RELATED CONCEPTS

Appendix A, “Intermediate results and arithmetic precision,” on page 603

RELATED REFERENCES

VALUE clause (*Enterprise COBOL Language Reference*)
“TRUNC” on page 310

Examples: numeric data and internal representation

The following table shows the internal representation of numeric items.

Table 6. Internal representation of numeric items

Numeric type	PICTURE and USAGE and optional SIGN clause	Value	Internal representation
External decimal	PIC S9999 DISPLAY	+ 1234	F1 F2 F3 C4
		- 1234	F1 F2 F3 D4
		1234	F1 F2 F3 C4
	PIC 9999 DISPLAY	1234	F1 F2 F3 F4
	PIC S9999 DISPLAY	+ 1234	C1 F2 F3 F4
	SIGN LEADING	- 1234	D1 F2 F3 F4
	PIC S9999 DISPLAY	+ 1234	4E F1 F2 F3 F4
	SIGN LEADING SEPARATE	- 1234	60 F1 F2 F3 F4
	PIC S9999 DISPLAY	+ 1234	F1 F2 F3 F4 4E
	SIGN TRAILING SEPARATE	- 1234	F1 F2 F3 F4 60

Table 6. Internal representation of numeric items (continued)

Numeric type	PICTURE and USAGE and optional SIGN clause	Value	Internal representation
Binary	PIC S9999 BINARY COMP COMP-4	+ 1234 - 1234	04 D2 FB 2E
	COMP-5	+ 12345 ¹ - 12345 ¹	30 39 CF C7
	PIC 9999 BINARY COMP COMP-4	1234	04 D2
	COMP-5	60000 ¹	EA 60
Internal decimal	PIC S9999 PACKED-DECIMAL COMP-3	+ 1234 - 1234	01 23 4C 01 23 4D
	PIC 9999 PACKED-DECIMAL COMP-3	+ 1234 - 1234	01 23 4F 01 23 4F
Internal floating point	COMP-1	+ 1234	43 4D 20 00
Internal floating point	COMP-2	+ 1234 - 1234	43 4D 20 00 00 00 00 00 C3 4D 20 00 00 00 00 00
External floating point	PIC +9(2).9(2)E+99 DISPLAY	+ 1234	4E F1 F2 4B F3 F4 C5 4E F0 F2
		- 1234	60 F1 F2 4B F3 F4 C5 4E F0 F2
1. The example demonstrates that COMP-5 data items can contain values of magnitude up to the capacity of the native binary representation (2, 4, or 8 bytes), rather than being limited to the value implied by the number of 9s in the PICTURE clause.			

Data format conversions

When the code in your program involves the interaction of items with different data formats, the compiler converts these items as follows:

- Temporarily, for comparisons and arithmetic operations
- Permanently, for assignment to the receiver in a MOVE or COMPUTE statement

A conversion is actually a move of a value from one data item to another. The compiler performs any conversions that are required during the execution of arithmetic or comparisons with the same rules that are used for MOVE and COMPUTE statements.

When possible, the compiler performs a move to preserve numeric value as opposed to a direct digit-for-digit move.

Conversion generally requires additional storage and processing time because data is moved to an internal work area and converted before the operation is performed. The results might also have to be moved back into a work area and converted again.

Conversions between fixed-point data formats (external decimal, packed decimal, or binary) are without loss of precision as long as the target field can contain all the digits of the source operand.

A loss of precision is possible in conversions between fixed-point data formats and floating-point data formats (short floating point, long floating point, or external floating point). These conversions happen during arithmetic evaluations that have a mixture of both fixed-point and floating-point operands.

RELATED REFERENCES

“Conversions and precision”

“Sign representation and processing” on page 45

Conversions and precision

Because both fixed-point and external floating-point items have decimal characteristics, references to fixed-point items in the following examples include external floating-point items also unless stated otherwise.

When the compiler converts from fixed-point to internal floating-point format, fixed-point numbers in base 10 are converted to the numbering system used internally.

When the compiler converts short form to long form for comparisons, zeros are used for padding the shorter number.

When a USAGE COMP-1 data item is moved to a fixed-point data item with more than nine digits, the fixed-point data item will receive only nine significant digits, and the remaining digits will be zero.

When a USAGE COMP-2 data item is moved to a fixed-point data item with more than 18 digits, the fixed-point data item will receive only 18 significant digits, and the remaining digits will be zero.

Conversions that preserve precision

If a fixed-point data item with six or fewer digits is moved to a USAGE COMP-1 data item and then returned to the fixed-point data item, the original value is recovered.

If a USAGE COMP-1 data item is moved to a fixed-point data item of nine or more digits and then returned to the USAGE COMP-1 data item, the original value is recovered.

If a fixed-point data item with 15 or fewer digits is moved to a USAGE COMP-2 data item and then returned to the fixed-point data item, the original value is recovered.

If a USAGE COMP-2 data item is moved to a fixed-point (not external floating-point) data item of 18 or more digits and then returned to the USAGE COMP-2 data item, the original value is recovered.

Conversions that result in rounding

If a USAGE COMP-1 data item, a USAGE COMP-2 data item, an external floating-point data item, or a floating-point literal is moved to a fixed-point data item, rounding occurs in the low-order position of the target data item.

If a USAGE COMP-2 data item is moved to a USAGE COMP-1 data item, rounding occurs in the low-order position of the target data item.

If a fixed-point data item is moved to an external floating-point data item and the PICTURE of the fixed-point data item contains more digit positions than the PICTURE of the external floating-point data item, rounding occurs in the low-order position of the target data item.

RELATED CONCEPTS

Appendix A, “Intermediate results and arithmetic precision,” on page 603

Sign representation and processing

Sign representation affects the processing and interaction of your numeric data.

Given $X'sd'$, where s is the sign representation and d represents the digit, the valid sign representations for external decimal (USAGE DISPLAY without the SIGN IS SEPARATE clause) are:

Positive:

C, A, E, and F

Negative:

D and B

The COBOL NUMPROC compiler option affects sign processing for external decimal and internal decimal data. NUMPROC has no effect on binary data or floating-point data.

NUMPROC(PFD)

Given $X'sd'$, where s is the sign representation and d represents the digit, when you use NUMPROC(PFD), the compiler assumes that the sign in your data is one of three preferred signs:

Signed positive or 0:

$X'C'$

Signed negative:

$X'D'$

Unsigned or alphanumeric:

$X'F'$

Based on this assumption, the compiler uses whatever sign it is given to process data. The preferred sign is generated only where necessary (for example, when unsigned data is moved to signed data). Using the NUMPROC(PFD) option can save processing time, but you must use preferred signs with your data for correct processing.

NUMPROC(NOPFD)

When the NUMPROC(NOPFD) compiler option is in effect, the compiler accepts any valid sign configuration. The preferred sign is always generated in the receiver. NUMPROC(NOPFD) is less efficient than NUMPROC(PFD), but you should use it whenever data that does not use preferred signs might exist.

If an unsigned, external-decimal sender is moved to an alphanumeric receiver, the sign is unchanged (even with NUMPROC(NOPFD)).

NUMPROC(MIG)

When NUMPROC(MIG) is in effect, the compiler generates code that is similar to that produced by OS/VS COBOL. This option can be especially useful if you migrate OS/VS COBOL programs to IBM Enterprise COBOL for z/OS.

RELATED REFERENCES

"NUMPROC" on page 293

Checking for incompatible data (numeric class test)

The compiler assumes that the values you supply for a data item are valid for the item's PICTURE and USAGE clauses, and assigns the values without checking for validity. When you give an item a value that is incompatible with its data description, references to that item in the PROCEDURE DIVISION are undefined and your results will be unpredictable.

It can happen that values are passed into your program and assigned to items that have incompatible data descriptions for those values. For example, nonnumeric data might be moved or passed into a field that is defined as numeric. Or a signed number might be passed into a field that is defined as unsigned. In both cases, the receiving fields contain invalid data. Ensure that the contents of a data item conform to its PICTURE and USAGE clauses before using the data item in any further processing steps.

You can use the numeric class test to perform data validation. For example:

Linkage Section.

```
01 Count-x      Pic 999.
```

```
...
```

Procedure Division Using Count-x.

```
    If Count-x is numeric then display "Data is good"
```

The numeric class test checks the contents of a data item against a set of values that are valid for the particular PICTURE and USAGE of the data item. For example, a packed-decimal item is checked for hexadecimal values X'0' through X'9' in the digit positions, and for a valid sign value in the sign position (whether separate or nonseparate).

For external decimal, external floating-point, and packed-decimal items, the numeric class test is affected by the NUMPROC compiler option and the NUMCLS option (which is set at installation time). To determine the NUMCLS setting used at your installation, consult your system programmer.

If NUMCLS(PRIM) is in effect at your installation, use the following table to find the values that the compiler considers valid for the sign.

Table 7. NUMCLS(PRIM) and valid signs

	NUMPROC(NOPFD)	NUMPROC(PFD)	NUMPROC(MIG)
Signed	C, D, F	C, D, +0 (positive zero)	C, D, F
Unsigned	F	F	F
Separate sign	+, -	+, -, +0 (positive zero)	+, -

If NUMCLS(ALT) is in effect at your installation, use the following table to find the values that the compiler considers valid for the sign.

Table 8. NUMCLS(ALT) and valid signs

	NUMPROC (NOPFD)	NUMPROC (PFD)	NUMPROC (MIG)
Signed	A to F	C, D, +0 (positive zero)	A to F
Unsigned	F	F	F
Separate sign	+, -	+, -, +0 (positive zero)	+, -

RELATED REFERENCES

“NUMPROC” on page 293

Performing arithmetic

You can use any of several COBOL language features to perform arithmetic:

- “COMPUTE and other arithmetic statements”
- “Arithmetic expressions” on page 48
- “Numeric intrinsic functions” on page 48
- “Math and date Language Environment services” on page 49

COMPUTE and other arithmetic statements

Use the COMPUTE statement for most arithmetic evaluations rather than ADD, SUBTRACT, MULTIPLY, and DIVIDE statements. Often you can code one COMPUTE statement instead of several individual statements.

The COMPUTE statement assigns the result of an arithmetic expression to one or more data items:

```
Compute z      = a + b / c ** d - e
Compute x y z = a + b / c ** d - e
```

Some arithmetic might be more intuitive using arithmetic statements other than COMPUTE. For example:

COMPUTE	Equivalent arithmetic statements
Compute Increment = Increment + 1	Add 1 to Increment
Compute Balance = Balance - Overdraft	Subtract Overdraft from Balance
Compute IncrementOne = IncrementOne + 1 Compute IncrementTwo = IncrementTwo + 1 Compute IncrementThree = IncrementThree + 1	Add 1 to IncrementOne, IncrementTwo, IncrementThree

You might also prefer to use the DIVIDE statement (with its REMAINDER phrase) for division in which you want to process a remainder. The REM intrinsic function also provides the ability to process a remainder.

RELATED CONCEPTS

“Fixed-point versus floating-point arithmetic” on page 53

Appendix A, “Intermediate results and arithmetic precision,” on page 603

Arithmetic expressions

You can use arithmetic expressions in many (but not all) places in statements where numeric data items are allowed. For example, you can use arithmetic expressions as comparands in relation conditions:

If $(a + b) > (c - d + 5)$ Then. . .

Arithmetic expressions can consist of a single numeric literal, a single numeric data item, or a single intrinsic function reference. They can also consist of several of these items connected by arithmetic operators. Arithmetic operators are evaluated in the following order of precedence:

Table 9. Order of evaluation of arithmetic operators

Operator	Meaning	Order of evaluation
Unary + or -	Algebraic sign	First
**	Exponentiation	Second
/ or *	Division or multiplication	Third
Binary + or -	Addition or subtraction	Last

Operators at the same level of precedence are evaluated from left to right; however, you can use parentheses to change the order of evaluation. Expressions in parentheses are evaluated before the individual operators are evaluated. Parentheses, necessary or not, make your program easier to read.

RELATED CONCEPTS

“Fixed-point versus floating-point arithmetic” on page 53

Appendix A, “Intermediate results and arithmetic precision,” on page 603

Numeric intrinsic functions

You can use numeric intrinsic functions only in places where numeric expressions are allowed. These functions can save you time because you don’t have to code the many common types of calculations that they provide.

Numeric intrinsic functions return a signed numeric value. They are treated as temporary numeric data items.

Many of the capabilities of numeric intrinsic functions are also provided by Language Environment callable services.

Numeric functions are classified into these categories:

Integer

Those that return an integer

Floating point

Those that return a long (64-bit) or extended-precision (128-bit) floating-point value (depending on whether you compile using the default option `ARITH(COMPAT)` or using `ARITH(EXTEND)`)

Mixed Those that return an integer, a floating-point value, or a fixed-point number with decimal places, depending on the arguments

You can use intrinsic functions to perform several different arithmetic operations, as outlined in the following table.

Table 10. Numeric intrinsic functions

Number handling	Date and time	Finance	Mathematics	Statistics
LENGTH MAX MIN NUMVAL NUMVAL-C ORD-MAX ORD-MIN	CURRENT-DATE DATE-OF-INTEGER DATE-TO-YYYYMMDD DATEVAL DAY-OF-INTEGER DAY-TO-YYYYDDD INTEGER-OF-DATE INTEGER-OF-DAY UNDATE WHEN-COMPILED YEAR-TO-YYYY YEARWINDOW	ANNUITY PRESENT-VALUE	ACOS ASIN ATAN COS FACTORIAL INTEGER INTEGER-PART LOG LOG10 MOD REM SIN SQRT SUM TAN	MEAN MEDIAN MIDRANGE RANDOM RANGE STANDARD-DEVIATION VARIANCE

“Examples: numeric intrinsic functions” on page 51

Nesting functions and arithmetic expressions

You can reference one function as the argument of another. A nested function is evaluated independently of the outer function, except when determining whether a mixed function should be evaluated using fixed-point or floating-point instructions.

You can also nest an arithmetic expression as an argument to a numeric function:

Compute $x = \text{Function Sum}(a \ b \ (c / d))$

In this example, there are only three function arguments: a , b , and the arithmetic expression (c / d) .

ALL subscripting and special registers

You can reference all the elements of a table (or array) as function arguments by using the ALL subscript.

You can use the integer special registers as arguments wherever integer arguments are allowed.

RELATED CONCEPTS

“Fixed-point versus floating-point arithmetic” on page 53

Appendix A, “Intermediate results and arithmetic precision,” on page 603

RELATED REFERENCES

“ARITH” on page 271

Math and date Language Environment services

Many of the capabilities of COBOL intrinsic functions are also provided by Language Environment callable services. Language Environment callable services provide a means of assigning arithmetic results to data items. They include mathematical functions, and date and time operations.

Math-oriented callable services

For most COBOL intrinsic functions there are corresponding math-oriented callable services you can use that produce the same results, as shown in the following table. When you compile with the default option `ARITH(COMPAT)`, COBOL floating-point intrinsic functions return long (64-bit) results. When you compile with option `ARITH(EXTEND)`, COBOL floating-point intrinsic functions (with the exception of `RANDOM`) return extended-precision (128-bit) results.

So for example (considering the first row of the table), if you compile using `ARITH(COMPAT)`, `CEEDACS` returns the same result as `ACOS`. If you compile using `ARITH(EXTEND)`, `CEESQACS` returns the same result as `ACOS`.

Table 11. Compatibility of math intrinsic functions and callable services

COBOL intrinsic function	Corresponding long-precision Language Environment callable service	Corresponding extended-precision Language Environment callable service	Results same for intrinsic function and callable service?
ACOS	CEEDACS	CEESQACS	Yes
ASIN	CEEDASN	CEESQASN	Yes
ATAN	CEEDATN	CEESQATN	Yes
COS	CEEDCOS	CEESQCOS	Yes
LOG	CEEDLOG	CEESQLOG	Yes
LOG10	CEEDLG1	CEESQLG1	Yes
RANDOM ¹	CEERAN0	none	No
REM	CEEDMOD	CEESQMOD	Yes
SIN	CEEDSIN	CEESQSIN	Yes
SQRT	CEEDSQT	CEESQSQT	Yes
TAN	CEEDTAN	CEESQTAN	Yes
1. <code>RANDOM</code> returns a long (64-bit) floating-point result even if you pass it a 31-digit argument and compile using option <code>ARITH(EXTEND)</code> .			

Both the `RANDOM` intrinsic function and `CEERAN0` service generate random numbers between zero and one. However, because each uses its own algorithm, `RANDOM` and `CEERAN0` produce different random numbers from the same seed.

Even for functions that produce the same results, how you use intrinsic functions and Language Environment callable services differs. The rules for the data types required for intrinsic function arguments are less restrictive. For numeric intrinsic functions, you can use arguments that are of any numeric data type. When you invoke a Language Environment callable service with a `CALL` statement, however, you must ensure that the parameters match the numeric data types required by that service (generally `COMP-1` or `COMP-2`).

The error handling of intrinsic functions and Language Environment callable services sometimes differs. If you pass an explicit feedback token when calling the Language Environment math services, you must check the feedback code after each call and take explicit action to deal with errors. However, if you call with the feedback token explicitly `OMITTED`, you do not need to check the token; Language Environment automatically signals any errors.

Date callable services

Both the COBOL date intrinsic functions and the Language Environment date callable services are based on the Gregorian calendar. However, the starting dates can differ depending on the setting of the INTDATE compiler option. When the default setting of INTDATE(ANSI) is in effect, COBOL uses January 1, 1601 as day 1. When INTDATE(LILIAN) is in effect, COBOL uses October 15, 1582 as day 1. Language Environment always uses October 15, 1582 as day 1.

This means that if you use INTDATE(LILIAN), you get equivalent results from COBOL intrinsic functions and Language Environment callable date services.

The following table shows the results when INTDATE(ANSI) is in effect.

Table 12. INTDATE(ANSI) and compatibility of date intrinsic functions and callable services

COBOL intrinsic function	Language Environment callable service	Results
INTEGER-OF-DATE	CEECBLDY	Compatible
DATE-OF-INTEGER	CEEDATE with picture string YYYYMMDD	Incompatible
DAY-OF-INTEGER	CEEDATE with picture string YYYYDDD	Incompatible
INTEGER-OF-DATE	CEEDAYS	Incompatible

The following table shows the results when INTDATE(LILIAN) is in effect.

Table 13. INTDATE(LILIAN) and compatibility of date intrinsic functions and callable services

COBOL intrinsic function	Language Environment callable service	Results
DATE-OF-INTEGER	CEEDATE with picture string YYYYMMDD	Compatible
DAY-OF-INTEGER	CEEDATE with picture string YYYYDDD	Compatible
INTEGER-OF-DATE	CEEDAYS	Compatible
INTEGER-OF-DATE	CEECBLDY	Incompatible

RELATED CONCEPTS

“Fixed-point versus floating-point arithmetic” on page 53

Appendix A, “Intermediate results and arithmetic precision,” on page 603

RELATED TASKS

“Using Language Environment callable services” on page 597

RELATED REFERENCES

“ARITH” on page 271

Examples: numeric intrinsic functions

The following examples and accompanying explanations show intrinsic functions in each of several categories.

General number handling

Suppose you want to find the maximum value of two prices (represented as alphanumeric items with dollar signs), put this value into a numeric field in an

output record, and determine the length of the output record. You can use NUMVAL-C (a function that returns the numeric value of an alphanumeric string) and the MAX and LENGTH functions to do this:

```
01 X                      Pic 9(2).
01 Price1                  Pic x(8)  Value "$8000".
01 Price2                  Pic x(8)  Value "$2000".
01 Output-Record.
   05 Product-Name        Pic x(20).
   05 Product-Number      Pic 9(9).
   05 Product-Price       Pic 9(6).
. . .
Procedure Division.
   Compute Product-Price =
       Function Max (Function Numval-C(Price1) Function Numval-C(Price2))
   Compute X = Function Length(Output-Record)
```

Additionally, to ensure that the contents in Product-Name are in uppercase letters, you can use the following statement:

```
Move Function Upper-case (Product-Name) to Product-Name
```

Date and time

The following example shows how to calculate a due date that is 90 days from today. The first eight characters returned by the CURRENT-DATE function represent the date in a four-digit year, two-digit month, and two-digit day format (YYYYMMDD). The date is converted to its integer value; then 90 is added to this value and the integer is converted back to the YYYYMMDD format.

```
01 YYYYMMDD              Pic 9(8).
01 Integer-Form          Pic S9(9).
. . .
   Move Function Current-Date(1:8) to YYYYMMDD
   Compute Integer-Form = Function Integer-of-Date(YYYYMMDD)
   Add 90 to Integer-Form
   Compute YYYYMMDD = Function Date-of-Integer(Integer-Form)
   Display 'Due Date: ' YYYYMMDD
```

Finance

Business investment decisions frequently require computing the present value of expected future cash inflows to evaluate the profitability of a planned investment. The present value of an amount that you expect to receive at a given time in the future is that amount, which, if invested today at a given interest rate, would accumulate to that future amount.

For example, assume that a proposed investment of \$1,000 produces a payment stream of \$100, \$200, and \$300 over the next three years, one payment per year respectively. The following COBOL statements calculate the present value of those cash inflows at a 10% interest rate:

```
01 Series-Amt1            Pic 9(9)V99      Value 100.
01 Series-Amt2            Pic 9(9)V99      Value 200.
01 Series-Amt3            Pic 9(9)V99      Value 300.
01 Discount-Rate          Pic S9(2)V9(6)   Value .10.
01 Todays-Value           Pic 9(9)V99.
. . .
   Compute Todays-Value =
       Function
           Present-Value(Discount-Rate Series-Amt1 Series-Amt2 Series-Amt3)
```

You can use the ANNUITY function in business problems that require you to determine the amount of an installment payment (annuity) necessary to repay the principal and interest of a loan. The series of payments is characterized by an equal amount each period, periods of equal length, and an equal interest rate each

period. The following example shows how you can calculate the monthly payment required to repay a \$15,000 loan in three years at a 12% annual interest rate (36 monthly payments, interest per month = .12/12):

```
01 Loan          Pic 9(9)V99.
01 Payment       Pic 9(9)V99.
01 Interest      Pic 9(9)V99.
01 Number-Periods Pic 99.
. . .
  Compute Loan = 15000
  Compute Interest = .12
  Compute Number-Periods = 36
  Compute Payment =
    Loan * Function Annuity((Interest / 12) Number-Periods)
```

Mathematics

The following COBOL statement demonstrates that you can nest intrinsic functions, use arithmetic expressions as arguments, and perform previously complex calculations simply:

```
Compute Z = Function Log(Function Sqrt (2 * X + 1)) + Function Rem(X 2)
```

Here in the addend the intrinsic function REM (instead of a DIVIDE statement with a REMAINDER clause) returns the remainder of dividing X by 2.

Statistics

Intrinsic functions make calculating statistical information easier. Assume you are analyzing various city taxes and want to calculate the mean, median, and range (the difference between the maximum and minimum taxes):

```
01 Tax-S          Pic 99v999 value .045.
01 Tax-T          Pic 99v999 value .02.
01 Tax-W          Pic 99v999 value .035.
01 Tax-B          Pic 99v999 value .03.
01 Ave-Tax        Pic 99v999.
01 Median-Tax     Pic 99v999.
01 Tax-Range      Pic 99v999.
. . .
  Compute Ave-Tax   = Function Mean  (Tax-S Tax-T Tax-W Tax-B)
  Compute Median-Tax = Function Median (Tax-S Tax-T Tax-W Tax-B)
  Compute Tax-Range = Function Range  (Tax-S Tax-T Tax-W Tax-B)
```

Fixed-point versus floating-point arithmetic

Many statements in a program could involve arithmetic. For example, each of the following types of COBOL statements requires some arithmetic evaluation:

- General arithmetic


```
compute report-matrix-col = (emp-count ** .5) + 1
add report-matrix-min to report-matrix-max giving report-matrix-tot
```
- Expressions and functions


```
compute report-matrix-col = function sqrt(emp-count) + 1
compute whole-hours       = function integer-part((average-hours) + 1)
```
- Arithmetic comparisons


```
if report-matrix-col <    function sqrt(emp-count) + 1
if whole-hours          not = function integer-part((average-hours) + 1)
```

How you code arithmetic in a program (whether an arithmetic statement, an intrinsic function, an expression, or some combination of these nested within each other) determines whether the evaluation is done in floating-point or fixed-point arithmetic.

Floating-point evaluations

In general, if your arithmetic coding has either of the characteristics listed below, it is evaluated in floating-point arithmetic:

- An operand or result field is floating point.

An operand is floating point if you code it as a floating-point literal or if you code it as a data item that is defined as USAGE COMP-1, USAGE COMP-2, or external floating point (USAGE DISPLAY with a floating-point PICTURE).

An operand that is a nested arithmetic expression or a reference to a numeric intrinsic function results in floating-point arithmetic when any of the following conditions is true:

- An argument in an arithmetic expression results in floating point.
- The function is a floating-point function.
- The function is a mixed function with one or more floating-point arguments.

- An exponent contains decimal places.

An exponent contains decimal places if you use a literal that contains decimal places, give the item a PICTURE containing decimal places, or use an arithmetic expression or function whose result has decimal places.

An arithmetic expression or numeric function yields a result with decimal places if any operand or argument (excluding divisors and exponents) has decimal places.

Fixed-point evaluations

In general, if an arithmetic operation contains neither of the characteristics listed above for floating point, the compiler causes it to be evaluated in fixed-point arithmetic. In other words, arithmetic evaluations are handled as fixed point only if all the operands are fixed point, the result field is defined to be fixed point, and none of the exponents represent values with decimal places. Nested arithmetic expressions and function references must also represent fixed-point values.

Arithmetic comparisons (relation conditions)

When you compare numeric expressions using a relational operator, the numeric expressions (whether they are data items, arithmetic expressions, function references, or some combination of these) are comparands in the context of the entire evaluation. That is, the attributes of each can influence the evaluation of the other: both expressions are evaluated in fixed point, or both are evaluated in floating point. This is also true of abbreviated comparisons even though one comparand does not explicitly appear in the comparison. For example:

`if (a + d) = (b + e) and c`

This statement has two comparisons: $(a + d) = (b + e)$, and $(a + d) = c$. Although $(a + d)$ does not explicitly appear in the second comparison, it is a comparand in that comparison. Therefore, the attributes of c can influence the evaluation of $(a + d)$.

The compiler handles comparisons (and the evaluation of any arithmetic expressions nested in comparisons) in floating-point arithmetic if either comparand is a floating-point value or resolves to a floating-point value.

The compiler handles comparisons (and the evaluation of any arithmetic expressions nested in comparisons) in fixed-point arithmetic if both comparands are fixed-point values or resolve to fixed-point values.

Implicit comparisons (no relational operator used) are not handled as a unit, however; the two comparands are treated separately as to their evaluation in floating-point or fixed-point arithmetic. In the following example, five arithmetic expressions are evaluated independently of one another's attributes, and then are compared to each other.

```
evaluate (a + d)
    when (b + e) thru c
    when (f / g) thru (h * i)
    . . .
end-evaluate
```

"Examples: fixed-point and floating-point evaluations"

RELATED REFERENCES

"Arithmetic expressions in nonarithmetic statements" on page 611

Examples: fixed-point and floating-point evaluations

Assume you define the data items for an employee table in the following manner:

```
01 employee-table.
    05 emp-count          pic 9(4).
    05 employee-record occurs 1 to 1000 times
        depending on emp-count.
        10 hours          pic +9(5)e+99.
    . . .
01 report-matrix-col      pic 9(3).
01 report-matrix-min      pic 9(3).
01 report-matrix-max      pic 9(3).
01 report-matrix-tot      pic 9(3).
01 average-hours          pic 9(3)v9.
01 whole-hours            pic 9(4).
```

These statements are evaluated using floating-point arithmetic:

```
compute report-matrix-col = (emp-count ** .5) + 1
compute report-matrix-col = function sqrt(emp-count) + 1
if report-matrix-tot < function sqrt(emp-count) + 1
```

These statements are evaluated using fixed-point arithmetic:

```
add report-matrix-min to report-matrix-max giving report-matrix-tot
compute report-matrix-max =
    function max(report-matrix-max report-matrix-tot)
if whole-hours not = function integer-part((average-hours) + 1)
```

Using currency signs

Many programs need to process financial information and present that information using the appropriate currency signs. With COBOL currency support (and the appropriate code page for your printer or display unit), you can use one or more of the following signs in a program:

- Symbols such as the dollar sign (\$)
- Currency signs of more than one character (such as USD or EUR)
- Euro sign, established by the Economic and Monetary Union (EMU)

To specify the symbols for displaying financial information, use the CURRENCY SIGN clause (in the SPECIAL-NAMES paragraph in the CONFIGURATION SECTION) with the PICTURE characters that relate to the symbols. In the following example, the PICTURE character \$ indicates that the currency sign \$US is to be used:

Currency Sign is "\$US" with Picture Symbol "\$".

```
77 Invoice-Amount      Pic $$,$$9.99.
   . . .
   Display "Invoice amount is " Invoice-Amount.
```

In this example, if Invoice-Amount contained 1500.00, the display output would be:
Invoice amount is \$US1,500.00

By using more than one CURRENCY SIGN clause in your program, you can allow for multiple currency signs to be displayed.

You can use a hexadecimal literal to indicate the currency sign value. This could be useful if the data-entry method for the source program does not allow the entry of the intended characters easily. The following example shows the hexadecimal value X'9F' used as the currency sign:

Currency Sign X'9F' with Picture Symbol 'U'.

```
01 Deposit-Amount      Pic UUUUU9.99.
```

If there is no corresponding character for the euro sign on your keyboard, you need to specify it as a hexadecimal value in the CURRENCY SIGN clause. The hexadecimal value for the euro sign is either X'9F' or X'5A' depending on the code page in use, as shown in the following table.

Table 14. Hexadecimal values of the euro sign

Code page CCSID	Applicable countries	Modified from	Euro sign
1140	USA, Canada, Netherlands, Portugal, Australia, New Zealand	037	X'9F'
1141	Austria, Germany	273	X'9F'
1142	Denmark, Norway	277	X'5A'
1143	Finland, Sweden	278	X'5A'
1144	Italy	280	X'9F'
1145	Spain, Latin America - Spanish	284	X'9F'
1146	UK	285	X'9F'
1147	France	297	X'9F'
1148	Belgium, Canada, Switzerland	500	X'9F'
1149	Iceland	871	X'9F'

“Example: multiple currency signs”

Example: multiple currency signs

The following example shows how you can display values in both euro currency (as EUR) and Swiss francs (as CHF):

```
IDENTIFICATION DIVISION.
PROGRAM-ID. EuroSamp.
Environment Division.
Configuration Section.
Special-Names.
    Currency Sign is "CHF " with Picture Symbol "F"
    Currency Sign is "EUR " with Picture Symbol "U".
Data Division.
```



```

Working-Storage Section.
01 Deposit-in-Euro      Pic S9999V99 Value 8000.00.
01 Deposit-in-CHF       Pic S9999V99.
01 Deposit-Report.
    02 Report-in-Franc  Pic -FFFFF9.99.
    02 Report-in-Euro   Pic -UUUUU9.99.
. . .
01 EUR-to-CHF-Conv-Rate Pic 9V99999 Value 1.53893.
. . .
PROCEDURE DIVISION.
Report-Deposit-in-CHF-and-EUR.
    Move Deposit-in-Euro to Report-in-Euro
    . . .
    Compute Deposit-in-CHF Rounded
        = Deposit-in-Euro * EUR-to-CHF-Conv-Rate
    On Size Error
        Perform Conversion-Error
    Not On Size Error
        Move Deposit-in-CHF to Report-in-Franc
        Display "Deposit in Euro = " Report-in-Euro
        Display "Deposit in Franc = " Report-in-Franc
    End-Compute
    . . .
    Goback.
Conversion-Error.
    Display "Conversion error from EUR to CHF"
    Display "Euro value: " Report-in-Euro.

```

The above example produces the following display output:

```

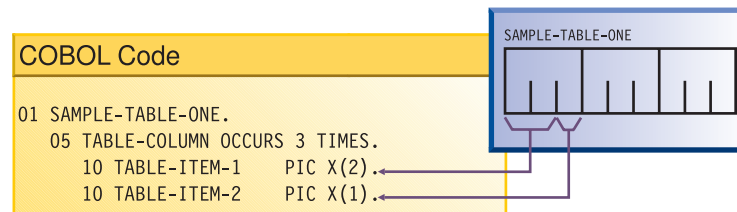
Deposit in Euro = EUR 8000.00
Deposit in Franc = CHF 12311.44

```

The exchange rate used in this example is for illustrative purposes only.

Chapter 4. Handling tables

A *table* is a collection of data items that have the same description, such as account totals or monthly averages. A table is the COBOL equivalent of an array of elements. It consists of a table name and subordinate items called *table elements*.



In the example above, SAMPLE-TABLE-ONE is the group item that contains the table. TABLE-COLUMN names the table element of a one-dimensional table that occurs three times.

Rather than define repetitious items as separate, consecutive entries in the DATA DIVISION, you can use the OCCURS clause in the DATA DIVISION entry to define a table. This practice has these advantages:

- The code clearly shows the unity of the items (the table elements).
- You can use subscripts and indexes to refer to the table elements.
- You can easily repeat data items.

Tables are important for increasing the speed of a program, especially one that looks up records.

RELATED TASKS

- “Defining a table (OCCURS)”
- “Referring to an item in a table” on page 61
- “Putting values into a table” on page 64
- “Nesting tables” on page 60
- “Creating variable-length tables (DEPENDING ON)” on page 68
- “Searching a table” on page 71
- “Processing table items using intrinsic functions” on page 73
- “Handling tables efficiently” on page 583

Defining a table (OCCURS)

To code a table, give the table a group name and define a subordinate item (the *table element*) that is to be repeated *n* times. *table-name* is the group name in the following example:

```
01 table-name.  
  05 element-name OCCURS n TIMES.  
    . . . (subordinate items of the table element might follow)
```

The table element definition (which includes the OCCURS clause) is subordinate to the group item that contains the table. The OCCURS clause cannot appear in a level-01 description.

To create tables of two to seven dimensions, use nested OCCURS clauses.

RELATED TASKS

“Creating variable-length tables (DEPENDENT ON)” on page 68

“Nesting tables”

“Putting values into a table” on page 64

“Referring to an item in a table” on page 61

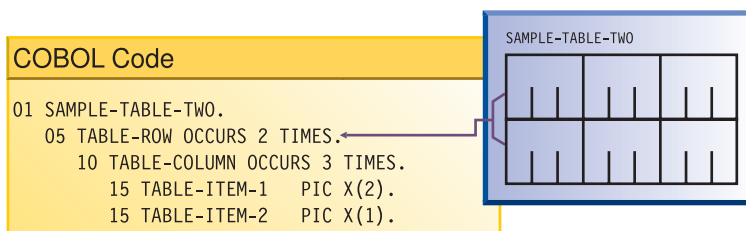
“Searching a table” on page 71

RELATED REFERENCES

OCCURS clause (*Enterprise COBOL Language Reference*)

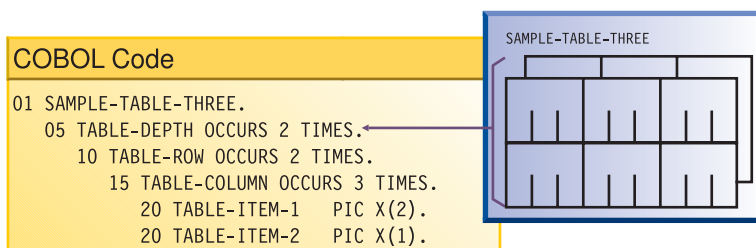
Nesting tables

To create a two-dimensional table, define a one-dimensional table in each occurrence of another one-dimensional table. For example:



In SAMPLE-TABLE-TWO, TABLE-ROW is an element of a one-dimensional table that occurs two times. TABLE-COLUMN is an element of a two-dimensional table that occurs three times in each occurrence of TABLE-ROW.

To create a three-dimensional table, define a one-dimensional table in each occurrence of another one-dimensional table, which is itself contained in each occurrence of another one-dimensional table. For example:



In SAMPLE-TABLE-THREE, TABLE-DEPTH is an element of a one-dimensional table that occurs two times. TABLE-ROW is an element of a two-dimensional table that occurs two times within each occurrence of TABLE-DEPTH. TABLE-COLUMN is an element of a three-dimensional table that occurs three times within each occurrence of TABLE-ROW.

Subscripting

In a two-dimensional table, the two subscripts correspond to the row and column numbers. In a three-dimensional table, the three subscripts correspond to the depth, row, and column numbers.

The following valid references to SAMPLE-TABLE-THREE use literal subscripts. The spaces are required in the second example.

```
TABLE-COLUMN (2, 2, 1)
TABLE-COLUMN (2 2 1)
```

In either table reference, the first value (2) refers to the second occurrence within TABLE-DEPTH, the second value (2) refers to the second occurrence within TABLE-ROW, and the third value (1) refers to the first occurrence within TABLE-COLUMN.

The following reference to SAMPLE-TABLE-TWO uses variable subscripts. The reference is valid if SUB1 and SUB2 are data names that contain positive integer values within the range of the table.

```
TABLE-COLUMN (SUB1 SUB2)
```

Indexing

Consider the following three-dimensional table, SAMPLE-TABLE-FOUR:

```
01 SAMPLE-TABLE-FOUR
   05 TABLE-DEPTH OCCURS 3 TIMES INDEXED BY INX-A.
      10 TABLE-ROW OCCURS 4 TIMES INDEXED BY INX-B.
         15 TABLE-COLUMN OCCURS 8 TIMES INDEXED BY INX-C PIC X(8).
```

Suppose you code the following relative indexing reference to SAMPLE-TABLE-FOUR:

```
TABLE-COLUMN (INX-A + 1, INX-B + 2, INX-C - 1)
```

This reference causes the following computation of the displacement to the TABLE-COLUMN element:

```
(contents of INX-A) + (256 * 1)
+ (contents of INX-B) + (64 * 2)
+ (contents of INX-C) - (8 * 1)
```

This calculation is based on the following element lengths:

- Each occurrence of TABLE-DEPTH is 256 bytes in length (4 * 8 * 8).
- Each occurrence of TABLE-ROW is 64 bytes in length (8 * 8).
- Each occurrence of TABLE-COLUMN is 8 bytes in length.

RELATED TASKS

“Defining a table (OCCURS)” on page 59

“Referring to an item in a table”

“Putting values into a table” on page 64

“Creating variable-length tables (DEPENDING ON)” on page 68

“Searching a table” on page 71

“Processing table items using intrinsic functions” on page 73

“Handling tables efficiently” on page 583

RELATED REFERENCES

OCCURS clause (*Enterprise COBOL Language Reference*)

Referring to an item in a table

A table element has a collective name, but the individual items within it do not have unique data names.

To refer to an item, you have a choice of three techniques:

- Use the data name of the table element, along with its occurrence number (called a *subscript*) in parentheses. This technique is called subscripting.

- Use the data name of the table element, along with a value (called an *index*) that is added to the address of the table to locate an item (the displacement from the beginning of the table). This technique is called indexing, or subscripting using index-names.
- Use both subscripts and indexes together.

RELATED TASKS

“Indexing” on page 63

“Subscripting”

Subscripting

The lowest possible subscript value is 1, which points to the first occurrence of the table element. In a one-dimensional table, the subscript corresponds to the row number.

You can use a data-name or a literal for a subscript.

If a data item with a literal subscript is of fixed length, the compiler resolves the location of the data item.

When you use a data-name as a variable subscript, you must describe the data name as an elementary numeric integer. The most efficient format is COMPUTATIONAL (COMP) with a PICTURE size smaller than five digits. You cannot use a subscript with a data-name that is used as a subscript.

The code generated for the application resolves the location of a variable subscript at run time.

You can increment or decrement a literal or variable subscript by a specified integer amount. For example:

```
TABLE-COLUMN (SUB1 - 1, SUB2 + 3)
```

You can change part of a table element rather than the whole element. Simply refer to the character position and length of the substring to be changed within the subscripted element. For example:

```
01 ANY-TABLE.
   05 TABLE-ELEMENT      PIC X(10)
      OCCURS 3 TIMES
      VALUE "ABCDEFGHIJ".
. . .
MOVE "?? " TO TABLE-ELEMENT (1) (3 : 2).
```

The MOVE statement moves the value ?? into table element number 1, beginning at character position 3, for a length of 2:



RELATED TASKS

“Indexing” on page 63

“Putting values into a table” on page 64

“Searching a table” on page 71

“Handling tables efficiently” on page 583

Indexing

You create an index using OCCURS INDEXED BY.

For example:

```
05 TABLE-ITEM PIC X(8)
   OCCURS 10 INDEXED BY INX-A.
```

The compiler calculates the value contained in the index as the occurrence number (subscript) minus 1, multiplied by the length of the table element. Therefore, for the fifth occurrence of TABLE-ITEM, the binary value contained in INX-A is $(5 - 1) * 8$, or 32.

You can use this index to index another table only if both table descriptions have the same number of table elements, and the table elements are the same length.

If you use USAGE IS INDEX to create an index, you can use the index data item with any table. For example:

```
77 INX-B  USAGE IS INDEX.
. . .
|   SET INX-A TO 10
|   SET INX-B TO INX-A.
|   PERFORM VARYING INX-A FROM 1 BY 1 UNTIL INX-A > INX-B
|   DISPLAY TABLE-ITEM (INX-A)
|   . . .
|   END-PERFORM.
```

INX-A is used to traverse table TABLE-ITEM above, but could be used to traverse other tables also. INX-B is used to hold the index of the last element of the table. The advantage of this type of coding is that calculation of offsets of table elements is minimized, and no conversion is necessary for the UNTIL condition.

You can increment or decrement an index-name by an unsigned numeric literal. The literal is considered to be an occurrence number. It is converted to an index value before being added to or subtracted from the index-name.

Initialize the index-name with a SET, PERFORM VARYING, or SEARCH ALL statement. You can then also use it in SEARCH or relational condition statements. To change the value, use a PERFORM, SEARCH, or SET statement.

Use the SET statement to assign to an index the value that you stored in the index data item defined by USAGE IS INDEX. For example, when you load records into a variable-length table, you can store the index value of the last record read in a data item defined as USAGE IS INDEX. Then you can test for the end of the table by comparing the current index value with the index value of the last record. This technique is useful when you look through or process the table.

Because you are comparing a physical displacement, you can use index data items only in SEARCH and SET statements or for comparisons with indexes or other index data items. You cannot use index data items as subscripts or indexes.

RELATED TASKS

“Subscripting” on page 62

“Putting values into a table”
“Searching a table” on page 71
“Processing table items using intrinsic functions” on page 73
“Handling tables efficiently” on page 583

RELATED REFERENCES

INDEXED BY phrase (*Enterprise COBOL Language Reference*)
INDEX phrase (*Enterprise COBOL Language Reference*)

Putting values into a table

Use one of these methods to put values into a table:

- Load the table dynamically.
- Initialize the table (INITIALIZE statement).
- Assign values when you define the table (VALUE clause).

RELATED TASKS

“Loading a table dynamically”
“Loading a variable-length table” on page 69
“Initializing a table (INITIALIZE)”
“Assigning values when you define a table (VALUE)” on page 65
“Assigning values to a variable-length table” on page 70

Loading a table dynamically

If the initial values of your table are different with each execution of your program, you can define the table without initial values. You can then read the changed values into the table before your program refers to the table.

To load a table, use the PERFORM statement and either subscripting or indexing.

When reading data to load your table, test to make sure that the data does not exceed the space allocated for the table. Use a named value (rather than a literal) for the item count. Then, if you make the table bigger, you need to change only one value, instead of all references to a literal.

“Example: PERFORM and subscripting” on page 66
“Example: PERFORM and indexing” on page 67

RELATED REFERENCES

PERFORM with VARYING phrase (*Enterprise COBOL Language Reference*)

Initializing a table (INITIALIZE)

You can load your table with a value during execution with the INITIALIZE statement. For example, to fill a table with 3s, you can use this code:

```
INITIALIZE TABLE-ONE REPLACING NUMERIC DATA BY 3.
```

The INITIALIZE statement cannot load a variable-length table (one that was defined using OCCURS DEPENDING ON).

RELATED REFERENCES

INITIALIZE statement (*Enterprise COBOL Language Reference*)

Assigning values when you define a table (VALUE)

If your table contains stable values (such as days and months), set the specific values the table holds when you define it.

See static values in tables in one of these ways:

- Initialize each table item individually.
- Initialize an entire table at the 01 level.
- Initialize all occurrences of a given table element to the same value.

Initializing each table item individually

If the table is small, you can use this technique:

1. Declare a record that contains the same items as are in the table.
2. Set the initial value of each item in a VALUE clause.
3. Code a REDEFINES entry to make the record into a table.

For example:

```
*****
***      E R R O R   F L A G   T A B L E      ***
*****
01  Error-Flag-Table                               Value Spaces.
   88 No-Errors                                   Value Spaces.
     05 Type-Error                               Pic X.
     05 Shift-Error                              Pic X.
     05 Home-Code-Error                          Pic X.
     05 Work-Code-Error                          Pic X.
     05 Name-Error                              Pic X.
     05 Initials-Error                           Pic X.
     05 Duplicate-Error                          Pic X.
     05 Not-Found-Error                          Pic X.
01  Filler Redefines Error-Flag-Table.
   05 Error-Flag Occurs 8 Times
       Indexed By Flag-Index                      Pic X.
```

(In this example, the items could all be initialized with one VALUE clause at the 01 level, because each item is being initialized to the same value.)

To initialize larger tables, use MOVE, PERFORM, or INITIALIZE statements.

Initializing a table at the 01 level

Code a level-01 record and assign to it, through the VALUE clause, the contents of the whole table. Then, in a subordinate level data item, use an OCCURS clause to define the individual table items.

For example:

```
01  TABLE-ONE                                VALUE "1234".
   05 TABLE-TWO OCCURS 4 TIMES                PIC X.
```

Initializing all occurrences of a table element

You can use the VALUE clause on a table element to initialize the element to the indicated value. For example:

```
01  T2.
   05 T-OBJ                                PIC 9    VALUE 3.
   05 T OCCURS 5 TIMES
       DEPENDING ON T-OBJ.
       10 X                                PIC XX   VALUE "AA".
       10 Y                                PIC 99   VALUE 19.
       10 Z                                PIC XX   VALUE "BB".
```

The above code causes all the X elements (1 through 5) to be initialized to AA, all the Y elements (1 through 5) to be initialized to 19, and all the Z elements (1 through 5) to be initialized to BB. T-0BJ is then set to 3.

RELATED REFERENCES

REDEFINES clause (*Enterprise COBOL Language Reference*)

PERFORM statement (*Enterprise COBOL Language Reference*)

INITIALIZE statement (*Enterprise COBOL Language Reference*)

OCCURS clause (*Enterprise COBOL Language Reference*)

Example: PERFORM and subscripting

This example traverses an error flag table using subscripting until an error code that has been set is found. If an error code is found, the corresponding error message is moved to a print report field.

```

. . .
*****
***      E R R O R   F L A G   T A B L E      ***
*****
01 Error-Flag-Table                               Value Spaces.
   88 No-Errors                                   Value Spaces.
   05 Type-Error                                 Pic X.
   05 Shift-Error                                Pic X.
   05 Home-Code-Error                            Pic X.
   05 Work-Code-Error                            Pic X.
   05 Name-Error                                 Pic X.
   05 Initials-Error                             Pic X.
   05 Duplicate-Error                            Pic X.
   05 Not-Found-Error                           Pic X.
01 Filler Redefines Error-Flag-Table.
   05 Error-Flag Occurs 8 Times
77 ERROR-ON                                         Pic X Value "E".
   Indexed By Flag-Index                           Pic X.
*****
***      E R R O R   M E S S A G E   T A B L E      ***
*****
01 Error-Message-Table.
   05 Filler                                     Pic X(25) Value
      "Transaction Type Invalid".
   05 Filler                                     Pic X(25) Value
      "Shift Code Invalid".
   05 Filler                                     Pic X(25) Value
      "Home Location Code Inval.".
   05 Filler                                     Pic X(25) Value
      "Work Location Code Inval.".
   05 Filler                                     Pic X(25) Value
      "Last Name - Blanks".
   05 Filler                                     Pic X(25) Value
      "Initials - Blanks".
   05 Filler                                     Pic X(25) Value
      "Duplicate Record Found".
   05 Filler                                     Pic X(25) Value
      "Commuter Record Not Found".
01 Filler Redefines Error-Message-Table.
   05 Error-Message Occurs 8 Times
      Indexed By Message-Index                     Pic X(25).
. . .
PROCEDURE DIVISION.
. . .
Perform
  Varying Sub From 1 By 1
  Until No-Errors
  If Error-Flag (Sub) = Error-On
  Move Space To Error-Flag (Sub)

```

```

        Move Error-Message (Sub) To Print-Message
        Perform 260-Print-Report
    End-If
End-Perform
. . .

```

Example: PERFORM and indexing

This example traverses an error flag table using indexing until an error code that has been set is found. If an error code is found, the corresponding error message is moved to a print report field.

```

. . .
*****
***          E R R O R   F L A G   T A B L E          ***
*****
01 Error-Flag-Table                                Value Spaces.
  88 No-Errors                                      Value Spaces.
    05 Type-Error                                  Pic X.
    05 Shift-Error                                  Pic X.
    05 Home-Code-Error                              Pic X.
    05 Work-Code-Error                              Pic X.
    05 Name-Error                                   Pic X.
    05 Initials-Error                               Pic X.
    05 Duplicate-Error                              Pic X.
    05 Not-Found-Error                              Pic X.
01 Filler Redefines Error-Flag-Table.
  05 Error-Flag Occurs 8 Times
    Indexed By Flag-Index                          Pic X.
*****
***          E R R O R   M E S S A G E   T A B L E          ***
*****
01 Error-Message-Table.
  05 Filler                                         Pic X(25) Value
    "Transaction Type Invalid".
  05 Filler                                         Pic X(25) Value
    "Shift Code Invalid".
  05 Filler                                         Pic X(25) Value
    "Home Location Code Inval.".
  05 Filler                                         Pic X(25) Value
    "Work Location Code Inval.".
  05 Filler                                         Pic X(25) Value
    "Last Name - Blanks".
  05 Filler                                         Pic X(25) Value
    "Initials - Blanks".
  05 Filler                                         Pic X(25) Value
    "Duplicate Record Found".
  05 Filler                                         Pic X(25) Value
    "Commuter Record Not Found".
01 Filler Redefines Error-Message-Table.
  05 Error-Message Occurs 8 Times
    Indexed By Message-Index                      Pic X(25).
. . .
PROCEDURE DIVISION.
. . .
Set Flag-Index To 1
Perform Until No-Errors
  Search Error-Flag
    When Error-Flag (Flag-Index) = Error-0n
      Move Space To Error-Flag (Flag-Index)
      Set Message-Index To Flag-Index
      Move Error-Message (Message-Index) To
        Print-Message
      Perform 260-Print-Report
    End-Search
End-Perform
. . .

```

Creating variable-length tables (DEPENDING ON)

If you do not know before run time how many times a table element occurs, you need to set up a variable-length table definition. To do this, use the OCCURS DEPENDING ON (ODO) clause. For example:

```
X OCCURS 1 TO 10 TIMES DEPENDING ON Y
```

In this example, *X* is called the *ODO subject*, and *Y* is the *ODO object*.

Two factors affect the successful manipulation of variable-length records:

- Correct calculation of record lengths

The length of the variable portions of a group item is the product of the object of the DEPENDING ON phrase and the length of the subject of the OCCURS clause.

- Conformance of the data in the object of the OCCURS DEPENDING ON clause to its PICTURE clause

If the content of the ODO object does not match its PICTURE clause, the program could abnormally terminate. You must ensure that the ODO object correctly specifies the current number of occurrences of table elements.

The following example shows a group item (REC-1) that contains both the subject and object of the OCCURS DEPENDING ON clause. The way the length of the group item is determined depends on whether it is sending or receiving data.

```
WORKING-STORAGE SECTION.
```

```
01 MAIN-AREA.  
  03 REC-1.  
    05 FIELD-1                      PIC 9.  
    05 FIELD-2 OCCURS 1 TO 5 TIMES  
      DEPENDING ON FIELD-1          PIC X(05).  
01 REC-2.  
  03 REC-2-DATA                     PIC X(50).
```

If you want to move REC-1 (the sending item in this case) to REC-2, the length of REC-1 is determined immediately before the move, using the current value in FIELD-1. If the content of FIELD-1 conforms to its PICTURE (that is, if FIELD-1 contains an external decimal item), the move can proceed based on the actual length of REC-1. Otherwise, the result is unpredictable. You must ensure that the ODO object has the correct value before you initiate the move.

When you do a move to REC-1 (the receiving item in this case), the length of REC-1 is determined using the maximum number of occurrences. In this example, that would be five occurrences of FIELD-2, plus FIELD-1, for a length of 26 bytes.

In this case, you need not set the ODO object (FIELD-1) before referencing REC-1 as a receiving item. However, the sending field's ODO object (not shown) must be set to a valid numeric value between 1 and 5 for the ODO object of the receiving field to be validly set by the move.

However, if you do a move to REC-1 (again the receiving item) where REC-1 is followed by a variably located group (a type of *complex ODO*), the actual length of REC-1 is calculated immediately before the move. In the following example, REC-1 and REC-2 are in the same record, but REC-2 is not subordinate to REC-1 and is therefore variably located:

```
01 MAIN-AREA  
  03 REC-1.  
    05 FIELD-1                      PIC 9.  
    05 FIELD-3                      PIC 9.
```

```

05 FIELD-2 OCCURS 1 TO 5 TIMES
    DEPENDING ON FIELD-1      PIC X(05).
03 REC-2.
05 FIELD-4 OCCURS 1 TO 5 TIMES
    DEPENDING ON FIELD-3      PIC X(05).

```

When you do a MOVE to REC-1 in this case, the actual length of REC-1 is calculated immediately before the move using the current value of the ODO object (FIELD-1). The compiler issues a message letting you know that the actual length was used. This case requires that you set the value of the ODO object before using the group item as a receiving field.

The following example shows how to define a variable-length table when the ODO object (here LOCATION-TABLE-LENGTH) is outside the group.

```

DATA DIVISION.
FILE SECTION.
FD  LOCATION-FILE
    RECORDING MODE F
    BLOCK 0 RECORDS
    RECORD 80 CHARACTERS
    LABEL RECORD STANDARD.
01  LOCATION-RECORD.
    05  LOC-CODE          PIC XX.
    05  LOC-DESCRIPTION   PIC X(20).
    05  FILLER            PIC X(58).
. . .
WORKING-STORAGE SECTION.
01  FLAGS.
    05  LOCATION-EOF-FLAG PIC X(5) VALUE SPACE.
        88  LOCATION-EOF    VALUE "FALSE".
01  MISC-VALUES.
    05  LOCATION-TABLE-LENGTH PIC 9(3) VALUE ZERO.
    05  LOCATION-TABLE-MAX    PIC 9(3) VALUE 100.
*****
***          L O C A T I O N   T A B L E          ***
***          FILE CONTAINS LOCATION CODES.        ***
*****
01  LOCATION-TABLE.
    05  LOCATION-CODE OCCURS 1 TO 100 TIMES
        DEPENDING ON LOCATION-TABLE-LENGTH PIC X(80).

```

RELATED CONCEPTS

Appendix B, “Complex OCCURS DEPENDING ON,” on page 613

RELATED TASKS

“Assigning values to a variable-length table” on page 70

“Loading a variable-length table”

Enterprise COBOL Compiler and Run-Time Migration Guide

RELATED REFERENCES

OCCURS DEPENDING ON clause (*Enterprise COBOL Language Reference*)

Loading a variable-length table

You can use a *do-until* structure (a TEST AFTER loop) to control the loading of a variable-length table. For example, after the following code runs, LOCATION-TABLE-LENGTH contains the subscript of the last item in the table.

```

DATA DIVISION.
FILE SECTION.
FD  LOCATION-FILE
    RECORDING MODE F
    BLOCK 0 RECORDS

```

```

RECORD 80 CHARACTERS
LABEL RECORD STANDARD.
01 LOCATION-RECORD.
   05 LOC-CODE          PIC XX.
   05 LOC-DESCRIPTION   PIC X(20).
   05 FILLER            PIC X(58).
. . .
WORKING-STORAGE SECTION.
01 FLAGS.
   05 LOCATION-EOF-FLAG PIC X(5) VALUE SPACE.
   88 LOCATION-EOF      VALUE "YES".
01 MISC-VALUES.
   05 LOCATION-TABLE-LENGTH PIC 9(3) VALUE ZERO.
   05 LOCATION-TABLE-MAX    PIC 9(3) VALUE 100.
*****
***          L O C A T I O N   T A B L E          ***
***          FILE CONTAINS LOCATION CODES.        ***
*****
01 LOCATION-TABLE.
   05 LOCATION-CODE OCCURS 1 TO 100 TIMES
      DEPENDING ON LOCATION-TABLE-LENGTH PIC X(80).
. . .
PROCEDURE DIVISION.
. . .
Perform Test After
   Varying Location-Table-Length From 1 By 1
   Until Location-EOF
   Or Location-Table-Length = Location-Table-Max
Move Location-Record To
   Location-Code (Location-Table-Length)
Read Location-File
   At End Set Location-EOF To True
End-Read
End-Perform

```

Assigning values to a variable-length table

You can use a VALUE clause on a group item that contains an OCCURS clause with the DEPENDING ON phrase. Each subordinate structure that contains the DEPENDING ON phrase is initialized using the maximum number of occurrences. If you define the entire table with the DEPENDING ON phrase, all the elements are initialized using the maximum defined value of the DEPENDING ON object.

If the *ODO object* has a VALUE clause, it is logically initialized after the *ODO subject* has been initialized. For example, in the following code:

```

01 TABLE-THREE          VALUE "ABCDE".
   05 X                  PIC 9.
   05 Y OCCURS 5 TIMES
      DEPENDING ON X     PIC X.

```

the ODO subject Y(1) is initialized to 'A', Y(2) to 'B', . . . , Y(5) to 'E', and finally the ODO object X is initialized to 3. Any subsequent reference to TABLE-THREE (such as in a DISPLAY statement) refers to the first three elements, Y(1) through Y(3).

RELATED TASKS

Enterprise COBOL Compiler and Run-Time Migration Guide

RELATED REFERENCES

OCCURS DEPENDING ON clause (*Enterprise COBOL Language Reference*)

Searching a table

COBOL provides two search techniques for tables: *serial* and *binary*.

To do serial searches, use SEARCH and indexing. For variable-length tables, you can use PERFORM with subscripting or indexing.

To do binary searches, use SEARCH ALL and indexing.

A binary search can be considerably more efficient than a serial search. For a serial search, the number of comparisons is of the order of n , the number of entries in the table. For a binary search, the number of comparisons is only of the order of the logarithm (base 2) of n . A binary search, however, requires that the table items already be sorted.

RELATED TASKS

“Doing a serial search (SEARCH)”

“Doing a binary search (SEARCH ALL)” on page 72

Doing a serial search (SEARCH)

Use the SEARCH statement to do a serial search beginning at the current index setting. To modify the index setting, use the SET statement.

The conditions in the WHEN option are evaluated in the order in which they appear:

- If none of the conditions is satisfied, the index is increased to correspond to the next table element, and the WHEN conditions are evaluated again.
- If one of the WHEN conditions is satisfied, the search ends. The index remains pointing to the table element that satisfied the condition.
- If the entire table has been searched and no conditions were met, the AT END imperative statement is executed if there is one. If you do not use AT END, control passes to the next statement in your program.

You can reference only one level of a table (a table element) with each SEARCH statement. To search multiple levels of a table, use nested SEARCH statements. Delimit each nested SEARCH statement with END-SEARCH.

If the found condition comes after some intermediate point in the table, you can speed up the search. Use the SET statement to set the index to begin the search after that point.

Arranging the table so that the data used most often is at the beginning also enables more efficient serial searching. If the table is large and is presorted, a binary search is more efficient.

“Example: serial search”

RELATED REFERENCES

SEARCH statement (*Enterprise COBOL Language Reference*)

Example: serial search

Suppose you define a three-dimensional table, each with its own index (set to 1, 4, and 1, respectively). The innermost table (TABLE-ENTRY3) has an ascending key. The object of the search is to find a particular string in the innermost table.

```

01 TABLE-ONE.
   05 TABLE-ENTRY1 OCCURS 10 TIMES
      INDEXED BY TE1-INDEX.
   10 TABLE-ENTRY2 OCCURS 10 TIMES
      INDEXED BY TE2-INDEX.
   15 TABLE-ENTRY3 OCCURS 5 TIMES
      ASCENDING KEY IS KEY1
      INDEXED BY TE3-INDEX.
      20 KEY1 PIC X(5).
      20 KEY2 PIC X(10).
. . .
PROCEDURE DIVISION.
. . .
  SET TE1-INDEX TO 1
  SET TE2-INDEX TO 4
  SET TE3-INDEX TO 1
  MOVE "A1234" TO KEY1 (TE1-INDEX, TE2-INDEX, TE3-INDEX + 2)
  MOVE "AAAAAAA00" TO KEY2 (TE1-INDEX, TE2-INDEX, TE3-INDEX + 2)
. . .
  SEARCH TABLE-ENTRY3
    AT END
      MOVE 4 TO RETURN-CODE
    WHEN TABLE-ENTRY3(TE1-INDEX, TE2-INDEX, TE3-INDEX)
      = "A1234AAAAAAA00"
      MOVE 0 TO RETURN-CODE
  END-SEARCH

```

Values after execution:

```

TE1-INDEX = 1
TE2-INDEX = 4
TE3-INDEX points to the TABLE-ENTRY3 item
              that equals "A1234AAAAAAA00"
RETURN-CODE = 0

```

Doing a binary search (SEARCH ALL)

When you use SEARCH ALL to do a binary search, you do not need to set the index before you begin. The index used is always the one associated with the first index name in the OCCURS clause. The index varies during execution to maximize the search efficiency.

To use the SEARCH ALL statement, your table must already be ordered on the key or keys coded in the OCCURS clause. You can use any key in the WHEN condition, but you must test all preceding data-names in the KEY option, if any. The test must be an equal-to condition, and the KEY *data-name* must be either the subject of the condition or the name of a conditional variable with which the tested condition-name is associated. The WHEN condition can also be a compound condition, formed from simple conditions with AND as the only logical connective. The key and its object of comparison must be compatible.

“Example: binary search”

RELATED REFERENCES

SEARCH statement (*Enterprise COBOL Language Reference*)

Example: binary search

Suppose you define a table that contains 90 elements of 40 bytes each, with three keys. The primary and secondary keys (KEY-1 and KEY-2) are in ascending order, but the least significant key (KEY-3) is in descending order:

```

01 TABLE-A.
   05 TABLE-ENTRY OCCURS 90 TIMES
      ASCENDING KEY-1, KEY-2

```



```

        DESCENDING KEY-3
        INDEXED BY INDX-1.
10 PART-1      PIC 99.
10 KEY-1       PIC 9(5).
10 PART-2      PIC 9(6).
10 KEY-2       PIC 9(4).
10 PART-3      PIC 9(18).
10 KEY-3       PIC 9(5).

```

You can search this table using the following instructions:

```

SEARCH ALL TABLE-ENTRY
  AT END
  PERFORM NOENTRY
  WHEN KEY-1 (INDX-1) = VALUE-1 AND
    KEY-2 (INDX-1) = VALUE-2 AND
    KEY-3 (INDX-1) = VALUE-3
  MOVE PART-1 (INDX-1) TO OUTPUT-AREA
END-SEARCH

```

If an entry is found in which the three keys are equal to the given values (VALUE-1, VALUE-2, and VALUE-3), PART-1 of that entry will be moved to OUTPUT-AREA. If matching keys are not found in any of the entries in TABLE-A, the NOENTRY routine is performed.

Processing table items using intrinsic functions

You can use an intrinsic function to process an alphanumeric or numeric table item. However, the data description of the table item must be compatible with the argument requirements for the function.

Use a subscript or index to reference an individual data item as a function argument. For example, assuming Table-One is a 3x3 array of numeric items, you can find the square root of the middle element with this statement:

```
Compute X = Function Sqrt(Table-One(2,2))
```

You might often need to process the data in tables iteratively. For intrinsic functions that accept multiple arguments, you can use the ALL subscript to reference all the items in the table or a single dimension of the table. The iteration is handled automatically, making your code shorter and simpler.

You can mix scalars and array arguments for functions that accept multiple arguments:

```
Compute Table-Median = Function Median(Arg1 Table-One(ALL))
```

“Example: intrinsic functions”

RELATED TASKS

“Using intrinsic functions (built-in functions)” on page 32

RELATED REFERENCES

Intrinsic functions (*Enterprise COBOL Language Reference*)

Example: intrinsic functions

This example sums a cross-section of Table-Two:

```
Compute Table-Sum = FUNCTION SUM (Table-Two(ALL, 3, ALL))
```

Assuming that Table-Two is a 2x3x2 array, the statement above causes the following elements to be summed:

```
Table-Two(1,3,1)
Table-Two(1,3,2)
Table-Two(2,3,1)
Table-Two(2,3,2)
```

This example computes values for all employees.

```
01 Employee-Table.
   05 Emp-Count      Pic s9(4) usage binary.
   05 Emp-Record     Occurs 1 to 500 times
                     depending on Emp-Count.
       10 Emp-Name    Pic x(20).
       10 Emp-Idme    Pic 9(9).
       10 Emp-Salary  Pic 9(7)v99.
. . .
Procedure Division.
   Compute Max-Salary = Function Max(Emp-Salary(ALL))
   Compute I = Function Ord-Max(Emp-Salary(ALL))
   Compute Avg-Salary = Function Mean(Emp-Salary(ALL))
   Compute Salary-Range = Function Range(Emp-Salary(ALL))
   Compute Total-Payroll = Function Sum(Emp-Salary(ALL))
```

Chapter 5. Selecting and repeating program actions

Use COBOL control language to choose program actions based on the outcome of logical tests, to iterate over selected parts of your program and data, and to identify statements to be performed as a group. These controls include:

- IF statement
- EVALUATE statement
- Switches and flags
- PERFORM statement

RELATED TASKS

“Selecting program actions”

“Repeating program actions” on page 83

Selecting program actions

You can provide for different program actions depending on the tested value of one or more data items.

The IF and EVALUATE statements in COBOL test one or more data items by means of a conditional expression.

RELATED TASKS

“Coding a choice of actions”

“Coding conditional expressions” on page 79

RELATED REFERENCES

IF statement (*Enterprise COBOL Language Reference*)

EVALUATE statement (*Enterprise COBOL Language Reference*)

Coding a choice of actions

Use IF . . . ELSE to code a choice between two processing actions. (The word THEN is optional in a COBOL program.)

```
IF condition-p
    statement-1
ELSE
    statement-2
END-IF
```

When one of the processing choices is no action, code the IF statement with or without ELSE. Because the ELSE clause is optional, you can code the following:

```
IF condition-q
    statement-1
END-IF
```

This coding is suitable for simple programming cases. For complex logic, you probably need to use the ELSE clause. For example, suppose you have nested IF statements with an action for only one of the processing choices; you could use the ELSE clause and code the null branch of the IF statement with the CONTINUE statement:

```
IF condition-q
    statement-1
ELSE
    CONTINUE
END-IF
```

Use the EVALUATE statement to code a choice among three or more possible conditions instead of just two. The EVALUATE statement is an expanded form of the IF statement that allows you to avoid nesting IF statements for such coding, a common source of logic errors and debugging problems.

With the EVALUATE statement, you can test any number of conditions in a single statement and have separate actions for each. In structured programming terms, this is a case structure. It can also be thought of as a decision table.

“Example: EVALUATE using THRU phrase” on page 78

“Example: EVALUATE using multiple WHEN statements” on page 78

“Example: EVALUATE testing several conditions” on page 78

RELATED TASKS

“Coding conditional expressions” on page 79

“Using the EVALUATE statement” on page 77

“Using nested IF statements”

Using nested IF statements

When an IF statement has another IF statement as one of its possible processing branches, these IF statements are said to be nested. Theoretically, there is no limit to the depth of nested IF statements. However, when the program has to test a variable for more than two values, EVALUATE is the better choice.

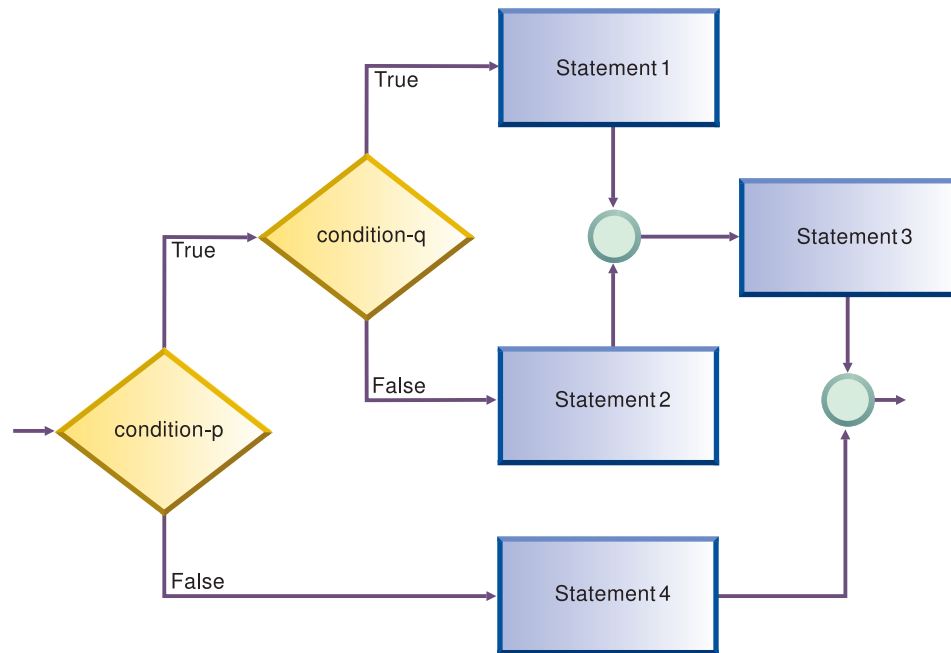
Use nested IF statements sparingly. The logic can be difficult to follow, although explicit scope terminators and proper indentation help.

The following pseudocode depicts a nested IF statement:

```
IF condition-p
    IF condition-q
        statement-1
    ELSE
        statement-2
    END-IF
    statement-3
ELSE
    statement-4
END-IF
```

Here an IF is nested, along with a sequential structure, in one branch of another IF. In a structure like this, the END-IF closing the inner nested IF is very important. Use END-IF instead of a period, because a period would end the outer IF structure as well.

The following figure shows the logic structure for nested IF statements.



RELATED TASKS

“Coding a choice of actions” on page 75

RELATED REFERENCES

Explicit scope terminators (*Enterprise COBOL Language Reference*)

Using the EVALUATE statement

Use the EVALUATE statement to test several conditions and design a different action for each, a construct often known as a *case structure*. The expressions to be tested are called selection subjects; the answer selected is called a selection object. You can code multiple subjects and multiple objects in the same structure.

You can code the EVALUATE statement to handle the case where multiple conditions lead to the same processing by using the THRU phrase and by using multiple WHEN statements.

When evaluated, each pair of selection subjects and selection objects must belong to the same class (numeric, character, CONDITION TRUE or FALSE).

The execution of the EVALUATE statement ends when:

- The statements associated with the selected WHEN phrase are performed.
- The statements associated with the WHEN OTHER phrase are performed.
- No WHEN conditions are satisfied.

WHEN phrases are tested in the order they are coded. Therefore, you should order these phrases for the best performance: code first the WHEN phrase containing selection objects most likely to be satisfied, then the next most likely, and so on. An exception is the WHEN OTHER phrase, which must come last.

RELATED TASKS

“Coding a choice of actions” on page 75

Example: EVALUATE using THRU phrase: This example shows how you can use the THRU phrase to easily code several conditions in a range of values that lead to the same processing action. In this example, CARPOOL-SIZE is the selection subject; 1, 2, and 3 THRU 6 are the selection objects.

```
EVALUATE CARPOOL-SIZE
  WHEN 1
    MOVE "SINGLE" TO PRINT-CARPOOL-STATUS
  WHEN 2
    MOVE "COUPLE" TO PRINT-CARPOOL-STATUS
  WHEN 3 THRU 6
    MOVE "SMALL GROUP" TO PRINT-CARPOOL STATUS
  WHEN OTHER
    MOVE "BIG GROUP" TO PRINT-CARPOOL STATUS
END-EVALUATE
```

The following nested IF statements represent the same logic:

```
IF CARPOOL-SIZE = 1 THEN
  MOVE "SINGLE" TO PRINT-CARPOOL-STATUS
ELSE
  IF CARPOOL-SIZE = 2 THEN
    MOVE "COUPLE" TO PRINT-CARPOOL-STATUS
  ELSE
    IF CARPOOL-SIZE >= 3 and CARPOOL-SIZE <= 6 THEN
      MOVE "SMALL GROUP" TO PRINT-CARPOOL-STATUS
    ELSE
      MOVE "BIG GROUP" TO PRINT-CARPOOL-STATUS
    END-IF
  END-IF
END-IF
```

Example: EVALUATE using multiple WHEN statements: You can use multiple WHEN statements when several conditions lead to the same processing action. This gives you more flexibility than using the THRU phrase, because the conditions do not have to evaluate to values that fall in a range or evaluate to alphanumeric values.

```
EVALUATE MARITAL-CODE
  WHEN "M"
    ADD 2 TO PEOPLE-COUNT
  WHEN "S"
  WHEN "D"
  WHEN "W"
    ADD 1 TO PEOPLE-COUNT
END-EVALUATE
```

The following nested IF statements represent the same logic:

```
IF MARITAL-CODE = "M" THEN
  ADD 2 TO PEOPLE-COUNT
ELSE
  IF MARITAL-CODE = "S" OR
    MARITAL-CODE = "D" OR
    MARITAL-CODE = "W" THEN
    ADD 1 TO PEOPLE-COUNT
  END-IF
END-IF
```

Example: EVALUATE testing several conditions: In this example both selection subjects in a WHEN phrase must satisfy the TRUE, TRUE condition before the phrase is performed. If both subjects do not evaluate to TRUE, the next WHEN phrase is processed.

```
Identification Division.
  Program-ID. MiniEval.
Environment Division.
```

```

Configuration Section.
Source-Computer. IBM-390.
Data Division.
Working-Storage Section.
01  Age                Pic  999.
01  Sex                Pic  X.
01  Description        Pic  X(15).
01  A                  Pic  999.
01  B                  Pic  9999.
01  C                  Pic  9999.
01  D                  Pic  9999.
01  E                  Pic  99999.
01  F                  Pic  999999.
Procedure Division.
PN01.
  Evaluate True Also True
    When Age < 13 Also Sex = "M"
      Move "Young Boy" To Description
    When Age < 13 Also Sex = "F"
      Move "Young Girl" To Description
    When Age > 12 And Age < 20 Also Sex = "M"
      Move "Teenage Boy" To Description
    When Age > 12 And Age < 20 Also Sex = "F"
      Move "Teenage Girl" To Description
    When Age > 19 Also Sex = "M"
      Move "Adult Man" To Description
    When Age > 19 Also Sex = "F"
      Move "Adult Woman" To Description
    When Other
      Move "Invalid Data" To Description
  End-Evaluate
  Evaluate True Also True
    When A + B < 10 Also C = 10
      Move "Case 1" To Description
    When A + B > 50 Also C = ( D + E ) / F
      Move "Case 2" To Description
    When Other
      Move "Case Other" To Description
  End-Evaluate
Stop Run.

```

Coding conditional expressions

Using the IF and EVALUATE statements, you can code program actions that will be performed depending on the truth value of a conditional expression. The following are some of the conditions that you can specify:

- Relation conditions, such as:
 - Numeric comparisons
 - Alphanumeric comparisons
 - DBCS comparisons
 - National comparisons
- Class conditions; for example, to test whether a data item:
 - IS NUMERIC
 - IS ALPHABETIC
 - IS DBCS
 - IS KANJI
 - IS NOT KANJI
- Condition-name conditions, to test the value of a conditional variable that you define

- Sign condition, to test whether a numeric operand IS POSITIVE, NEGATIVE, or ZERO
- Switch-status condition, to test the status of UPSI switches that you name in the SPECIAL-NAMES paragraph
- Complex conditions, such as:
 - Negated conditions; for example, NOT (A IS EQUAL TO B)
 - Combined conditions (conditions combined with logical operators AND or OR)

RELATED CONCEPTS

“Switches and flags”

RELATED TASKS

“Defining switches and flags”

“Resetting switches and flags” on page 81

“Checking for incompatible data (numeric class test)” on page 46

“Comparing national data items” on page 111

RELATED REFERENCES

Rules for condition-name values (*Enterprise COBOL Language Reference*)

Switch-status condition (*Enterprise COBOL Language Reference*)

Sign condition (*Enterprise COBOL Language Reference*)

Comparing numeric and alphanumeric operands (*Enterprise COBOL Language Reference*)

Combined conditions (*Enterprise COBOL Language Reference*)

Class condition (*Enterprise COBOL Language Reference*)

Switches and flags

Some program decisions are based on whether the value of a data item is true or false, on or off, yes or no. Control these two-way decisions with level-88 items with meaningful names (*condition-names*) to act as switches.

Other program decisions depend on the particular value or range of values of a data item. When you use condition-names to give more than just on or off values to a field, the field is generally referred to as a flag.

Flags and switches make your code easier to change. If you need to change the values for a condition, you have to change only the value of that level-88 condition-name.

For example, suppose a program uses a condition-name to test a field for a given salary range. If the program must be changed to check for a different salary range, you need to change only the value of the condition-name in the DATA DIVISION. You do not need to make changes in the PROCEDURE DIVISION.

RELATED TASKS

“Defining switches and flags”

“Resetting switches and flags” on page 81

Defining switches and flags

In the DATA DIVISION, define level-88 items to give meaningful names (condition names) to values that will act as switches or flags.

To test for more than two values, as flags, assign more than one condition name to a field by using multiple level-88 items.

The reader can easily follow your code if you choose meaningful condition names and if the values assigned have some association with logical values.

“Example: switches”

“Example: flags”

Example: switches

To test for an end-of-file condition for an input file named Transaction-File, you could use the following data definitions:

WORKING-STORAGE Section.

01 Switches.

05 Transaction-EOF-Switch Pic X value space.

88 Transaction-EOF value "y".

The level-88 description says a condition named Transaction-EOF is turned on when Transaction-EOF-Switch has value 'y'. Referencing Transaction-EOF in your PROCEDURE DIVISION expresses the same condition as testing for Transaction-EOF-Switch = "y". For example, the following statement causes the report to be printed only if your program has read to the end of the Transaction-File and if the Transaction-EOF-Switch has been set to 'y':

```
If Transaction-EOF Then
    Perform Print-Report-Summary-Lines
```

Example: flags

Consider a program that updates a master file. The updates are read from a transaction file. The transaction file's records contain a field for the function to be performed: add, change, or delete. In the record description of the input file code a field for the function code using level-88 items:

01 Transaction-Input Record

05 Transaction-Type Pic X.

88 Add-Transaction Value "A".

88 Change-Transaction Value "C".

88 Delete-Transaction Value "D".

The code in the PROCEDURE DIVISION for testing these condition-names might look like this:

Evaluate True

When Add-Transaction

Perform Add-Master-Record-Paragraph

When Change-Transaction

Perform Update-Exisitng-Record-Paragraph

When Delete-Transaction

Perform Delete-Master-Record-Paragraph

End-Evaluate

Resetting switches and flags

Throughout your program, you might need to reset switches or change flags back to the original values they have in their data descriptions. To do so, use either a SET statement or define your own data item to use.

When you use the SET *condition-name* TO TRUE statement, the switch or flag is set back to the original value that was assigned in its data description.

For a level-88 item with multiple values, SET *condition-name* TO TRUE assigns the first value (here, A):

88 Record-is-Active Value "A" "0" "S"

Using the SET statement and meaningful condition-names makes it easy for the reader to follow your code.

"Example: set switch on"

"Example: set switch off"

Example: set switch on

The SET statement in the following example does the same thing as Move "y" to Transaction-EOF-Switch:

```
01 Switches
   05 Transaction-EOF-Switch      Pic X Value space.
   88 Transaction-EOF           Value "y".
. . .
Procedure Division.
000-Do-Main-Logic.
    Perform 100-Initialize-Paragraph
    Read Update-Transaction-File
        At End Set Transaction-EOF to True
    End-Read
```

The following example shows how to assign a value for a field in an output record based on the transaction code of an input record.

```
01 Input-Record.
   05 Transaction-Type           Pic X(9).
. . .
01 Data-Record-Out.
   05 Data-Record-Type          Pic X.
   88 Record-Is-Active          Value "A".
   88 Record-Is-Suspended       Value "S".
   88 Record-Is-Deleted         Value "D".
   05 Key-Field                 Pic X(5).
. . .
Procedure Division.
. . .
    Evaluate Transaction-Type of Input-Record
        When "ACTIVE"
            Set Record-Is-Active to TRUE
        When "SUSPENDED"
            Set Record-Is-Suspended to TRUE
        When "DELETED"
            Set Record-Is-Deleted to TRUE
    End-Evaluate
```

Example: set switch off

You could use a data item called SWITCH-OFF throughout your program to set on/off switches to off, as in the following code:

```
01 Switches
   05 Transaction-EOF-Switch      Pic X Value space.
   88 Transaction-EOF           Value "y".
01 SWITCH-OFF                   Pic X Value "n".
. . .
Procedure Division.
. . .
    Move SWITCH-OFF to Transaction-EOF-Switch
```

This code resets the switch to indicate that the end of the file has not been reached.

Repeating program actions

Use the PERFORM statement to run a paragraph and then implicitly return control to the next executable statement. In effect, the PERFORM statement is a way of coding a closed subroutine that you can enter from many different parts of the program.

Use the PERFORM statement to loop (repeat the same code) a set number of times or to loop based on the outcome of a decision.

PERFORM statements can be inline or out-of-line.

RELATED TASKS

“Choosing inline or out-of-line PERFORM”

“Coding a loop” on page 84

“Coding a loop through a table” on page 85

“Executing multiple paragraphs or sections” on page 85

RELATED REFERENCES

PERFORM statement (*Enterprise COBOL Language Reference*)

Choosing inline or out-of-line PERFORM

The inline PERFORM statement has the same general rules as the out-of-line PERFORM statement except for one area: statements within the inline PERFORM statement are executed rather than those within the range of the procedure named in the out-of-line PERFORM statement.

To determine whether to code an inline or out-of-line PERFORM statement, consider the following questions:

- Is the PERFORM statement used from several places?

Use out-of-line PERFORM when you use the same piece of code from several places in your program.

- Which placement of the statement will be easier to read?

Use an out-of-line PERFORM if the logical flow of the program will be less clear because the PERFORM extends over several screens. If, however, the PERFORM paragraph is short, an inline PERFORM can save the trouble of skipping around in the code.

- What are the efficiency tradeoffs?

Avoid the overhead of branching around an out-of-line PERFORM if performance is an issue. But remember, even out-of-line PERFORM coding can improve code optimization, so efficiency gains should not be overemphasized.

In the 1974 COBOL standard, the PERFORM statement is out-of-line and thus requires an explicit branch to a separate paragraph and has an implicit return. If the performed paragraph is in the subsequent sequential flow of your program, it is also executed in that flow of the logic. To avoid this additional execution, you must place the paragraph outside the normal sequential flow (for example, after the GOBACK) or code a branch around it.

The subject of an inline PERFORM is an imperative statement. Therefore, you must code statements (other than imperative statements within an inline PERFORM) with explicit scope terminators. Each paragraph performs one logical function.

“Example: inline PERFORM statement” on page 84

Example: inline PERFORM statement

This example shows the structure of an inline PERFORM statement with the required scope terminators and the required END-PERFORM statement.

```
Perform 100-Initialize-Paragraph
* The following is an inline PERFORM
  Perform Until Transaction-EOF
    Read Update-Transaction-File Into WS-Transaction-Record
    At End
      Set Transaction-EOF To True
    Not At End
      Perform 200-Edit-Update-Transaction
      If No-Errors
        Perform 300-Update-Commuter-Record
      Else
        Perform 400-Print-Transaction-Errors
      * End-If is a required scope terminator
      End-If
      Perform 410-Re-Initialize-Fields
    * End-Read is a required scope terminator
    End-Read
  End-Perform
```

Coding a loop

Use the PERFORM . . . TIMES statement to execute a paragraph a certain number of times:

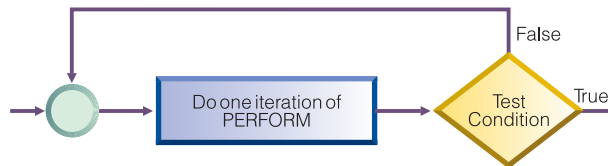
```
PERFORM 010-PROCESS-ONE-MONTH 12 TIMES
INSPECT . . .
```

When control reaches the PERFORM statement, the code for the paragraph 010-PROCESS-ONE-MONTH is executed 12 times before control is transferred to the INSPECT statement.

Use the PERFORM . . . UNTIL statement to execute a paragraph until a condition you choose is satisfied. You can use either of the following forms:

```
PERFORM . . . WITH TEST AFTER . . . UNTIL . . .
PERFORM . . . [WITH TEST BEFORE] . . . UNTIL . . .
```

Use the PERFORM . . . WITH TEST AFTER . . . UNTIL if you want to execute the paragraph at least once and then test before any subsequent execution. This statement is equivalent to the do-until structure:

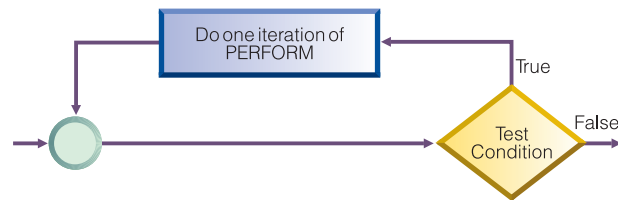


In the following example, the implicit WITH TEST BEFORE phrase provides a do-while structure:

```
PERFORM 010-PROCESS-ONE-MONTH
  UNTIL MONTH GREATER THAN 12
INSPECT . . .
```

When control reaches the PERFORM statement, the condition (MONTH EQUAL DECEMBER) is tested. If the condition is satisfied, control is transferred to the INSPECT statement. If the condition is not satisfied, 010-PROCESS-ONE-MONTH is executed, and

the condition is tested again. This cycle continues until the condition tests as true. (To make your program easier to read, you might want to code the WITH TEST BEFORE clause.)



Coding a loop through a table

You can use `PERFORM . . . VARYING` to initialize a table. In this form of the `PERFORM` statement, a variable is increased or decreased and tested until a condition is satisfied.

Thus you use the `PERFORM` statement to control a loop through a table. You can use either of the following forms:

```

PERFORM . . . WITH TEST AFTER . . . VARYING . . . UNTIL . . .
PERFORM . . . [WITH TEST BEFORE] . . . VARYING . . . UNTIL .

```

The following code shows an example of looping through a table to check for invalid data:

```

PERFORM TEST AFTER VARYING WS-DATA-IX
  FROM 1 BY 1
  UNTIL WS-DATA-IX = 12
  IF WS-DATA (WS-DATA-IX) EQUALS SPACES
    SET SERIOUS-ERROR TO TRUE
    DISPLAY ELEMENT-NUM-MSG5
  END-IF
END-PERFORM
INSPECT . . .

```

In the code above, when control reaches the `PERFORM` statement, `WS-DATA-IX` is set equal to 1 and the `PERFORM` statement is executed. Then the condition (`WS-DATA-IX = 12`) is tested. If the condition is true, control drops through to the `INSPECT` statement. If it is false, `WS-DATA-IX` is increased by 1, the `PERFORM` statement is executed, and the condition is tested again. This cycle of execution and testing continues until `WS-DATA-IX` is equal to 12.

In terms of the application, this loop controls input-checking for the 12 fields of item `WS-DATA`. Empty fields are not allowed, and this section of code loops through and issues error messages as appropriate.

Executing multiple paragraphs or sections

In structured programming, the paragraph you execute is usually a single paragraph. However, you can execute a group of paragraphs, a single section, or a group of sections using the `PERFORM . . . THRU` statement.

When you use `PERFORM . . . THRU` use a paragraph-EXIT statement to clearly indicate the end point for the series of paragraphs.

Intrinsic functions can make the coding of the iterative processing of tables simpler and easier.

RELATED TASKS

“Processing table items using intrinsic functions” on page 73

Chapter 6. Handling strings

COBOL provides language constructs for performing the following operations associated with string data items:

- Joining and splitting data items
- Manipulating null-terminated strings, such as counting or moving characters
- Referring to substrings by their ordinal position and, if needed, length
- Tallying and replacing data items, such as counting the number of times a specific character occurs in a data item
- Converting data items, such as changing to uppercase or lowercase
- Evaluating data items, such as determining the length of a data item

RELATED TASKS

“Joining data items (STRING)”

“Splitting data items (UNSTRING)” on page 89

“Manipulating null-terminated strings” on page 91

“Referring to substrings of data items” on page 93

“Tallying and replacing data items (INSPECT)” on page 95

“Converting data items (intrinsic functions)” on page 97

“Evaluating data items (intrinsic functions)” on page 99

Chapter 7, “Processing character data in an international environment,” on page 103

Joining data items (STRING)

Use the STRING statement to join all or parts of several data items into one data item. One STRING statement can save you several MOVE statements.

The STRING statement transfers data items into the receiving item in the order that you indicate. In the STRING statement you can also specify the following:

- Delimiters that cause a sending field to be ended and another to be started
- Actions to be taken when the single receiving field is filled before all of the sending characters have been processed (ON OVERFLOW condition)

You can specify a national item for any literal or identifier operand except the POINTER identifier. However, if you specify a national item, you must specify all of the literal and identifier operands (except the POINTER identifier) as national.

“Example: STRING statement” on page 88

RELATED TASKS

“Handling errors in joining and splitting strings” on page 202

RELATED REFERENCES

STRING statement (*Enterprise COBOL Language Reference*)

Example: STRING statement

In the following example, the STRING statement selects and formats information from record RCD-01 as an output line: line number, customer name and address, invoice number, next billing date, and balance due. The balance is truncated to the dollar figure shown.

In the FILE SECTION, the following record is defined:

```
01 RCD-01.
  05 CUST-INFO.
    10 CUST-NAME      PIC X(15).
    10 CUST-ADDR      PIC X(35).
  05 BILL-INFO.
    10 INV-NO         PIC X(6).
    10 INV-AMT        PIC $,$,$$.99.
    10 AMT-PAID       PIC $,$,$$.99.
    10 DATE-PAID      PIC X(8).
    10 BAL-DUE        PIC $,$,$$.99.
    10 DATE-DUE       PIC X(8).
```

In the WORKING-STORAGE SECTION, the following fields are defined:

```
77 RPT-LINE          PIC X(120).
77 LINE-POS          PIC S9(3).
77 LINE-NO           PIC 9(5) VALUE 1.
77 DEC-POINT         PIC X VALUE ".".
```

The record RCD-01 contains the following information (the symbol *b* indicates a blank space):

```
J.B.bSMITHbbbb
444bSPRINGbST.,bCHICAGO,bILL.bbbbb
A14275
$4,736.85
$2,400.00
09/22/76
$2,336.85
10/22/76
```

In the PROCEDURE DIVISION, the programmer initializes RPT-LINE to SPACES and sets LINE-POS, the data item to be used as the POINTER field, to 4. (By coding the POINTER phrase of the STRING statement, you can use the explicit pointer field to control placement of data in the receiving field.) Then, the programmer codes this STRING statement:

```
STRING
  LINE-NO SPACE CUST-INFO INV-NO SPACE DATE-DUE SPACE
  DELIMITED BY SIZE
  BAL-DUE
  DELIMITED BY DEC-POINT
  INTO RPT-LINE
  WITH POINTER LINE-POS.
```

STRING program results

When the STRING statement is performed, items are moved into RPT-LINE as shown in the table below.

Item	Positions
LINE-NO	4 - 8
Space	9
CUST-INFO	10 - 59
INV-NO	60 - 65

Item	Positions
Space	66
DATE-DUE	67 - 74
Space	75
Portion of BAL-DUE that precedes the decimal point	76 - 81

After the STRING statement is performed, the value of LINE-POS is 82, and RPT-LINE appears as shown below.

Column								
4	10			60	67		76	
↓	↓			↓	↓		↓	
00001	J.B. SMITH	444	SPRING ST., CHICAGO, ILL	A14275	10/22/76		\$2,336	

Splitting data items (UNSTRING)

Use the UNSTRING statement to split one sending field into several receiving fields. One UNSTRING statement can save you several MOVE statements.

In the UNSTRING statement you can specify the following:

- Delimiters that, when encountered in the sending field, cause the current receiving field to stop receiving and the next to begin receiving
- Fields that store the number of characters placed in receiving fields
- A field that stores a count of the total number of characters transferred
- Special actions to take if all the receiving fields are filled before the end of the sending item is reached

You can specify national items as the sending field, receiving fields, and delimiters. However, if you specify a national item, you must specify all of these operands as national.

“Example: UNSTRING statement”

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

RELATED TASKS

“Handling errors in joining and splitting strings” on page 202
Enterprise COBOL Compiler and Run-Time Migration Guide

RELATED REFERENCES

UNSTRING statement (*Enterprise COBOL Language Reference*)

Example: UNSTRING statement

In the following example, selected information is taken from the input record. Some is organized for printing and some for further processing.

In the FILE SECTION, the following records are defined:

```

* Record to be acted on by the UNSTRING statement:
01 INV-RCD.
   05 CONTROL-CHARS          PIC XX.
   05 ITEM-INDENT             PIC X(20).
   05 FILLER                  PIC X.
   05 INV-CODE                PIC X(10).
   05 FILLER                  PIC X.
   05 NO-UNITS                PIC 9(6).
   05 FILLER                  PIC X.
   05 PRICE-PER-M            PIC 99999.
   05 FILLER                  PIC X.
   05 RTL-AMT                 PIC 9(6).99.

*
* UNSTRING receiving field for printed output:
01 DISPLAY-REC.
   05 INV-NO                  PIC X(6).
   05 FILLER                  PIC X VALUE SPACE.
   05 ITEM-NAME               PIC X(20).
   05 FILLER                  PIC X VALUE SPACE.
   05 DISPLAY-DOLS            PIC 9(6).

*
* UNSTRING receiving field for further processing:
01 WORK-REC.
   05 M-UNITS                  PIC 9(6).
   05 FIELD-A                 PIC 9(6).
   05 WK-PRICE REDEFINES FIELD-A PIC 9999V99.
   05 INV-CLASS               PIC X(3).

*
* UNSTRING statement control fields
77 DBY-1                      PIC X.
77 CTR-1                      PIC S9(3).
77 CTR-2                      PIC S9(3).
77 CTR-3                      PIC S9(3).
77 CTR-4                      PIC S9(3).
77 DLTR-1                    PIC X.
77 DLTR-2                    PIC X.
77 CHAR-CT                   PIC S9(3).
77 FLDS-FILLED               PIC S9(3).

```

In the PROCEDURE DIVISION, the programmer writes the following UNSTRING statement:

```

* Move subfields of INV-RCD to the subfields of DISPLAY-REC
* and WORK-REC:
  UNSTRING INV-RCD
    DELIMITED BY ALL SPACES OR "/" OR DBY-1
    INTO ITEM-NAME COUNT IN CTR-1
      INV-NO DELIMITER IN DLTR-1 COUNT IN CTR-2
      INV-CLASS
      M-UNITS COUNT IN CTR-3
      FIELD-A
      DISPLAY-DOLS DELIMITER IN DLTR-2 COUNT IN CTR-4
    WITH POINTER CHAR-CT
    TALLYING IN FLDS-FILLED
    ON OVERFLOW GO TO UNSTRING-COMPLETE.

```

Before issuing the UNSTRING statement, the programmer places the value 3 in CHAR-CT (the POINTER field) to avoid working with the two control characters in INV-RCD. A period (.) is placed in DBY-1 for use as a delimiter, and the value 0 (zero) is placed in FLDS-FILLED (the TALLYING field). The data is then read into INV-RCD, as shown below.

Column						
1	10	20	30	40	50	60
↓	↓	↓	↓	↓	↓	↓
ZY	FOUR-PENNY-NAILS		707890/BBA	475120	00122	000379.50

UNSTRING program results

When the UNSTRING statement is performed, the following steps take place:

- Positions 3 through 18 (FOUR-PENNY-NAILS) of INV-RCD are placed in ITEM-NAME, left justified in the area, and the four unused character positions are padded with spaces. The value 16 is placed in CTR-1.
- Because ALL SPACES is coded as a delimiter, the five contiguous SPACE characters in positions 19 through 23 are considered to be one occurrence of the delimiter.
- Positions 24 through 29 (707890) are placed in INV-NO. The delimiter character, /, is placed in DLTR-1, and the value 6 is placed in CTR-2.
- Positions 31 through 33 are placed in INV-CLASS. The delimiter is a SPACE, but because no field has been defined as a receiving area for delimiters, the SPACE in position 34 is bypassed.
- Positions 35 through 40 (475120) are examined and placed in M-UNITS. The value 6 is placed in CTR-3. The delimiter is a SPACE, but because no field has been defined as a receiving area for delimiters, the SPACE in position 41 is bypassed.
- Positions 42 through 46 (00122) are placed in FIELD-A and right justified in the area. The high-order digit position is filled with a 0 (zero). The delimiter is a SPACE, but because no field has been defined as a receiving area for delimiters, the SPACE in position 47 is bypassed.
- Positions 48 through 53 (000379) are placed in DISPLAY-DOLLS. The period (.) delimiter character in DBY-1 is placed in DLTR-2, and the value 6 is placed in CTR-4.
- Because all receiving fields have been acted on and two characters of data in INV-RCD have not been examined, the ON OVERFLOW exit is taken, and execution of the UNSTRING statement is completed.

After the UNSTRING statement is performed, the fields contain the values shown below.

Field	Value
DISPLAY-REC	707890 FOUR-PENNY-NAILS 000379
WORK-REC	4751200000122BBA
CHAR-CT (the POINTER field)	55
FLDS-FILLED (the TALLYING field)	6

Manipulating null-terminated strings

You can construct and manipulate null-terminated strings (passed to or from a C program, for example), by various mechanisms:

- Use null-terminated literal constants (Z". . . ").
- Use an INSPECT statement to count the number of characters in a null-terminated string:

```

MOVE 0 TO char-count
INSPECT source-field TALLYING char-count
                     FOR CHARACTERS
                     BEFORE X"00"

```

- Use an UNSTRING statement to move characters in a null-terminated string to a target field, and get the character count:

```

WORKING-STORAGE SECTION.
01 source-field          PIC X(1001).
01 char-count           COMP-5 PIC 9(4).
01 target-area.
   02 individual-char OCCURS 1 TO 1000 TIMES DEPENDING ON char-count
                       PIC X.

. . .
PROCEDURE DIVISION.
. . .
   UNSTRING source-field DELIMITED BY X"00"
                       INTO target-area
                       COUNT IN char-count

   ON OVERFLOW
       DISPLAY "source not null terminated or target too short"

. . .
END-UNSTRING

```

- Use a SEARCH statement to locate trailing null or space characters. Define the string being examined as a table of single characters.
- Check each character in a field in a loop (PERFORM). You can examine each character in the field by using a reference modifier such as source-field (I:1).

“Example: null-terminated strings”

RELATED REFERENCES

Alphanumeric literals (*Enterprise COBOL Language Reference*)

Example: null-terminated strings

The following example shows several ways you can manipulate null-terminated strings:

```

01 L pic X(20) value z'ab'.
01 M pic X(20) value z'cd'.
01 N pic X(20).
01 N-Length pic 99 value zero.
01 Y pic X(13) value 'Hello, World!'.

. . .
* Display null-terminated string
  Inspect N tallying N-length
          for characters before initial x'00'
  Display 'N: ' N(1:N-Length) ' Length: ' N-Length

. . .
* Move null-terminated string to alphanumeric, strip null
  Unstring N delimited by X'00' into X

. . .
* Create null-terminated string
  String Y      delimited by size
          X'00' delimited by size
          into N.

. . .
* Concatenate two null-terminated strings to produce another
  String L      delimited by x'00'
  M            delimited by x'00'
  X'00'         delimited by size
  into N.

```

Referring to substrings of data items

Refer to a substring of a character-string data item (including alphanumeric, DBCS, and national data items) by using a reference modifier. Intrinsic functions that return character-string values can include a reference modifier.

The following example shows how to use a reference modifier to refer to a substring of a data item:

```
Move Customer-Record(1:20) to Orig-Customer-Name
```

As this example shows, you code two values separated by a colon, in parentheses, immediately following the data item:

- Ordinal position (from the left) of the character that you want the substring to start with
- Length of the desired substring

The length is optional. If you omit the length, the substring extends to the end of the item. Omit the length when possible as a simpler and less error-prone coding technique.

You can code either of the two values as a variable or as an arithmetic expression.

Because numeric function identifiers can be used anywhere that arithmetic expressions are allowed, you can use them in the reference modifier as the leftmost character position or as the length.

You can also refer to substrings of table entries, including variable-length entries. To refer to a substring of a table entry, you must code the subscript expression before the reference modifier. For example, assuming that PRODUCT-TABLE is a properly coded table of character strings, to move D to the fourth character in the second string in the table, you could code this statement:

```
MOVE 'D' to PRODUCT-TABLE (2), (4:1)
```

Both numbers in the reference modifier must have a value of at least 1. Their sum should not exceed the total length of the data item by more than 1 so that you do not reference beyond the end of the desired substring.

If the leftmost character position or the length value is a fixed-point noninteger, truncation occurs to create an integer. If either is a floating-point noninteger, rounding occurs to create an integer.

The following options detect out-of-range reference modifiers, and flag violations with a run-time message:

- SSRANGE compiler option
- CHECK run-time option

You can reference-modify national data items. The reference modifier position and length for a national item are expressed in terms of national characters.

RELATED CONCEPTS

“Reference modifiers” on page 94

“Unicode and encoding of language characters” on page 105

RELATED TASKS

“Referring to an item in a table” on page 61

RELATED REFERENCES

"SSRANGE" on page 304

Reference modification (*Enterprise COBOL Language Reference*)

Function definitions (*Enterprise COBOL Language Reference*)

Reference modifiers

Assume that you want to retrieve the current time from the system and display its value in an expanded format. You can retrieve the current time with the `ACCEPT` statement, which returns the hours, minutes, seconds, and hundredths of seconds in this format:

```
HHMMSSss
```

However, you might prefer to view the current time in this format:

```
HH:MM:SS
```

Without reference modifiers, you would have to define data items for both formats. You would also have to write code to convert from one format to the other.

With reference modifiers, you do not need to provide names for the subfields that describe the `TIME` elements. The only data definition you need is for the time as returned by the system. For example:

```
01 REFMOD-TIME-ITEM          PIC X(8).
```

The following code retrieves and expands the time value:

```
ACCEPT REFMOD-TIME-ITEM FROM TIME.
DISPLAY "CURRENT TIME IS: "
* Retrieve the portion of the time value that corresponds to
* the number of hours:
REFMOD-TIME-ITEM (1:2)
"."
* Retrieve the portion of the time value that corresponds to
* the number of minutes:
REFMOD-TIME-ITEM (3:2)
"."
* Retrieve the portion of the time value that corresponds to
* the number of seconds:
REFMOD-TIME-ITEM (5:2)
```

"Example: arithmetic expressions as reference modifiers"

"Example: intrinsic functions as reference modifiers" on page 95

RELATED TASKS

"Referring to substrings of data items" on page 93

"Using national data (Unicode) in COBOL" on page 106

RELATED REFERENCES

Reference modification (*Enterprise COBOL Language Reference*)

Example: arithmetic expressions as reference modifiers

Suppose that a field contains some right-justified characters, and you want to move the characters to another field where they will be left justified. You can do that using reference modifiers and an `INSPECT` statement.

Suppose the program has the following data:

```

01 LEFTY      PIC X(30).
01 RIGHTY     PIC X(30) JUSTIFIED RIGHT.
01 I          PIC 9(9)  USAGE BINARY.

```

The program counts the number of leading spaces and, using arithmetic expressions in a reference modifier, moves the right-justified characters into another field, justified to the left:

```

MOVE SPACES TO LEFTY
MOVE ZERO TO I
INSPECT RIGHTY
    TALLYING I FOR LEADING SPACE.
IF I IS LESS THAN LENGTH OF RIGHTY THEN
    MOVE RIGHTY ( I + 1 : LENGTH OF RIGHTY - I ) TO LEFTY
END-IF

```

The MOVE statement transfers characters from RIGHTY, beginning at the position computed as I + 1 for a length that is computed as LENGTH OF RIGHTY - I, into the field LEFTY.

Example: intrinsic functions as reference modifiers

The following code fragment causes a substring of Customer-Record to be moved into the data item WS-name. The substring is determined at run time.

```

05 WS-name      Pic x(20).
05 Left-posn    Pic 99.
05 I            Pic 99.
. . .
Move Customer-Record(Function Min(Left-posn I):Function Length(WS-name)) to WS-name

```

If you want to use a noninteger function in a position requiring an integer function, you can use the INTEGER or INTEGER-PART function to convert the result to an integer. For example:

```
Move Customer-Record(Function Integer(Function Sqrt(I)): ) to WS-name
```

RELATED REFERENCES

INTEGER-PART (*Enterprise COBOL Language Reference*)

INTEGER (*Enterprise COBOL Language Reference*)

Tallying and replacing data items (INSPECT)

Use the INSPECT statement to do the following tasks:

- Fill selected portions of a data item with a value. If you specify a national data item, you must also specify a national value.
- Replace portions of a data item with a corresponding portion of another data item. If you specify any national items or literals in the statement, you must specify all items as national.
- Count the number of times a specific character (zero, space, or asterisk, for example) occurs in a data item. For a national data item, the count is in national characters.

“Examples: INSPECT statement” on page 96

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

RELATED REFERENCES

INSPECT statement (*Enterprise COBOL Language Reference*)

Examples: INSPECT statement

The following examples show some uses of the INSPECT statement.

In the following example, the INSPECT statement is used to examine and replace characters in data item DATA-2. The number of times a leading 0 occurs in the data item is accumulated in COUNTR. Every instance of the character A that follows the first instance of the character C is replaced by the character 2.

```
77 COUNTR          PIC 9   VALUE ZERO.
01 DATA-2         PIC X(11).
. . .
  INSPECT DATA-2
    TALLYING COUNTR FOR LEADING "0"
    REPLACING FIRST "A" BY "2" AFTER INITIAL "C"
```

DATA-2 before	COUNTR after	DATA-2 after
00ACADEMY00	2	00AC2DEMY00
0000ALABAMA	4	0000ALABAMA
CHATHAM0000	0	CH2THAM0000

In the following example, the INSPECT statement is used to examine and replace characters in data item DATA-3. Every character in the data item that precedes the first instance of a quotation mark (") is replaced by the character 0.

```
77 COUNTR          PIC 9   VALUE ZERO.
01 DATA-3         PIC X(8).
. . .
  INSPECT DATA-3
    REPLACING CHARACTERS BY ZEROS BEFORE INITIAL QUOTE
```

DATA-3 before	COUNTR after	DATA-3 after
456"ABEL	0	000"ABEL
ANDES"12	0	00000"12
"Twas BR	0	"Twas BR

The following example shows the use of INSPECT CONVERTING with AFTER and BEFORE phrases to examine and replace characters in data item DATA-4. All characters in the data item that follow the first instance of the character / but that precede the first instance of the character ? (if any) are translated from lowercase to uppercase.

```
01 DATA-4         PIC X(11).
. . .
  INSPECT DATA-4
    CONVERTING
      "abcdefghijklmnopqrstuvwxyz" TO
      "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
    AFTER INITIAL "/"
    BEFORE INITIAL "?"
```

DATA-4 before	DATA-4 after
a/five/?six	a/FIVE/?six
r/Rexx/RRRr	r/REXX/RRRR
zfour?inspe	zfour?inspe

Converting data items (intrinsic functions)

You can use intrinsic functions to convert character-string data items to:

- Uppercase or lowercase
- Reverse order
- Numbers
- One code page to another

You can also use the INSPECT statement to convert characters.

“Examples: INSPECT statement” on page 96

You can use the NATIONAL-OF and DISPLAY-OF intrinsic functions to convert to and from national (Unicode) strings.

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE)

```
01 Item-1          Pic x(30) Value "Hello World!".
01 Item-2          Pic x(30).
. . .
Display Item-1
Display Function Upper-case(Item-1)
Display Function Lower-case(Item-1)
Move Function Upper-case(Item-1) to Item-2
Display Item-2
```

The code above displays the following messages on the system logical output device:

```
Hello World!
HELLO WORLD!
hello world!
HELLO WORLD!
```

The DISPLAY statements do not change the actual contents of Item-1, but affect only how the letters are displayed. However, the MOVE statement causes uppercase letters to be moved to the actual contents of Item-2.

Converting to reverse order (REVERSE)

The following code reverses the order of the characters in Orig-cust-name.

```
Move Function Reverse(Orig-cust-name) To Orig-cust-name
```

For example, if the starting value is JOHNSONbbb, the value after the statement is performed is bbbNOSNHQJ, where *b* represents a blank space.

When you reverse the order of a national string, the result is a national string.

Converting to numbers (NUMVAL, NUMVAL-C)

The NUMVAL and NUMVAL-C functions convert character strings to numbers. Use these functions to convert alphanumeric data items that contain free-format character-representation numbers to numeric form, and process them numerically. For example:

```

01 R          Pic x(20) Value "- 1234.5678".
01 S          Pic x(20) Value " $12,345.67CR".
01 Total      Usage is Comp-1.
. . .
    Compute Total = Function Numval(R) + Function Numval-C(S)

```

Use NUMVAL-C when the argument includes a currency symbol or comma, or both, as shown in the example. You can also place an algebraic sign before or after the character string, and the sign will be processed. The arguments must not exceed 18 digits when you compile with the default option ARITH(COMPAT) (*compatibility mode*) nor 31 digits when you compile with ARITH(EXTEND) (*extended mode*), not including the editing symbols.

NUMVAL and NUMVAL-C return long (64-bit) floating-point values in compatibility mode, and return extended-precision (128-bit) floating-point values in extended mode. A reference to either of these functions, therefore, represents a reference to a numeric data item.

When you use NUMVAL or NUMVAL-C, you do not need to statically declare numeric data in a fixed format, nor input data in a precise manner. For example, suppose you define numbers to be entered as follows:

```

01 X          Pic S999V99 leading sign is separate.
. . .
    Accept X from Console

```

The user of the application must enter the numbers exactly as defined by the PICTURE clause. For example:

```

+001.23
-300.00

```

However, using the NUMVAL function, you could code:

```

01 A          Pic x(10).
01 B          Pic S999V99.
. . .
    Accept A from Console
    Compute B = Function Numval(A)

```

The input could then be:

```

1.23
-300

```

Converting from one code page to another

You can nest the DISPLAY-OF and NATIONAL-OF intrinsic functions to easily convert from any code page to any other code page. For example, the following code converts an EBCDIC string to an ASCII string:

```

77 EBCDIC-CCSID PIC 9(4) BINARY VALUE 1140.
77 ASCII-CCSID PIC 9(4) BINARY VALUE 819.
77 Input-EBCDIC PIC X(80).
77 ASCII-Output PIC X(80).
* Convert EBCDIC to ASCII
  Move Function
    Display-of
      ( Function National-of
        (Input-EBCDIC EBCDIC-CCSID),
        ASCII-CCSID
      )
    to ASCII-output

```

RELATED CONCEPTS

“Formats for numeric data” on page 40

RELATED TASKS

“Assigning input from a screen or file (ACCEPT)” on page 29

“Displaying values on a screen or in a file (DISPLAY)” on page 30

“Converting national data” on page 107

RELATED REFERENCES

NUMVAL (*Enterprise COBOL Language Reference*)

NUMVAL-C (*Enterprise COBOL Language Reference*)

“ARITH” on page 271

Evaluating data items (intrinsic functions)

You can use several intrinsic functions in evaluating data items:

- CHAR and ORD for evaluating integers and single alphanumeric characters with respect to the collating sequence used in your program
- MAX, MIN, ORD-MAX, and ORD-MIN for finding the largest and smallest items in a series of data items, including national data items
- LENGTH for finding the length of data items, including national data items
- WHEN-COMPILED for finding the date and time the program was compiled

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

RELATED TASKS

“Evaluating single characters for collating sequence”

“Finding the largest or smallest data item”

“Finding the length of data items” on page 101

“Finding the date of compilation” on page 102

Evaluating single characters for collating sequence

To find out the ordinal position of a given character in the collating sequence, use the ORD function with the character as the argument. ORD returns an integer representing that ordinal position. One convenient way to find a character’s ordinal position is to use a one-character substring of a data item as the argument to ORD:

```
IF Function Ord(Customer-record(1:1)) IS > 194 THEN . . .
```

If you know the ordinal position in the collating sequence of a character, and want to know the character that it corresponds to, use the CHAR function with the integer ordinal position as the argument. CHAR returns the desired character:

```
INITIALIZE Customer-Name REPLACING ALPHABETIC BY Function Char(65)
```

RELATED REFERENCES

CHAR (*Enterprise COBOL Language Reference*)

ORD (*Enterprise COBOL Language Reference*)

Finding the largest or smallest data item

If you want to know which of two or more alphanumeric, alphabetic, or national data items has the largest value, use the MAX or ORD-MAX function. Supply the data items in question as arguments. If you want to know which item contains the smallest value, use the MIN or ORD-MIN function. These functions evaluate the values

according to the collating sequence. You can also use MAX, ORD-MAX, MIN, or ORD-MIN for numbers. In that case, the algebraic values of the arguments are compared.

MAX and MIN

The MAX and MIN functions return the contents of one of the arguments that you supply.

For example, suppose you have these data definitions:

```
05 Arg1 Pic x(10) Value "THOMASSON ".
05 Arg2 Pic x(10) Value "THOMAS    ".
05 Arg3 Pic x(10) Value "VALLEJO   ".
```

The following statement assigns VALLEJObbb to the first 10 character positions of Customer-record, where *b* represents a blank space:

```
Move Function Max(Arg1 Arg2 Arg3) To Customer-record(1:10)
```

If you use MIN instead, then THOMASbbbb is assigned.

If you specify a national item for any argument, you must specify all arguments as national.

ORD-MAX and ORD-MIN

The functions ORD-MAX and ORD-MIN return an integer that represents the ordinal position of the argument with the largest or smallest value in the list of arguments that you supply (counting from the left).

If you used the ORD-MAX function in the example above, you would receive a syntax error message at compile time; the reference to a numeric function is in an invalid place. The following is a valid use of the ORD-MAX function:

```
Compute x = Function Ord-max(Arg1 Arg2 Arg3)
```

This code assigns the integer 3 to *x* if the same arguments are used as in the previous example. If you use ORD-MIN instead, the integer 2 is returned. The above examples would probably be more realistic if Arg1, Arg2, and Arg3 were instead successive elements of an array (table).

If you specify a national item for any argument, you must specify all arguments as national.

Returning variable-length results with alphanumeric functions

The results of alphanumeric functions could be of varying lengths and values depending on the function arguments.

In the following example, the amount of data moved to R3 and the results of the COMPUTE statement depend on the values and sizes of R1 and R2:

```
01 R1 Pic x(10) value "e".
01 R2 Pic x(05) value "f".
01 R3 Pic x(20) value spaces.
01 L Pic 99.
. . .
Move Function Max(R1 R2) to R3
Compute L = Function Length(Function Max(R1 R2))
```

Here, R2 is evaluated to be larger than R1. Therefore:

- The string 'fbbbb' is moved to R3, where *b* represents a blank space. (The unfilled character positions in R3 are padded with spaces.)

- L evaluates to the value 5.

If R1 contained 'g' instead of 'e', then R1 would evaluate as larger than R2, and:

- The string 'gbbbbbbbbb' would be moved to R3. (The unfilled character positions in R3 would be padded with spaces.)
- The value 10 would be assigned to L.

You might be dealing with variable-length output from alphanumeric functions. Plan your program accordingly. For example, you might need to think about using variable-length files when the records you are writing could be of different lengths:

File Section.

FD Output-File Recording Mode V.

01 Short-Customer-Record Pic X(50).

01 Long-Customer-Record Pic X(70).

. . .

Working-Storage Section.

01 R1 Pic x(50).

01 R2 Pic x(70).

. . .

If R1 > R2

Write Short-Customer-Record from R1

Else

Write Long-Customer-Record from R2

End-if

RELATED TASKS

"Performing arithmetic" on page 47

"Processing table items using intrinsic functions" on page 73

RELATED REFERENCES

ORD-MAX (*Enterprise COBOL Language Reference*)

ORD-MIN (*Enterprise COBOL Language Reference*)

Finding the length of data items

You can use the LENGTH function in many contexts (including numeric data and tables) to determine the length of string items.

The following COBOL statement demonstrates moving a data item into that field in a record that holds customer names:

```
Move Customer-name To Customer-record(1:Function Length(Customer-name))
```

The LENGTH function returns the length of a national item in national characters.

You can also use the LENGTH OF special register, which returns the length in bytes even for national data. Coding either Function Length(Customer-name) or LENGTH OF Customer-name returns the same result for alphanumeric items: the length of Customer-name in bytes.

You can use the LENGTH function only where arithmetic expressions are allowed. However, you can use the LENGTH OF special register in a greater variety of contexts. For example, you can use the LENGTH OF special register as an argument to an intrinsic function that allows integer arguments. (You cannot use an intrinsic function as an operand to the LENGTH OF special register.) You can also use the LENGTH OF special register as a parameter in a CALL statement.

RELATED TASKS

“Performing arithmetic” on page 47

“Processing table items using intrinsic functions” on page 73

RELATED REFERENCES

LENGTH (*Enterprise COBOL Language Reference*)

Finding the date of compilation

If you want to know the date and time when a program was compiled, you can use the WHEN-COMPILED function. The result returned has 21 character positions, with the first 16 positions in the following format:

YYYYMMDDhhmmsshh

These characters show the four-digit year, month, day, and time (in hours, minutes, seconds, and hundredths of seconds) of compilation.

The WHEN-COMPILED special register is another means you can use to find the date and time of compilation. It has the following format:

MM/DD/YYhh.mm.ss

The WHEN-COMPILED special register supports only a two-digit year, and carries the time out only to seconds. This special register be used only as the sending field in a MOVE statement.

RELATED REFERENCES

WHEN-COMPILED (*Enterprise COBOL Language Reference*)

Chapter 7. Processing character data in an international environment

Enterprise COBOL supports Unicode at run time. Unicode provides a consistent and efficient way to encode plain text. Using Unicode, you can develop software that will work with various national languages.

Use these COBOL facilities to code and compile programs with encoding of national character data and culturally sensitive collation orders for such character data:

- National data type, defined with USAGE NATIONAL and PICTURE symbol N
- National literals, specified with literal prefix N or NX
- Intrinsic functions:
 - NATIONAL-OF to return a character string in UTF-16 representation
 - DISPLAY-OF to convert a national string to a selected code page (EBCDIC, ASCII, EUC, or UTF-8)
- Compiler options:
 - CODEPAGE to specify the code page to use for alphanumeric and double-byte character set (DBCS) data in your program
 - NSYMBOL to control whether national or DBCS processing is used for the N symbol in literals and PICTURE clauses

In addition, when you are working with national data, certain coding situations such as handling strings, sorting and merging, and passing data require special attention.

Table 15. COBOL statements and national data

COBOL statement	Can be national	Comment	For more information
ACCEPT	<i>identifier-1</i>	Converted from EBCDIC only if the CONSOLE option is specified directly or indirectly.	"Assigning input from a screen or file (ACCEPT)" on page 29
CALL	<i>identifier-2, identifier-3, identifier-4, identifier-5; literal-2, literal-3</i>		"Passing data" on page 411
COPY . . .REPLACING	<i>operand-1, operand-2</i>		COPY statement (<i>Enterprise COBOL Language Reference</i>)
DISPLAY	<i>identifier-1</i>	Converted to EBCDIC only if the CONSOLE option is specified directly or indirectly.	"Displaying values on a screen or in a file (DISPLAY)" on page 30
INITIALIZE	REPLACING	If you specify REPLACING NATIONAL, <i>identifier-2</i> and <i>literal-1</i> must be of class national, and vice versa.	"Examples: initializing data items" on page 26
INSPECT	Identifiers and literals other than <i>identifier-3</i> (the TALLYING identifier)	If any of these is of class national, all must be.	"Tallying and replacing data items (INSPECT)" on page 95

Table 15. COBOL statements and national data (continued)

COBOL statement	Can be national	Comment	For more information
INVOKE	method-name as <i>identifier-2</i> or <i>literal-1</i> ; <i>identifier-3</i> or <i>literal-2</i> in the BY VALUE phrase		"Invoking methods (INVOKE)" on page 506
MERGE	Merge keys	The COLLATING SEQUENCE phrase does not apply.	"Setting sort or merge criteria" on page 189
MOVE	Both the sender and receiver	If the sender is a national data item, the receiver must be also.	"Assigning values to elementary or group data items (MOVE)" on page 27
Format-2 (binary) SEARCH	Both the key data item and the search argument	A search argument can be an alphanumeric or national item when the corresponding key is a national item. If a search argument is a national item, the corresponding key must be a national data item.	"Doing a binary search (SEARCH ALL)" on page 72
SORT	Sort keys	The COLLATING SEQUENCE phrase does not apply.	"Setting sort or merge criteria" on page 189
STRING	Any identifiers and literals other than <i>identifier-4</i> (the POINTER identifier)	If any of these is of class national, all must be.	"Joining data items (STRING)" on page 87
UNSTRING	Delimiters (<i>identifier-2</i> , <i>identifier-3</i>), data receiving fields (<i>identifier-4</i>), delimiter receiving fields) <i>identifier-5</i> ; <i>literal-3</i> , <i>literal-4</i>	If any of these is of class national, all must be.	"Splitting data items (UNSTRING)" on page 89

The use of national data affects these intrinsic functions:

Table 16. Intrinsic functions and national data

Intrinsic function	Argument type can be national?	Function type	For more information
LENGTH	Yes	Integer	"Finding the length of data items" on page 101
LOWER-CASE, UPPER-CASE	Yes	National	"Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE)" on page 97
MAX, MIN	Yes	National	"Finding the largest or smallest data item" on page 99
ORD-MAX, ORD-MIN	Yes	Integer	"Finding the largest or smallest data item" on page 99
REVERSE	Yes	National	"Converting to reverse order (REVERSE)" on page 97

RELATED CONCEPTS

"Unicode and encoding of language characters" on page 105

RELATED TASKS

"Using national data (Unicode) in COBOL" on page 106
"Converting national data" on page 107
"Processing UTF-8 data" on page 109
"Processing Chinese GB 18030 data" on page 110
"Comparing national data items" on page 111
"Processing alphanumeric data items that contain DBCS data" on page 112
Appendix C, "Converting double-byte character set (DBCS) data," on page 619

RELATED REFERENCES

"CODEPAGE" on page 274
"NSYMBOL" on page 291

Unicode and encoding of language characters

Enterprise COBOL provides basic run-time support for Unicode, which can handle tens of thousands of characters covering all commonly used characters and symbols in the world compared to the up to 256 characters that ASCII and EBCDIC support.

Each *character set* is a defined set of characters, but is not associated with a coded representation. A *coded character set* (also referred to here as a *code page*) is a set of unambiguous rules that relate the characters of the set to their coded representation. Each code page has a name and is like a table that sets up the symbols for representing a character set; each symbol is a unique bit pattern, or *code point*. (Each IBM code page also has a *coded character set identifier (CCSID)*, which is a value from 1 to 65,536.)

There are several encoding schemes in Unicode, called Unicode Transformation Format (UTF), such as UTF-8, UTF-16, and UTF-32. Enterprise COBOL uses UTF-16 (CCSID 1200) in big-endian format as the representation for the national data type.

UTF-8 represents ASCII invariant characters a-z, A-Z, 0-9, and certain special characters such as ' @ , . + - = / * () identically as in ASCII. UTF-16 represents such characters as X'00nn' where X'nn' is the representation of the character in ASCII.

For example, the string 'ABC' in UTF-16 would be NX'004100420043'. In UTF-8 it would be X'414243'.

One or more *encoding units* are used to represent a character in a coded character set. For UTF-16, an encoding unit takes 2 bytes of storage. Any character defined in any EBCDIC, ASCII, or EUC code page is represented in one UTF-16 encoding unit when the character is converted to the national data representation.

Cross-platform considerations: Enterprise COBOL does not support UTF-16 with byte order marks or UTF-16 in little-endian format (UTF-16LE) in national data items. If you are porting UTF-16 data or UTF-16LE data from another platform, you must convert that data to UTF-16 big-endian format.

RELATED TASKS

Chapter 7, "Processing character data in an international environment," on page 103

Using national data (Unicode) in COBOL

In Enterprise COBOL, you can specify Unicode data by means of:

- National data items
- National literals
- Figurative constants as national characters

These declarations affect the amount of storage needed.

National data items

Define data items with `USAGE NATIONAL` to hold Unicode strings. Code a `PICTURE` clause that consists only of one or more `PICTURE` symbols `N`.

If you specify a `PICTURE` clause but do not specify a `USAGE` clause for data items that consist only of one or more `PICTURE` symbols `N`, you can use the compiler option `NSYMBOL(NATIONAL)` to ensure that the items are treated as national data items (instead of as DBCS items).

National literals

To specify national literals, use the prefix character `N` and compile with the option `NSYMBOL(NATIONAL)`. For example, you can use either of these notations:

```
N"character-data"  
N'character-data'
```

When you use `NSYMBOL(DBCS)`, the literal prefix character `N` specifies a DBCS literal, not a national literal.

To specify a national literal as a hexadecimal value, use the prefix character `NX`. For example, you can use either of these notations:

```
NX"hexadecimal-digits"  
NX'hexadecimal-digits'
```

Each of the following `MOVE` statements sets the data item `X` to the Unicode value `AB`:

```
01 X pic NN usage national.  
...  
    Move NX"00410042" to X  
    Move N"AB" to X  
    Move "AB" to X
```

Do not use alphanumeric hexadecimal literals in contexts that call for a national literal, because such usage is easily misunderstood. For example, the statement:

```
Move X"C1C2C3C4" to X
```

also results in moving Unicode `AB` (not the bit pattern `C1C2C3C4`) to `X`.

National characters as figurative constants

You can use the figurative constant `ALL literal` for national literals. It represents all or part of the string that is generated by successive concatenations of the encoding units that make up the literal.

When you use the figurative constant `QUOTE`, `SPACE`, or `ZERO` in a context that requires national characters, the figurative constant represents a national character value. However, you cannot use the figurative constants `HIGH-VALUE` and `LOW-VALUE`

in a context that requires national characters, such as a MOVE statement, an implicit MOVE, or a relation condition with national operands.

You cannot use national literals in the SPECIAL-NAMES paragraph.

Storage of national data

Use this table to compare alphanumeric (DISPLAY), DBCS (DISPLAY-1), and Unicode (NATIONAL) encoding and to plan your storage usage:

Table 17. Encoding and size of alphanumeric and national data

Characteristic	DISPLAY	DISPLAY-1	NATIONAL
Character encoding unit	1 byte	2 bytes	2 bytes
Code page ¹	EBCDIC	EBCDIC DBCS	UTF-16BE
Encoding units per character	1	1	1 or 2 ²
Bytes per character	1 byte	2 bytes	2 or 4 bytes
<div><div>1. Use the CODEPAGE compiler option to specify the code page for the EBCDIC code page applicable to alphanumeric or DBCS data. National literals in your source program are converted to UTF-16 for use at run time.</div><div>2. Most characters are represented in UTF-16 using one encoding unit. In particular, the following characters are represented using a single UTF-16 encoding unit per character:<ul style="list-style-type: none">• COBOL characters A-Z, a-z, 0-9, space, + -*/= \$,;:"'()><:'• All characters that are converted from an EBCDIC, ASCII, or EUC code page</div></div>			

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 105

RELATED TASKS

“Converting national data”

“Comparing national data items” on page 111

“Processing UTF-8 data” on page 109

RELATED REFERENCES

“CODEPAGE” on page 274

“NSYMBOL” on page 291

Converting national data

You can convert alphanumeric, DBCS, and integer data items to national strings by using the MOVE statement. (Such implicit conversions also take place in other COBOL statements, such as a comparison of an alphanumeric data item with a national data item.) You can also convert to and from national (Unicode) strings by using the intrinsic functions NATIONAL-OF and DISPLAY-OF, respectively. Using the intrinsic functions allows you to specify a code page for the conversion that is different from the code page in effect with the CODEPAGE compiler option.

Converting alphanumeric and integer to national data (MOVE)

You can use the MOVE statement to convert alphanumeric, DBCS, and integer items to national. When you move an alphanumeric item to a national item, it is converted to the representation of the national data receiver (UTF-16 Unicode). When you move an alphanumeric-edited item, numeric integer, or numeric-edited item to a national item, it is treated as if it were first moved to an alphanumeric data item of the size not requiring padding or truncation.

If the number of characters of the converted data is less than the size of the national data item that you specify, the data is padded with default Unicode UTF-16 space characters (NX'0020'). If the number of characters of the converted data is more than the size of the national item, the trailing characters are truncated. You need to ensure that such truncation does not occur within a character.

Converting alphanumeric to national data (NATIONAL-OF)

Use the NATIONAL-OF intrinsic function to convert an alphabetic, alphanumeric, or DBCS item to a character string represented in Unicode (UTF-16). Specify the source code page as an argument, if the source is encoded in a different code page than is in effect with the CODEPAGE compiler option.

Converting national to alphanumeric data (DISPLAY-OF)

Use the DISPLAY-OF intrinsic function to convert a national item to a character string represented in the code page that you specify. If you specify an EBCDIC or ASCII code page that combines SBCS and DBCS characters, the returned string might contain a mixture of SBCS and DBCS characters. The DBCS substrings are delimited by shift-in and shift-out characters if the code page in effect for the function is an EBCDIC code page.

Overriding the default code page

In some cases, you might need to convert data to or from a code page that differs from the CCSID specified as the CODEPAGE option value. To do this, convert the item by using a conversion function in which you specify the code page for the item explicitly.

If you specify a code page as an argument to DISPLAY-OF and it differs from the code page that is in effect with the CODEPAGE compiler option, do not use the DISPLAY-OF function result in any operations that involve implicit conversion (such as an assignment to, or comparison with, a national data item). Such operations assume the EBCDIC code page that is specified in the CODEPAGE compiler option.

Conversion exceptions

Implicit or explicit conversion between national and alphanumeric data could fail and generate a severity-3 Language Environment condition. Failures could occur if any of the follow occur:

- Unicode Conversion Services was not installed on your system.
- The code page that you specified (implicitly or explicitly) is not a valid code page.
- The combination of the CCSID that you specified explicitly or implicitly (such as by using the CODEPAGE compiler option) and the UTF-16 Unicode CCSID (1200) was not configured on your system as a valid conversion pair for the Unicode Conversion Services on the system.

A character that does not have a counterpart in the target CCSID does not result in a conversion exception. Such a character is converted to a substitution character of the target code page.

“Example: converting national data” on page 109

RELATED TASKS

Customizing Unicode support for COBOL (*Enterprise COBOL Customization Guide*)

Example: converting national data

The following example shows the use of the NATIONAL-OF and DISPLAY-OF intrinsic functions and the MOVE statement for converting to and from Unicode strings. It also demonstrates the need for explicit conversions when you operate on strings encoded in multiple code pages in the same program.

```
CBL CODEPAGE(00037)
* . . .
01 Data-in-Unicode      pic N(100) usage national.
01 Data-in-Greek        pic X(100).
01 other-data-in-US-English pic X(12) value "PRICE in $ =".
* . . .
    Read Greek-file into Data-in-Greek
    Move function National-of(Data-in-Greek, 00875)
      to Data-in-Unicode
* . . . process Data-in-Unicode here . . .
    Move function Display-of(Data-in-Unicode, 00875)
      to Data-in-Greek
    Write Greek-record from Data-in-Greek
```

The above example works correctly: Data-in-Greek is converted as data represented in CCSID 00875 (Greek) explicitly. However, the following statement would result in an incorrect conversion (unless all the characters in the item happen to be among those with a common representation in the Greek and the English code pages):

Move Data-in-Greek to Data-in-Unicode

Data-in-Greek is converted to Unicode by this MOVE statement based on the CCSID 00037 (U.S. English) to UTF-16 conversion. This conversion would not produce the expected results because Data-in-Greek is actually encoded in CCSID 00875.

If you can correctly set the CODEPAGE compiler option to CCSID 00875 (that is, the rest of your program also handles EBCDIC data in Greek), you can code the same example correctly as follows:

```
CBL CODEPAGE(00037)
* . . .
01 Data-in-Unicode pic N(100) usage national.
01 Data-in-Greek   pic X(100).
* . . .
    Read Greek-file into Data-in-Greek
* . . . process Data-in-Greek here ...
* . . . or do the following (if need to process data in Unicode)
    Move Data-in-Greek to Data-in-Unicode
* . . . process Data-in-Unicode
    Move function Display-of(Data-in-Unicode) to Data-in-Greek
    Write Greek-record from Data-in-Greek
```

Processing UTF-8 data

When you need to process UTF-8 data, first convert the data to UTF-16 Unicode in a national data item. After processing the national data, convert it back to UTF-8 for output. For the conversions, use the intrinsic functions NATIONAL-OF and DISPLAY-OF. Use code page 1208 for UTF-8 data.

You need to do two steps to convert ASCII or EBCDIC data to UTF-8:

1. Use the function NATIONAL-OF to convert the ASCII or EBCDIC string to national (UTF-16).
2. Use the function DISPLAY-OF to convert the national string (UTF-16) to UTF-8.

The following example illustrates these steps, converting Greek EBCDIC data to UTF-8:

```
01 Greek-EBCDIC pic X(10) value "αβγδεζηθ".
01 UnicodeString pic N(10).
01 UTF-8-String pic X(20).
   Move function National-of(Greek-EBCDIC, 00875) to UnicodeString
   Move function Display-of(UnicodeString, 01208) to UTF-8-String
```

RELATED TASKS

“Converting national data” on page 107

Processing Chinese GB 18030 data

Enterprise COBOL does not have any explicit support for GB 18030, but does support processing GB 18030 characters in the following ways:

- You can use DBCS data to process GB 18030 characters that are represented in CCSID 1388.
- You can use Unicode data to define and process GB 18030 characters that are represented in CCSID 01200 (GB 18030 characters that do not require UTF-16 surrogates).
- You can process data in any code page (including CCSID 1388) by converting it to Unicode, processing the data as Unicode, then converting it back to the original code page representation.

When you need to process Chinese GB 18030 data that requires conversion, first convert the input data to UTF-16 Unicode in a national data item. After processing the national data, convert it back to Chinese GB 18030 for output. For the conversions, use the intrinsic functions NATIONAL-OF and DISPLAY-OF, and specify code page 1388 as the second argument of each.

The following example illustrates these conversions:

```
01 Chinese-EBCDIC pic X(16) value "奥林匹克运动会".
01 Chinese-GB18030-String pic X(16).
01 UnicodeString pic N(14).
. . .
   Move function National-of(Chinese-EBCDIC, 1388) to UnicodeString
* Process data in Unicode
   Move function Display-of(UnicodeString, 1388) to Chinese-GB18030-String
```

GB 18030 characters are encoded through the existing Chinese EBCDIC code page, CCSID 1388, which has been expanded to include the GB 18030 characters that do not require UTF-16 surrogate values. *Surrogate values* in UTF-16 are those characters that require two 2-byte encoding units (4 bytes) for each character.

RELATED TASKS

“Converting national data” on page 107

Comparing national data items

You can compare national data items explicitly or implicitly with other national data items in relation conditions. You can code conditional expressions that use national data items in the following statements:

- EVALUATE
- IF
- INSPECT
- PERFORM
- SEARCH
- STRING
- UNSTRING

You can compare national data items explicitly or implicitly with certain nonnational items in relation conditions in the following statements:

- EVALUATE
- IF
- PERFORM
- SEARCH

All comparisons that involve a national operand are national comparisons. The operands must follow the rules for valid comparisons. The PROGRAM COLLATING SEQUENCE does not affect comparisons that involve national operands.

Comparing national operands

When you compare two national operands of the same length, they are determined to be equal if all pairs of the corresponding characters are equal. Otherwise, comparison of the binary values of the first pair of unequal characters determines the operand with the larger binary value.

When you compare operands of unequal lengths, the shorter operand is treated as if it were padded on the right with default Unicode UTF-16 space characters (NX'0020') to the length of the longer operand.

Comparing national and numeric operands

You can compare national literals or national data items to integer literals or numeric data items of USAGE DISPLAY. The numeric operand is treated as if it were moved to an elementary alphanumeric item, and an alphanumeric comparison is done.

Comparing national and alphabetic or alphanumeric operands

You can compare national literals or data items to alphabetic or alphanumeric data items. The alphabetic or alphanumeric operand is treated as if it were moved to an elementary national item, and a national comparison is done.

Comparing national and group operands

You can compare a national literal or data item to a group. The national operand is treated as if it were moved to a group item of the same size as the group operand, and the two groups are compared.

RELATED TASKS

- "Using national data (Unicode) in COBOL" on page 106
- "Coding a choice of actions" on page 75
- "Tallying and replacing data items (INSPECT)" on page 95
- "Coding a loop" on page 84
- "Doing a serial search (SEARCH)" on page 71
- "Joining data items (STRING)" on page 87
- "Splitting data items (UNSTRING)" on page 89

RELATED REFERENCES

- Relation condition (*Enterprise COBOL Language Reference*)
- Comparison of numeric and alphanumeric operands (*Enterprise COBOL Language Reference*)

Processing alphanumeric data items that contain DBCS data

If you use byte-oriented alphanumeric operations (for example, STRING, UNSTRING, or reference modification) on an alphanumeric data item that contains DBCS characters, results are unpredictable. You should instead do these steps:

1. Convert the item to Unicode in a national data item by using a MOVE statement or the NATIONAL-OF function.
2. Process the national item as needed.
3. Convert the result back to alphanumeric by using the DISPLAY-OF function.

RELATED TASKS

- "Joining data items (STRING)" on page 87
- "Splitting data items (UNSTRING)" on page 89
- "Referring to substrings of data items" on page 93
- "Converting national data" on page 107

Chapter 8. Processing files

Reading and writing data is an essential part of every program. Your program retrieves information, processes it as you request, and then produces the results.

The source of the information and the target for the results can be one or more of the following:

- Another program
- Direct-access storage device
- Magnetic tape
- Printer
- Terminal
- Card reader or punch

The information as it exists on an external device is in a physical record or block, a collection of information that is handled as a unit by the system during input or output operations.

Your COBOL program does not directly handle physical records. It processes logical records. A logical record can correspond to a complete physical record, part of a physical record, or to parts or all of one or more physical records. Your COBOL program handles logical records exactly as you have defined them.

In COBOL, a collection of logical records is a file, a sequence of pieces of information that your program can process.

RELATED CONCEPTS

"File organization and input-output devices"

RELATED TASKS

"Choosing file organization and access mode" on page 115

"Allocating files" on page 117

"Checking for input or output errors" on page 118

File organization and input-output devices

Depending on the input-output devices, your file organization can be sequential, line sequential, indexed, or relative. Decide on the file types and devices to be used when you design your program.

You have the following choices of file organization:

Sequential file organization

The chronological order in which records are entered when a file is created establishes the arrangement of the records. Each record except the first has a unique predecessor record, and each record except the last has a unique successor record. Once established, these relationships do not change.

The access (record transmission) mode allowed for sequential files is sequential only.

Line-sequential file organization

Line-sequential files are sequential files that reside on the hierarchical file system (HFS) and that contain only characters as data. Each record ends with a new-line character.

The only access (record transmission) mode allowed for line-sequential files is sequential.

Indexed file organization

Each record in the file contains a special field whose contents form the record key. The position of the key is the same in each record. The index component of the file establishes the logical arrangement of the file, an ordering by record key. The actual physical arrangement of the records in the file is not significant to your COBOL program.

An indexed file can also use alternate indexes in addition to the record key. These keys let you access the file using a different logical ordering of the records.

The access (record transmission) modes allowed for indexed files are sequential, random, or dynamic. When you read or write indexed files sequentially, the sequence is that of the key values.

Relative file organization

Records in the file are identified by their location relative to the beginning of the file. The first record in the file has a relative record number of 1, the tenth record has a relative record number of 10, and so on.

The access (record transmission) modes allowed for relative files are sequential, random, or dynamic. When relative files are read or written sequentially, the sequence is that of the relative record number.

With IBM Enterprise COBOL for z/OS, requests to the operating system for the storage and retrieval of records from input-output devices are handled by the two access methods QSAM and VSAM, and the UNIX file system.

The device type upon which you elect to store your data could affect the choices of file organization available to you. Direct-access storage devices provide greater flexibility in the file organization options. Sequential-only devices limit organization options but have other characteristics, such as the portability of tapes, that might be useful.

Sequential-only devices

Terminals, printers, card readers, and punches are called *unit-record devices* because they process one line at a time. Therefore, you must also process records one at a time sequentially in your program when it reads from or writes to unit-record devices.

On tape, records are ordered sequentially, so your program must process them sequentially. Use QSAM physical sequential files when processing tape files. The records on tape can be fixed length or variable length. The rate of data transfer is faster than it is for cards.

Direct-access storage devices

Direct-access storage devices hold many records. The record arrangement of files stored on these devices determines the ways that your program can process the data. When using direct-access devices, you have greater flexibility within your program, because you can use several types of file organization:

- Sequential (VSAM or QSAM)

- Line sequential (UNIX)
- Indexed (VSAM)
- Relative (VSAM)

RELATED TASKS

“Allocating files” on page 117

Chapter 9, “Processing QSAM files,” on page 119

Chapter 10, “Processing VSAM files,” on page 147

Chapter 11, “Processing line-sequential files,” on page 175

“Choosing file organization and access mode”

Choosing file organization and access mode

Consider the following guidelines when determining which file organization and access mode to use in your application:

- If your application accesses records (fixed-length or variable-length records) only sequentially and does not insert records between existing ones, a QSAM or VSAM sequential file is the simplest type.
- If you are developing an application for UNIX that sequentially accesses records that contain only printable characters and certain control characters, line-sequential files work the best.
- If your application requires both sequential and random access (fixed-length or variable-length records), a VSAM indexed file is the most flexible type.
- If your application randomly inserts and deletes records, a relative file works well.

If a large percentage of a file is referenced or updated in your application, sequential processing is faster than random or dynamic access. If a small percentage of records is processed during each run of your application, use random or dynamic access.

The following table shows the possible file organizations, access modes, and record formats for COBOL files.

Table 18. File organization, access mode, and record format

File organization	Sequential access	Random access	Dynamic access	Fixed length	Variable length
QSAM (physical sequential)	X			X	X
Line sequential	X			X ¹	X
VSAM sequential (ESDS)	X			X	X
VSAM indexed (KSDS)	X	X	X	X	X
VSAM relative (RRDS)	X	X	X	X	X
1. The data itself is in variable format but can be read into and written from COBOL fixed-length records.					

RELATED REFERENCES

“Format for coding input and output” on page 116

“Allowable control characters” on page 176

Format for coding input and output

The following code shows the general format of input-output coding. Explanations of the user-supplied information follow the code.

```
IDENTIFICATION DIVISION.  
    .  
    .  
    .  
ENVIRONMENT DIVISION.  
INPUT-OUTPUT SECTION.  
FILE-CONTROL.  
    SELECT filename ASSIGN TO assignment-name (1) (2)  
    ORGANIZATION IS org ACCESS MODE IS access (3) (4)  
    FILE STATUS IS file-status (5)  
    .  
    .  
    .  
DATA DIVISION.  
FILE SECTION.  
FD filename  
01 recordname (6)  
   nn . . . fieldlength & type (7) (8)  
   nn . . . fieldlength & type  
    .  
    .  
    .  
WORKING-STORAGE SECTION  
01 file-status PICTURE 99.  
    .  
    .  
    .  
PROCEDURE DIVISION.  
    .  
    .  
    .  
    OPEN iomode filename (9)  
    .  
    .  
    .  
    READ filename  
    .  
    .  
    .  
    WRITE recordname  
    .  
    .  
    .  
    CLOSE filename  
    .  
    .  
    .  
    STOP RUN.
```

The user-supplied information in the code above is as follows:

(1) *filename*

Any legal COBOL name. You must use the same file name on the SELECT and the FD statements, and on the READ, OPEN, and CLOSE statements. In addition, the file name is required if you use the START or DELETE statements. This name is not necessarily the actual name of the data set as known to the system. Each file requires its own SELECT, FD, and input-output statements.

(2) *assignment-name*

Any name you choose, provided that it follows COBOL and system naming rules. The name can be 1-30 characters long if it is a user-defined word, or 1-160 characters long if it is a literal. You code the *name* part of the *assignment-name* on a DD statement, in an ALLOCATE command (TSO) or as an environment variable (for example, in an export command) (UNIX).

(3) *org* The organization can be SEQUENTIAL, LINE SEQUENTIAL, INDEXED, or RELATIVE. This clause is optional for QSAM files.

(4) *access*

The access mode can be SEQUENTIAL, RANDOM, or DYNAMIC. For sequential file processing, including line-sequential, you can omit this clause.

(5) *file-status*

The two-character COBOL FILE STATUS key.

(6) *recordname*

The name of the record used in the WRITE and REWRITE statements.

(7) *fieldlength*

The logical length of the field.

(8) *type*

The record format of the file. If you break the record entry beyond the level-01 description, each element should map accurately against the fields in the record.

(9) *iomode*

The INPUT or OUTPUT mode. If you are only reading from a file, code INPUT. If you are only writing to it, code OUTPUT or EXTEND. If you are both reading and writing, code I-O, except for organization LINE SEQUENTIAL.

RELATED TASKS

Chapter 9, "Processing QSAM files," on page 119

Chapter 10, "Processing VSAM files," on page 147

Chapter 11, "Processing line-sequential files," on page 175

Allocating files

For any type of file (sequential, line sequential, indexed, or relative) in your z/OS or UNIX applications, you can define the external name with either a ddname or an environment variable name. The external name is the name in the *assignment-name* of the ASSIGN clause.

If the file is in the HFS, you can use either a DD definition or an environment variable to define the file by specifying its path name with the PATH keyword.

The environment variable name must be uppercase. The allowable attributes for its value depend on the organization of the file being defined.

Because you can define the external name in either of two ways, the COBOL run time goes through the following steps to find the definition of the file:

1. If the ddname is explicitly allocated, it is used. The definition can be from a DD statement in JCL, an ALLOCATE command from TSO/E, or a user-initiated dynamic allocation.
2. If the ddname is not explicitly allocated and an environment variable of the same name is set, the value of the environment variable is used.

The file is dynamically allocated using the attributes specified by the environment variable. At a minimum, you must specify either the PATH() or DSN() option. All options and attributes must be in uppercase, except for the *path-name* suboption of the PATH option, which is case sensitive. You cannot specify a temporary data set name in the DSN() option.

File status code 98 results from any of the following:

- The contents (including a value of null or all blanks) of the environment variable are not valid.
- The dynamic allocation of the file fails.
- The dynamic deallocation of the file fails.

The COBOL run time checks the contents of the environment variable at each OPEN statement. If a file with the same external name was dynamically allocated by a previous OPEN statement and the contents of the environment variable have changed since that OPEN, the run time dynamically deallocates the previous allocation and reallocates the file using the options currently set in the environment variable. If the contents of the environment variable have not changed, the run time uses the current allocation.

3. If neither a `ddname` nor an environment variable is defined, the following occurs:
 - If the allocation is for a QSAM file and the CBLQDA run-time option is in effect, CBLQDA dynamic allocation processing takes place for those eligible files. This type of “implicit” dynamic allocation persists for the life of the run unit and cannot be reallocated.
 - Otherwise the allocation fails.

The COBOL run time deallocates all dynamic allocations at run unit termination, except “implicit” CBLQDA allocations.

RELATED TASKS

“Setting and accessing environment variables” on page 384

“Defining and allocating QSAM files” on page 134

“Dynamically creating QSAM files with CBLQDA” on page 130

“Allocating VSAM files” on page 169

Checking for input or output errors

After each input or output statement is performed, the `FILE STATUS` key is updated with a value that indicates the success or failure of the operation. Using a `FILE STATUS` clause, test the `FILE STATUS` key after each input or output statement, and call an error-handling procedure if a nonzero file status code is returned.

With VSAM files, you can use a second *data-name* in the `FILE STATUS` clause to get additional VSAM return code information.

Another way of handling errors in input and output operations is to code `ERROR` (synonymous with `EXCEPTION`) declaratives, as explained in the references below.

RELATED TASKS

“Handling errors in input and output operations” on page 203

“Coding `ERROR` declaratives” on page 207

“Using file status keys” on page 208

Chapter 9. Processing QSAM files

Queued sequential access method (QSAM) files are unkeyed files in which the records are placed one after another, according to entry order. Your program can process these files only sequentially, retrieving (with the READ statement) records in the same order as they are in the file. Each record is placed after the preceding record.

To process QSAM files in your program, use COBOL language statements that:

- Identify and describe the QSAM files in the ENVIRONMENT DIVISION and the DATA DIVISION.
- Process the records in these files in the PROCEDURE DIVISION.

After you have created a record, you cannot change its length or its position in the file, and you cannot delete it. You can, however, update QSAM files on direct-access storage devices (using REWRITE), though not in the HFS.

QSAM files can be on tape, direct-access storage devices (DASDs), unit-record devices, and terminals. QSAM processing is best for tables and intermediate storage.

You can also access byte-stream files in the HFS using QSAM. These files are binary byte-oriented sequential files with no record structure. The record definitions that you code in your COBOL program and the length of the variables that you read into and write from determine the amount of data transferred.

RELATED CONCEPTS

“Labels for QSAM files” on page 141

Using access methods (*z/OS DFSMS: Using Data Sets*)

RELATED TASKS

“Defining QSAM files and records in COBOL”

“Coding input and output statements for QSAM files” on page 129

“Handling errors in QSAM files” on page 133

“Working with QSAM files” on page 133

“Processing QSAM ASCII files on tape” on page 144

“Processing ASCII file labels” on page 145

Defining QSAM files and records in COBOL

Use the FILE-CONTROL entry to:

- Define the files in your COBOL program as QSAM files.
- Associate the files with the external file-names (ddnames or environment variable names). (An *external file-name* is the name by which a file is known to the operating system.)

In the following example, COMMUTER-FILE-MST is your program’s name for the file; COMMUTR is the external name.

```
FILE-CONTROL.
  SELECT COMMUTER-FILE-MST
  ASSIGN TO S-COMMUTR
  ORGANIZATION IS SEQUENTIAL
  ACCESS MODE IS SEQUENTIAL.
```

Your ASSIGN clause *name* can include an S- before the external name (ddname or environment variable name) to document that the file is a QSAM file.

Both the ORGANIZATION and ACCESS MODE clauses are optional.

RELATED TASKS

“Establishing record formats”

“Setting block sizes” on page 127

Establishing record formats

In the FD entry in the DATA DIVISION, code the record format and whether the records are blocked. In the associated record description entry or entries, define the *record-name* and record length.

You can code a record format of F, V, S, or U in the RECORDING MODE clause. COBOL determines the record format from the RECORD clause or from the record descriptions associated with your FD entry for the file. If you want the records to be blocked, code the BLOCK CONTAINS clause in your FD entry.

The following example shows how the FD entry might look for a file with fixed-length records:

```
FILE SECTION.
FD  COMMUTER-FILE-MST
   RECORDING MODE IS F
   BLOCK CONTAINS 0 RECORDS
   RECORD CONTAINS 80 CHARACTERS.
01  COMMUTER-RECORD-MST.
   05  COMMUTER-NUMBER      PIC  X(16).
   05  COMMUTER-DESCRIPTION PIC  X(64).
```

A recording mode of S is not supported for files in the HFS. The above example is appropriate for such a file.

RELATED CONCEPTS

“Logical records”

RELATED TASKS

“Requesting fixed-length format” on page 121

“Requesting variable-length format” on page 122

“Requesting spanned format” on page 124

“Requesting undefined format” on page 126

“Defining QSAM files and records in COBOL” on page 119

Logical records

The term *logical record* is used in a slightly different way in the COBOL language and in z/OS QSAM. For format-V and format-S files, the QSAM logical record includes a 4-byte prefix in front of the user data portion of the record that is not included in the definition of a COBOL logical record. For format-F and format-U files, and for HFS byte-stream files, the definitions of QSAM logical record and COBOL logical record are identical.

In this information, *QSAM logical record* refers to the QSAM definition, and *logical record* refers to the COBOL definition.

RELATED REFERENCES

- "Layout of format-F records"
- "Layout of format-V records" on page 123
- "Layout of format-S records" on page 125
- "Layout of format-U records" on page 126

Requesting fixed-length format

Fixed-length records are in format F. Use RECORDING MODE F to explicitly request this format.

You can omit the RECORDING MODE clause. The compiler determines the recording mode to be F if the length of the largest level-01 record associated with the file is not greater than the block size coded in the BLOCK CONTAINS clause, and you take one of the following actions:

- Use the RECORD CONTAINS *integer* clause (RECORD clause format 1).
When you use this clause, the file is always fixed format with record length *integer*, even if there are multiple level-01 record description entries with different lengths associated with the file.
- Omit the RECORD CONTAINS *integer* clause, but code the same fixed size and no OCCURS DEPENDING ON clause for all level-01 record description entries associated with the file. This fixed size is the record length.

In an unblocked format-F file, the logical record is the same as the block.

In a blocked format-F file, the number of logical records in a block (the blocking factor) is constant for every block in the file, except the last block, which might be shorter. Files in the HFS are never blocked.

RELATED CONCEPTS

"Logical records" on page 120

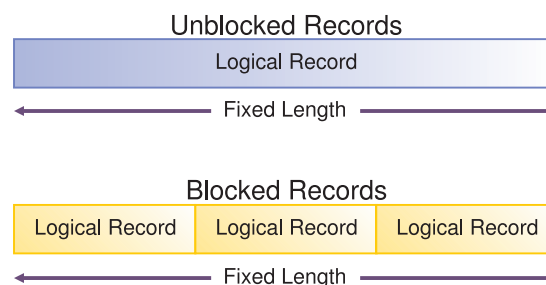
RELATED TASKS

- "Requesting variable-length format" on page 122
- "Requesting spanned format" on page 124
- "Requesting undefined format" on page 126
- "Establishing record formats" on page 120

RELATED REFERENCES

"Layout of format-F records"

Layout of format-F records: The layout of format-F QSAM records is shown below.



RELATED CONCEPTS

“Logical records” on page 120

RELATED TASKS

“Requesting fixed-length format” on page 121

Fixed-length record formats (z/OS DFSMS: Using Data Sets)

RELATED REFERENCES

“Layout of format-V records” on page 123

“Layout of format-S records” on page 125

“Layout of format-U records” on page 126

Requesting variable-length format

Variable-length records can be in format V or format D. Format-D records are variable-length records on ASCII tape files. Format-D records are processed in the same way as format-V records. Use RECORDING MODE V for both.

You can omit the RECORDING MODE clause. The compiler determines the recording mode to be V if the largest level-01 record associated with the file is not greater than the block size set in the BLOCK CONTAINS clause, and you take one of the following actions:

- Use the RECORD IS VARYING clause (RECORD clause format 3).
If you provide values for *integer-1* and *integer-2* (RECORD IS VARYING FROM *integer-1* TO *integer-2*), the maximum record length is the value coded for *integer-2*, regardless of the lengths coded in the level-01 record description entries associated with the file.
If you omit *integer-1* and *integer-2*, the maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.
- Use the RECORD CONTAINS *integer-1* TO *integer-2* clause (RECORD clause format 2).
Make *integer-1* and *integer-2* match the minimum length and the maximum length of the level-01 record description entries associated with the file. The maximum record length is the *integer-2* value.
- Omit the RECORD clause, but code multiple level-01 records (associated with the file) that are of different sizes or contain an OCCURS DEPENDING ON clause.
The maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.

When you specify a READ INTO statement for a format-V file, the record size read for that file is used in the MOVE statement generated by the compiler. Consequently, you might not get the result you expect if the record just read does not correspond to the level-01 record description. All other rules of the MOVE statement apply. For example, when you specify a MOVE statement for a format-V record read in by the READ statement, the size of the record moved corresponds to its level-01 record description.

When you specify a READ statement for a format-V file followed by a MOVE of the level-01 record, the actual record length is not used. The program will attempt to move the number of bytes described by the level-01 record description. If this number exceeds the actual record length and extends outside the area addressable by the program, results are unpredictable. If the number of bytes described by the level-01 record description is shorter than the physical record read, truncation of bytes beyond the 01-level description occurs. To find the actual length of a variable-length record, specify data-name-1 in format 3 of the RECORD clause of the File Definition (FD).

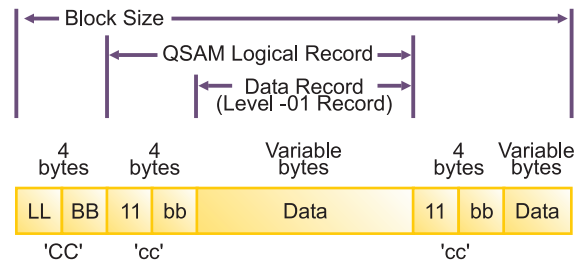
RELATED TASKS

“Requesting fixed-length format” on page 121
“Requesting spanned format” on page 124
“Requesting undefined format” on page 126
“Establishing record formats” on page 120

RELATED REFERENCES

“Layout of format-V records”
Moving from the VS COBOL II run time (*Enterprise COBOL Compiler and Run-Time Migration Guide*)

Layout of format-V records: Format-V QSAM records have control fields (shown below) preceding the data. The QSAM logical record length is determined by adding 4 bytes (for the control fields) to the record length defined in your program, but you must not include these 4 bytes in the description of the record and record length.



CC The first 4 bytes of each block contain control information.

LL Represents 2 bytes designating the length of the block (including the 'CC' field).

BB Represents 2 bytes reserved for system use.

cc The first 4 bytes of each logical record contain control information.

11 Represents 2 bytes designating the logical record length (including the 'cc' field).

bb Represents 2 bytes reserved for system use.

The block length is determined as follows:

- Unblocked format-V records: CC + cc + the data portion
- Blocked format-V records: CC + the cc of each record + the data portion of each record

The operating system provides the control bytes when the file is written; the control byte fields do not appear in your description of the logical record in the DATA DIVISION of your program. COBOL allocates input and output buffers large enough to accommodate the control bytes. These control fields in the buffer are not available for you to use in your program. When variable-length records are written on unit record devices, control bytes are neither printed nor punched. They appear, however, on other external storage devices, as well as in buffer areas of storage. If you move V-mode records from an input buffer to a WORKING-STORAGE area, they'll be moved without the control bytes.

Files in the HFS are never blocked.

RELATED CONCEPTS

“Logical records” on page 120

RELATED TASKS

“Requesting variable-length format” on page 122

RELATED REFERENCES

“Layout of format-F records” on page 121

“Layout of format-S records” on page 125

“Layout of format-U records” on page 126

Requesting spanned format

Spanned records are in format S. A spanned record is a QSAM logical record that can be contained in one or more physical blocks. You can code `RECORDING MODE S` for spanned records in QSAM files assigned to magnetic tape or to direct access devices. Do not request spanned records for files in the HFS.

You can omit the `RECORDING MODE` clause. The compiler determines the recording mode to be S if the maximum record length plus 4 is greater than the block size set in the `BLOCK CONTAINS` clause.

For files with format S in your program, the compiler determines the maximum record length with the same rules used for format V. The length is based on your usage of the `RECORD` clause.

When creating files containing format-S records, and a record is larger than the remaining space in a block, COBOL writes a segment of the record to fill the block. The rest of the record is stored in the next block or blocks, depending on its length. COBOL supports QSAM spanned records up to 32,760 bytes long.

When retrieving files with format-S records, your program can retrieve only complete records.

Benefits of format-S files: You can efficiently use external storage and still organize your files with logical record lengths by defining files with format-S records:

- You can set block lengths to efficiently use track capacities on direct access devices.
- You are not required to adjust the logical record lengths to device-dependent physical block lengths. One logical record can span two or more physical blocks.
- You have greater flexibility when you want to transfer logical records between direct access storage types.

You will, however, have additional overhead in processing format-S files.

Format-S files and READ INTO: By specifying a `READ INTO` statement for a format-S file, the record size just read for that file is used in the `MOVE` statement generated by the compiler. Consequently, you might not get the result you expect if the record just read does not correspond to the level-01 record description. All other rules of the `MOVE` statement apply.

RELATED CONCEPTS

“Logical records” on page 120

“Spanned blocked and unblocked files” on page 125

RELATED TASKS

“Requesting fixed-length format” on page 121
“Requesting variable-length format” on page 122
“Requesting undefined format” on page 126
“Establishing record formats” on page 120

RELATED REFERENCES

“Layout of format-S records”

Spanned blocked and unblocked files: A spanned blocked QSAM file is made up of blocks, each containing one or more logical records or segments of logical records. The logical records can be either fixed or variable in length and their size can be smaller than, equal to, or larger than the physical block size. There are no required relationships between logical records and physical block sizes.

A spanned unblocked file is made up of physical blocks, each containing one logical record or one segment of a logical record. The logical records can be either fixed or variable in length. When the physical block contains one logical record, the block length is determined by the logical record size. When a logical record has to be segmented, the system always writes the largest physical block possible. The system segments the logical record when the entire logical record cannot fit on a track.

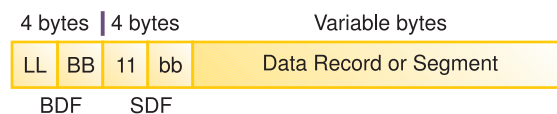
RELATED CONCEPTS

“Logical records” on page 120

RELATED TASKS

“Requesting spanned format” on page 124

Layout of format-S records: Spanned records are preceded by control fields, as shown below.



Each block is preceded by a block descriptor field. There is only one block descriptor field at the beginning of each physical block.

Each segment of a record in a block, even if the segment is the entire record, is preceded by a segment descriptor field. There is one segment descriptor field for each record segment in the block. The segment descriptor field also indicates whether the segment is the first, the last, or an intermediate segment.

You do not describe these fields in the DATA DIVISION of your COBOL program, and the fields are not available for you to use in your program.

RELATED TASKS

“Requesting spanned format” on page 124

RELATED REFERENCES

“Layout of format-F records” on page 121
“Layout of format-V records” on page 123
“Layout of format-U records” on page 126

Requesting undefined format

Format-U records have undefined or unspecified characteristics. With format U, you can process blocks that do not meet format-F or format-V specifications.

When you use format-U files, each block of storage is one logical record. A read of a format-U file returns the entire block as a record, and a write to a format-U file writes a record out as a block.

The compiler determines the recording mode to be U only if you code `RECORDING MODE U`.

It is recommended that you not use format U to update or extend a file that was written with a different record format. If you use format U to update a file that was written with a different format, the `RECFM` in the data set label could be changed or the data set could contain records written in different formats.

The record length is determined in your program based on how you use the `RECORD` clause:

- If you use the `RECORD CONTAINS integer` clause (`RECORD` clause format 1), the record length is the *integer* value, regardless of the lengths of the level-01 record description entries associated with the file.
- If you use the `RECORD IS VARYING` clause (`RECORD` clause format 3), the record length is determined based on whether you code *integer-1* and *integer-2*.
If you code *integer-1* and *integer-2* (`RECORD IS VARYING FROM integer-1 TO integer-2`), the maximum record length is the *integer-2* value, regardless of the lengths of the level-01 record description entries associated with the file.
If you omit *integer-1* and *integer-2*, the maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.
- If you use the `RECORD CONTAINS integer-1 TO integer-2` clause (`RECORD` clause format 2), with *integer-1* and *integer-2* matching the minimum length and the maximum length of the level-01 record description entries associated with the file, the maximum record length is the *integer-2* value.
- If you omit the `RECORD` clause, the maximum record length is determined to be the size of the largest level-01 record description entry associated with the file.

Format-U files and READ INTO: When you specify a `READ INTO` statement for a format-U file, the size of the record just read for that file is used in the `MOVE` statement generated by the compiler. Consequently, you might not get the result you expect if the record just read does not correspond to the level-01 record description. All other rules of the `MOVE` statement apply.

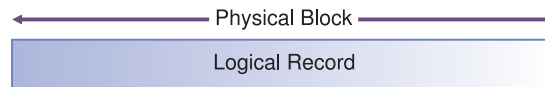
RELATED TASKS

“Requesting fixed-length format” on page 121
“Requesting variable-length format” on page 122
“Requesting spanned format” on page 124
“Establishing record formats” on page 120

RELATED REFERENCES

“Layout of format-U records”

Layout of format-U records: Each block of external storage is handled as a logical record. There are no record-length or block-length fields.



RELATED CONCEPTS

"Logical records" on page 120

RELATED TASKS

"Requesting undefined format" on page 126

RELATED REFERENCES

"Layout of format-F records" on page 121

"Layout of format-V records" on page 123

"Layout of format-S records" on page 125

Setting block sizes

In COBOL, you establish the size of a physical record with the `BLOCK CONTAINS` clause. If you omit this clause, the compiler assumes that the records are not blocked. Blocking QSAM files on tape and disk can enhance processing speed and minimize storage requirements. You can block UNIX system services files (including those in the HFS), PDSE members, and spooled data sets, but doing so has no effect on how the system stores the data.

If you set the block size explicitly in the `BLOCK CONTAINS` clause, it must not be greater than the maximum block size for the device. The block size set for a format-F file must be an integral multiple of the record length.

If your program uses QSAM files on tape, use a physical block size of at least 12 to 18 bytes. Otherwise, the block will be skipped over when a parity check occurs while doing one of the following:

- Reading a block of records of fewer than 12 bytes
- Writing a block of records of fewer than 18 bytes

Generally larger blocks give you better performance. Blocks of only a few kilobytes are particularly inefficient; you should choose a block size of at least tens of kilobytes. If you specify record blocking and omit the block size, the system will pick a block size that is optimal for device utilization and for data transfer speed.

Letting z/OS determine block size

We recommend that to maximize performance, you not explicitly set the block size for a blocked file in your COBOL source program. For new blocked data sets, it is simpler to allow z/OS to supply a system-determined block size. To use this feature, follow these guidelines:

- Code `BLOCK CONTAINS 0` in your source program.
- Do not code `RECORD CONTAINS 0` in your source program.
- Do not code a `BLKSIZE` value in the JCL DD statement.

Setting block size explicitly

If you prefer to set a block size explicitly, your program will be most flexible if you follow these guidelines:

- Code `BLOCK CONTAINS 0` in your source program.
- Code a `BLKSIZE` value in the ddname definition (the JCL DD statement).

For extended-format data sets on z/OS DFSMS adds a 32-byte block suffix to the physical record. If you specify a block size explicitly (using JCL or ISPF), do not include the size of this block suffix in the block size. This block suffix is not available for you to use in your program. DFSMS allocates the space used to read in the block suffix. However, when you calculate how many blocks of a extended-format data set will fit on a track of a direct access device, you need to include the size of the block suffix in the block size.

If you specify a block size larger than 32760 directly on your BLOCK CONTAINS clause or indirectly with the use of BLOCK CONTAINS *n* RECORDS, and you do not meet both the following conditions, the OPEN of the data set fails with file status code 90:

- You use OS/390 V2R10.0 DFSMS or later.
- You define the data set to be tape.

For existing blocked data sets, it is simplest to:

- Code BLOCK CONTAINS 0 in your source program.
- Code no BLKSIZE value in the ddname definition.

When you omit the BLKSIZE from the ddname definition, the block size is automatically obtained by the system from the data set label.

Taking advantage of LBI

You can improve the performance of tape data sets by using OS/390 V2R10.0 DFSMS or later, which provides the large block interface (LBI) for large block sizes. When it is available, the COBOL run time automatically uses this facility for those tape files for which you use system-determined block size. LBI is also used for those files for which you explicitly define a block size in JCL or a BLOCK CONTAINS clause. Use of the LBI allows block sizes to exceed 32760 if the tape device supports it.

The LBI is not used in all cases. An attempt to use a block size greater than 32760 in the following cases is diagnosed at compile time or results in a failure at OPEN:

- Spanned records
- OPEN I-0

Using a block size that exceeds 32760 might result in your not being able to read the tape on another system. A tape that you create with a block size greater than 32760 can be read only on an MVS system that uses OS/390 V2R10.0 DFSMS or later and has a tape device that supports block sizes greater than 32760. If you specify a block size that is too large for the file, the device, or the operating system level, a run-time message is issued.

To limit a system-determined block size to 32760, do not specify BLKSIZE anywhere, and set one of the following to 32760. The block-size limit is the first nonzero value supplied in the following order of precedence:

1. Specify the BLKSZLIM keyword on your DD statement for the data set.
2. Have your systems programmer set BLKSZLIM for the data class using the BLKSZLIM keyword.
3. Have your systems programmer set a block-size limit for the system in the DEVSUPxx member of SYS1.PARMLIB using the keyword TAPEBLKSZLIM.

If no BLKSIZE or BLKSZLIM value is available from any source, the system limits BLKSIZE to 32760. You can then enable block sizes larger than 32760 in one of two ways:

- Specify a BLKSZLIM value greater than 32760 in the DD statement for the file and use BLOCK CONTAINS 0 in your COBOL source.
- Specify a value greater than 32760 for the BLKSIZE in the DD statement or in the BLOCK CONTAINS clause in your COBOL source.

BLKSZLIM is device-independent.

Block size and the DCB RECFM subparameter

Under z/OS, you can code the S or T option in the DCB RECFM subparameter:

- Use the S (standard) option in the DCB RECFM subparameter for a format-F record with only standard blocks (ones that have no truncated blocks or unfilled tracks in the file, except for the last block of the file). S is also supported for records on tape. It is ignored if the records are not on DASD or tape.

Using this standard block option might improve input-output performance, especially for direct access devices.

- The T (track overflow) option for QSAM files is no longer useful.

RELATED TASKS

“Defining QSAM files and records in COBOL” on page 119
z/OS DFSMS: Using Data Sets

RELATED REFERENCES

BLOCK CONTAINS clause (*Enterprise COBOL Language Reference*)

Coding input and output statements for QSAM files

Code the following input and output statements to process a QSAM file or a byte-stream file in the HFS using QSAM:

OPEN Makes the file available to your program.

You can open all QSAM files as INPUT, OUTPUT, or EXTEND (depending on device capabilities).

You can also open QSAM files on direct access storage devices as I-0. You cannot open HFS files as I-0; you will receive a file status of 37 if you attempt to do so.

READ Reads a record from the file.

With sequential processing, your program reads one record after another in the same order in which they were entered when the file was created.

WRITE Creates a record in the file.

Your program writes new records to the end of the file.

REWRITE

Updates a record. You cannot update a file in the HFS using REWRITE.

CLOSE Releases the connection between the file and your program.

RELATED TASKS

“Opening QSAM files” on page 130
“Adding records to QSAM files” on page 131

“Updating QSAM files” on page 131
“Writing QSAM files to a printer or spooled data set” on page 131
“Closing QSAM files” on page 132

RELATED REFERENCES

OPEN statement (*Enterprise COBOL Language Reference*)
READ statement (*Enterprise COBOL Language Reference*)
WRITE statement (*Enterprise COBOL Language Reference*)
REWRITE statement (*Enterprise COBOL Language Reference*)
CLOSE statement (*Enterprise COBOL Language Reference*)
Status key (Common processing facilities) (*Enterprise COBOL Language Reference*)

Opening QSAM files

Before your program can use any READ, WRITE, or REWRITE statements to process records in a file, it must first open the file with an OPEN statement.

An OPEN statement works if both of the following are true:

- The file is available or has been dynamically allocated.
- The *fixed file attributes* coded in the ddname definition or the data set label for a file match the attributes coded for that file in the SELECT and FD statements of your COBOL program.

Mismatches in the file organization attributes, code set, maximum record size, or record type (fixed or variable) result in a file status code 39, and the OPEN statement fails. Mismatches in maximum record size and record type are not considered errors when opening files in the HFS.

For fixed-length QSAM files, when you code RECORD CONTAINS 0 in the FD, the record size attributes are not in conflict. The record size is taken from the DD statement or the data set label, and the OPEN statement is successful.

Code CLOSE WITH LOCK so that the file cannot be opened again while the program is running.

Use the REVERSED option of the OPEN statement to process tape files in reverse order. Execution of the OPEN statement will then position the file at its end. Subsequent READ statements read the data records in reverse order, starting with the last record. The REVERSED option is supported only for files with fixed-length records.

RELATED TASKS

“Dynamically creating QSAM files with CBLQDA”

RELATED REFERENCES

OPEN statement (*Enterprise COBOL Language Reference*)

Dynamically creating QSAM files with CBLQDA

A file is considered to be available on z/OS when it has been identified to the operating system using a DD statement, an export command (an environment variable), or a TSO ALLOCATE command. (For availability, a DD statement with a misspelled ddname is equivalent to a missing DD statement; an environment variable with a value that is not valid is equivalent to an unset variable.)

Sometimes a QSAM file is unavailable on the operating system, but the COBOL language defines that the file be created. The file is implicitly created for you if you use the run-time option CBLQDA and one of the following circumstances exists:

- The file is being opened for OUTPUT, regardless of the OPTIONAL phrase.

- An OPTIONAL file is being opened as EXTEND or I-0.

Optional files are files that are not necessarily present each time the program is run. You can define files opened in INPUT, I-0, or EXTEND mode as optional by using the SELECT OPTIONAL phrase in the FILE-CONTROL paragraph.

The file is allocated with the system default attributes established at your installation and the attributes coded in the SELECT and FD statements in your program.

Do not confuse this implicit allocation mechanism with the dynamic allocation of files through the use of environment variables. That explicit dynamic allocation requires a valid environment variable to be set. This CBLQDA support is used only when the QSAM file is unavailable as defined above, which includes no valid environment variable being set.

Under z/OS, files created using the CBLQDA option are temporary data sets and do not exist after the program has run.

RELATED TASKS

“Opening QSAM files” on page 130

Adding records to QSAM files

To add to a QSAM file, open the file as EXTEND and use the WRITE statement to add records immediately after the last record in the file.

To add records to a file opened as I-0, you must first close the file and open it as EXTEND.

RELATED REFERENCES

READ statement (*Enterprise COBOL Language Reference*)

WRITE statement (*Enterprise COBOL Language Reference*)

Updating QSAM files

You can update QSAM files that reside on direct access storage devices only. You cannot update files in the HFS.

Replace an existing record with another record of the same length by doing these steps:

1. Open the file as I-0.
2. Use REWRITE to update an existing record in the file. (The last file processing statement before REWRITE must have been a successful READ statement.)

You cannot open as I-0 an extended format data set that you allocate in the compressed format.

RELATED REFERENCES

REWRITE statement (*Enterprise COBOL Language Reference*)

Writing QSAM files to a printer or spooled data set

COBOL provides language statements to control the size of a printed page and control the vertical positioning of records.

Controlling the page size

Use the LINAGE clause of the FD entry to control the size of your printed page: the number of lines in the top and bottom margins and in the footing area of the page. When you use the LINAGE clause, COBOL handles the file as if you had also requested the ADV compiler option.

If you use the LINAGE clause in combination with WRITE BEFORE/AFTER ADVANCING *nn* LINES, be careful about the values you set. With the ADVANCING *nn* LINES clause, COBOL first calculates the sum of LINAGE-COUNTER plus *nn*. Subsequent actions depend on the size of *nn*. The END-OF-PAGE imperative statement is performed after the LINAGE-COUNTER is increased. Consequently, the LINAGE-COUNTER could be pointing to the next logical page instead of to the current footing area when the END-OF-PAGE statement is performed.

AT END-OF-PAGE or NOT AT END-OF-PAGE imperative statements are performed only if the write operation completes successfully. If the write operation is unsuccessful, control is passed to the end of the WRITE statement, omitting all conditional phrases.

Controlling the vertical positioning of records

Use the WRITE ADVANCING statement to control the vertical positioning of each record you write on a printed page.

- . . . BEFORE ADVANCING prints the record before the page is advanced.
- . . . AFTER ADVANCING prints the record after the page is advanced.

Specify the number of lines the page is advanced with an integer (or an *identifier* with a *mnemonic-name*) following ADVANCING. If you omit the ADVANCING option from your WRITE statement, you get the equivalent of:

```
AFTER ADVANCING 1 LINE
```

RELATED REFERENCES

WRITE statement (*Enterprise COBOL Language Reference*)

Closing QSAM files

Use the CLOSE statement to disconnect your program from the QSAM file. If you try to close a file that is already closed, you will get a logic error.

If you do not close a QSAM file, the file is automatically closed for you under the following conditions, except for files defined in any OS/VS COBOL programs in the run unit:

- When the run unit ends normally, the run time closes all open files that are defined in any COBOL programs in the run unit.
- If the run unit ends abnormally and you have set the TRAP(ON) run-time option, the run time closes all open files that are defined in any COBOL programs in the run unit.
- When Language Environment condition handling is completed and the application resumes in a routine other than where the condition occurred, the run time closes all open files that are defined in any COBOL programs in the run unit that might be called again and reentered.

You can change the location where the program resumes running (after a condition is handled) by moving the resume cursor with the Language Environment CEEMRCR callable service or by using HLL language constructs such as a C longjmp.

- When you use CANCEL for a COBOL subprogram, the run time closes any open nonexternal files that are defined in that program.
- When a COBOL subprogram with the INITIAL attribute returns control, the run time closes any open nonexternal files that are defined in that program.
- When a thread of a multithreaded application ends, both external and nonexternal files that you opened from within that same thread are closed.

File status key data items that you define in the WORKING-STORAGE SECTION are set when these implicit CLOSE operations are performed, but your EXCEPTION/ERROR and LABEL declaratives are not invoked.

If you open a QSAM file in a multithreaded application, you must close it from the same thread of execution from which the file was opened. Attempting to close the file from a different thread results in a close failure with file-status condition 90.

RELATED REFERENCES

CLOSE statement (*Enterprise COBOL Language Reference*)

Handling errors in QSAM files

When an input-statement or output-statement operation fails, COBOL does not take corrective action for you. You choose whether or not your program will continue running after a less-than-severe input or output error occurs.

COBOL provides these ways for you to intercept and handle certain QSAM input and output errors:

- End of file phrase (AT END)
- EXCEPTION/ERROR declarative
- FILE STATUS clause
- INVALID KEY phrase

If you do not code a FILE STATUS key or a declarative, serious QSAM processing errors will cause a message to be issued and a Language Environment condition to be signaled, which will cause an abend if you specify the run-time option ABTERMENC(ABEND).

If you use the FILE STATUS clause or the EXCEPTION/ERROR declarative, code EROPT=ACC in the DCB of the DD statement for that file. Otherwise, your COBOL program will not be able to continue processing after some error conditions.

If you use the FILE STATUS clause, be sure to check the key and take appropriate action based on its value. If you do not check the key, your program might continue, but the results will probably not be what you expected.

RELATED TASKS

“Handling errors in input and output operations” on page 203

Working with QSAM files

This section describes:

- “Defining and allocating QSAM files” on page 134
- “Retrieving QSAM files” on page 136
- “Ensuring file attributes match your program” on page 137

- “Using striped extended-format QSAM data sets” on page 139

RELATED REFERENCES

“Allocation of buffers for QSAM files” on page 140

Defining and allocating QSAM files

You can define a QSAM file or a byte-stream file in the HFS using either a DD statement or an environment variable. When you use an environment variable, the name must be in uppercase. Allocation of these files follows the general rules for the allocation of COBOL files. When you use an environment variable to define a QSAM file, specify the MVS data set as follows:

DSN(*dataset-name*) or DSN(*dataset-name(member-name)*). *dataset-name* must be fully qualified and cannot be a temporary data set (that is, it must not start with &).

You can optionally specify the following attributes in any order following the DSN:

- A disposition value, one of: NEW, OLD, SHR, or MOD
- TRACKS or CYL
- SPACE(*nnn,mmm*)
- VOL(*volume-serial*)
- UNIT(*type*)
- KEEP, DELETE, CATALOG, or UNCATALOG
- STORCLAS(*storage-class*)
- MGMTCLAS(*management-class*)
- DATACLAS(*data-class*)

You can use either an environment variable or a DD definition to define a file in the HFS. To do this, define one of the following with a name that matches the external name on your ASSIGN clause:

- A DD allocation that uses PATH=*'absolute-path-name'* and FILEDATA=BINARY
- An environment variable with a value PATH(*pathname*), where *pathname* is an absolute path name (starting with /).

For compatibility with releases of COBOL before COBOL for OS/390 & VM Version 2 Release 2, you can also specify FILEDATA=TEXT when using a DD allocation for HFS files, but this use is not recommended. To process text files in the HFS, use LINE SEQUENTIAL organization. If you do use QSAM to process text files in the HFS, you cannot use environment variables to define the files.

When you define a QSAM file, use the specified parameters to do the following:

Table 19. QSAM file allocation

What you want to do	DD parameter to use	EV keyword to use
Name the file	DSNAME (data set name)	DSN
Select the type and quantity of input-output devices to be allocated for the file.	UNIT	UNIT for type only
Give instructions for the volume in which the file will reside and for volume mounting.	VOLUME, or let the system choose an output volume.	VOL

Table 19. QSAM file allocation (continued)

What you want to do	DD parameter to use	EV keyword to use
Allocate the type and amount of space the file needs. (For direct access storage devices only.)	SPACE	SPACE for the amount of space (primary and secondary only); TRACKS or CYL for the type of space
Specify the type (and some of the contents of) the label associated with the file.	LABEL	n/a
Indicate whether you want to catalog, pass, or keep the file after the job step is completed.	DISP	NEW, OLD, SHR, MOD plus KEEP, DELETE, CATALOG, or UNCATALOG
Complete any data control block information that you want to add.	DCB subparameters	n/a

Some of the information about the QSAM file must always be coded in the FILE-CONTROL entry, the FD entry, and other COBOL clauses. Other information must be coded in the DD statement or environment variable for output files. For input files, the system can obtain information from the file label (for standard label files). If DCB information is provided in the DD statement for input files, it overrides information on the data set label. For example, the amount of space allocated for a new direct-access device file can be set in the DD statement by the SPACE parameter.

You cannot express certain characteristics of QSAM files in the COBOL language, but you can code them in the DD statement for the file using the DCB parameter. Use the subparameters of the DCB parameter to provide information that the system needs for completing the data set definition, including the following:

- Block size (BLKSIZE=), if BLOCK CONTAINS 0 RECORDS was coded at compile time (which is recommended)
- Options to be executed if an error occurs in reading or writing a record
- TRACK OVERFLOW or standard blocks
- Mode of operation for a card reader or punch

DCB attributes coded for a DD DUMMY do not override those coded in the FD entry of your COBOL program.

RELATED TASKS

“Setting block sizes” on page 127

“Defining QSAM files and records in COBOL” on page 119

“Allocating files” on page 117

RELATED REFERENCES

“Parameters for creating QSAM files”

MVS JCL Reference

Parameters for creating QSAM files

The following DD statement parameters are frequently used to create QSAM files.

```

DSNAME= [ dataset-name
DSN=     dataset-name(member-name)
         &&name
         &&name(member-name) ]

UNIT=   ( name[,unitcount] )

VOLUME= ( [PRIVATE] [,RETAIN] [,vol-sequence-num] [,volume-count] ...
VOL=     ... [ ,SER=(volume-serial[,volume-serial]...) ]
           [ ,REF= [ dsname
                    *.ddname
                    *.stepname.ddname
                    *.stepname.procstep.ddname ] ] )

SPACE=   ( [TRK
           CYL
           average-record-length] , (primary-quantity[,secondary-quantity] [,directory-quantity]))

LABEL=   ( [Data-set-sequence-number,] [ NL
                                         SL
                                         SUL ] [ ,EXPDT= [ yyddd
                                                             yyyy/ddd ] ] )
                                         [ ,RETPD=xxxx ] )

DISP=    ( [NEW
           MOD ] [ ,DELETE
                  ,KEEP
                  ,PASS
                  ,CATLG ] [ ,DELETE
                             ,KEEP
                             ,CATLG ] )

DCB=     ( subparameter-list )

```

RELATED TASKS

“Defining and allocating QSAM files” on page 134

Retrieving QSAM files

You retrieve QSAM files, cataloged or not, by using job control statements or environment variables.

Cataloged files

All data set information, such as volume and space, is stored in the catalog and file label. All you have to code are the data set name and a disposition. When you use a DD statement, this is the DSNAME parameter and the DISP parameter. When you use an environment variable, this is the DSN parameter and one of the parameters OLD, SHR, or MOD.

Noncataloged files

Some information is stored in the file label, but you must code the unit and volume information as well as the *dsname* and disposition.

If you are using JCL, and you created the file in the current job step or in a previous job step in the current job, you can refer to the previous DD statement for most of the data set information. You do, however, need to code DSNAME and DISP.

RELATED REFERENCES

“Parameters for retrieving QSAM files”

Parameters for retrieving QSAM files

The following DD statement parameters are used to retrieve previously created files.

```

DSNAME= [ dataset-name
DSN=    dataset-name(member-name)
        *.ddname
        *.stepname.ddname
        &&name
        &&name(member-name) ]

UNIT=   ( name[,unitcount] )

VOLUME= ( subparameter-list )
VOL=

LABEL=  ( subparameter-list )


DISP=   ( [ OLD
           SHR
           MOD ] [ ,DELETE
                  ,KEEP
                  ,PASS
                  ,CATLG
                  ,UNCATLG ] [ ,DELETE
                               ,KEEP
                               ,CATLG
                               ,UNCATLG ] )

DCB=    ( subparameter-list )

```

RELATED TASKS

“Retrieving QSAM files” on page 136

Ensuring file attributes match your program

When the fixed file attributes coded in the DD statement or the data set label for a file and the attributes coded for that file in the SELECT and FD statements of your COBOL program are not consistent, an OPEN statement in your program might not work. Mismatches in the attributes for file organization, record format (fixed or variable), record length, or the code set result in a file status code 39, and the OPEN statement fails. An exception exists for files in the HFS: mismatches in record format and record length do not cause an error.

To prevent common file status 39 problems, follow the guidelines listed below for processing files that are existing, new, or dynamically created by COBOL.

Remember that information in the JCL or environment variable overrides information in the data set label.

Processing existing files

When your program processes an existing file, code the description of the file in your COBOL program to be consistent with the file attributes of the data set. Use these guidelines to define the maximum record length.

Table 20. Maximum record length of QSAM files

For this format	Specify this
V or S	Exactly 4 bytes smaller than the length attribute of the data set
F	Same as the length attribute of the data set
U	Same as the length attribute of the data set

Defining variable-length (format-V) records

The easiest way to define variable-length records in your program is to use RECORD IS VARYING FROM *integer-1* TO *integer-2* in the FD entry and set an appropriate value for *integer-2*. For example, assume that you have determined the length attribute of the data set to be 104 (LRECL=104). Remembering that the maximum record length is determined from the RECORD IS VARYING clause (in which values are set) and not from the level-01 record descriptions, you could define a format-V file in your program with this code:

```
FILE SECTION.  
FD  COMMUTER-FILE-MST  
    RECORDING MODE IS V  
    RECORD IS VARYING FROM 4 TO 100 CHARACTERS.  
01  COMMUTER-RECORD-A          PIC X(4).  
01  COMMUTER-RECORD-B          PIC X(75).
```

Defining format-U records

Assume that the existing file in the previous example was format-U instead of format-V. If the 104 bytes are all user data, you could define the file in your program with this code:

```
FILE SECTION.  
FD  COMMUTER-FILE-MST  
    RECORDING MODE IS U  
    RECORD IS VARYING FROM 4 TO 104 CHARACTERS.  
01  COMMUTER-RECORD-A          PIC X(4).  
01  COMMUTER-RECORD-B          PIC X(75).
```

Defining fixed-length records

To define fixed-length records in your program, use either the RECORD CONTAINS *integer* clause, or omit this clause and code all level-01 record descriptions to be the same fixed size. In either case, use a value that equals the value of the length attribute of the data set. When you intend to use the same program to process different files at run time and the files have differing fixed-length record lengths, the recommended way to avoid record-length conflicts is to code RECORD CONTAINS 0.

If the existing file is an ASCII data set (DCB=(OPTCD=Q)), you must use the CODE-SET clause in the program's FD entry for the file.

Processing new files

When your COBOL program will write records to a new file that is made available before the program is run, ensure that the file attributes you code in the DD statement, the environment variable, or the allocation do not conflict with the attributes you have coded in your program. Usually, you need to code only a minimum of parameters when predefining your files.

When you do need to explicitly set a length attribute for the data set (for example, you are using an ISPF allocation panel or if your DD statement is for a batch job in which the program uses RECORD CONTAINS 0):

- For format-V and format-S files, set a length attribute that is 4 bytes larger than that defined in the program.
- For format-F and format-U files, set a length attribute that is the same as that defined in the program.
- If you open your file as OUTPUT and write it to a printer, the compiler might add 1 byte to the record length to account for the carriage control character, depending on the ADV compiler option and the COBOL language used in your program. In such a case, take the added byte into account when coding the LRECL.

For example, suppose your program contains the following code for a file with variable-length records:

```
FILE SECTION.  
FD  COMMUTER-FILE-MST  
   RECORDING MODE IS V  
   RECORD CONTAINS 10 TO 50 CHARACTERS.  
01  COMMUTER-RECORD-A          PIC X(10).  
01  COMMUTER-RECORD-B          PIC X(50).
```

The LRECL in your DD statement or allocation should be 54.

Processing files dynamically created by COBOL

When you have not made a file available with a DD statement or a TSO ALLOCATE command and your COBOL program defines that the file be created, Enterprise COBOL dynamically allocates the file. When the file is opened, the file attributes coded in your program are used. You do not have to worry about file attribute conflicts.

RELATED TASKS

“Requesting fixed-length format” on page 121

“Requesting variable-length format” on page 122

“Requesting undefined format” on page 126

“Dynamically creating QSAM files with CBLQDA” on page 130

Using striped extended-format QSAM data sets

A striped extended-format QSAM data set is an extended-format QSAM data set that is spread over multiple volumes, allowing parallel data access.

Striped extended-format QSAM data sets can benefit an application with these characteristics:

- The application processes files that contain large volumes of data.
- The time for the input and output operations to the files significantly affects overall performance.

For you to gain the maximum benefit from using QSAM striped data sets, DFSMS needs to be able to allocate the required number of buffers above the 16-MB line.

When you develop applications that contain files allocated to QSAM striped data sets, follow these guidelines:

- Avoid using a QSAM striped data set for a file that cannot have buffers allocated above the 16-MB line.
- Omit the RESERVE clause in the FILE-CONTROL paragraph entry for the file. Omitting the RESERVE clause allows DFSMS to determine the optimum number of buffers for the data set.
- Compile your program with the DATA(31) and RENT compiler options, and make the load module AMODE 31.
- Specify the ALL31(ON) run-time option if the file is an EXTERNAL file with format-F, format-V, or format-U records.

Notice that all striped data sets are extended format data sets, but not all extended format data sets are striped.

RELATED TASKS

z/OS DFSMS: Using Data Sets (performance considerations)

RELATED REFERENCES

“Allocation of buffers for QSAM files”

Allocation of buffers for QSAM files

DFSMS automatically allocates buffers for storing input and output for QSAM files above or below the 16-MB line as appropriate for the file being used. Most QSAM files have buffers allocated above the 16-MB line. Exceptions are:

- Programs running in AMODE 24.
- Programs compiled with the DATA(24) and RENT options.
- Programs compiled with the NORENT and RMODE(24) options.
- Programs compiled with the NORENT and RMODE(AUTO) options.
- EXTERNAL files, when the ALL31(OFF) run-time option is being specified. To specify the ALL31(ON) run-time option, all programs in the run unit must be capable of running in 31-bit addressing mode.
- Files allocated to the TSO terminal.
- A file with format-S (spanned) records, if the file is any of the following:
 - An EXTERNAL file (even if the ALL31(ON) option is specified)
 - A file specified in a SAME RECORD AREA clause of the I-O-CONTROL paragraph
 - A blocked file that is opened I-O and updated using the REWRITE statement

RELATED CONCEPTS

“Storage and its addressability” on page 34

RELATED TASKS

“Using striped extended-format QSAM data sets” on page 139

Accessing HFS files using QSAM

You can process byte-stream files in the hierarchical file system (HFS) as ORGANIZATION SEQUENTIAL files using QSAM. To do this, specify as the *assignment-name* on the ASSIGN clause one of the following:

ddname

A DD allocation that identifies the file with the keywords PATH= and FILEDATA=BINARY

Environment variable name

An environment variable with the run-time value of the HFS path for the file

Observe the following restrictions:

- Spanned record format is not supported.
- OPEN I-O and REWRITE are not supported. If you attempt one of these operations, you will get the following file status conditions:
 - 37 from OPEN I-O
 - 47 from REWRITE (because you could not have successfully opened the file as I-O)

Usage notes

- File status 39 (fixed file attribute conflict) is not enforced for either of the following:
 - Record-length conflict
 - Record-type conflict (fixed versus variable)

- A READ returns the number of bytes equal to that of the maximum logical record size for the file except for the last record, which might be shorter.

For example, suppose your file definition has 01 record descriptions of 3, 5, and 10 bytes long, and you write the following three records: 'abc', 'defgh', and 'ijklmnopqr', in that order. Your first READ of this file returns 'abcdefghij', your second READ returns 'klmnopqr ', and your third READ results in the AT END condition.

For compatibility with releases of IBM COBOL before COBOL for OS/390 & VM Version 2 Release 2, you can also specify FILEDATA=TEXT when using a DD allocation for HFS files, but this use is not recommended. To process text files in the HFS, use the LINE SEQUENTIAL organization. If you use QSAM to process text files in the HFS, you cannot use environment variables to define the files.

RELATED TASKS

"Allocating files" on page 117

"Defining and allocating QSAM files" on page 134

Accessing HFS files via BSAM and QSAM (z/OS DFSMS: Using Data Sets)

Labels for QSAM files

You can use labels to identify magnetic tape and direct access volumes and data sets. The operating system uses label processing routines to identify and verify labels and locate volumes and data sets.

There are two kinds of labels: standard and nonstandard. IBM Enterprise COBOL for z/OS does not support nonstandard user labels. In addition, standard user labels contain user-specified information about the associated data set.

Standard labels consist of volume labels and groups of data set labels. Volume labels precede or follow data on the volume, and identify and describe the volume. The data set labels precede or follow each data set on the volume, and identify and describe the data set.

- The data set labels that precede the data set are called *header labels*.
- The data set labels that follow the data set are called *trailer labels*. They are similar to the header labels, except that they also contain a count of blocks in the data set.
- The data set label groups can optionally include standard user labels.
- The volume label groups can optionally include standard user labels.

RELATED TASKS

"Using trailer and header labels"

RELATED REFERENCES

"Format of standard labels" on page 143

Using trailer and header labels

You can create, examine, or update user labels when the beginning or end of a data set or volume (reel) is reached. End-of-volume or beginning-of-volume exits are allowed. You can also create or examine intermediate trailers and headers.

You can create, examine, or update up to eight header labels and eight trailer labels on each volume of the data set. (QSAM EXTEND works in a manner identical to OUTPUT except that the beginning-of-file label is not processed.) Labels reside on

the initial volume of a multivolume data set. This volume must be mounted as CLOSE if trailer labels are to be created, examined, or updated. Trailer labels for files opened as INPUT or I-O are processed when a CLOSE statement is performed for the file that has reached an AT END condition.

If you code a header or trailer with the wrong position number, the result is unpredictable. (Data management might force the label to the correct relative position.)

When you use standard label processing, code the label type of the standard and user labels (SUL) on the DD statement that describes the data set.

Getting a user-label track

If you use a LABEL subparameter of SUL for direct access volumes, a separate user-label track will be allocated when the data set is created. This additional track is allocated at initial allocation and for sequential data sets at end-of-volume (volume switch). The user-label track (one per volume of a sequential data set) will contain both user header and user trailer labels. If a LABEL name is referenced outside the user LABEL declarative, results are unpredictable.

Handling user labels

The USE AFTER LABEL declarative provides procedures for handling user labels on supported files. The AFTER option indicates processing of standard user labels.

List the labels as *data-names* in the LABEL RECORDS clause in the FD entry for the file.

Table 21. Handling of QSAM user labels

When the file is opened as:	And:	Result:
INPUT	USE . . . LABEL declarative is coded for the OPEN option or for the file.	The label is read and control is passed to the LABEL declarative.
OUTPUT	USE . . . LABEL declarative is coded for the OPEN option or for the file.	A buffer area for the label is provided and control is passed to the LABEL declarative.
INPUT or I-O	CLOSE statement is performed for the file that has reached the AT END condition.	Control is passed to the LABEL declarative for processing trailer labels.

You can specify a special exit by using the statement GO TO MORE-LABELS. When this statement results in an exit from a label DECLARATIVE SECTION, the system does one of the following:

- Writes the current beginning or ending label and then reenters the USE section at its beginning to create more labels. After creating the last label, the system exits by performing the last statement of the section.
- Reads an additional beginning or ending label, and then reenters the USE section at its beginning to check more labels. When processing user labels, the system reenters the section only if there is another user label to check. Hence, a program path that flows through the last statement in the section is not needed.

If a GO TO MORE-LABELS statement is not performed for a user label, the DECLARATIVE SECTION is not reentered to check or create any immediately succeeding user labels.

Format of standard labels

Standard labels are 80-character records that are recorded in EBCDIC or ASCII. The first four characters are always used to identify the labels. The figure below shows these *identifiers* for tape.

Table 22. Identifiers for standard tape labels

Identifier	Description
VOL1	Volume label
HDR1 or HDR2	Data set header labels
EOV1 or EOV2	Data set trailer labels (end-of-volume)
EOF1 or EOF2	Data set trailer labels (end-of-data-set)
UHL1 to UHL8	User header labels
UTL1 to UTL8	User trailer labels

The format of the label for a direct-access volume is the almost the same as the format of the label group for a tape volume label group. The difference is that a data set label of the initial DASTO volume label consists of the data set control block (DSCB). The DSCB appears in the volume table of contents (VTOC) and contains the equivalent of the tape data set header and trailer, in addition to control information such as space allocation.

Standard user labels

User labels are optional within the standard label groups.

The format used for user header labels (UHL1-8) and user trailer labels (UTL1-8) consists of a label 80 characters in length recorded in either:

- EBCDIC on DASD or on IBM standard labeled tapes
- ASCII or ISO/ANSI labeled tapes

The first 3 bytes consist of the characters that identify the label as either:

- UHL for a user header label (at the beginning of a data set)
- UTL for a user trailer label (at the end-of-volume or end-of-data set)

The next byte contains the relative position of this label within a set of labels of the same type. One through eight labels are permitted.

The remaining 76 bytes consist of user-specified information.

Standard user labels are not supported for QSAM striped data sets.

Processing QSAM ASCII files on tape

If your program processes an QSAM ASCII file, do the following:

1. Request the ASCII alphabet.
2. Define the record formats.
3. Define the ddname (with JCL).

In addition, if your program processes numeric data items from ASCII files, use the separately signed numeric data type (SIGN IS LEADING SEPARATE).

The CODEPAGE compiler option has no effect on the code page used for conversions between ASCII and EBCDIC for ASCII tape support. See the z/OS DFSMS documentation for information about how CCSIDs used for the ASCII tape support are selected and what the default CCSIDs are.

Requesting the ASCII alphabet

In the SPECIAL-NAMES paragraph, code STANDARD-1 for ASCII:

```
ALPHABET-NAME IS STANDARD-1
```

In the FD statement for the file, code:

```
CODE-SET IS ALPHABET-NAME
```

Defining the record formats

Process QSAM ASCII tape files with any of these record formats:

- Fixed length (format F)
- Undefined (format U)
- Variable length (format V)

If you are using variable-length records, you cannot explicitly code format D; instead, code RECORDING MODE V. The format information is internally converted to D mode. D-mode records have a 4-byte record descriptor for each record.

Defining the ddname

Under z/OS, processing ASCII files requires special JCL coding. Code these subparameters of the DCB parameter in the DD statement:

BUFOFF=[*L* | *n*]

L A 4-byte block prefix that contains the block length (including the block prefix).

n The length of the block prefix:

- For input, from 0 through 99
- For output, either 0 or 4

Use this value if you coded BLOCK CONTAINS 0.

BLKSIZE=*n*

n The size of the block, including the length of the block prefix.

LABEL=[AL | AUL | NL]

- AL** American National Standard (ANS) labels.
- AUL** ANS and user labels.
- NL** No labels.

OPTCD=Q

- Q** This value is required for ASCII files and is the default if the file is created using Enterprise COBOL.

RELATED TASKS

“Processing ASCII file labels”

Converting Character Data (*z/OS DFSMS: Using Data Sets*)

Processing ASCII file labels

Standard label processing for ASCII files is the same as standard label processing for EBCDIC files. The system translates ASCII code into EBCDIC before processing.

All ANS user labels are optional. ASCII files can have user header labels (UHL*n*) and user trailer labels (UTL*n*). There is no limit to the number of user labels at the beginning and the end of a file; you can write as many labels as you need. All user labels must be 80 bytes in length.

To create or verify user labels (user label exit), code a USE AFTER STANDARD LABEL procedure. You cannot use USE BEFORE STANDARD LABEL procedures.

ASCII files on tape can have:

- ANS labels
- ANS and user labels
- No labels

Any labels on an ASCII tape must be in ASCII code only. Tapes containing a combination of ASCII and EBCDIC cannot be read.

RELATED TASKS

“Processing QSAM ASCII files on tape” on page 144

Chapter 10. Processing VSAM files

Virtual storage access method (VSAM) is an access method for files on direct-access storage devices. With VSAM you can:

- Load a file
- Retrieve records from a file
- Update a file
- Add, replace, and delete records in a file

VSAM processing has these advantages over QSAM:

- Protection of data against unauthorized access
- Compatibility across systems
- Independence of devices (no need to be concerned with block size and other control information)
- Simpler JCL (information needed by the system is provided in integrated catalogs)
- Ability to use indexed file organization or relative file organization

The lists below show how VSAM terms differ from COBOL terms and other terms that you might be familiar with.

VSAM term	COBOL term	Similar non-VSAM term
Data set	File	Data set
Entry-sequenced data set (ESDS)	Sequential file	QSAM data set
Key-sequenced data set (KSDS)	Indexed file	ISAM data set
Relative-record data set (RRDS)	Relative file	BDAM data set
Control interval		Block
Control interval size (CISZ)		Block size
Buffers (BUFNI/BUFND)		BUFNO
Access method control block (ACB)		Data control block (DCB)
Cluster (CL)		Data set
Cluster definition		Data set allocation
AMP parameter of JCL DD statement		DCB parameter of JCL DD statement
Record size		Record length

The term *file* in this VSAM information refers to either a COBOL file or a VSAM data set.

If you have complex requirements or frequently use VSAM, review the VSAM publications for your operating system.

RELATED CONCEPTS

“VSAM files” on page 148

RELATED TASKS

“Defining VSAM file organization and records” on page 149

“Coding input and output statements for VSAM files” on page 155

“Protecting VSAM files with a password” on page 164

“Handling errors in VSAM files” on page 164

“Working with VSAM data sets under z/OS and UNIX” on page 165
“Improving VSAM performance” on page 171

RELATED REFERENCES

z/OS DFSMS: Using Data Sets

z/OS DFSMS Macro Instructions for Data Sets

z/OS DFSMS: Access Method Services for Catalogs

VSAM files

The physical organization of VSAM data sets differs considerably from those used by other access methods. VSAM data sets are held in control intervals (CI) and control areas (CA). The size of these is normally determined by the access method, and the way in which they are used is not visible to you.

You can use three types of file organization with VSAM.

VSAM sequential file organization

(Also referred to as VSAM ESDS (entry-sequenced data set) organization.)

In VSAM sequential file organization, the records are stored in the order in which they were entered. VSAM entry-sequenced data sets are equivalent to QSAM sequential files. The order of the records is fixed.

VSAM indexed file organization

(Also referred to as VSAM KSDS (key-sequenced data set) organization.) In a VSAM indexed file (KSDS), the records are ordered according to the collating sequence of an embedded prime key field, which you define. The prime key consists of one or more consecutive characters in the records.

The prime key uniquely identifies the record and determines the sequence in which it is accessed with respect to other records. A prime key for a record might be, for example, an employee number or an invoice number.

VSAM relative file organization

(Also referred to as VSAM fixed-length or variable-length RRDS (relative-record data set) organization.) A VSAM relative-record data set (RRDS) contains records ordered by their relative key. The relative key is the relative record number that represents the location of the record relative to where the file begins. The relative record number identifies the fixed- or variable-length record.

In a VSAM fixed-length RRDS, records are placed in a series of fixed-length slots in storage. Each slot is associated with a relative record number. For example, in a fixed-length RRDS containing 10 slots, the first slot has a relative record number of 1, and the tenth slot has a relative record number of 10.

In a VSAM variable-length RRDS, the records are ordered according to their relative record number. Records are stored and retrieved according to the relative record number that you set.

Throughout this documentation, the term *VSAM relative-record data set* (or *RRDS*) is used to mean both relative-record data sets with fixed-length records and with variable-length records, unless they need to be differentiated.

The following table compares the different types of VSAM data sets in terms of several characteristics.

Table 23. Comparison of VSAM data set types

Characteristic	Entry-sequenced data set (ESDS)	Key-sequenced data set (KSDS)	Relative-record data set (RRDS)
Order of records	Order in which they are written	Collating sequence by key field	Order of relative record number
Access	Sequential	By key through an index	By relative record number, which is handled like a key
Alternate indexes	Can have one or more alternate indexes, although not supported in COBOL	Can have one or more alternate indexes	Cannot have alternate indexes
Relative byte address (RBA) and relative record number (RRN) of a record	RBA cannot change.	RBA can change.	RRN cannot change.
Space for adding records	Uses space at the end of the data set	Uses distributed free space for inserting records and changing their lengths in place	For fixed-length RRDS, uses empty slots in the data set For variable-length RRDS, uses distributed free space and changes the lengths of added records in place
Space from deleting records	You cannot delete a record, but you can reuse its space for a record of the same length.	Space from a deleted or shortened record is automatically reclaimed in a control interval.	Space from a deleted record can be reused.
Spanned records	Can have spanned records	Can have spanned records	Cannot have spanned records
Reuse as work file	Can be reused unless it has an alternate index, is associated with key ranges, or exceeds 123 extents per volume	Can be reused unless it has an alternate index, is associated with key ranges, or exceeds 123 extents per volume	Can be reused

RELATED TASKS

“Specifying sequential organization for VSAM files” on page 150

“Specifying indexed organization for VSAM files” on page 150

“Specifying relative organization for VSAM files” on page 151

“Defining VSAM files” on page 166

Defining VSAM file organization and records

Use the FILE-CONTROL entry in the ENVIRONMENT DIVISION to define the VSAM file organization and access modes for the files in your COBOL program.

In the FILE SECTION of the DATA DIVISION, code a file description (FD) entry for the file. In the associated record description entry or entries, define the *record-name* and record length. Code the logical size of the records with the RECORD clause.

Important: You can process VSAM data sets in Enterprise COBOL programs only after you define them with access method services.

The following table summarizes VSAM file organization, access modes, and record formats (fixed or variable length).

Table 24. VSAM file organization, access mode, and record format

File organization	Sequential access	Random access	Dynamic access	Fixed length	Variable length
VSAM sequential (ESDS)	Yes	No	No	Yes	Yes
VSAM indexed (KSDS)	Yes	Yes	Yes	Yes	Yes
VSAM relative (RRDS)	Yes	Yes	Yes	Yes	Yes

RELATED TASKS

“Specifying sequential organization for VSAM files”

“Specifying indexed organization for VSAM files”

“Specifying relative organization for VSAM files” on page 151

“Using file status keys” on page 208

“Using VSAM return codes (VSAM files only)” on page 209

“Defining VSAM files” on page 166

“Specifying access modes for VSAM files” on page 153

Specifying sequential organization for VSAM files

Identify VSAM ESDS files in your COBOL program with the `ORGANIZATION IS SEQUENTIAL` clause.

You can access (read or write) records in sequential files only sequentially.

After you place a record in the file, you cannot shorten, lengthen, or delete it. However, you can update (REWRITE) a record if the length does not change. New records are added at the end of the file.

The following example shows typical `FILE-CONTROL` entries for a VSAM sequential file (ESDS):

```
SELECT S-FILE
  ASSIGN TO SEQUENTIAL-AS-FILE
  ORGANIZATION IS SEQUENTIAL
  ACCESS IS SEQUENTIAL
  FILE STATUS IS FSTAT-CODE VSAM-CODE.
```

RELATED CONCEPTS

“VSAM files” on page 148

Specifying indexed organization for VSAM files

Identify VSAM KSDS in your COBOL program with the `ORGANIZATION IS INDEXED` clause.

Code a prime key for the record by using the clause:

```
RECORD KEY IS data-name
```

Here *data-name* is the name of the key field as you defined it in the record description entry in the `DATA DIVISION`. The collation of index record keys is based on the binary value of the key, regardless of the class or the category of the key.

The following example shows the statements for a VSAM indexed file (KSDS) that is accessed dynamically. In addition to the primary key, `COMMUTER-NO`, there is an alternate key, `LOCATION-NO`:

```
SELECT I-FILE
      ASSIGN TO INDEXED-FILE
      ORGANIZATION IS INDEXED
      ACCESS IS DYNAMIC
      RECORD KEY IS IFILE-RECORD-KEY
      ALTERNATE RECORD KEY IS IFILE-ALTREC-KEY
      FILE STATUS IS FSTAT-CODE VSAM-CODE.
```

Alternate keys

In addition to the primary key, you can also code one or more alternate keys to use for retrieving records. Using alternate keys, you can access the indexed file to read records in some sequence other than the prime key sequence. For example, you could access the file through employee department rather than through employee number. Alternate keys need not be unique. More than one record will be accessed, given a department number as a key. This is permitted if alternate keys are coded to allow duplicates.

You define the alternate key in your COBOL program with the `ALTERNATE RECORD KEY` clause:

```
ALTERNATE RECORD KEY IS data-name
```

Here *data-name* is the name of the key field as you defined it in the record description entry in the `DATA DIVISION`. The collation of alternate keys is based on the binary value of the key, regardless of the class or the category of the key.

Alternate index

To use an alternate index, you need to define a data set (using access method services) called the alternate index (AIX). The AIX contains one record for each value of a given alternate key; the records are in sequential order by alternate key value. Each record contains the corresponding primary keys of all records in the associated indexed files that contain the alternate key value.

RELATED CONCEPTS

“VSAM files” on page 148

RELATED TASKS

“Creating alternate indexes” on page 167

Specifying relative organization for VSAM files

Identify VSAM RRDS files in your COBOL program with the `ORGANIZATION IS RELATIVE` clause.

Use the `RELATIVE KEY IS` clause to associate each logical record with its relative record number.

The following example shows a relative-record data set (RRDS) that is accessed randomly by the value in the relative key `ITEM-NO`:

```
SELECT R-FILE
      ASSIGN TO RELATIVE-FILE
      ORGANIZATION IS RELATIVE
      ACCESS IS RANDOM
      RELATIVE KEY IS RFILE-RELATIVE-KEY
      FILE STATUS IS FSTAT-CODE VSAM-CODE.
```

You can use a randomizing routine to associate a key value in each record with the relative record number for that record. Although there are many techniques to convert a record key to a relative record number, the most commonly used randomizing algorithm is the division/remainder technique. With this technique, you divide the key by a value equal to the number of slots in the data set to produce a quotient and remainder. When you add one to the remainder, the result will be a valid relative record number.

Alternate indexes are not supported for VSAM RRDS.

Fixed-length and variable-length RRDS

In an RRDS with fixed-length records, each record occupies one slot, and you store and retrieve records according to the relative record number of that slot. When you load the file, you have the option of skipping over slots and leaving them empty.

When you load an RRDS with variable-length records, you can skip over relative record numbers. Unlike fixed-length RRDS, a variable-length RRDS does not have slots. Instead, the free space that you define allows for more efficient record insertions.

VSAM variable-length RRDS is supported on OS/390 and z/OS.

Simulating variable-length RRDS

Use VSAM variable-length RRDS when possible. But if you cannot use the VSAM support, Enterprise COBOL provides another way for you to have relative-record data sets with variable-length records. This support, called *COBOL simulated variable-length RRDS*, is provided by the SIMVRD|NOSIMVRD run-time option. When you use the SIMVRD option, Enterprise COBOL simulates variable-length RRDS using a VSAM KSDS.

The coding that you use in your COBOL program to identify and describe VSAM variable-length RRDS and COBOL simulated variable-length RRDS is similar. How you use the SIMVRD run-time option and whether you define the VSAM file as a RRDS or KSDS differs, however.

To use a variable-length RRDS, do the following steps, depending on whether you want to simulate an RRDS:

Table 25. Steps for using variable-length RRDS

Step	VSAM variable-length RRDS	COBOL simulated variable-length RRDS
1	Define the file in your COBOL program with the ORGANIZATION IS RELATIVE clause.	Same
2	Use FD statements in your COBOL program to describe the records with variable-length sizes.	Same, but you must also code RECORD IS VARYING on the FD statements of every COBOL program that accesses the data set.
3	Use the NOSIMVRD run-time option.	Use the SIMVRD run-time option.

Table 25. Steps for using variable-length RRDS (continued)

Step	VSAM variable-length RRDS	COBOL simulated variable-length RRDS
4	Define the VSAM file through access method services as an RRDS.	Define the VSAM file through access method services as follows: DEFINE CLUSTER INDEXED KEYS(4,0) RECORDSIZE(<i>avg</i> , <i>m</i>) where: <i>avg</i> Is the average size of the COBOL records; strictly less than <i>m</i> . <i>m</i> Is greater than or equal to the maximum size COBOL record + 4.

In step 2 for simulated variable-length RRDS, coding other language elements that imply a variable-length record format does not give you COBOL simulated variable-length RRDS. For example, these clauses alone do not give you correct file access:

- Multiple FD records of different lengths
- OCCURS . . . DEPENDING ON in the record definitions
- RECORD CONTAINS integer-1 TO integer-2 CHARACTERS

When you define the cluster in step 4 for simulated variable-length RRDS, observe these restrictions:

- Do not define an alternate index.
- Do not specify a KEYRANGE.
- Do not specify SPANNED.

Also, use the REUSE parameter when you open for output a file that contains records.

Errors: When you work with simulated variable-length relative data sets and true VSAM RRDS data sets, you get an OPEN file status 39 if your COBOL file definition and the VSAM data set attributes do not match.

RELATED CONCEPTS

“VSAM files” on page 148

RELATED TASKS

“Defining VSAM files” on page 166

Specifying access modes for VSAM files

You can access records in VSAM sequential files only sequentially. You can access records in VSAM indexed and relative files in three ways: sequentially, randomly, or dynamically.

For sequential access, code ACCESS IS SEQUENTIAL in the FILE-CONTROL entry. Records in indexed files are then accessed in the order of the key field selected (either primary or alternate). Records in relative files are accessed in the order of the relative record numbers.

For random access, code ACCESS IS RANDOM in the FILE-CONTROL entry. Records in indexed files are then accessed according to the value you place in a key field. Records in relative files are accessed according to the value you place in the relative key.

For dynamic access, code ACCESS IS DYNAMIC in the FILE-CONTROL entry. Dynamic access is a mixed sequential-random access in the same program. Using dynamic access, you can write one program to perform both sequential and random processing, accessing some records in sequential order and others by their keys.

“Example: using dynamic access with VSAM files”

RELATED TASKS

“Reading records from a VSAM file” on page 160

Example: using dynamic access with VSAM files

Suppose that you have an indexed file of employee records and the employee’s hourly wage forms the record key. Your program is processing those employees who earn between \$10.00 and \$12.00 per hour and those who earn \$20.00 per hour and above.

Using dynamic access of VSAM files, the program would do as follows:

1. Retrieve the first record randomly (with a random-retrieval READ) based on the key of 1000.
2. Read sequentially (using READ NEXT) until the salary field exceeds 1200.
3. Retrieve the next record randomly, this time based on a key of 2000.
4. Read sequentially until the end of the file.

RELATED TASKS

“Reading records from a VSAM file” on page 160

Defining record lengths for VSAM files

VSAM records can be fixed or variable in length. COBOL determines the record format from the RECORD clause and the record descriptions associated with your FD entry for the file.

Because the concept of blocking has no meaning for VSAM files, you can omit the BLOCK CONTAINS clause. The clause is syntax-checked, but it has no effect on how the program runs.

Defining fixed-length records

To define the records to be fixed length, use one of the following coding options:

Table 26. Definition of VSAM fixed-length records

RECORD clause	Clause format	Record length	Comments
Code RECORD CONTAINS <i>integer</i> .	1	Fixed in size with a length of <i>integer-2</i>	The lengths of the level-01 record description entries associated with the file do not matter.

Table 26. Definition of VSAM fixed-length records (continued)

RECORD clause	Clause format	Record length	Comments
Omit the RECORD clause, but code all level-01 records (associated with the file) as the same size and none with an OCCURS DEPENDING ON clause.		The fixed size that you coded	

Defining variable-length records

To define the records to be variable-length, use one of the following coding options:

Table 27. Definition of VSAM variable-length records

RECORD clause	Clause format	Maximum record length	Comments
Code RECORD IS VARYING FROM <i>integer-1</i> TO <i>integer-2</i> .	3	<i>integer-2</i> value	The lengths of the level-01 record description entries associated with the file do not matter.
Code RECORD IS VARYING.	3	Size of the largest level-01 record description entry associated with the file	The compiler determines the maximum record length.
Code RECORD CONTAINS <i>integer-1</i> TO <i>integer-2</i> .	2	<i>integer-2</i> value	The minimum record length is the <i>integer-1</i> value.
Omit the RECORD clause, but code multiple level-01 records (associated with the file) that are of different sizes or that contain an OCCURS DEPENDING ON clause.		Size of the largest level-01 record description entry associated with the file	The compiler determines the maximum record length.

When you specify a READ INTO statement for a format-V file, the record size read for that file is used in the MOVE statement generated by the compiler. Consequently, you might not get the result you expect if the record read in does not correspond to the level-01 record description. All other rules of the MOVE statement apply. For example, when you specify a MOVE statement for a format-V record read in by the READ statement, the size of the record corresponds to its level-01 record description.

RELATED TASKS

Enterprise COBOL Compiler and Run-Time Migration Guide

Coding input and output statements for VSAM files

Use these COBOL statements for processing VSAM files:

OPEN To connect the VSAM data set to your COBOL program for processing.

WRITE To add records to a file or load a file.

START To establish the current location in the cluster for a READ NEXT statement.

START does not retrieve a record; it only sets the current record pointer.

READ and READ NEXT

To retrieve records from a file.

REWRITE

To update records.

DELETE To logically remove records from indexed and relative files only.

CLOSE To disconnect the VSAM data set from your program.

All of the following factors determine which input and output statements you can use for a given VSAM data set:

- Access mode (sequential, random, or dynamic)
- File organization (ESDS, KSDS, or RRDS)
- Mode of OPEN statement (INPUT, OUTPUT, I-O, or EXTEND)

The following table shows the possible combinations with sequential files (ESDS). The X indicates that you can use the statement with the open mode at the top of the column.

Table 28. I/O statements for VSAM sequential files

Access mode	COBOL statement	OPEN INPUT	OPEN OUTPUT	OPEN I-O	OPEN EXTEND
Sequential	OPEN	X	X	X	X
	WRITE		X		X
	START				
	READ	X		X	
	REWRITE			X	
	DELETE				
	CLOSE	X	X	X	X

The following table shows the possible combinations you can use with indexed (KSDS) files and relative (RRDS) files. The X indicates that you can use the statement with the open mode at the top of the column.

Table 29. I/O statements for VSAM relative and indexed files

Access mode	COBOL statement	OPEN INPUT	OPEN OUTPUT	OPEN I-O	OPEN EXTEND
Sequential	OPEN	X	X	X	X
	WRITE		X		X
	START	X		X	
	READ	X		X	
	REWRITE			X	
	DELETE			X	
	CLOSE	X	X	X	X

Table 29. I/O statements for VSAM relative and indexed files (continued)

Access mode	COBOL statement	OPEN INPUT	OPEN OUTPUT	OPEN I-O	OPEN EXTEND
Random	OPEN	X	X	X	
	WRITE		X	X	
	START				
	READ	X		X	
	REWRITE			X	
	DELETE			X	
	CLOSE	X	X	X	
Dynamic	OPEN	X	X	X	
	WRITE		X	X	
	START	X		X	
	READ	X		X	
	REWRITE			X	
	DELETE			X	
	CLOSE	X	X	X	

The fields you code in the FILE STATUS clause are updated by VSAM after each input-output statement to indicate the success or failure of the operation.

RELATED CONCEPTS

“File position indicator”

RELATED TASKS

“Opening a file (ESDS, KSDS, or RRDS)” on page 158

“Reading records from a VSAM file” on page 160

“Updating records in a VSAM file” on page 161

“Adding records to a VSAM file” on page 162

“Replacing records in a VSAM file” on page 162

“Deleting records from a VSAM file” on page 163

“Closing VSAM files” on page 163

RELATED REFERENCES

Status key (Common processing facilities) (*Enterprise COBOL Language Reference*)

File position indicator

The file position indicator marks the next record to be accessed for sequential COBOL requests. You do not set the file position indicator anywhere in your program; it is set by successful OPEN, START, READ, and READ NEXT statements. Subsequent READ or READ NEXT requests use the established file position indicator location and update it.

The file position indicator is not used or affected by the output statements WRITE, REWRITE, or DELETE. The file position indicator has no meaning for random processing.

RELATED TASKS

“Reading records from a VSAM file” on page 160

Opening a file (ESDS, KSDS, or RRDS)

Before you can use any WRITE, START, READ, REWRITE, or DELETE statements to process records in a file, you must first open the file with an OPEN statement. File availability and creation affect OPEN processing, optional files, and file status codes 05 and 35.

For example, if you OPEN EXTEND, OPEN I-0, or OPEN INPUT a file that is neither optional nor available, you get file status 35 and the OPEN statement fails. If the file is OPTIONAL, the OPEN EXTEND, OPEN I-0, or OPEN INPUT creates the file and returns file status 05.

An OPEN operation works successfully only when you set fixed file attributes in the DD statement or data set label for a file and specify consistent attributes for that file in the SELECT and FD statements of your COBOL program. Mismatches in the following items result in a file status code 39, and the OPEN statement fails:

- Attributes for file organization (sequential, relative, or indexed)
- Prime record key
- Alternate record keys
- Maximum record size
- Record type (fixed or variable)

How you code the OPEN statement in your COBOL program for a VSAM file depends on whether the file is empty (a file that has never contained records) or loaded. For either type of file, your program should check the file status key after each OPEN statement.

RELATED TASKS

“Opening an empty file”

“Opening a loaded file (a file with records)” on page 160

RELATED REFERENCES

“Statements to load records into a VSAM file” on page 159

Opening an empty file

To open a file that has never contained records (an empty file), use the following statements depending on the type of file:

- OPEN OUTPUT for ESDS files.
- OPEN OUTPUT or OPEN EXTEND for KSDS and RRDS files. (Either coding has the same effect.) If you have coded the file for random or dynamic access and the file is optional, you can use OPEN I-0.

Optional files are files that are not necessarily present each time the program is run. You can define files opened in INPUT, I-0, or OUTPUT mode as optional by defining them with the SELECT OPTIONAL phrase in the FILE-CONTROL section of your program.

Initially loading records sequentially into a file: Initially loading a file means writing records into the file for the first time. This is not the same as writing records into a file from which all previous records have been deleted.

To initially load a VSAM file:

1. Open the file.
2. Use sequential processing (ACCESS IS SEQUENTIAL) because it is faster.

3. Use WRITE to add a record to the file.

Using OPEN OUTPUT to load a VSAM file significantly improves the performance of your program. Using OPEN I-O or OPEN EXTEND has a negative impact on the performance of your program.

When you load VSAM indexed files sequentially, you optimize both loading performance and subsequent processing performance, because sequential processing maintains user-defined free space. Future insertions will be more efficient.

With ACCESS IS SEQUENTIAL, you must write the records in ascending RECORD KEY order.

When you load VSAM relative files sequentially, the records are placed in the file in the ascending order of relative record numbers.

Initially loading a file randomly or dynamically: You can use random or dynamic processing to load a file, but they are not as efficient as sequential processing. Because VSAM does not support random or dynamic processing, COBOL has to perform some extra processing to enable you to use ACCESS IS RANDOM or ACCESS IS DYNAMIC with OPEN OUTPUT or OPEN I-O. These steps prepare the file for use and give it the status of a loaded file, having been used at least once.

In addition to extra overhead for preparing files for use, random processing does not consider any user-defined free space. As a result, any future insertions might be inefficient. Sequential processing maintains user-defined free space.

Loading a VSAM data set with access method services: You can load or update a VSAM data set with the access method services REPRO command. Use REPRO whenever possible.

RELATED TASKS

“Opening a loaded file (a file with records)” on page 160

RELATED REFERENCES

“Statements to load records into a VSAM file”

REPRO (z/OS DFSMS: Access Method Services for Catalogs)

Statements to load records into a VSAM file

Table 30. Statements to load records into a VSAM file

Division	ESDS	KSDS	RRDS
ENVIRONMENT DIVISION	SELECT ASSIGN FILE STATUS PASSWORD ACCESS MODE	SELECT ASSIGN ORGANIZATION IS INDEXED RECORD KEY ALTERNATE RECORD KEY FILE STATUS PASSWORD ACCESS MODE	SELECT ASSIGN ORGANIZATION IS RELATIVE RELATIVE KEY FILE STATUS PASSWORD ACCESS MODE
DATA DIVISION	FD entry	FD entry	FD entry

Table 30. Statements to load records into a VSAM file (continued)

Division	ESDS	KSDS	RRDS
PROCEDURE DIVISION	OPEN OUTPUT OPEN EXTEND WRITE CLOSE	OPEN OUTPUT OPEN EXTEND WRITE CLOSE	OPEN OUTPUT OPEN EXTEND WRITE CLOSE

RELATED TASKS

“Opening an empty file” on page 158

“Updating records in a VSAM file” on page 161

Opening a loaded file (a file with records)

To open a file that already contains records, use OPEN INPUT, OPEN I-O, or OPEN EXTEND.

If you open a VSAM entry-sequenced or relative-record file as EXTEND, the added records are placed after the last existing records in the file.

If you open a VSAM key-sequenced file as EXTEND, each record you add must have a record key higher than the highest record in the file.

RELATED TASKS

“Opening an empty file” on page 158

“Working with VSAM data sets under z/OS and UNIX” on page 165

RELATED REFERENCES

“Statements to load records into a VSAM file” on page 159

z/OS DFSMS: Access Method Services for Catalogs

Reading records from a VSAM file

Use the READ statement to retrieve (READ) records from a file. To read a record, you must have opened the file INPUT or I-O. Your program should check the file status key after each READ.

You can retrieve records in VSAM sequential files only in the sequence in which they were written.

You can retrieve records in VSAM indexed and relative record files in any of the following ways:

Sequentially

According to the ascending order of the key you are using, the RECORD KEY or the ALTERNATE RECORD KEY, beginning at the current position of the file position indicator for indexed files, or according to ascending relative record locations for relative files

Randomly

In any order, depending on how you set the RECORD KEY or ALTERNATE RECORD KEY or the RELATIVE KEY before your READ request

Dynamically

Mixed sequential and random

With dynamic access, you can switch between reading a specific record directly and reading records sequentially, by using READ NEXT for sequential retrieval and READ for random retrieval (by key).

When you want to read sequentially, beginning at a specific record, use **START** before the **READ NEXT** statement to set the file position indicator to point to a particular record. When you code **START** followed by **READ NEXT**, the next record is read and the file position indicator is reset to the next record. You can move the file position indicator randomly by using **START**, but all reading is done sequentially from that point.

START *file-name* **KEY IS EQUAL TO ALTERNATE-RECORD-KEY**

When a direct **READ** is performed for a VSAM indexed file, based on an alternate index for which duplicates exist, only the first record in the data set (base cluster) with that alternate key value is retrieved. You need a series of **READ NEXT** statements to retrieve each of the data set records with the same alternate key. A file status code of 02 is returned if there are more records with the same alternate key value to be read; a code of 00 is returned when the last record with that key value has been read.

RELATED CONCEPTS

“File position indicator” on page 157

RELATED TASKS

“Specifying access modes for VSAM files” on page 153

Updating records in a VSAM file

To update a VSAM file, use the **ENVIRONMENT DIVISION** and **DATA DIVISION** statements to load records into a VSAM file and the following **PROCEDURE DIVISION** statements to update VSAM files.

Table 31. Statements to update records in a VSAM file

Access method	ESDS	KSDS	RRDS
ACCESS IS SEQUENTIAL	OPEN EXTEND WRITE CLOSE <i>or</i> OPEN I-O READ REWRITE CLOSE	OPEN EXTEND WRITE CLOSE <i>or</i> OPEN I-O READ REWRITE DELETE CLOSE	OPEN EXTEND WRITE CLOSE <i>or</i> OPEN I-O READ REWRITE DELETE CLOSE
ACCESS IS RANDOM	Not applicable	OPEN I-O READ WRITE REWRITE DELETE CLOSE	OPEN I-O READ WRITE REWRITE DELETE CLOSE
ACCESS IS DYNAMIC (sequential processing)	Not applicable	OPEN I-O READ NEXT WRITE REWRITE START DELETE CLOSE	OPEN I-O READ NEXT WRITE REWRITE START DELETE CLOSE

Table 31. Statements to update records in a VSAM file (continued)

Access method	ESDS	KSDS	RRDS
ACCESS IS DYNAMIC (random processing)	Not applicable	OPEN I-O READ WRITE REWRITE DELETE CLOSE	OPEN I-O READ WRITE REWRITE DELETE CLOSE

RELATED REFERENCES

“Statements to load records into a VSAM file” on page 159

Adding records to a VSAM file

Use the COBOL WRITE statement to add a record to a file without replacing any existing records. The record to be added must not be larger than the maximum record size that you set when you defined the file. Your program should check the file status key after each WRITE statement.

Adding records sequentially

Use ACCESS IS SEQUENTIAL and code the WRITE statement to add records sequentially to the end of a VSAM file that has been opened with either OUTPUT or EXTEND.

Sequential files are always written sequentially.

For indexed files, you must write new records in ascending key sequence. If you open the file EXTEND, the record keys of the records to be added must be higher than the highest primary record key on the file when you opened the file.

For relative files, the records must be in sequence. If you include a RELATIVE KEY data item in the SELECT clause, the relative record number of the record to be written is placed in that data item.

Adding records randomly or dynamically

When you write records to an indexed data set and ACCESS IS RANDOM or ACCESS IS DYNAMIC, you can write the records in any order.

Replacing records in a VSAM file

To replace records in a VSAM file, use REWRITE on a file that you have opened for I-O. If you try to use REWRITE on a file that is not opened I-O, the record is not rewritten and the status key is set to 49. Your program should check the file status key after each REWRITE statement.

- For sequential files, the length of the record you rewrite must be the same as the length of the original record.
- For indexed files, you can change the length of the record you rewrite.
- For variable-length relative files, you can change the length of the record you rewrite.

To replace records randomly or dynamically, your program need not read the record to be rewritten. Instead, to position the record that you want to update, do as follows:

- For indexed files, move the record key to the RECORD KEY data item and then issue the REWRITE.
- For relative files, move the relative record number to the RELATIVE KEY data item and then issue the REWRITE.

Deleting records from a VSAM file

Open the file I-O and use the DELETE statement to remove an existing record from an indexed or relative file. You cannot use DELETE on a sequential file.

When you use ACCESS IS SEQUENTIAL or the file contains spanned records, your program must first read the record to be deleted. The DELETE then removes the record that was read. If the DELETE is not preceded by a successful READ, the deletion is not done and the status key value is set to 92.

When you use ACCESS IS RANDOM or ACCESS IS DYNAMIC, your program need not first read the record to be deleted. To delete a record, move the key of the record to be deleted to the RECORD KEY data item and then issue the DELETE. Your program should check the file status key after each DELETE statement.

Closing VSAM files

Use the CLOSE statement to disconnect your program from the VSAM file. If you try to close a file that is already closed, you will get a logic error. Check the file status key after each CLOSE statement.

If you do not close a VSAM file, the file is automatically closed for you under the following conditions, except for files defined in any OS/VS COBOL programs in the run unit:

- When the run unit ends normally, all open files defined in any COBOL programs in the run unit are closed.
- When the run unit ends abnormally, if the TRAP(ON) run-time option has been set, all open files defined in any COBOL programs in the run unit are closed.
- When Language Environment condition handling is completed and the application resumes in a routine other than where the condition occurred, open files defined in any COBOL programs in the run unit that might be called again and reentered are closed.

You can change the location where a program resumes after a condition is handled. To make this change, you can, for example, move the resume cursor with the CEEMRCR callable service or use HLL language constructs such as a C longjmp statement.

- When you issue CANCEL for a COBOL subprogram, any open nonexternal files defined in that program are closed.
- When a COBOL subprogram with the INITIAL attribute returns control, any open nonexternal files defined in that program are closed.
- When a thread of a multithreaded application ends, both external and nonexternal files that were opened from within that same thread are closed.

File status key data items that you define in the WORKING-STORAGE SECTION are set when these implicit CLOSE operations are performed, but your EXCEPTION/ERROR and LABEL declaratives are not invoked.

If you open a VSAM file in a multithreaded application, you must close it from the same thread of execution. Attempting to close the file from a different thread results in a close failure with file-status condition 90.

Handling errors in VSAM files

When an input statement or output statement operation fails, COBOL does not perform corrective action for you.

All OPEN and CLOSE errors with a VSAM file, whether logical errors in your program or input/output errors on the external storage media, return control to your COBOL program, even when you have coded no DECLARATIVE and no FILE STATUS clause.

If any other input or output statement operation fails, you choose whether your program will continue running after a less-than-severe input/output error occurs.

COBOL provides these ways for you to intercept and handle certain VSAM input and output errors:

- End-of-file phrase (AT END)
- EXCEPTION/ERROR declarative
- FILE STATUS clause (file status key and VSAM return code)
- INVALID KEY phrase

You should define a status key for each VSAM file that you define in your program. Check the status key value after every input or output request, especially OPEN and CLOSE.

If you do not code a FILE STATUS key or a declarative, serious VSAM processing errors will cause a message to be issued and a Language Environment condition to be signaled, which will cause an abend if you specify the run-time option ABTERMENC(ABEND).

RELATED TASKS

“Handling errors in input and output operations” on page 203

“Using VSAM return codes (VSAM files only)” on page 209

RELATED REFERENCES

VSAM macro return and reason codes (*z/OS DFSMS Macro Instructions for Data Sets*)

Protecting VSAM files with a password

Although the preferred security mechanism on a z/OS system is RACF, Enterprise COBOL also supports using explicit passwords on VSAM files to prevent unauthorized access and update.

To use explicit passwords, code the PASSWORD clause in the SELECT statement of your program. Use this clause only if the catalog entry for the files includes a read or an update password.

- If the catalog entry includes a read password, you cannot open and access the file in a COBOL program unless you use the password clause in the FILE-CONTROL paragraph and describe it in the DATA DIVISION. The *data-name* referred to must contain a valid password when the file is opened.
- If the catalog entry includes an update password, you can open and access it, but not update it, unless you code the password clause in the FILE-CONTROL paragraph and describe it in the DATA DIVISION.

- If the catalog entry includes both a read password and an update password, specify the update password to both read and update the file in your program.

If your program only retrieves records and does not update them, you need only the read password. If your program loads files or updates them, you need to specify the update password that was cataloged.

For indexed files, the PASSWORD data item for the RECORD KEY must contain the valid password before the file can be successfully opened.

If you password-protect a VSAM indexed file, you must also password-protect every alternate index in order to be fully password-protected. Where you place the PASSWORD clause becomes important because each alternate index has its own password. The PASSWORD clause must directly follow the key clause to which it applies.

“Example: password protection for a VSAM indexed file”

Example: password protection for a VSAM indexed file

The following example shows the COBOL code used for a VSAM indexed file with password protection.

```

. . .
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT LIBFILE
    ASSIGN TO PAYMAST
    ORGANIZATION IS INDEXED
    RECORD KEY IS EMPL-NUM
    PASSWORD IS BASE-PASS
    ALTERNATE RECORD KEY IS EMPL-PHONE
    PASSWORD IS PATH1-PASS
. . .
WORKING-STORAGE SECTION.
01 BASE-PASS                PIC X(8) VALUE "25BSREAD".
01 PATH1-PASS              PIC X(8) VALUE "25ATREAD".

```

Working with VSAM data sets under z/OS and UNIX

There are some special considerations for VSAM files under z/OS and UNIX in terms of coding access method services (IDCAMS) commands, environment variables, and JCL.

A VSAM file is *available* if all of the following are true:

- You define it using access method services.
- You define it for your program by providing a DD statement, an environment variable, or an ALLOCATE command for it.
- It has previously contained a record.

A VSAM file is *unavailable* if it has never contained a record, even if you have defined it.

You always get a return code of zero on completion of the OPEN statement for a VSAM sequential file.

Use the access method services REPRO command to empty a file. Deleting records in this manner resets the high-use relative byte address (RBA) of the file to zero. The file is effectively empty and appears to COBOL as if it never contained a record.

RELATED TASKS

"Defining files to the operating system" on page 10

"Defining VSAM files"

"Creating alternate indexes" on page 167

"Allocating VSAM files" on page 169

"Sharing VSAM files through RLS" on page 170

Defining VSAM files

You can process VSAM entry-sequenced, key-sequenced, and relative-record data sets in Enterprise COBOL only after you define them through access method services (IDCAMS).

A VSAM *cluster* is a logical definition for a VSAM data set and has one or two components:

- The data component of a VSAM cluster contains the data records.
- The index component of a VSAM key-sequenced cluster consists of the index records.

Use the access method services DEFINE CLUSTER command to define your VSAM data sets (clusters). This process includes creating an entry in an integrated catalog without any data transfer.

Define the following information about the cluster:

- Name of the entry
- Name of the catalog to contain this definition and its password (can use default name).
- Organization (sequential, indexed, or relative)
- Device and volumes that the data set will occupy
- Space required for the data set
- Record size and control interval sizes (CISIZE)
- Passwords (if any) required for future access

Depending on what kind of data set is in the cluster, also define the following information for each cluster:

- For VSAM indexed data sets (KSDS), specify length and position of the prime key in the records.
- For VSAM fixed-length relative-record data sets (RRDS), specify the record size as greater than or equal to the maximum size COBOL record:

```
DEFINE CLUSTER NUMBERED  
RECORDSIZE(n,n)
```

When you define a data set in this way, all records will be padded to the fixed slot size *n*. If you use the RECORD IS VARYING ON *data-name* form of the RECORD clause, a WRITE or REWRITE will use the length specified in the DEPENDING ON *data-name* as the length of the record to be transferred by VSAM. This data is then padded to the fixed slot size. READ statements always return the fixed slot size in the DEPENDING ON *data-name*.

- For VSAM variable-length relative-record data sets (RRDS), specify the average size COBOL record expected and the maximum size COBOL record expected:

```
DEFINE CLUSTER NUMBERED  
RECORDSIZE(avg,m)
```

The average size COBOL record expected must be less than the maximum size COBOL record expected.

- For COBOL simulated variable-length relative-record data sets, specify the average size of the COBOL records and a size that is greater than or equal to the maximum size COBOL record plus 4:

```
DEFINE CLUSTER INDEXED
KEYS(4,0)
RECORDSIZE(avg,m)
```

The average size COBOL record expected must be less than the maximum size COBOL record expected.

RELATED TASKS

“Creating alternate indexes”

“Allocating VSAM files” on page 169

“Specifying relative organization for VSAM files” on page 151

RELATED REFERENCES

z/OS DFSMS: Access Method Services for Catalogs

Creating alternate indexes

An alternate index provides access to the records in a data set using more than one key. It accesses records in the same way as the prime index key of an indexed data set (KSDS).

When planning to use an alternate index, you must know:

- The type of data set (base cluster) with which the index will be associated
- Whether the keys will be unique or not unique
- Whether the index is to be password protected
- Some of the performance aspects of using alternate indexes

Because an alternate index is, in practice, a VSAM data set that contains pointers to the keys of a VSAM data set, you must define the alternate index and the alternate index path (the entity that establishes the relationship between the alternate index and the prime index). After you define an alternate index, make a catalog entry to establish the relationship (or path) between the alternate index and its base cluster. This path allows you to access the records of the base cluster through the alternate keys.

To use an alternate index, you need to follow these steps:

1. Define the alternate index by using the `DEFINE ALTERNATEINDEX` command. In it, define the following:
 - Name of the alternate index
 - Name of its related VSAM indexed data set
 - Location in the record of any alternate indexes and whether they are unique or not
 - Whether or not alternate indexes are to be updated when the data set is changed
 - Name of the catalog to contain this definition and its password (can use default name)

In your COBOL program the alternate index is identified solely by the `ALTERNATE RECORD KEY` clause of the `FILE CONTROL` paragraph. The `ALTERNATE RECORD KEY` definitions must match the definitions that you have made in the catalog entry. Any password entries that you have cataloged should be coded directly after the `ALTERNATE RECORD KEY` phrase.

2. Relate the alternate index to the base cluster (the data set to which the alternate index gives you access) by using the DEFINE PATH command. In it, define the following:

- Name of the path
- Alternate index to which the path is related
- Name of the catalog that contains the alternate index

The base cluster and alternate index are described by entries in the same catalog.

3. Load the VSAM indexed data set.
4. Build the alternate index by using (typically) the BLDINDEX command. Identify the input file as the indexed data set (base cluster) and the output file as the alternate index or its path. This command BLDINDEX reads all the records in your VSAM indexed data set (or base cluster) and extracts the data needed to build the alternate index.

Alternatively, you can use the run-time option AIXBLD to build the alternate index at run time. However, this option might adversely affect run-time performance.

“Example: entries for alternate indexes”

RELATED REFERENCES

AIXBLD (COBOL only) (*Language Environment Programming Reference*)

Example: entries for alternate indexes

The following example maps the relationships between the COBOL FILE-CONTROL entry and the DD statements or environment variables for a VSAM indexed file with two alternate indexes.

Using JCL:

```
//MASTERA DD DSN=clustername,DISP=OLD (1)
//MASTERA1 DD DSN=path1,DISP=OLD (2)
//MASTERA2 DD DSN=path2,DISP=OLD (3)
```

Using environment variables:

```
export MASTERA=DSN(clustername),OLD (1)
export MASTERA=DSN(path1),OLD (2)
export MASTERA=DSN(path2),OLD (3)
```

```
FILE-CONTROL.
  SELECT MASTER-FILE ASSIGN TO MASTERA (4)
  RECORD KEY IS EM-NAME
  PASSWORD IS PW-BASE (5)
  ALTERNATE RECORD KEY IS EM-PHONE (6)
  PASSWORD IS PW-PATH1
  ALTERNATE RECORD KEY IS EM-CITY (7)
  PASSWORD IS PW-PATH2.
```

- (1) The base cluster name is *clustername*.
- (2) The name of the first alternate index path is *path1*.
- (3) The name of the second alternate index path is *path2*.
- (4) The ddname or environment variable name for the base cluster is specified with the ASSIGN clause.
- (5) Passwords immediately follow their indexes.
- (6) The key EM-PHONE relates to the first alternate index.

- (7) The key EM-CITY relates to the second alternate index.

RELATED TASKS

“Creating alternate indexes” on page 167

Allocating VSAM files

You must predefine and catalog all VSAM data sets through the access method services DEFINE command. Most of the information about a VSAM data set is in the catalog. You need to specify only minimal DD or environment variable information for a VSAM file. When you use an environment variable, the name must be in uppercase. Usually the input and data buffers are the only variables that you are concerned about.

Allocation of VSAM files (indexed, relative, and sequential) follows the general rules for the allocation of COBOL files. If you use an environment variable to allocate a VSAM file, you must specify these options in the order shown, but no others:

- DSN(*dsname*), where *dsname* is the name of the base cluster
- OLD or SHR

The basic DD statement that you need for your VSAM files is:

```
//ddname DD DSN=dsname,DISP=SHR,AMP=AMORG
```

The corresponding export command is:

```
export evname="DSN(dsname),SHR"
```

In either case, *dsname* must be the same as the name used in the access method services DEFINE CLUSTER or DEFINE PATH command. DISP must be OLD or SHR because the data set is already cataloged. If you specify MOD when using JCL, the data set is treated as OLD.

AMP is a VSAM JCL parameter used to supplement the information that the program supplies about the data set. AMP takes effect when your program opens the VSAM file. Any information that you set through the AMP parameter takes precedence over the information that is in the catalog or that the program supplies.

The AMP parameter is not required except under the following circumstances:

- You use a dummy VSAM data set. For example,

```
//ddname DD DUMMY,AMP=AMORG
```
- You request additional index or data buffers. For example,

```
//ddname DD DSN=VSAM.dsname,DISP=SHR,  
// AMP=('BUFNI=4,BUFND=8')
```

You cannot specify AMP if you allocate your VSAM data set with an environment variable.

For a VSAM base cluster, specify the same system-name (ddname or environment variable name) that you specify in the ASSIGN clause of the SELECT statement in your COBOL program.

When you use alternate indexes in your COBOL program, you must specify not only a system-name (using a DD statement or environment variable) for the base cluster, but also one for each alternate index path. No language mechanism exists to explicitly declare system-names for alternate index paths within the program.

Therefore, you must adhere to the following guidelines for forming the system-name (ddname or environment variable name) for each alternate index path:

- Concatenate the base cluster name with an integer.
- Begin with 1 for the path associated with the first alternate record defined for the file in your program (ALTERNATE RECORD KEY clause of the SELECT statement).
- Increment by 1 for the path associated with each successive alternate record definition for that file.

For example, if the system-name of a base cluster is ABCD, the system name for the first alternate index path defined for the file in your program is ABCD1, the system-name for the second alternate index path is ABCD2, and so on.

If the length of the base cluster system-name and sequence number exceeds eight characters, the base cluster portion of the system-name is truncated on the right to reduce the concatenated result to eight characters. For example, if the system-name of a base cluster is ABCDEFGH, the system name of the first alternate index path is ABCDEFG1, the tenth is ABCDEF10, and so on.

RELATED TASKS

“Allocating files” on page 117

RELATED REFERENCES

MVS JCL Reference

Sharing VSAM files through RLS

By using the VSAM JCL parameter RLS, you can specify the use of record level sharing with VSAM. Use RLS=CR when consistent read protocols are required, and RLS=NRI when no read integrity protocols are required. Specifying the RLS parameter is the only way to request the RLS mode when running COBOL programs.

You cannot specify RLS if you allocate your VSAM data set with an environment variable.

Preventing update problems with VSAM files in RLS mode

When a VSAM data set is opened in RLS mode for I-O (updates), the first READ causes an exclusive lock of the record regardless of the value of RLS=CR or RLS=NRI that you specify. If the COBOL file is defined as ACCESS RANDOM, VSAM releases the exclusive lock on the record after a WRITE or REWRITE statement is issued or a READ statement is issued for another record. When a WRITE or REWRITE is done, VSAM writes the record immediately.

However, if the COBOL file is defined as ACCESS DYNAMIC, VSAM does not release the exclusive lock on the record after a WRITE or REWRITE statement nor after a READ statement unless the I-O statement causes VSAM to move to another control interval (CI). As a result, if a WRITE or REWRITE was done, VSAM does not write the record until processing is moved to another CI and the lock is released. When using ACCESS DYNAMIC, one way to cause the record to be written immediately, to release the exclusive lock immediately, or both, is to define the VSAM data set to allow only one record per CI.

Specifying RLS=CR locks a record and prevents an update to it until another READ is requested for another record. While a lock on the record being read is in effect, other users can request a READ for the same record, but they cannot update the

record until the read lock is released. When you specify RLS=NRI, no lock will be in effect when a READ for input is issued and another user might update the record.

The locking rules for RLS=CR can cause the application to wait for availability of a record lock, and this wait might slow down the READ for input.

You might need to modify your application logic to use the RLS=CR capability. Do not use the RLS JCL parameter for batch jobs that update nonrecoverable spheres until you are sure that the application functions correctly in a multiple updater environment.

When you open a VSAM data set in RLS mode for INPUT or I-O processing, it is a good idea to issue an OPEN or START *immediately* before a READ. If there is a delay between the OPEN or START and the actual READ, another user might add records before the record on which the application is positioned after the OPEN or START. The COBOL run time points explicitly to the beginning of the VSAM data set at the time when OPEN was requested, but another user might add records that would alter the true beginning of the VSAM data set if the READ is delayed.

Restrictions when using RLS

The following restrictions apply to RLS mode:

- The VSAM cluster attributes KEYRANGE and IMBED are not supported when you open a VSAM file in RLS mode.
- The VSAM cluster attribute REPLICATE is not recommended with RLS mode because the benefits are negated by the system-wide buffer pool and potentially large CF cache structure in the storage hierarchy.
- The AIXBLD run-time option is not supported when you open a VSAM file in RLS mode, because VSAM does not allow an empty path to be opened. If you need the AIXBLD run-time option to build the alternate index data set, open the VSAM data set in non-RLS mode.
- Temporary data sets are not allowed in RLS mode.
- The SIMVRD run-time option is not supported for VSAM files opened in RLS mode.

Handling errors in VSAM files in RLS mode

If your application accesses a VSAM data set in RLS mode, be sure to check the file status and VSAM feedback codes after *each* request.

If your application encounters “SMSVSAM server not available” while processing input or output, explicitly close the VSAM file before you try to open it again. VSAM generates return code 16 for failures like “SMSVSAM server not available,” and there is no feedback code. You can have your COBOL programs check the first two bytes of the second file status area for a VSAM return code 16.

The COBOL run time generates message IGZ0205W and automatically closes the file if the error occurs during OPEN processing.

All other RLS mode errors return a VSAM return code of 4, 8, or 12.

Improving VSAM performance

Most likely, your system programmer is responsible for tuning the performance of COBOL and VSAM. As an application programmer, you can control the aspects of VSAM listed in this table.

Table 32. Methods for improving VSAM performance

Aspect of VSAM	What you can do	Rationale and comments
Invoking access methods service	Build your alternate indexes in advance, using IDCAMS.	
Buffering	<p>For sequential access, request more data buffers; for random access, request more index buffers. Specify both BUFND and BUFNI when ACCESS IS DYNAMIC.</p> <p>Avoid coding additional buffers unless your application will run interactively; and then code buffers only when response-time problems arise that might be caused by delays in input and output.</p>	The default is one index (BUFNI) and two data buffers (BUFND).
Loading records, using access methods services	<p>Use the access methods service REPRO command when:</p> <ul style="list-style-type: none"> • The target indexed data set already contains records. • The input sequential data set contains records to be updated or inserted into the indexed data set. <p>If you use a COBOL program to load the file, use OPEN OUTPUT and ACCESS SEQUENTIAL.</p>	The REPRO command can update an indexed data set as fast or faster than any COBOL program under these conditions.
File access modes	For best performance, access records sequentially.	Dynamic access is less efficient than sequential access, but more efficient than random access. Random access results in increased EXCPs because VSAM must access the index for each request.
Key design	Design the key in the records so that the high-order portion is relatively constant and the low-order portion changes often.	This method compresses the key best.
Multiple alternate indexes	Avoid using multiple alternate indexes.	Updates must be applied through the primary paths and are reflected through multiple alternate paths, perhaps slowing performance,
Relative file organization	Use VSAM fixed-length relative data sets rather than VSAM variable-length relative data sets.	Although not as space efficient, VSAM fixed-length relative data sets are more run-time efficient than VSAM variable-length relative data sets, which have performance characteristics comparable to COBOL simulated relative data sets.

Table 32. Methods for improving VSAM performance *(continued)*

Aspect of VSAM	What you can do	Rationale and comments
Control interval sizes (CISZ)	<p>Provide your system programmer with information about the data access and future growth of your VSAM data sets. From this information, your system programmer can determine the best control interval size (CISZ) and FREESPACE size (FSPC).</p> <p>Choose proper values for CISZ and FSPC to minimize control area (CA) splits. You can diagnose the current number of CA splits by issuing the LISTCAT ALL command on the cluster, and then compress (using EXPORT or IMPORT or REPRO) the cluster to omit all CA splits periodically.</p>	<p>VSAM calculates CISZ to best fit the direct-access storage device (DASD) usage algorithm, which might not, however, be efficient for your application.</p> <p>An average CISZ of 4K is suitable for most applications. A smaller CISZ means faster retrieval for random processing at the expense of inserts (that is, more CISZ splits and therefore more space in the data set). A larger CISZ results in the transfer of more data across the channel for each READ. This is more efficient for sequential processing, similar to a large OS BLKSIZE.</p> <p>Many control area (CA) splits are unfavorable for VSAM performance. The FREESPACE value can affect CA splits, depending on how the file is used.</p>

RELATED TASKS

“Specifying access modes for VSAM files” on page 153

Deciding how big a virtual resource pool to provide (*z/OS DFSMS: Using Data Sets*)

Selecting the optimal percentage of free space (*z/OS DFSMS: Using Data Sets*)

RELATED REFERENCES

z/OS DFSMS: Access Method Services for Catalogs

Chapter 11. Processing line-sequential files

Line-sequential files are files that reside in the hierarchical file system (HFS) and that contain only printable characters and certain control characters as data. Each record ends with an EBCDIC new-line character (X'15'), which is not included in the length of the record. Because these are sequential files, records are placed one after another according to entry order. Your program can process these files only sequentially, retrieving (with the READ statement) records in the same order as they are in the file. A new record is placed after the preceding record.

To process line-sequential files in your program, use COBOL language statements that:

- Identify and describe the files in the ENVIRONMENT DIVISION and the DATA DIVISION
- Process the records in the files in the PROCEDURE DIVISION

After you have created a record, you cannot change its length or its position in the file, and you cannot delete it.

RELATED CONCEPTS

UNIX System Services User's Guide

RELATED TASKS

"Defining line-sequential files and records in COBOL"

"Describing the structure of a line-sequential file" on page 176

"Coding input-output statements for line-sequential files" on page 177

"Handling errors in line-sequential files" on page 180

"Defining and allocating line-sequential files" on page 177

RELATED REFERENCES

"Allowable control characters" on page 176

Defining line-sequential files and records in COBOL

Use the FILE-CONTROL entry in the ENVIRONMENT DIVISION to:

- Define the files in your COBOL program as line-sequential files.
- Associate them with the external file-names (ddnames or environment variable names). An external file-name is the name by which a file is known to the operating system.

In the following example, COMMUTER-FILE is the name that your program uses for the file; COMMUTR is the external name.

```
FILE-CONTROL.  
  SELECT COMMUTER-FILE  
  ASSIGN TO COMMUTR  
  ORGANIZATION IS LINE SEQUENTIAL  
  ACCESS MODE IS SEQUENTIAL  
  FILE STATUS IS ECODE.
```

Your ASSIGN *assignment-name* clause must not include an organization field (S- or AS-) before the external name. The ACCESS phrase and the FILE STATUS phrase are optional.

RELATED TASKS

“Describing the structure of a line-sequential file”

“Coding input-output statements for line-sequential files” on page 177

“Defining and allocating line-sequential files” on page 177

RELATED REFERENCES

“Allowable control characters”

Allowable control characters

The control characters shown in the table below are the only characters other than printable characters that line-sequential files can contain. The hexadecimal values are in EBCDIC.

Hexadecimal value	Control character
X'05'	Horizontal tab
X'0B'	Vertical tab
X'0C'	Form feed
X'0D'	Carriage return
X'0E'	DBCS shift-out
X'0F'	DBCS shift-in
X'15'	New-line
X'16'	Backspace
X'2F'	Alarm

The new-line character is treated as a record delimiter. The other control characters are treated as data and are part of the record.

RELATED TASKS

“Defining line-sequential files and records in COBOL” on page 175

Describing the structure of a line-sequential file

In the FILE SECTION of the DATA DIVISION, code a file description (FD) entry for the file. In the associated record description entry or entries, define the *record-name* and record length.

Code the logical size of the records with the RECORD clause. Line-sequential files are stream files. Because of their character-oriented nature, the physical records are of variable length.

The following examples show how the FD entry might look for a line-sequential file:

With fixed-length records:

```
FILE SECTION.  
FD  COMMUTER-FILE  
   RECORD CONTAINS 80 CHARACTERS.  
01  COMMUTER-RECORD.  
    05  COMMUTER-NUMBER          PIC  X(16).  
    05  COMMUTER-DESCRIPTION     PIC  X(64).
```

With variable-length records:

```
FILE SECTION.  
FD  COMMUTER-FILE  
   RECORD VARYING FROM 16 TO 80 CHARACTERS.
```



```

01 COMMUTER-RECORD.
   05 COMMUTER-NUMBER      PIC X(16).
   05 COMMUTER-DESCRIPTION PIC X(64).

```

If you code the same fixed size and no OCCURS DEPENDING ON clause for any level-01 record description entries associated with the file, that fixed size is the logical record length. However, because blanks at the end of a record are not written to the file, the physical records might be of varying lengths.

RELATED TASKS

“Defining line-sequential files and records in COBOL” on page 175

“Coding input-output statements for line-sequential files”

“Defining and allocating line-sequential files”

RELATED REFERENCES

Data Division—file description entries (*Enterprise COBOL Language Reference*)

Defining and allocating line-sequential files

You can define a line-sequential file in the HFS using either a DD statement or an environment variable. Allocation of these files follows the general rules for allocating COBOL files.

To define a line-sequential file, define one of the following with a name that matches the external name on your ASSIGN clause:

- A DD allocation:
 - A DD statement that specifies `PATH='absolute-path-name'`
 - A TSO allocation that specifies `PATH('absolute-path-name')`

You can optionally also specify these options:

- PATHOPTS
- PATHMODE
- PATHDISP
- An environment variable with a value of `PATH(absolute-path-name)`. No other values can be specified.

For example, to have your COBOL program use HFS file `/u/myfiles/commuterfile` for a COBOL file with an *assignment-name* of `COMMUTR`, you would use the following command:

```
export COMMUTR="PATH(/u/myfiles/commuterfile)"
```

RELATED TASKS

“Allocating files” on page 117

“Defining line-sequential files and records in COBOL” on page 175

RELATED REFERENCES

MVS JCL Reference

Coding input-output statements for line-sequential files

Code the following input and output statements to process a line-sequential file:

OPEN To make the file available to your program.

You can open a line-sequential file as `INPUT`, `OUTPUT`, or `EXTEND`. You cannot open a line-sequential file as `I-O`.

READ To read a record from the file.

With sequential processing, your program reads one record after another in the same order in which they were entered when the file was created.

WRITE To create a record in the file.

Your program writes new records to the end of the file.

CLOSE To release the connection between the file and your program.

RELATED TASKS

“Defining line-sequential files and records in COBOL” on page 175

“Describing the structure of a line-sequential file” on page 176

“Opening line-sequential files”

“Reading records from line-sequential files”

“Adding records to line-sequential files” on page 179

“Closing line-sequential files” on page 179

“Handling errors in line-sequential files” on page 180

RELATED REFERENCES

OPEN statement (*Enterprise COBOL Language Reference*)

READ statement (*Enterprise COBOL Language Reference*)

WRITE statement (*Enterprise COBOL Language Reference*)

CLOSE statement (*Enterprise COBOL Language Reference*)

Opening line-sequential files

Before your program can use any READ or WRITE statements to process records in a file, it must first open the file with an OPEN statement.

An OPEN statement works if the file is available or has been dynamically allocated.

Code CLOSE WITH LOCK so that the file cannot be opened again while the program is running.

RELATED TASKS

“Reading records from line-sequential files”

“Adding records to line-sequential files” on page 179

“Closing line-sequential files” on page 179

“Defining and allocating line-sequential files” on page 177

RELATED REFERENCES

OPEN statement (*Enterprise COBOL Language Reference*)

CLOSE statement (*Enterprise COBOL Language Reference*)

Reading records from line-sequential files

To read from a line-sequential file, open the file and use the READ statement.

With sequential processing, your program reads one record after another in the same order in which the records were entered when the file was created.

Characters in the file record are read one at a time into the record area until one of the following conditions occurs:

- The record delimiter (the EBCDIC new-line character) is encountered.
The delimiter is discarded and the remainder of the record area is filled with spaces. (Record area is longer than the file record.)

- The entire record area is filled with characters.
If the next unread character is the record delimiter, it is discarded. The next READ reads from the first character of the next record. (Record area is the same length as the file record.)
Otherwise the next unread character is the first character to be read by the next READ. (Record area is shorter than the file record.)

RELATED TASKS

“Opening line-sequential files” on page 178
 “Adding records to line-sequential files”
 “Closing line-sequential files”
 “Defining and allocating line-sequential files” on page 177

RELATED REFERENCES

OPEN statement (*Enterprise COBOL Language Reference*)
 WRITE statement (*Enterprise COBOL Language Reference*)

Adding records to line-sequential files

To add to a line-sequential file, open the file as EXTEND and use the WRITE statement to add records immediately after the last record in the file.

Blanks at the end of the record area are removed and the record delimiter is added. The characters in the record area from the first character up to and including the added record delimiter are written to the file as one record.

Records written to line-sequential files must contain only USAGE DISPLAY and DISPLAY-1 items. External decimal data items must be unsigned or declared with the SEPARATE CHARACTER phrase if signed.

RELATED TASKS

“Opening line-sequential files” on page 178
 “Reading records from line-sequential files” on page 178
 “Closing line-sequential files”
 “Defining and allocating line-sequential files” on page 177

RELATED REFERENCES

OPEN statement (*Enterprise COBOL Language Reference*)
 WRITE statement (*Enterprise COBOL Language Reference*)

Closing line-sequential files

Use the CLOSE statement to disconnect your program from a line-sequential file. If you try to close a file that is already closed, you will get a logic error.

If you do not close a line-sequential file, the file is automatically closed for you under the following conditions:

- When the run unit ends normally.
- When the run unit ends abnormally, if the TRAP(ON) run-time option is set.
- When Language Environment condition handling is completed and the application resumes in a routine other than where the condition occurred, open files defined in any COBOL programs in the run unit that might be called again and reentered are closed.

You can change the location where the program resumes (after a condition is handled) by moving the resume cursor with the Language Environment CEEMRCR callable service or using HLL language constructs such as a C longjmp call.

File status codes are set when these implicit CLOSE operations are performed, but EXCEPTION/ERROR declaratives are not invoked.

RELATED TASKS

- “Opening line-sequential files” on page 178
- “Reading records from line-sequential files” on page 178
- “Adding records to line-sequential files” on page 179
- “Defining and allocating line-sequential files” on page 177

RELATED REFERENCES

CLOSE statement (*Enterprise COBOL Language Reference*)

Handling errors in line-sequential files

When an input or output statement operation fails, COBOL does not take corrective action for you. You choose whether or not your program will continue running after an input or output error occurs.

COBOL provides these techniques for intercepting and handling certain line-sequential input and output errors:

- End of file phrase (AT END)
- EXCEPTION/ERROR declarative
- FILE STATUS clause

If you do not use one of these techniques, an error in processing input or output raises a Language Environment condition.

If you use the FILE STATUS clause, be sure to check the key and take appropriate action based on its value. If you do not check the key, it is possible that your program could continue; but the results will probably not be what you expected.

RELATED TASKS

- “Coding input-output statements for line-sequential files” on page 177
- “Handling errors in input and output operations” on page 203

Chapter 12. Sorting and merging files

You can arrange records in a particular sequence by using the SORT or MERGE statements:

SORT statement

Accepts input (from a file or an internal procedure) that is not in sequence, and produces output (to a file or an internal procedure) in a requested sequence. You can add, delete, or change records before or after they are sorted.

MERGE statement

Compares records from two or more sequenced files and combines them in order. You can add, delete, or change records after they are merged.

You can mix SORT and MERGE statements in the same COBOL program. A program can contain any number of sort and merge operations. They can be the same operation performed many times or different operations. However, one operation must finish before another begins.

With Enterprise COBOL, your IBM licensed program for sorting and merging must be DFSORT or an equivalent. Where DFSORT is mentioned, you can use any equivalent sort or merge product.

COBOL programs that contain SORT or MERGE statements can reside above or below the 16-MB line.

The general procedure for sorting or merging is as follows:

1. Describe the sort or merge file to be used for sorting or merging.
2. Describe the input to be sorted or merged. If you want to process the records before you sort them, code an input procedure.
3. Describe the output from sorting or merging. If you want to process the records after you sort or merge them, code an output procedure.
4. Request the sort or merge.
5. Determine whether the sort or merge operation was successful.

Restrictions:

- You cannot run a COBOL program that contains SORT or MERGE statements under UNIX. This restriction includes BPXBATCH.
- You cannot use SORT or MERGE statements in programs compiled with the THREAD option. This includes programs that use object-oriented syntax and multithreaded applications, both of which require the THREAD option.

RELATED CONCEPTS

“Sort and merge process” on page 182

RELATED TASKS

“Describing the sort or merge file” on page 182

“Describing the input to sorting or merging” on page 183

“Describing the output from sorting or merging” on page 185

“Requesting the sort or merge” on page 188

“Determining whether the sort or merge was successful” on page 192

“Improving sort performance with FASTSORT” on page 193
“Controlling sort behavior” on page 195
DFSORT Application Programming Guide

RELATED REFERENCES

“CICS SORT application restrictions” on page 199
SORT statement (*Enterprise COBOL Language Reference*)
MERGE statement (*Enterprise COBOL Language Reference*)

Sort and merge process

During the sorting of a file, all of its records are ordered according to the contents of one or more fields (*keys*) in each record. If there are multiple keys, the records are first sorted according to the content of the first (or primary) key, then according to the content of the second key, and so on. You can sort the records in either ascending or descending order of each key.

To sort a file, use the COBOL SORT statement.

During the merging of two or more files (which must already be sorted), the records are combined and ordered according to the contents of one or more keys in each record. As with sorting, the records are first ordered according to the content of the primary key, then according to the content of the second key, and so on. You can order the records in either ascending or descending order of each key.

Use MERGE . . . USING to name the files that you want to combine into one sequenced file. The merge operation compares keys in the records of the input files, and passes the sequenced records one by one to the RETURN statement of an output procedure or to the file that you name in the GIVING phrase.

RELATED REFERENCES

SORT statement (*Enterprise COBOL Language Reference*)
MERGE statement (*Enterprise COBOL Language Reference*)

Describing the sort or merge file

Describe the sort file to be used for sorting or merging:

1. Write one or more SELECT clauses in the FILE-CONTROL paragraph of the ENVIRONMENT DIVISION to name a sort file. For example:

```
ENVIRONMENT DIVISION.  
INPUT-OUTPUT SECTION.  
FILE-CONTROL.  
    SELECT Sort-Work-1 ASSIGN TO SortFile.
```

Sort-Work-1 is the name of the file in your program. Use this name to refer to the file.
2. Describe the sort file in an SD entry in the FILE SECTION of the DATA DIVISION. Every SD entry must contain a record description. For example:

```
DATA DIVISION.  
FILE SECTION.  
SD  Sort-Work-1  
   RECORD CONTAINS 100 CHARACTERS.  
01  SORT-WORK-1-AREA.  
   05  SORT-KEY-1    PIC  X(10).  
   05  SORT-KEY-2    PIC  X(10).  
   05  FILLER        PIC  X(80).
```

You need SELECT clauses and SD entries for sorting or merging even if you are sorting or merging data items from WORKING-STORAGE or LOCAL-STORAGE only.

The file described in an SD entry is the working file used for a sort or merge operation. You cannot perform any input or output operations on this file. You do not need to provide a ddname definition for the file.

RELATED REFERENCES

"FILE SECTION entries" on page 14

Describing the input to sorting or merging

Describe the input file or files for sorting or merging by following this procedure:

1. Write one or more SELECT statements in the FILE-CONTROL paragraph of the ENVIRONMENT DIVISION to name the input files. For example:

```
ENVIRONMENT DIVISION.  
INPUT-OUTPUT SECTION.  
FILE-CONTROL.  
    SELECT Input-File ASSIGN TO InFile.
```

Input-File is the name of the file in your program. Use this name to refer to the file.

2. Describe the input file (or files when merging) in an FD entry in the FILE SECTION of the DATA DIVISION. For example:

```
DATA DIVISION.  
FILE SECTION.  
FD Input-File  
    LABEL RECORDS ARE STANDARD  
    BLOCK CONTAINS 0 CHARACTERS  
    RECORDING MODE IS F  
    RECORD CONTAINS 100 CHARACTERS.  
01 Input-Record    PIC X(100).
```

RELATED TASKS

"Coding the input procedure" on page 184

"Requesting the sort or merge" on page 188

RELATED REFERENCES

"FILE SECTION entries" on page 14

Example: describing sort and input files for SORT

The following example shows the ENVIRONMENT DIVISION and DATA DIVISION entries needed to describe sort files and an input file.

```
ID Division.  
Program-ID. Smp1Sort.  
Environment Division.  
Input-Output Section.  
File-Control.  
*  
* Assign name for a working file is  
* treated as documentation.  
*  
    Select Sort-Work-1 Assign To SortFile.  
    Select Sort-Work-2 Assign To SortFile.  
    Select Input-File Assign To InFile.  
* . . .  
Data Division.  
File Section.  
SD Sort-Work-1
```

```

        Record Contains 100 Characters.
01 Sort-Work-1-Area.
    05 Sort-Key-1    Pic X(10).
    05 Sort-Key-2    Pic X(10).
    05 Filler        Pic X(80).
SD Sort-Work-2
    Record Contains 30 Characters.
01 Sort-Work-2-Area.
    05 Sort-Key      Pic X(5).
    05 Filler        Pic X(25).
FD Input-File
    Label Records Are Standard
    Block Contains 0 Characters
    Recording Mode is F
    Record Contains 100 Characters.
01 Input-Record      Pic X(100).
. . .
Working-Storage Section.
01 EOS-Sw            Pic X.
01 Filler.
    05 Table-Entry Occurs 100 Times
        Indexed By X1    Pic X(30).
. . .

```

RELATED TASKS

“Requesting the sort or merge” on page 188

Coding the input procedure

If you want to process the records in an input file before they are released to the sort program, use the INPUT PROCEDURE phrase of the SORT statement. You can use an input procedure to do the following:

- Release data items to the sort file from WORKING-STORAGE or LOCAL-STORAGE.
- Release records that have already been read in elsewhere in the program.
- Read records from an input file, select or process them, and release them to the sort file.

Each input procedure must be contained in either paragraphs or sections. For example, to release records from a table in WORKING-STORAGE or LOCAL-STORAGE to the sort file SORT-WORK-2, you could code as follows:

```

        SORT SORT-WORK-2
          ON ASCENDING KEY SORT-KEY
          INPUT PROCEDURE 600-SORT3-INPUT-PROC
        . . .
600-SORT3-INPUT-PROC SECTION.
    PERFORM WITH TEST AFTER
        VARYING X1 FROM 1 BY 1 UNTIL X1 = 100
        RELEASE SORT-WORK-2-AREA FROM TABLE-ENTRY (X1)
    END-PERFORM.

```

To transfer records to the sort program, all input procedures must contain at least one RELEASE or RELEASE FROM statement. To release A from X, for example, you can code:

```

MOVE X TO A.
RELEASE A.

```

Alternatively, you can code:

```

RELEASE A FROM X.

```

The following table compares the RELEASE and RELEASE FROM statements.

RELEASE	RELEASE FROM
<pre> MOVE EXT-RECORD TO SORT-EXT-RECORD PERFORM RELEASE-SORT-RECORD . . . RELEASE-SORT-RECORD. RELEASE SORT-RECORD FROM SORT-EXT-RECORD </pre>	<pre> PERFORM RELEASE-SORT-RECORD . . . RELEASE-SORT-RECORD. RELEASE SORT-RECORD FROM SORT-EXT-RECORD </pre>

RELATED REFERENCES

“Restrictions on input and output procedures” on page 187
RELEASE statement (*Enterprise COBOL Language Reference*)

Describing the output from sorting or merging

If the output from sorting or merging is a file, describe the file by following this procedure:

1. Write a SELECT statement in the FILE-CONTROL paragraph of the ENVIRONMENT DIVISION to name the output file. For example:

```

ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT Output-File ASSIGN TO OutFile.

```

Output-File is the name of the file in your program. Use this name to refer to the file.

2. Describe the output file (or files when merging) in an FD entry in the FILE SECTION of the DATA DIVISION. For example:

```

DATA DIVISION.
FILE SECTION.
FD Output-File
   LABEL RECORDS ARE STANDARD
   BLOCK CONTAINS 0 CHARACTERS
   RECORDING MODE IS F
   RECORD CONTAINS 100 CHARACTERS.
01 Output-Record   PIC X(100).

```

RELATED TASKS

“Coding the output procedure”
“Requesting the sort or merge” on page 188

RELATED REFERENCES

“FILE SECTION entries” on page 14

Coding the output procedure

If you want to select, edit, or otherwise change sorted records before writing them from the sort work file into another file, use the OUTPUT PROCEDURE phrase of the SORT statement.

Each output procedure must be contained in either a section or a paragraph. An output procedure must include both of the following elements:

- At least one RETURN or RETURN INTO statement
- Any statements necessary to process the records that are made available, one at a time, by the RETURN statement

The RETURN statement makes each sorted record available to the output procedure. (The RETURN statement for a sort file is similar to a READ statement for an input file.)

You can use the AT END and END-RETURN phrases with the RETURN statement. The imperative statements on the AT END phrase are performed after all the records have been returned from the sort file. The END-RETURN explicit scope terminator delimits the scope of the RETURN statement.

If you use the RETURN INTO statement instead of RETURN, the records will be returned to WORKING-STORAGE, LOCAL-STORAGE, or to an output area.

Coding considerations when using DFSORT

When a RETURN statement does not encounter an AT END condition before a COBOL program finishes running, the SORT statement could end abnormally with DFSORT message IEC025A. To avoid this situation, do these steps:

1. Code the RETURN statement with the AT END phrase.
2. Ensure that the RETURN statement is executed until the AT END condition is encountered.

The AT END condition occurs after the last record is returned to the program from the sort work file and a subsequent RETURN statement is executed.

“Example: coding the output procedure when using DFSORT”

RELATED REFERENCES

“Restrictions on input and output procedures” on page 187
RETURN statement (*Enterprise COBOL Language Reference*)

Example: coding the output procedure when using DFSORT

The following example shows a coding technique that ensures that the RETURN statement encounters the AT END condition before the program finishes running. The RETURN statement, coded with the AT END phrase, is executed until the AT END condition occurs.

```
IDENTIFICATION DIVISION.
DATA DIVISION.
FILE SECTION.
SD OUR-FILE.
01 OUR-SORT-REC.
   03 SORT-KEY          PIC X(10).
   03 FILLER            PIC X(70).
. . .
WORKING-STORAGE SECTION.
01 WS-SORT-REC          PIC X(80).
01 END-OF-SORT-FILE-INDICATOR PIC X VALUE 'N'.
   88 NO-MORE-SORT-RECORDS      VALUE 'Y'.
. . .
PROCEDURE DIVISION.
A-CONTROL SECTION.
   SORT OUR-FILE ON ASCENDING KEY SORT-KEY
   INPUT PROCEDURE IS B-INPUT
   OUTPUT PROCEDURE IS C-OUTPUT.
. . .
B-INPUT SECTION.
   MOVE . . . . . TO WS-SORT-REC.
   RELEASE OUR-SORT-REC FROM WS-SORT-REC.
. . .
C-OUTPUT SECTION.
   DISPLAY 'STARTING READS OF SORTED RECORDS: '.
```

```

RETURN OUR-FILE
  AT END
    SET NO-MORE-SORT-RECORDS TO TRUE.
PERFORM WITH TEST BEFORE UNTIL NO-MORE-SORT-RECORDS
  IF SORT-RETURN = 0 THEN
    DISPLAY 'OUR-SORT-REC = ' OUR-SORT-REC
    RETURN OUR-FILE
  AT END
    SET NO-MORE-SORT-RECORDS TO TRUE
END-IF
END-PERFORM.

```

Restrictions on input and output procedures

The following restrictions apply to each input or output procedure called by SORT and to each output procedure called by MERGE:

- The procedure must not contain any SORT or MERGE statements.
- You can use ALTER, GO TO, and PERFORM statements in the procedure to refer to procedure names outside the input or output procedure. However, control must return to the input or output procedure after a GO TO or PERFORM statement.
- The remainder of the PROCEDURE DIVISION must not contain any transfers of control to points inside the input or output procedure (with the exception of the return of control from a declarative section).
- In an input or output procedure, you can call a program that follows standard linkage conventions. However, the called program cannot issue a SORT or MERGE statement.
- During a SORT or MERGE operation, the SD data item is used. You must not use it in the output procedure before the first RETURN executes. If you move data into this record area before the first RETURN statement, the first record to be returned will be overwritten.
- Language Environment condition handling does not allow user-written condition handlers to be established in an input or output procedure.

RELATED TASKS

“Coding the input procedure” on page 184

“Coding the output procedure” on page 185

Planning to link-edit and run (*Language Environment Programming Guide*)

Defining sort and merge data sets

To use DFSORT under z/OS, code DD statements in the run-time JCL to describe the necessary data sets:

Sort or merge work

Define a minimum of three data sets: SORTWK01, SORTWK02, SORTWK03, . . . , SORTWKnn (where nn is 99 or less). These data sets cannot be in the HFS.

SYSOUT Define for sort diagnostic messages, unless you change the data set name. (Change the name using either the MSGDDN keyword of the OPTION control statement in the SORT-CONTROL data set, or using the SORT-MESSAGE special register.)

SORTCKPT

Define if the sort or merge is to take checkpoints.

Input and output

Define input and output data sets, if any.

SORTLIB (DFSORT library)

Define the library containing the sort modules, for example, SYS1.SORTLIB.

RELATED TASKS

“Controlling sort behavior” on page 195

“Using checkpoint/restart with DFSORT” on page 198

Sorting variable-length records

Your sort work file will be variable length only if you define it to be variable length, even if the input file to the sort contains variable-length records.

The compiler will determine that the sort work file is variable length if you code one of the following in its SD entry:

- A RECORD IS VARYING clause
- Two or more record descriptions that define records with different sizes, or records that contain an OCCURS DEPENDING ON clause

You cannot code RECORDING MODE V for the sort work file because the SD entry does not allow the RECORDING MODE clause.

To improve sort performance on variable-length files, specify the most frequently occurring record length of the input file (the modal length) on the SMS= control card or in the SORT-MODE-SIZE special register.

RELATED TASKS

“Changing DFSORT defaults with control statements” on page 197

“Controlling sort behavior” on page 195

Requesting the sort or merge

To read records directly from an input file (files for MERGE) without any preliminary processing, use SORT . . . USING or MERGE . . . USING and the name of the input file (files) that you have declared in a SELECT statement. The compiler generates an input procedure to open the input file (files), read the records, release the records to the sort or merge program, and close the input file (files). The input file or files must not be open when the SORT or MERGE statement begins execution.

To transfer sorted or merged records from the sort or merge program directly to another file without any further processing, use SORT . . . GIVING or MERGE . . . GIVING and the name of the output file that you have declared in a SELECT statement. The compiler generates an output procedure to open the output file, return the records, write the records, and close the file. The output file must not be open when the SORT or MERGE statement begins execution. For example:

```
SORT Sort-Work-1
  ON ASCENDING KEY Sort-Key-1
  USING Input-File
  GIVING Output-File.
```

The USING or GIVING files in a SORT or MERGE statement can be sequential files residing in the HFS.

“Example: describing sort and input files for SORT” on page 183

If you want an input procedure to be performed on the sort records before they are sorted, use SORT . . . INPUT PROCEDURE. If you want an output procedure to be performed on the sorted records, use SORT . . . OUTPUT PROCEDURE. For example:

```
SORT Sort-Work-1
    ON ASCENDING KEY Sort-Key-1
    INPUT PROCEDURE EditInputRecords
    OUTPUT PROCEDURE FormatData.
```

“Example: sorting with input and output procedures” on page 190

Restriction: You cannot use an input procedure with the MERGE statement. The source of input to the merge operation must be a collection of already sorted files. However, if you want an output procedure to be performed on the merged records, use MERGE . . . OUTPUT PROCEDURE. For example:

```
MERGE Merge-Work
    ON ASCENDING KEY Merge-Key
    USING Input-File-1 Input-File-2 Input-File-3
    OUTPUT PROCEDURE ProcessOutput.
```

You must define *Merge-Work* in an SD statement in the FILE SECTION of the DATA DIVISION, and the input files in FD statements in the FILE SECTION.

Setting sort or merge criteria

To set sort or merge criteria, do these steps:

1. In the record description of the files to be sorted or merged, define the key or keys on which the operation is to be performed.
There is no maximum number of keys, but the keys must be located in the first 4092 bytes of the record description.
The total length of the keys cannot exceed 4092 bytes unless the EQUALS keyword is coded in the DFSORT OPTION control statement, in which case the total length of the keys must not exceed 4088 bytes.
Restriction: A key cannot be variably located.
2. In the SORT or MERGE statement, specify the key fields to be used for sequencing. You can code keys as ascending or descending. When you code more than one key, some can be ascending, and some descending.
The leftmost key is the primary key. The next key is the secondary key, and so on.

You can specify national data items as keys for sorting and merging. The binary collating sequence is applied to such keys. If you specify a national data item as a sort or merge key, any COLLATING SEQUENCE phrase in the SORT or MERGE statement does not apply to that key.

You can mix SORT and MERGE statements in the same COBOL program. A program can perform any number of sort or merge operations. However, one operation must end before another can begin.

RELATED CONCEPTS

Appendix B, “Complex OCCURS DEPENDING ON,” on page 613 (variably located items)

RELATED TASKS

“Defining sort and merge data sets” on page 187

RELATED REFERENCES

SORT control statement (*DFSORT Application Programming Guide*)

SORT statement (*Enterprise COBOL Language Reference*)

MERGE statement (*Enterprise COBOL Language Reference*)

Example: sorting with input and output procedures

The following example shows the use of an input and an output procedure in a SORT statement. The example also shows how you can define primary key SORT-GRID-LOCATION and secondary key SORT-SHIFT in the DATA DIVISION before using them in the SORT statement.

DATA DIVISION.

```
. . .
SD  SORT-FILE
    RECORD CONTAINS 115 CHARACTERS
    DATA RECORD SORT-RECORD.
01  SORT-RECORD.
    05  SORT-KEY.
        10  SORT-SHIFT                PIC X(1).
        10  SORT-GRID-LOCATION          PIC X(2).
        10  SORT-REPORT                PIC X(3).
    05  SORT-EXT-RECORD.
        10  SORT-EXT-EMPLOYEE-NUM     PIC X(6).
        10  SORT-EXT-NAME              PIC X(30).
        10  FILLER                    PIC X(73).
```

. . .
WORKING-STORAGE SECTION.

```
01  TAB1.
    05  TAB-ENTRY OCCURS 10 TIMES
        INDEXED BY TAB-INDX.
        10  WS-SHIFT                PIC X(1).
        10  WS-GRID-LOCATION          PIC X(2).
        10  WS-REPORT                PIC X(3).
        10  WS-EXT-EMPLOYEE-NUM     PIC X(6).
        10  WS-EXT-NAME              PIC X(30).
        10  FILLER                    PIC X(73).
```

. . .
PROCEDURE DIVISION.

```
. . .
    SORT SORT-FILE
        ON ASCENDING KEY SORT-GRID-LOCATION SORT-SHIFT
        INPUT PROCEDURE 600-SORT3-INPUT
        OUTPUT PROCEDURE 700-SORT3-OUTPUT.

. . .
600-SORT3-INPUT.
    PERFORM VARYING TAB-INDX FROM 1 BY 1 UNTIL TAB-INDX > 10
    RELEASE SORT-RECORD FROM TAB-ENTRY(TAB-INDX)
    END-PERFORM.

. . .
700-SORT3-OUTPUT.
    PERFORM VARYING TAB-INDX FROM 1 BY 1 UNTIL TAB-INDX > 10
    RETURN SORT-FILE INTO TAB-ENTRY(TAB-INDX)
    AT END DISPLAY 'Out Of Records In SORT File'
    END-RETURN
    END-PERFORM.
```

RELATED TASKS

“Requesting the sort or merge” on page 188

Choosing alternate collating sequences

You can sort or merge records on the EBCDIC or ASCII collating sequence, or on another collating sequence. The default collating sequence is EBCDIC unless you code the PROGRAM COLLATING SEQUENCE clause in the OBJECT-COMPUTER paragraph. To

override the sequence named in the PROGRAM COLLATING SEQUENCE clause, use the COLLATING SEQUENCE phrase of the SORT or MERGE statement. You can use different collating sequences for each SORT or MERGE statement in your program.

When you sort or merge an ASCII file, you have to request the ASCII collating sequence. To do so, code the COLLATING SEQUENCE phrase of the SORT or MERGE statement, where you define the *alphabet-name* as STANDARD-1 in the SPECIAL-NAMES paragraph.

RELATED TASKS

“Specifying the collating sequence” on page 8

RELATED REFERENCES

SORT statement (*Enterprise COBOL Language Reference*)

Classes and categories of data (*Enterprise COBOL Language Reference*)

Sorting on windowed date fields

You can specify windowed date fields as sort keys if your version of DFSORT supports the Y2PAST option. If so, DFSORT can sort or merge on the windowed date sequence.

To sort on a windowed date field, use the DATE FORMAT clause to define a windowed date field; then use the field as the sort key. DFSORT will use the same century window as that used by the compilation unit. Specify the century window with the YEARWINDOW compiler option.

DFSORT supports year-last windowed date fields, although the compiler itself does not provide automatic windowing for year-last windowed date fields in statements other than MERGE or SORT.

RELATED TASKS

“Sorting and merging by date” on page 567

RELATED REFERENCES

“YEARWINDOW” on page 315

DATE FORMAT clause (*Enterprise COBOL Language Reference*)

OPTION control statement (Y2PAST option) (*DFSORT Application Programming Guide*)

Preserving the original sequence of records with equal keys

You can preserve the order of identical collating records from input to output in one of these ways:

- Install DFSORT with the EQUALS option as the default.
- Provide, at run time, an OPTION card with the EQUALS keyword in the IGZSRTCD data set.
- Use the WITH DUPLICATES IN ORDER phrase in the SORT statement. Doing so adds the EQUALS keyword to the OPTION card in the IGZSRTCD data set.

Do not use the NOEQUALS keyword on the OPTION card *and* use the DUPLICATES phrase, or the run unit will end.

RELATED REFERENCES

OPTION control statement (*DFSORT Application Programming Guide*)

Determining whether the sort or merge was successful

The DFSORT program returns one of the following completion codes after a sort or merge has finished:

- 0 Successful completion of the sort or merge
- 16 Unsuccessful completion of the sort or merge

The completion code is stored in the SORT-RETURN special register. The contents of this register change after each SORT or MERGE statement is performed.

You should test for successful completion after each SORT or MERGE statement. For example:

```
      SORT SORT-WORK-2
        ON ASCENDING KEY SORT-KEY
        INPUT PROCEDURE IS 600-SORT3-INPUT-PROC
        OUTPUT PROCEDURE IS 700-SORT3-OUTPUT-PROC.
      IF SORT-RETURN NOT=0
        DISPLAY "SORT ENDED ABNORMALLY. SORT-RETURN = " SORT-RETURN.
      . . .
600-SORT3-INPUT-PROC SECTION.
      . . .
700-SORT3-OUTPUT-PROC SECTION.
      . . .
```

If you do not reference SORT-RETURN anywhere in your program, the COBOL run time tests the return code. If the return code is 16, COBOL issues a run-time diagnostic message.

If you test SORT-RETURN for one or more (but not necessarily all) SORT or MERGE statements, the COBOL run time does not check the return code.

By default, DFSORT diagnostic messages are sent to the SYSOUT data set. If you want to change this default, use the MSGDDN parameter of the DFSORT OPTION control card or use the SORT-MESSAGE special register.

RELATED TASKS

“Checking for sort errors with NOFASTSORT” on page 195

“Controlling sort behavior” on page 195

RELATED REFERENCES

DFSORT messages and return codes (*DFSORT Application Programming Guide*)

Stopping a sort or merge operation prematurely

To stop a sort or merge operation, use the SORT-RETURN special register. Move the integer 16 into the register in either of the following ways:

- Use MOVE in an input or output procedure.
Sort or merge processing will be stopped immediately after the next RELEASE or RETURN statement is performed.
- Reset the register in a declarative section entered during processing of a USING or GIVING file.
Sort or merge processing will be stopped immediately after the next implicit RELEASE or RETURN is performed, which will occur after a record has been read from or written to the USING or GIVING file.

Control then returns to the statement following the SORT or MERGE statement.

Improving sort performance with FASTSRT

Using the FASTSRT compiler option improves the performance of most sort operations. With FASTSRT, the DFSORT product (instead of Enterprise COBOL) performs the I/O on the input and output files you name in the following statements:

```
SORT . . . USING  
SORT . . . GIVING
```

The compiler issues informational messages to point out statements in which FASTSRT can improve performance.

Usage notes

- You cannot use the DFSORT options SORTIN or SORTOUT if you use FASTSRT. The FASTSRT compiler option does not apply to line-sequential files you use as USING or GIVING files.
- If you specify file status and use FASTSRT, file status is ignored during the sort.

RELATED REFERENCES

“FASTSRT” on page 284

“FASTSRT requirements for JCL”

“FASTSRT requirements for sort input and output files”

FASTSRT requirements for JCL

In the run-time JCL, you must assign the sort work files (SORTWKnn) to a direct-access device, not to tape data sets.

For the input and output files, the DCB parameter of the DD statement in the JCL must match the FD description.

FASTSRT requirements for sort input and output files

If you specify FASTSRT but your code does not meet FASTSRT requirements, the compiler issues a message and the COBOL run time performs the I/O instead. Your program will not experience the performance improvements otherwise possible.

To use FASTSRT, you must describe and process the input files to the sort, and the output files from the sort, in these ways:

- You can mention only one input file in the USING phrase. You can mention only one output file in the GIVING phrase.
- You cannot use an input procedure on an input file, nor an output procedure on an output file.

Instead of using input or output procedures, you might be able to use DFSORT control statements:

- INREC
- OUTFILE
- OUTREC
- INCLUDE
- OMIT
- STOPAFT

- SKIPREC
- SUM

Many DFSORT functions perform the same operations that are common in input or output procedures. Code the appropriate DFSORT control statements instead, and place them either in the IGZSRTCD data set or the SORTCNTL data set.

- Do not code the LINAGE clause for the output FD entry.
- Do not code any INPUT declarative (for input files), OUTPUT declarative (for output files), or file-specific declaratives (for either input or output files) to apply to any FDs used in the sort.
- Do not use a variable relative file as the input or output file.
- Do not use a line-sequential file as the input or output file.
- For either an input or an output file, the record descriptions of the SD and FD entry must define the same format (fixed or variable), and the largest records of the SD and FD entry must define the same record length.

Note that if you code a RELATIVE KEY clause for an output file, it will not be set by the sort.

Performance tip: If you block your input and output records, the sort performance could be significantly improved.

QSAM requirements

- QSAM files must have a record format of fixed, variable, or spanned.
- A QSAM input file can be empty.
- To use the same QSAM file for both input and output, you must describe the file using two different DD statements. For example, in the FILE-CONTROL SECTION you might code the following:

```
SELECT FILE-IN ASSIGN INPUTF.
SELECT FILE-OUT ASSIGN OUTPUTF.
```

In the DATA DIVISION, you would have an FD entry for both FILE-IN and FILE-OUT, where FILE-IN and FILE-OUT are identical except for their names.

In the PROCEDURE DIVISION, your SORT statement could look like this:

```
SORT file-name
  ASCENDING KEY data-name-1
  USING FILE-IN GIVING FILE-OUT
```

Then in your JCL, you would code:

```
//INPUTF DD DSN=INOUT,DISP=SHR
//OUTPUTF DD DSN=INOUT,DISP=SHR
```

where data set INOUT has been cataloged.

On the other hand, if you code the same file name in the USING and GIVING phrases, or assign the input and output files the same ddname, then the file can be accepted for FASTSRT either for input or output, but not both. If no other conditions disqualify the file from being eligible for FASTSRT on input, then the file will be accepted for FASTSRT on input, but not on output. If the file was found to be ineligible for FASTSRT on input, it might be eligible for FASTSRT on output.

A QSAM file that qualifies for FASTSRT can be accessed by the COBOL program while the SORT statement is being performed. For example, if the file is used for FASTSRT on input, you can access it in an output procedure; if it is used for FASTSRT on output, you can access it in an input procedure.

VSAM requirements

- A VSAM input file must not be empty.
- VSAM files cannot be password-protected.
- You cannot name the same VSAM file in both the USING and GIVING phrases.
- A VSAM file that qualifies for FASTSORT cannot be accessed by the COBOL program until the SORT statement processing is completed. For example, if the file qualifies for FASTSORT on input, you cannot access it in an output procedure and vice versa. (If you do so, OPEN will fail.)

RELATED TASKS

DFSORT Application Programming Guide

Checking for sort errors with NOFASTSORT

When you compile with the NOFASTSORT option, the sort process does not check for errors in open, close, or input or output operations for files that you reference in the USING or GIVING phrase of the SORT statement. Therefore, you might need to check whether the SORT statement completed successfully.

The code required depends on whether you code a FILE STATUS clause or an ERROR declarative for the files referenced in the USING and GIVING phrases, as shown in the table below.

Table 33. Methods for checking for sort errors with NOFASTSORT

FILE STATUS clause?	ERROR declarative?	Then do:
No	No	No special coding. Any failure during the sort process causes the program to end abnormally.
Yes	No	Test the SORT-RETURN special register after the SORT statement, and test the file status key. (Not recommended if you want complete file status checking, because the file status code is set but COBOL cannot check it.)
Maybe	Yes	In the ERROR declarative, set the SORT-RETURN special register to 16 to stop the sort process and indicate that it was not successful. Test the SORT-RETURN special register after the SORT statement.

RELATED TASKS

“Determining whether the sort or merge was successful” on page 192

“Using file status keys” on page 208

“Coding ERROR declaratives” on page 207

“Stopping a sort or merge operation prematurely” on page 192

Controlling sort behavior

You can control several aspects of sort behavior by the following means:

- Inserting values in special registers before the sort
- Using compiler options
- Using control statement keywords

You can also verify sort behavior by examining the contents of special registers after the sort.

The table below lists those aspects of sort behavior that you can affect using special registers or compiler options, and the equivalent sort control statement keywords if any.

Table 34. Methods for controlling sort behavior

To set or test	Use this special register or compiler option	Or this control statement (and keyword if applicable)
Amount of main storage to be reserved	SORT-CORE-SIZE special register	OPTION (keyword RESINV)
Amount of main storage to be used	SORT-CORE-SIZE special register	OPTION (keywords MAINSIZE or MAINSIZE=MAX)
Modal length of records in a file with variable-length records	SORT-MODE-SIZE special register	SMS=nnnnn
Name of sort control statement data set (default IGZSRTCD)	SORT-CONTROL special register	None
Name of sort message file (default SYSOUT)	SORT-MESSAGE special register	OPTION (keyword MSGDDN)
Number of sort records	SORT-FILE-SIZE special register	OPTION (keyword FILSZ)
Sort completion code	SORT-RETURN special register	None
Century window for sorting or merging on date fields	YEARWINDOW compiler option	OPTION (keyword Y2PAST)
Format of windowed date fields used as sort or merge keys	(Derived from PICTURE, USAGE, and DATE FORMAT clauses)	SORT (keyword FORMAT=Y2x)

Sort special registers

SORT-CONTROL is an eight-character COBOL special register that contains the ddname of the sort control statement file. If you do not want to use the default ddname IGZSRTCD, assign to SORT-CONTROL the ddname of the data set that contains your sort control statements.

The SORT-CORE-SIZE, SORT-FILE-SIZE, SORT-MESSAGE, and SORT-MODE-SIZE special registers are used in the SORT interface if you assign them nondefault values. At run time, however, any parameters on control statements in the sort control statement data set override corresponding settings in the special registers, and a message to that effect is issued.

You can use the SORT-RETURN special register to determine whether the sort or merge was successful and to stop a sort or merge operation prematurely.

A compiler warning message (W-level) is issued for each sort special register that you set in a program.

RELATED TASKS

“Determining whether the sort or merge was successful” on page 192

“Stopping a sort or merge operation prematurely” on page 192

“Changing DFSORT defaults with control statements” on page 197

“Allocating space for sort files” on page 198

Using DFSORT program control statements (*DFSORT Application Programming Guide*)

RELATED REFERENCES

“Default characteristics of the IGZSRTCD data set”

Changing DFSORT defaults with control statements

If you want to change DFSORT system defaults to improve sort performance, pass information to DFSORT through control statements in the run-time data set IGZSRTCD.

The control statements that you can include in the IGZSRTCD data set (in the order listed) are:

1. SMS=nnnnn, where nnnnn is the length in bytes of the most frequently occurring record size. (Use only if the SD file is variable length.)
2. OPTION (except keywords SORTIN or SORTOUT).
3. Other DFSORT control statements (except SORT, MERGE, RECORD, or END).

Code control statements between columns 2 and 71. You can continue a control statement record by ending the line with a comma and starting the next line with a new keyword. No labels or comments are allowed on a record, and a record itself cannot be a DFSORT comment statement.

RELATED TASKS

“Controlling sort behavior” on page 195

Using DFSORT program control statements (*DFSORT Application Programming Guide*)

RELATED REFERENCES

“Default characteristics of the IGZSRTCD data set”

Default characteristics of the IGZSRTCD data set

- LRECL=80.
- BLKSIZE=400.
- ddname is IGZSRTCD. (You can use a different ddname by coding it in the SORT-CONTROL special register.)

The IGZSRTCD data set is optional. If you defined a ddname for the SORT-CONTROL data set and you receive the message IGZ0027W, an OPEN failure occurred that you should investigate.

RELATED TASKS

“Controlling sort behavior” on page 195

Allocating storage for sort or merge operations

Certain parameters set during the installation of DFSORT determine the amount of storage it uses. In general, the more storage DFSORT has available, the faster the sort or merge operations in your program will be.

DFSORT installation should not allocate all the free space in the region for its COBOL operation, however. When your program is running, storage must be available for the following:

- COBOL programs that are dynamically called from an input or output procedure
- Language Environment run-time library modules
- Data management modules that can be loaded into the region for use by an input or output procedure

- Any storage obtained by these modules

For a specific sort or merge operation, you can override the DFSORT storage values set at installation. To do so, code the MAINSIZE and RESINV keywords on the OPTION control statement in the sort control statement data set, or use the SORT-CORE-SIZE special register.

Be careful not to override the storage allocation to the extent that all the free space in the region is used for sort operations in your COBOL program.

RELATED TASKS

“Controlling sort behavior” on page 195
DFSORT Installation and Customization

RELATED REFERENCES

OPTION control statement (*DFSORT Application Programming Guide*)

Allocating space for sort files

If you use NOFASTSORT or an input procedure, DFSORT does not know the size of the file that you are sorting. This can lead to an out-of-space condition when you are sorting large files or to overallocation of resources when you are sorting small files. If this occurs, you can use the SORT-FILE-SIZE special register to help DFSORT determine the amount of resource (for example, workspace or *hiperspace*) needed for the sort. Set SORT-FILE-SIZE to a reasonable estimate of the number of input records. This value is passed to DFSORT as its FILSZ=En value.

RELATED TASKS

“Controlling sort behavior” on page 195
 “Coding the input procedure” on page 184
DFSORT Application Programming Guide

Using checkpoint/restart with DFSORT

You cannot use checkpoints taken while DFSORT is running under z/OS to restart, unless the checkpoints are taken by DFSORT. Checkpoints taken by your COBOL program while SORT or MERGE statements execute are invalid; the restarts are detected and canceled.

To take a checkpoint during a sort or merge operation, follow these steps:

1. Add a DD statement for SORTCKPT in the JCL.
2. Code the RERUN clause in the I-O-CONTROL paragraph:
 RERUN ON *assignment-name*
3. Code the CKPT (or CHKPT) keyword on an OPTION control statement in the sort control statement data set (default ddname IGZSRTCD).

RELATED CONCEPTS

Chapter 32, “Interrupts and checkpoint/restart,” on page 545

RELATED TASKS

“Changing DFSORT defaults with control statements” on page 197
 “Setting checkpoints” on page 545

Sorting under CICS

There is no IBM sort product that is supported under CICS. However, you can use the SORT statement with a sort program you write that runs under CICS to sort small amounts of data.

You must have both an input and an output procedure for the SORT statement. In the input procedure, use the RELEASE statement to transfer records from the COBOL program to the sort program before the sort is performed. In the output procedure, use the RETURN statement to transfer records from the sort program to the COBOL program after the sort is performed.

RELATED TASKS

“Coding the input procedure” on page 184

“Coding the output procedure” on page 185

RELATED REFERENCES

“CICS SORT application restrictions”

CICS SORT application restrictions

The following restrictions apply to COBOL applications that run under CICS and use the SORT statement:

- SORT statements that include the USING or GIVING phrase are not supported.
- Sort control data sets are not supported. Data in the SORT-CONTROL special register is ignored.
- Using the following CICS commands in the input or output procedures can cause unpredictable results:
 - CICS LINK
 - CICS XCTL
 - CICS RETURN
 - CICS HANDLE
 - CICS IGNORE
 - CICS PUSH
 - CICS POP
- You can use CICS commands other than those in the preceding list provided you use the NOHANDLE or RESP option. Unpredictable results can occur if you do not use NOHANDLE or RESP.

Chapter 13. Handling errors

Anticipate possible coding or system problems by putting code into your program to handle them. Such code is like built-in distress flares or lifeboats. With this code, output data and files should not be corrupted, and the user will know when there is a problem.

Your error-handling code can take actions such as handling the situation, issuing a message, or halting the program. In any event, coding a warning message is a good idea.

You might create error-detection routines for data-entry errors or for errors as your installation defines them.

COBOL contains special elements to help you anticipate and correct error conditions:

- User-requested dumps
- ON OVERFLOW in STRING and UNSTRING operations
- ON SIZE ERROR in arithmetic operations
- Technique handling for input or output errors
- ON EXCEPTION or ON OVERFLOW in CALL statements
- User-written routines for handling errors

RELATED TASKS

"Handling errors in joining and splitting strings" on page 202

"Handling errors in arithmetic operations" on page 203

"Handling errors in input and output operations" on page 203

"Handling errors when calling programs" on page 213

"Writing routines for handling errors" on page 213

Requesting dumps

You can obtain a formatted dump of the run-time environment by calling the Language Environment service CEE3DMP. To obtain a system dump, you can request an abend without cleanup by calling the Language Environment service CEE3ABD with a cleanup value of zero.

Creating a formatted dump

You can cause a dump of the Language Environment run-time environment and the member language libraries at any prespecified point in your program. Simply code a call to the Language Environment callable service CEE3DMP. For example:

```
77 Title-1          Pic x(80)   Display.  
77 Options          Pic x(255) Display.  
01 Feedback-code    Pic x(12)   Display.  
.  
.  
.  
    Call "CEE3DMP" Using Title-1, Options, Feedback-code
```

To have symbolic variables included in the formatted dump produced by Language Environment, you must compile with the SYM suboption of the TEST compiler option and use the VARIABLES subparameter of CEE3DMP.

You can also request, through run-time options, that a dump be produced for error conditions of your choosing.

Creating a system dump

You can cause a system dump at any prespecified point in your program. Simply request an abend without cleanup by calling the Language Environment service CEE3ABD with a cleanup value of zero.

This callable service stops the run unit immediately, and a system dump is requested when the abend is issued.

RELATED REFERENCES

Language Environment Debugging Guide

CEE3DMP—generate dump (*Language Environment Programming Reference*)

Handling errors in joining and splitting strings

During the joining or splitting of strings, the pointer used by STRING or UNSTRING might fall outside the range of the receiving field. A potential overflow condition exists, but COBOL does not let the overflow happen. Instead, the STRING or UNSTRING operation is not completed, the receiving field remains unchanged, and control passes to the next sequential statement. You do not have an ON OVERFLOW clause on the STRING or UNSTRING statement, and you are not notified of the incomplete operation.

Consider the following statement:

```
String Item-1 space Item-2 delimited by Item-3
      into Item-4
      with pointer String-ptr
      on overflow
          Display "A string overflow occurred"
End-String
```

These are the data values before and after the statement is performed:

Data item	PICTURE	Value before	Value after
Item-1	X(5)	AAAAA	AAAAA
Item-2	X(5)	EEEEAA	EEEEAA
Item-3	X(2)	EA	EA
Item-4	X(8)	bbbbbbb ¹	bbbbbbb ¹
String-ptr	9(2)	0	0
1. The symbol <i>b</i> represents a blank space.			

Because String-ptr has a value of zero that falls short of the receiving field, an overflow condition occurs and the STRING operation is not completed. (The same result would occur if String-ptr were greater than nine.) If ON OVERFLOW had not been specified, you would not be notified that the contents of Item-4 remain unchanged.

Handling errors in arithmetic operations

The results of arithmetic operations might be larger than the fixed-point field that is to hold them, or you might have tried dividing by zero. In either case, the ON SIZE ERROR clause after the ADD, SUBTRACT, MULTIPLY, DIVIDE, or COMPUTE statement can handle the situation.

For ON SIZE ERROR to work correctly for fixed-point overflow and decimal overflow, you must specify the TRAP(ON) run-time option.

The imperative statement of the ON SIZE ERROR clause will be performed and the result field will not change in these cases:

- Fixed-point overflow
- Division by zero
- Zero raised to the zero power
- Zero raised to a negative number
- Negative number raised to a fractional power

Floating-point exponent overflow occurs when the value of a floating-point computation cannot be represented in the zSeries floating-point operand format. This type of overflow does not cause SIZE ERROR; an abend occurs instead. You could code a user-written condition handler to intercept the abend and provide your own error recovery logic.

“Example: checking for division by zero”

Example: checking for division by zero

Code your ON SIZE ERROR imperative statement so that it issues an informative message. For example:

```
DIVIDE-TOTAL-COST.  
    DIVIDE TOTAL-COST BY NUMBER-PURCHASED  
        GIVING ANSWER  
        ON SIZE ERROR  
            DISPLAY "ERROR IN DIVIDE-TOTAL-COST PARAGRAPH"  
            DISPLAY "SPENT " TOTAL-COST, " FOR " NUMBER-PURCHASED  
            PERFORM FINISH  
        END-DIVIDE  
    . . .  
FINISH.  
STOP RUN.
```

In this example, if division by zero occurs, the program writes a message identifying the trouble and halts program execution.

Handling errors in input and output operations

When an input or output operation fails, COBOL does not automatically take corrective action. You choose whether your program will continue running after a less-than-severe input or output error occurs.

You can use any of the following techniques for intercepting and handling certain input or output errors:

- End-of-file condition (AT END)
- ERROR declarative
- File status key

- File system return code
- INVALID KEY phrase
- Imperative-statement phrases on your READ or WRITE statement
- ERROR declaratives
- FILE STATUS clauses

For VSAM files, if you specify a FILE STATUS clause, you can also test the VSAM return code to direct your program to error-handling logic.

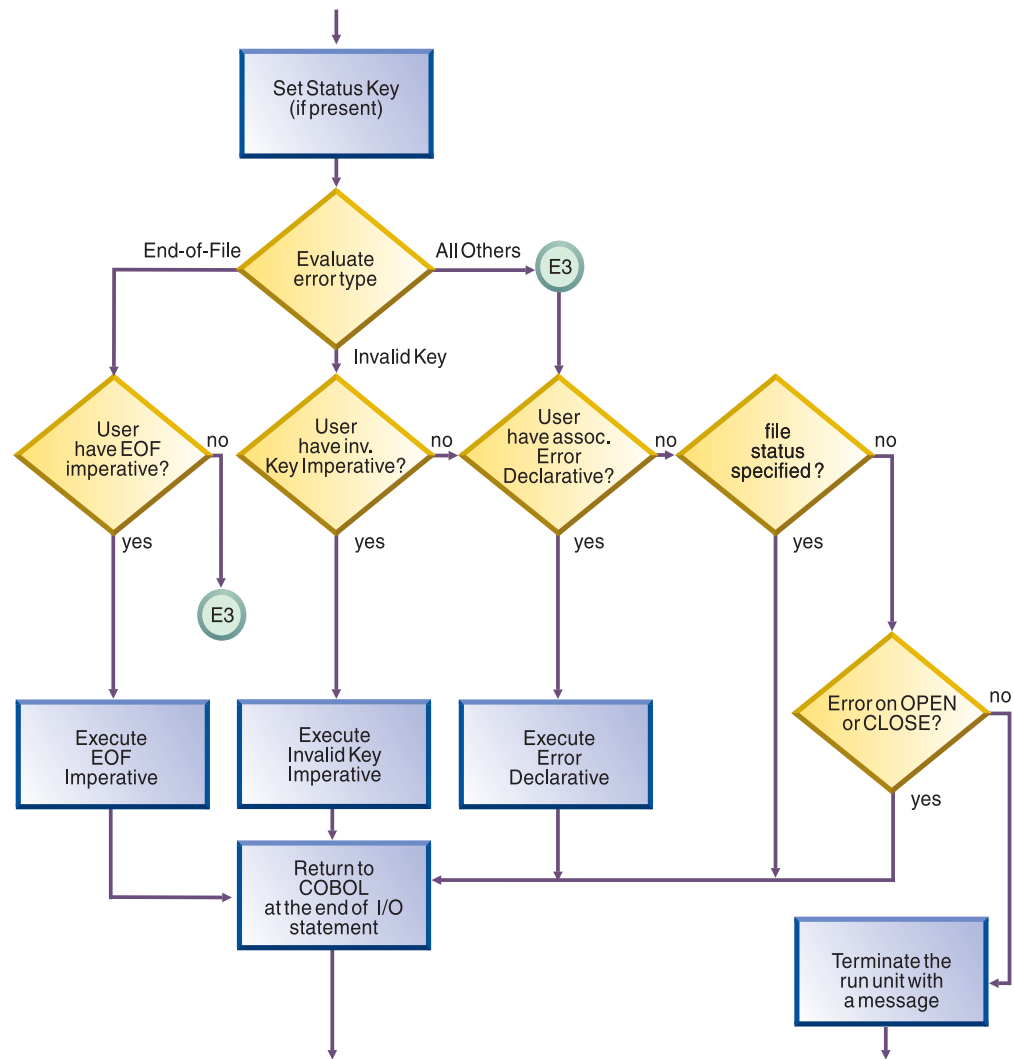
If you choose to have your program continue (by incorporating error-handling code into your design), you must code the appropriate error-recovery procedure. You might code, for example, a procedure to check the value of the file status key.

If you do not handle an input or output error in any of these ways, a severity-3 Language Environment condition is signaled, which causes the run unit to end if the condition is not handled.

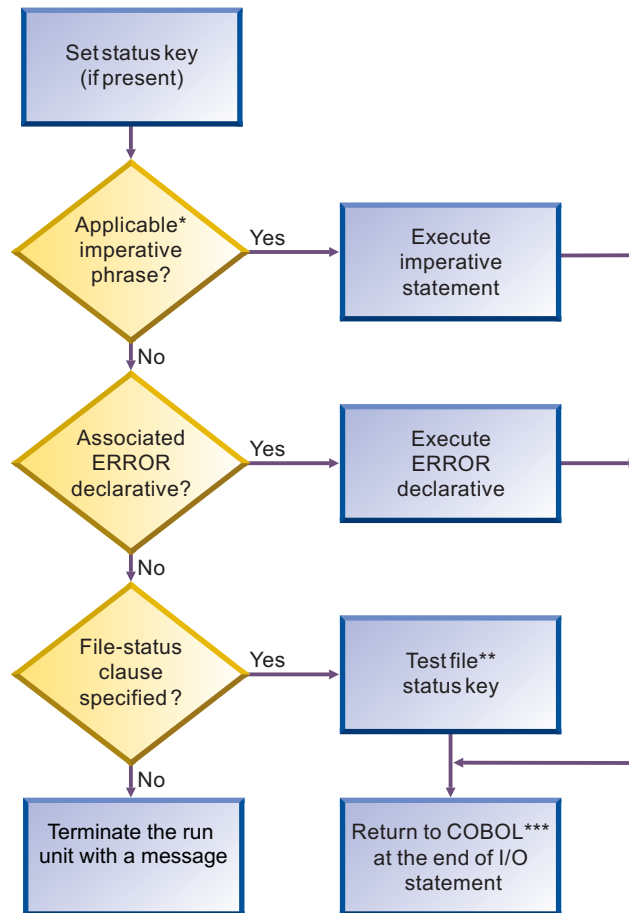
The following figures show the flow of logic after the indicated errors:

- VSAM input or output error
- QSAM and line-sequential input or output error

The following figure shows the flow of logic after a VSAM input or output error:



The following figure shows the flow of logic after an input or output error with QSAM or line-sequential files. The error can be from a READ statement, a WRITE statement, or a CLOSE statement with a REEL/UNIT clause (QSAM only).



*Possible phrases for QSAM are AT END, AT END-OF-PAGE, and INVALID KEY; for line sequential, AT END.

**You need to write the code to test the file status key.

***Execution of your COBOL program continues after the input or output statement that caused the error.

RELATED TASKS

"Using the end-of-file condition (AT END)"

"Coding ERROR declaratives" on page 207

"Using file status keys" on page 208

"Handling errors in QSAM files" on page 133

"Using VSAM return codes (VSAM files only)" on page 209

"Coding INVALID KEY phrases" on page 212

RELATED REFERENCES

Status key (Common processing facilities) (*Enterprise COBOL Language Reference*)

Using the end-of-file condition (AT END)

You code the AT END phrase of the READ statement to handle errors or normal conditions, according to your program design. If you code an AT END phrase, on end-of-file the phrase is performed. If you do not code an AT END phrase, the associated ERROR declarative is performed.

In many designs, reading sequentially to the end of a file is done intentionally, and the AT END condition is expected. For example, suppose you are processing a file containing transactions in order to update a master file:

```
PERFORM UNTIL TRANSACTION-EOF = "TRUE"  
  READ UPDATE-TRANSACTION-FILE INTO WS-TRANSACTION-RECORD  
  AT END  
    DISPLAY "END OF TRANSACTION UPDATE FILE REACHED"  
    MOVE "TRUE" TO TRANSACTION-EOF  
  END READ  
  . . .  
END-PERFORM
```

Any NOT AT END phrase you code is performed only if the READ statement completes successfully. If the READ operation fails because of a condition other than end-of-file, neither the AT END nor the NOT AT END phrase is performed. Instead, control passes to the end of the READ statement after performing any associated declarative procedure.

You might choose to code neither an AT END phrase nor an EXCEPTION declarative procedure, but a status key clause for the file. In that case, control passes to the next sequential instruction after the input or output statement that detected the end-of-file conditions. Here presumably you have some code to take appropriate action.

RELATED REFERENCES

AT END phrases (*Enterprise COBOL Language Reference*)

Coding ERROR declaratives

You can code one or more ERROR declarative procedures in your COBOL program that will be given control if an input or output error occurs. You can have:

- A single, common procedure for the entire program
- Procedures for each file open mode (whether INPUT, OUTPUT, I-O, or EXTEND)
- Individual procedures for each particular file

Place each such procedure in the declaratives section of your PROCEDURE DIVISION.

In your procedure, you can choose to try corrective action, retry the operation, continue, or end execution. You can use the ERROR declaratives procedure in combination with the file status key if you want a further analysis of the error.

If you continue processing a blocked file, you might lose the remaining records in a block after the record that caused the error.

Write an ERROR declarative procedure if you want the system to return control to your program after an error occurs. If you do not write an ERROR declarative procedure, your job could be canceled or abnormally terminated after an error occurs.

Multithreading: Take care to avoid deadlocks when coding I/O declaratives in your multithreaded applications. When an I/O operation results in a transfer of control to an I/O declarative, the automatic serialization lock associated with the file is held during the execution of the statements within the declarative. Thus if you code I/O operations within your declaratives, your logic might result in a deadlock as illustrated by this sample:

```

Declaratives.
D1 section.
Use after standard error procedure on F1
. . .
    Read F2.
. . .
D2 section.
Use after standard error procedure on F2
. . .
    Read F1.
. . .
End declaratives.
. . .
    Rewrite R1.
    Rewrite R2.

```

When this program is running on two threads, the following sequence of events might occur:

1. Thread 1: Rewrite R1 acquires lock on F1 and encounters I/O error.
2. Thread 1: Enter declarative D1, holding lock on F1.
3. Thread 2: Rewrite R2 acquires lock on F2 and encounters I/O error.
4. Thread 2: Enter declarative D2.
5. Thread 1: Read F2 from declarative D1; wait on F2 lock held by thread 2.
6. Thread 2: Read F1 from declarative D2; wait on F1 lock held by thread 1.
7. Deadlock.

RELATED REFERENCES

EXCEPTION/ERROR declarative (*Enterprise COBOL Language Reference*)

Using file status keys

After each input or output statement is performed on a file, the system updates values in the two digits of the file status key. In general, a zero in the first digit indicates a successful operation, and a zero in both digits means there is nothing abnormal. Establish a file status key by using the FILE STATUS clause in the FILE-CONTROL paragraph and data definitions in the DATA DIVISION.

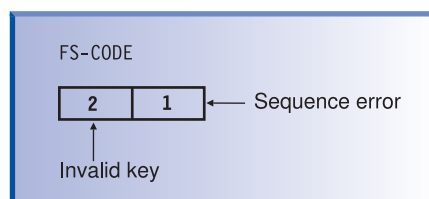
FILE STATUS IS *data-name-1*

The data item *data-name-1* specifies the two-character COBOL file status key that should be defined in the WORKING-STORAGE SECTION. This *data-name* cannot be variably located.

Your program can check the COBOL file status key to discover whether an error has been made and, if so, what type of error it is. For example, suppose a FILE STATUS clause is coded like this:

FILE STATUS IS FS-CODE

FS-CODE is used by COBOL to hold status information like this:



Follow these rules for each file:

- Define a different file status key for each file.

You can then determine the cause of a file input or output exception, such as an application logic error or a disk error.

- Check the file status key after every input or output request.

If it contains a value other than 0, your program can issue an error message or can act based on the value.

You do not have to reset the file status key code, because it is set after each input or output attempt.

For VSAM files, in addition to the file status key, you can code a second identifier in the FILE STATUS clause to get more detailed information about VSAM input or output requests.

You can use the file status key alone or in conjunction with the INVALID KEY option, or to supplement the EXCEPTION or ERROR declarative. Using the file status key in this way gives you precise information about the results of each input or output operation.

“Example: file status key”

RELATED REFERENCES

File status key (Common processing facilities) (*Enterprise COBOL Language Reference*)

Example: file status key

This COBOL code performs a simple check on the file status key after opening a file.

```
IDENTIFICATION DIVISION.
PROGRAM-ID. SIMCHK.
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT MASTERFILE ASSIGN TO AS-MASTERA
    FILE STATUS IS MASTER-CHECK-KEY
. . .
DATA DIVISION.
. . .
WORKING-STORAGE SECTION.
01 MASTER-CHECK-KEY          PIC X(2).
. . .
PROCEDURE DIVISION.
. . .
    OPEN INPUT MASTERFILE
    IF MASTER-CHECK-KEY NOT = "00"
        DISPLAY "Nonzero file status returned from OPEN " MASTER-CHECK-KEY
. . .
```

Using VSAM return codes (VSAM files only)

Often the two-character FILE STATUS code is too general to pinpoint the disposition of a request. You can get more detailed information about VSAM input or output requests by coding a second status area:

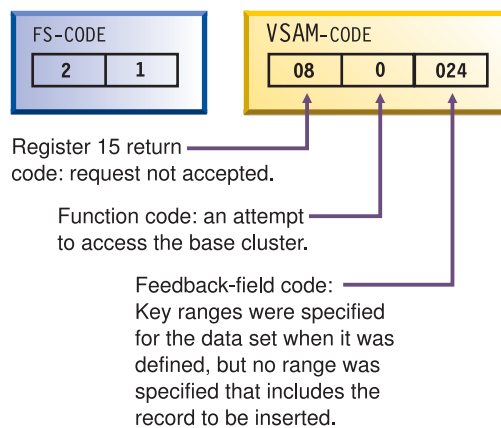
```
FILE STATUS IS data-name-1 data-name-8
```

The data item *data-name-1* specifies the two-character COBOL file status key. The data item *data-name-8* specifies a 6-byte data item that contains the VSAM return code when the COBOL file status key is not 0.

You can define the second status area, *data-name-8*, in the WORKING-STORAGE SECTION as in VSAM-CODE here:

```
01 RETURN-STATUS.
   05 FS-CODE          PIC X(2).
   05 VSAM-CODE.
      10 VSAM-R15-RETURN PIC S9(4) Usage Comp-5.
      10 VSAM-FUNCTION  PIC S9(4) Usage Comp-5.
      10 VSAM-FEEDBACK  PIC S9(4) Usage Comp-5.
```

Enterprise COBOL uses *data-name-8* to pass information supplied by VSAM. In the following example, FS-CODE corresponds to *data-name-1* and VSAM-CODE corresponds to *data-name-8*:



“Example: checking VSAM status codes”

RELATED REFERENCES

VSAM macro return and reason codes (*z/OS DFSMS Macro Instructions for Data Sets*)

Example: checking VSAM status codes

This COBOL code does the following:

- Reads an indexed file (starting at the fifth record)
- Checks the file status key after each input or output request
- Displays the VSAM codes when the file status key is not zero

This example also illustrates how output from this program might look if the file being processed contains six records.

```
IDENTIFICATION DIVISION
PROGRAM-ID. EXAMPLE.
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT VSAMFILE ASSIGN TO VSAMFILE
    ORGANIZATION IS INDEXED
    ACCESS DYNAMIC
    RECORD KEY IS VSAMFILE-KEY
    FILE STATUS IS FS-CODE VSAM-CODE.
DATA DIVISION.
```

```

FILE SECTION.
FD  VSAMFILE
   RECORD 30.
01  VSAMFILE-REC.
     10 VSAMFILE-KEY          PIC X(6).
     10 FILLER                PIC X(24).
WORKING-STORAGE SECTION.
01  RETURN-STATUS.
     05 FS-CODE               PIC XX.
     05 VSAM-CODE.
         10 VSAM-RETURN-CODE  PIC S9(2) Usage Binary.
         10 VSAM-COMPONENT-CODE PIC S9(1) Usage Binary.
         10 VSAM-REASON-CODE  PIC S9(3) Usage Binary.
PROCEDURE DIVISION.
   OPEN  INPUT VSAMFILE.
   DISPLAY "OPEN INPUT VSAMFILE FS-CODE: " FS-CODE.

   IF FS-CODE NOT = "00"
       PERFORM VSAM-CODE-DISPLAY
       STOP RUN
   END-IF.

   MOVE "000005" TO VSAMFILE-KEY.
   START VSAMFILE KEY IS EQUAL TO VSAMFILE-KEY.
   DISPLAY "START VSAMFILE KEY=" VSAMFILE-KEY
       " FS-CODE: " FS-CODE.
   IF FS-CODE NOT = "00"
       PERFORM VSAM-CODE-DISPLAY
   END-IF.

   IF FS-CODE = "00"
       PERFORM READ-NEXT UNTIL FS-CODE NOT = "00"
   END-IF.

   CLOSE VSAMFILE.
   STOP RUN.

READ-NEXT.
   READ VSAMFILE NEXT.
   DISPLAY "READ NEXT VSAMFILE FS-CODE: " FS-CODE.
   IF FS-CODE NOT = "00"
       PERFORM VSAM-CODE-DISPLAY
   END-IF.
   DISPLAY VSAMFILE-REC.

VSAM-CODE-DISPLAY.
   DISPLAY "VSAM-CODE ==>"
       " RETURN: " VSAM-RETURN-CODE,
       " COMPONENT: " VSAM-COMPONENT-CODE,
       " REASON: " VSAM-REASON-CODE.

```

Below is a sample of the output from the example program that checks VSAM code information:

```

OPEN INPUT VSAMFILE FS-CODE: 00
START VSAMFILE KEY=000005 FS-CODE: 00
READ NEXT VSAMFILE FS-CODE: 00
000005 THIS IS RECORD NUMBER 5
READ NEXT VSAMFILE FS-CODE: 00
000006 THIS IS RECORD NUMBER 6
READ NEXT VSAMFILE FS-CODE: 10
VSAM-CODE ==> RETURN: 08 COMPONENT: 2 REASON: 004

```

Coding INVALID KEY phrases

You can include INVALID KEY phrases on READ, START, WRITE, REWRITE, and DELETE requests for VSAM indexed and relative files. The INVALID KEY phrase is given control if an input or output error occurs because of a faulty index key.

Use the FILE STATUS clause with INVALID KEY to evaluate the status key and determine the specific INVALID KEY condition.

You can also include INVALID KEY on WRITE requests for QSAM files, but the INVALID KEY phrase has limited meaning here. It is used only if you try to write to a disk that is full.

INVALID KEY and ERROR declaratives

INVALID KEY phrases differ from ERROR declaratives in these ways:

- INVALID KEY phrases operate for only limited types of errors, whereas the ERROR declarative encompasses all forms.
- INVALID KEY phrases are coded directly onto the input or output verb, whereas ERROR declaratives are coded separately.
- INVALID KEY phrases are specific for a single input or output operation, whereas ERROR declaratives are more general.

If you code INVALID KEY in a statement that causes an INVALID KEY condition, control is transferred to the INVALID KEY imperative statement. Here, any ERROR declaratives you have coded are not performed.

NOT INVALID KEY

A NOT INVALID KEY phrase that you code is performed only if the statement completes successfully. If the operation fails because of a condition other than INVALID KEY, neither the INVALID KEY nor the NOT INVALID KEY phrase is performed. Instead control passes to the end of the statement after the program performs any associated ERROR declaratives.

“Example: FILE STATUS and INVALID KEY”

Example: FILE STATUS and INVALID KEY

Assume you have a file containing master customer records and need to update some of these records with information in a transaction update file. The program reads each transaction record, finds the corresponding record in the master file, and makes the necessary updates. The records in both files contain a field for a customer number, and each record in the master file has a unique customer number.

The FILE-CONTROL entry for the master file of customer records includes statements defining indexed organization, random access, MASTER-CUSTOMER-NUMBER as the prime record key, and CUSTOMER-FILE-STATUS as the file status key. The following example shows how you can use FILE STATUS with the INVALID KEY to more specifically determine why an input or output statement failed.

```
.  
  (read the update transaction record)  
.  
MOVE "TRUE" TO TRANSACTION-MATCH  
MOVE UPDATE-CUSTOMER-NUMBER TO MASTER-CUSTOMER-NUMBER  
READ MASTER-CUSTOMER-FILE INTO WS-CUSTOMER-RECORD  
  INVALID KEY
```

```
DISPLAY "MASTER CUSTOMER RECORD NOT FOUND"
DISPLAY "FILE STATUS CODE IS: " CUSTOMER-FILE-STATUS
MOVE "FALSE" TO TRANSACTION-MATCH
END-READ
```

Handling errors when calling programs

When a program dynamically calls a separately compiled program, the called program might be unavailable to the system. For example, the system could run out of storage or it could be unable to locate the load module. If you do not have an `ON EXCEPTION` or `ON OVERFLOW` phrase on the `CALL` statement, your application might abend.

Use the `ON EXCEPTION` phrase to perform a series of statements and to perform your own error handling. For example:

```
MOVE "REPORTA" TO REPORT-PROG
CALL REPORT-PROG
  ON EXCEPTION
    DISPLAY "Program REPORTA not available, using REPORTB."
    MOVE "REPORTB" TO REPORT-PROG
    CALL REPORT-PROG
  END-CALL
END-CALL
```

If program `REPORTA` is unavailable, control will continue with the `ON EXCEPTION` phrase.

The `ON EXCEPTION` phrase applies only to the availability of the called program. If an error occurs while the called program is running, the `ON EXCEPTION` phrase will not be performed.

RELATED TASKS

Enterprise COBOL Compiler and Run-Time Migration Guide

Writing routines for handling errors

You can handle most error conditions that might occur while your program is running by using the `ON EXCEPTION` phrase, the `ON SIZE ERROR` phrase, or other language constructs. But if an extraordinary condition like a machine check occurs, normally your application will not regain control; it will be abnormally terminated.

However, Enterprise COBOL and Language Environment provide a way for a user-written program to gain control when such conditions occur. Using Language Environment condition handling, you can write your own error-handling programs in COBOL. They can report, analyze, or even fix up and allow your program to resume running.

To have Language Environment pass control to your user-written error program, you must first identify and register its entry point to Language Environment. `PROCEDURE-POINTER` data items allow you to pass the entry address of procedure entry points to Language Environment services.

RELATED TASKS

"Using procedure and function pointers" on page 407

Part 2. Compiling and debugging your program

Chapter 14. Compiling under z/OS	217	Chapter 15. Compiling under UNIX	249
Compiling with JCL	217	Setting environment variables under UNIX	249
Using a cataloged procedure	218	Specifying compiler options under UNIX	250
Compile procedure (IGYWC)	219	Compiling and linking with the cob2 command	251
Compile and link-edit procedure (IGYWCL)	220	Defining input and output	251
Compile, link-edit, and run procedure (IGYWCLG)	221	Creating a DLL	252
Compile, load, and run procedure (IGYWCG)	222	Example: using cob2 to compile under UNIX	252
Compile, prelink, and link-edit procedure (IGYWCPL)	223	cob2	253
Compile, prelink, link-edit, and run procedure (IGYWCPLG)	224	cob2 input and output files	254
Prelink and link-edit procedure (IGYWPL)	226	Compiling using scripts	255
Compile, prelink, load, and run procedure (IGYWCPG)	226	Chapter 16. Compiling, linking, and running OO applications	257
Writing JCL to compile programs	228	Compiling, linking, and running OO applications under UNIX	257
Example: user-written JCL for compiling	229	Compiling OO applications under UNIX	257
Compiling under TSO	229	Preparing OO applications under UNIX	258
Example: ALLOCATE and CALL for compiling under TSO	230	Example: compiling and linking a COBOL class definition under UNIX	259
Example: CLIST for compiling under TSO	230	Running OO applications under UNIX	259
Starting the compiler from an assembler program	231	Running OO applications that start with a main method	260
Defining compiler input and output	232	Running OO applications that start with a COBOL program	260
Data sets used by the compiler under z/OS	233	Compiling, linking, and running OO applications using JCL or TSO/E	261
Logical record length and block size	234	Compiling OO applications using JCL or TSO/E	261
Defining the source code data set (SYSIN)	235	Preparing and running OO applications using JCL or TSO/E	262
Specifying source libraries (SYSLIB)	235	Example: compiling, linking, and running an OO application using JCL	263
Defining the output data set (SYSPRINT)	236	JCL for program TSTHELLO	264
Directing compiler messages to your terminal (SYSTEM)	236	Definition of class HelloJ	265
Creating object code (SYSLIN or SYSPUNCH)	236	Environment variable settings file, ENV	265
Creating an associated data file (SYSADATA)	237	Chapter 17. Compiler options	267
Defining the output Java data set (SYSJAVA)	237	Option settings for COBOL 85 Standard conformance	269
Defining the debug data set (SYSDEBUG)	237	Conflicting compiler options	269
Specifying compiler options under z/OS	238	ADATA	270
Specifying compiler options with the PROCESS (CBL) statement	238	ADV	271
Example: specifying compiler options using JCL	239	ARITH	271
Example: specifying compiler options under TSO	239	AWO	272
Compiler options and compiler output under z/OS	239	BUFSIZE	273
Compiling multiple programs (batch compilation)	241	CICS	273
Example: batch compilation	242	CODEPAGE	274
Specifying compiler options in a batch compilation	242	COMPILE	275
Example: precedence of options in a batch compilation	243	CURRENCY	276
Example: LANGUAGE option in a batch compilation	244	DATA	277
Correcting errors in your source program	245	DATEPROC	278
Generating a list of compiler error messages	246	DBCS	279
Messages and listings for compiler-detected errors	246	DECK	279
Format of compiler error messages	246	DIAGTRUNC	280
Severity codes for compiler error messages	247	DLL	281
		DUMP	281
		DYNAM	282

EXIT	283
EXPORTALL	283
FASTSRT	284
FLAG	284
FLAGSTD	285
INTDATE	287
LANGUAGE	287
LIB	288
LINECOUNT	289
LIST	289
MAP	290
NAME	291
NSYMBOL	291
NUMBER	292
NUMPROC	293
OBJECT	294
OFFSET	294
OPTIMIZE	295
OUTDD	296
PGMNAME	297
PGMNAME(COMPAT)	297
PGMNAME(LONGUPPER)	298
PGMNAME(LONGMIXED)	298
QUOTE/APOST	299
RENT	299
RMODE	300
SEQUENCE	301
SIZE	302
SOURCE	302
SPACE	303
SQL	303
SSRANGE	304
TERMINAL	305
TEST	306
THREAD	309
TRUNC	310
TRUNC example 1	312
TRUNC example 2	312
VBREF	313
WORD	313
XREF	314
YEARWINDOW	315
ZWB	316

Chapter 18. Compiler-directing statements . . . 317

Chapter 19. Debugging 321

Debugging with source language	322
Tracing program logic	322
Finding and handling input-output errors	323
Validating data	323
Finding uninitialized data	323
Generating information about procedures	324
Debugging lines	324
Debugging statements	324
Example: USE FOR DEBUGGING	324
Debugging using compiler options	325
Finding coding errors	326
Checking syntax only	326
Compiling conditionally	326
Finding line sequence problems	327

Checking for valid ranges	327
Selecting the level of error to be diagnosed	328
Example: embedded messages	328
Finding program entity definitions and references	329
Listing data items	330
Getting listings	331
Example: short listing	332
Example: SOURCE and NUMBER output	335
Example: MAP output	336
Example: embedded map summary	337
Terms used in MAP output	338
Symbols used in LIST and MAP output	338
Example: nested program map	340
Reading LIST output	340
Example: program initialization code	341
Signature information bytes: compiler options	343
Signature information bytes: DATA DIVISION	345
Signature information bytes: ENVIRONMENT DIVISION	346
Signature information bytes: PROCEDURE DIVISION verbs	346
Signature information bytes: more PROCEDURE DIVISION items	348
Example: assembler code generated from source code	349
Example: TGT memory map	350
Example: DSA memory map	351
Example: location and size of WORKING-STORAGE	352
Example: XREF output - data-name cross-references	352
Example: XREF output - program-name cross-references	353
Example: embedded cross-reference	353
Example: OFFSET compiler output	354
Example: VBREF compiler output	355
Preparing to use the debugger	355

Chapter 14. Compiling under z/OS

You can compile Enterprise COBOL programs under z/OS using job control language (JCL), TSO commands, CLISTs, or ISPF panels:

- For compiling with JCL, IBM provides a set of cataloged procedures, which can reduce the amount of JCL coding that you need to write. If the cataloged procedures do not meet your needs, you can write your own JCL. Using JCL, you can compile a single program or compile several programs as part of a batch job.
- When compiling under TSO, you can use TSO commands, CLISTs, or ISPF panels.

You can also compile in a z/OS UNIX shell by using the `cob2` command.

You might instead want to start the Enterprise COBOL compiler from an assembler program, for example, if your shop has developed a tool or interface that calls the Enterprise COBOL compiler.

As part of the compilation step, you need to define the data sets needed for the compilation and specify any compiler options necessary for your program and the desired output.

The compiler translates your COBOL program into language that the computer can process (object code). The compiler also lists errors in your source statements and provides supplementary information to help you debug and tune your program. Use compiler-directing statements and compiler options to control your compilation.

After compiling your program, you need to review the results of the compilation and correct any compiler-detected errors.

RELATED TASKS

"Compiling with JCL"

"Compiling under TSO" on page 229

Chapter 15, "Compiling under UNIX," on page 249

"Starting the compiler from an assembler program" on page 231

"Defining compiler input and output" on page 232

"Specifying compiler options under z/OS" on page 238

"Compiling multiple programs (batch compilation)" on page 241

"Correcting errors in your source program" on page 245

RELATED REFERENCES

Chapter 18, "Compiler-directing statements," on page 317

"Data sets used by the compiler under z/OS" on page 233

"Compiler options and compiler output under z/OS" on page 239

Compiling with JCL

You need to include the following information in the JCL for compilation:

- Job description
- Statement to run the compiler

- Definitions for the data sets needed (including the directory paths if using HFS files)

The simplest way to compile your program under z/OS is to code JCL that uses a cataloged procedure. A *cataloged procedure* is a set of job control statements placed in a partitioned data set called the procedure library (SYS1.PROCLIB).

The following JCL shows the general format for a cataloged procedure.

```
//jobname JOB parameters
//stepname EXEC [PROC=]procname[, {PARM=|PARM.stepname=} 'options']
//SYSIN DD data set parameters
. . . (source program to be compiled)
/*
//
```

Additional considerations apply when you use cataloged procedures to compile object-oriented programs.

“Example: sample JCL for a procedural DLL application” on page 428

RELATED TASKS

“Using a cataloged procedure”

“Writing JCL to compile programs” on page 228

“Specifying compiler options under z/OS” on page 238

“Specifying compiler options in a batch compilation” on page 242

“Compiling programs to create DLLs” on page 426

RELATED REFERENCES

“Data sets used by the compiler under z/OS” on page 233

Using a cataloged procedure

Specify a cataloged procedure in an EXEC statement in your JCL.

The following JCL calls the IBM-supplied cataloged procedure (IGYWC) for compiling an Enterprise COBOL program and defining the required data sets:

```
//JOB1 JOB1
//STPA EXEC PROC=IGYWC
//COBOL.SYSIN DD *
000100 IDENTIFICATION DIVISION
* (the source code)
...
/*
```

You can omit /* after the source code. If your source code is stored in a data set, replace SYSIN DD * with appropriate parameters that describe the data set.

You can use these procedures with any of the job schedulers that are part of z/OS. When a scheduler encounters parameters that it does not require, the scheduler either ignores them or substitutes alternative parameters.

If the compiler options are not explicitly supplied with the procedure, default options established at the installation apply. You can override these default options by using an EXEC statement that includes the desired options.

You can specify data sets to be in the hierarchical file system by overriding the corresponding DD statement. However, the compiler utility files (SYSUTx) and copy libraries (SYSLIB) you specify must be MVS data sets.

Additional details on invoking cataloged procedures, overriding and adding to EXEC statements, and overriding and adding to DD statements are in the Language Environment information.

RELATED TASKS

Language Environment Programming Guide

RELATED REFERENCES

"Compile procedure (IGYWC)"

"Compile and link-edit procedure (IGYWCL)" on page 220

"Compile, link-edit, and run procedure (IGYWCLG)" on page 221

"Compile, load, and run procedure (IGYWCG)" on page 222

"Compile, prelink, and link-edit procedure (IGYWCPL)" on page 223

"Compile, prelink, link-edit, and run procedure (IGYWCPLG)" on page 224

"Prelink and link-edit procedure (IGYWPL)" on page 226

"Compile, prelink, load, and run procedure (IGYWCPG)" on page 226

z/OS DFSMS: Program Management

Compile procedure (IGYWC)

The IGYWC procedure is a single-step procedure for compiling a program. It produces an object module. The compile steps in all other cataloged procedures that invoke the compiler are similar.

You must supply the following DD statement, indicating the location of the source program, in the input stream:

```
//COBOL.SYSIN DD *          (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following statements make up the IGYWC cataloged procedure.

```
//IGYWC PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200
//*
//*  COMPILE A COBOL PROGRAM
//*
//*  PARAMETER  DEFAULT VALUE  USAGE
//*  SYSLBLK    3200           BLKSIZE FOR OBJECT DATA SET
//*  LNGPRFX    IGY.V3R3M0     PREFIX FOR LANGUAGE DATA SET NAMES
//*
//*  CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
//*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSN=DSNAME=&LNGPRFX..SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN=DSNAME=&&LOADSET,UNIT=SYSDA,
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=&SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))          (2)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
```

- (1) STEPLIB can be installation-dependent.
- (2) SYSUT5 is needed only if the LIB option is used.

“Example: JCL for compiling using HFS”

Example: JCL for compiling using HFS: The following job uses procedure IGYWC to compile a COBOL program demo.cbl that is located in the hierarchical file system (HFS). It writes the generated compiler listing demo.lst, object file demo.o, and SYSADATA file demo.adt to the HFS.

```
//HFSDEMO JOB ,
// TIME=(1),MSGLEVEL=(1,1),MSGCLASS=H,CLASS=A,REGION=50M,
// NOTIFY=&SYSUID,USER=&SYSUID
//COMPILE EXEC IGYWC,
// PARM.COBOL='LIST,MAP,RENT,FLAG(I,I),XREF,ADATA'
//SYSPRINT DD PATH='/u/userid/cobol/demo.lst',      (1)
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),              (2)
// PATHMODE=SIRWXU,                               (3)
// FILEDATA=TEXT                                   (4)
//SYSLIN DD PATH='/u/userid/cobol/demo.o',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
// PATHMODE=SIRWXU
//SYSADATA DD PATH='/u/userid/cobol/demo.adt',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
// PATHMODE=SIRWXU
//SYSIN DD PATH='/u/userid/cobol/demo.cbl',
// PATHOPTS=ORDONLY,
// FILEDATA=TEXT,
// RECFM=F
```

- (1) PATH specifies the path name for an HFS file.
- (2) PATHOPTS indicates the access for the file (such as read or read-write) and sets the status for the file (such as append, create, or truncate).
- (3) PATHMODE indicates the permissions, or file access attributes, to be set when a file is created.
- (4) FILEDATA specifies whether the data is to be treated as text or binary.

You can use a mixture of HFS (PATH=*'hfs-directory-path'*) and MVS data sets (DSN=*traditional-data-set-name*) on the compilation DD statements shown in this example as overrides. However, the compiler utility files (DD statements SYSUTx) and COPY libraries (DD statements SYSLIB) must be MVS data sets.

RELATED REFERENCES

UNIX System Services Command Reference

MVS JCL Reference

“Data sets used by the compiler under z/OS” on page 233

Compile and link-edit procedure (IGYWCL)

The IGYWCL procedure is a two-step procedure to compile and link-edit a program. The COBOL job step produces an object module that is input to the linkage editor or binder. Other object modules can be added.

You must supply the following DD statement, indicating the location of the source program, in the input stream.

```
//COBOL.SYSIN DD *      (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following statements make up the IGYWCL cataloged procedure.

```
//IGYWCL PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200,
//          LIBPRFX='CEE',
//          PGMLIB='&&GOSET',GOPGM=GO
//*
//*  COMPILE AND LINK EDIT A COBOL PROGRAM
//*
//*  PARAMETER  DEFAULT VALUE  USAGE
//*  LNGPRFX    IGY.V3R3M0      PREFIX FOR LANGUAGE DATA SET NAMES
//*  SYSLBLK    3200            BLOCK SIZE FOR OBJECT DATA SET
//*  LIBPRFX    CEE             PREFIX FOR LIBRARY DATA SET NAMES
//*  PGMLIB     &&GOSET         DATA SET NAME FOR LOAD MODULE
//*  GOPGM      GO             MEMBER NAME FOR LOAD MODULE
//*
//*  CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
//*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSN=DSNAME=&LNGPRFX..SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN=DSNAME=&&LOADSET,UNIT=SYSDA,
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=&SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))          (2)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//LKED EXEC PGM=HEWL,COND=(8,LT,COBOL),REGION=1024K
//SYSLIB DD DSN=DSNAME=&LIBPRFX..SCEELKED,          (3)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN=DSNAME=&&LOADSET,DISP=(OLD,DELETE)
//          DD DDNAME=SYSIN
//SYSLMOD DD DSN=DSNAME=&PGMLIB(&GOPGM),
//          SPACE=(TRK,(10,10,1)),
//          UNIT=SYSDA,DISP=(MOD,PASS)
//SYSUT1 DD UNIT=SYSDA,SPACE=(TRK,(10,10))
```

- (1) STEPLIB can be installation-dependent.
- (2) SYSUT5 is needed only if the LIB option is used.
- (3) SYSLIB can be installation-dependent.

Compile, link-edit, and run procedure (IGYWCLG)

The IGYWCLG procedure is a three-step procedure to compile, link-edit, and run a program.

The COBOL job step produces an object module that is input to the linkage editor or binder. Other object modules can be added. If the COBOL program refers to any data sets, DD statements that define these data sets must also be supplied.

You must supply the following DD statement, indicating the location of the source program, in the input stream.

```
//COBOL.SYSIN DD *          (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following shows the statements that make up the IGYWCLG cataloged procedure.

```
//IGYWCLG PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200,
//          LIBPRFX='CEE',GOPGM=GO
//*
//*  COMPILER, LINK EDIT AND RUN A COBOL PROGRAM
//*
//*  PARAMETER  DEFAULT VALUE  USAGE
//*  LNGPRFX   IGY.V3R3M0      PREFIX FOR LANGUAGE DATA SET NAMES
//*  SYSLBLK   3200            BLKSIZE FOR OBJECT DATA SET
//*  LIBPRFX   CEE             PREFIX FOR LIBRARY DATA SET NAMES
//*  GOPGM     GO              MEMBER NAME FOR LOAD MODULE
//*
//*  CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
//*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSN=LIBPRFX..SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN=LIBPRFX..LOADSET,UNIT=SYSDA,
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))      (2)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//LKED EXEC PGM=HEWL,COND=(8,LT,COBOL),REGION=1024K
//SYSLIB DD DSN=LIBPRFX..SCEELKED,          (3)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN=LIBPRFX..LOADSET,DISP=(OLD,DELETE)
//          DD DDNAME=SYSIN
//SYSLMOD DD DSN=LIBPRFX..GOSET(&GOPGM),SPACE=(TRK,(10,10,1)),
//          UNIT=SYSDA,DISP=(MOD,PASS)
//SYSUT1 DD UNIT=SYSDA,SPACE=(TRK,(10,10))
//GO EXEC PGM=*.LKED.SYSLMOD,COND=(8,LT,COBOL),(4,LT,LKED)),
//          REGION=2048K
//STEPLIB DD DSN=LIBPRFX..SCEERUN,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//CEEDUMP DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
```

(1) STEPLIB can be installation-dependent.

(2) SYSUT5 is needed only if the LIB option is used.

(3) SYSLIB can be installation-dependent.

Compile, load, and run procedure (IGYWCG)

The IGYWCG procedure is a two-step procedure to compile, load, and run a program. The COBOL job step produces an object module that is input to the loader. If the COBOL program refers to any data sets, the DD statements that define these data sets must also be supplied.

You must supply the following DD statement, indicating the location of the source program, in the input stream.

```
//COBOL.SYSIN DD *          (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following shows the statements that make up the IGYWCG cataloged procedure.

```
//IGYWCG PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200,
//          LIBPRFX='CEE'
//*
//* COMPILE, LOAD AND RUN A COBOL PROGRAM
//*
/*  PARAMETER  DEFAULT VALUE  USAGE
/*  LNGPRFX    IGY.V3R3M0      PREFIX FOR LANGUAGE DATA SET NAMES
/*  SYSLBLK     3200            BLKSIZE FOR OBJECT DATA SET
/*  LIBPRFX     CEE             PREFIX FOR LIBRARY DATA SET NAMES
/*
/*  CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
/*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSNAME=&LNGPRFX..SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSNAME=&&LOADSET,UNIT=SYSDA,          (2)
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=&SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))          (3)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//GO EXEC PGM=LOADER,COND=(8,LT,COBOL),REGION=2048K
//SYSLIB DD DSNAME=&LIBPRFX..SCEELKED,          (4)
//          DISP=SHR
//SYSLOUT DD SYSOUT=*
//SYSLIN DD DSNAME=&&LOADSET,DISP=(OLD,DELETE)
//STEPLIB DD DSNAME=&LIBPRFX..SCEERUN,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//CEEDUMP DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
```

- (1) STEPLIB can be installation-dependent.
- (2) SYSLIN can reside in the HFS.
- (3) SYSUT5 is needed only if the LIB option is used.
- (4) SYSLIB can be installation-dependent.

Compile, prelink, and link-edit procedure (IGYWCPL)

The IGYWCPL procedure is a three-step procedure for compiling, prelinking, and link-editing a program.

You must supply the following DD statement, indicating the location of the source program, in the input stream.

```
SYSIN DD *          (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following shows the statements that make up the IGYWCPL cataloged procedure.

```
//IGYWCPL PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200,
//          LIBPRFX='CEE',PLANG=EDCPMSGE,
//          PGMLIB='&&GOSET',GOPGM=GO
//*
//*  COMPILE, PRELINK AND LINK EDIT A COBOL PROGRAM
//*
//*  PARAMETER  DEFAULT VALUE  USAGE
//*  LNGPRFX   IGY.V3R3M0      PREFIX FOR LANGUAGE DATA SET NAMES
//*  SYSLBLK    3200            BLOCK SIZE FOR OBJECT DATA SET
//*  LIBPRFX    CEE             PREFIX FOR LIBRARY DATA SET NAMES
//*  PLANG      EDCPMSGE        PRELINKER MESSAGES MODULE
//*  PGMLIB     &&GOSET          DATA SET NAME FOR LOAD MODULE
//*  GOPGM      GO              MEMBER NAME FOR LOAD MODULE
//*
//*  CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
//*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSNAME=&LNGPRFX..SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSNAME=&&LOADSET,UNIT=SYSDA,
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=&SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))          (2)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//PLKED EXEC PGM=EDCPRLK,PARM=' ',COND=(8,LT,COBOL),
//          REGION=2048K
//STEPLIB DD DSNAME=&LIBPRFX..SCEERUN,
//          DISP=SHR
//SYSMSGSD DD DSNAME=&LIBPRFX..SCEEMSGP(&PLANG),
//          DISP=SHR
//SYSLIB DD DUMMY
//SYSIN DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//SYSMOD DD DSNAME=&&PLKSET,UNIT=SYSDA,DISP=(NEW,PASS),
//          SPACE=(32000,(100,50)),
//          DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//SYSDEFSD DD DUMMY
//SYSOUT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//*
//LKED EXEC PGM=HEWL,COND=(8,LT,COBOL),REGION=1024K
//SYSLIB DD DSNAME=&LIBPRFX..SCEELKED,          (3)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSNAME=&&PLKSET,DISP=(OLD,DELETE)
//          DD DDNAME=SYSIN
//SYSMOD DD DSNAME=&PGMLIB(&GOPGM),
//          SPACE=(TRK,(10,10,1)),
//          UNIT=SYSDA,DISP=(MOD,PASS)
//SYSUT1 DD UNIT=SYSDA,SPACE=(TRK,(10,10))
```

(1) STEPLIB can be installation-dependent.

(2) SYSUT5 is needed only if the LIB option is used.

(3) SYSLIB can be installation-dependent.

Compile, prelink, link-edit, and run procedure (IGYWCPLG)

The IGYWCPLG procedure is a four-step procedure for compiling, prelinking, link-editing, and running a program.

You must supply the following DD statement, indicating the location of the source program, in the input stream.

```
SYSIN DD *          (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following shows the statements that make up the IGYWCPLG cataloged procedure.

```
//IGYWCPLG PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200,
//          PLANG=EDCPMSG,
//          LIBPRFX='CEE',GOPGM=GO
//*
/* COMPILE, PRELINK, LINK EDIT, AND RUN A COBOL PROGRAM
/*
/*  PARAMETER  DEFAULT VALUE  USAGE
/*  LNGPRFX   IGY.V3R3M0      PREFIX FOR LANGUAGE DATA SET NAMES
/*  SYSLBLK   3200            BLKSIZE FOR OBJECT DATA SET
/*  PLANG     EDCPMSG         PRELINKER MESSAGES MODULE
/*  LIBPRFX   CEE             PREFIX FOR LIBRARY DATA SET NAMES
/*  GOPGM     GO              MEMBER NAME FOR LOAD MODULE
/*
/* CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
/*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSN= &LNGPRFX..SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN= &&LOADSET,UNIT=SYSDA,
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=&SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))      (2)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//PLKED EXEC PGM=EDCPRLK,PARM=' ',COND=(8,LT,COBOL),
//          REGION=2048K
//STEPLIB DD DSN= &LIBPRFX..SCEERUN,
//          DISP=SHR
//SYSMSGSGS DD DSN= &LIBPRFX..SCEEMSGP(&PLANG),
//          DISP=SHR
//SYSLIB DD DUMMY
//SYSIN DD DSN= &&LOADSET,DISP=(OLD,DELETE)
//SYSMOD DD DSN= &&PLKSET,UNIT=SYSDA,DISP=(NEW,PASS),
//          SPACE=(32000,(100,50)),
//          DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//SYSDEFSD DD DUMMY
//SYSOUT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
/*
//LKED EXEC PGM=HEWL,COND=(8,LT,COBOL),REGION=1024K
//SYSLIB DD DSN= &LIBPRFX..SCEELKED,          (3)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN= &&PLKSET,DISP=(OLD,DELETE)
//          DD DDNAME=SYSIN
//SYSLMOD DD DSN= &&GOSET(&GOPGM),SPACE=(TRK,(10,10,1)),
//          UNIT=SYSDA,DISP=(MOD,PASS)
//SYSUT1 DD UNIT=SYSDA,SPACE=(TRK,(10,10))
```

```
//GO      EXEC PGM=*.LKED.SYSLMOD,COND=((8,LT,COBOL),(4,LT,LKED)),
//          REGION=2048K
//STEPLIB DD  DSNAME=&LIBPRFX..SCEERUN,
//          DISP=SHR
//SYSPRINT DD  SYSOUT=*
//CEEDUMP  DD  SYSOUT=*
//SYSUDUMP DD  SYSOUT=*
```

- (1) STEPLIB can be installation-dependent.
- (2) SYSUT5 is needed only if the LIB option is used.
- (3) SYSLIB can be installation-dependent.

Prelink and link-edit procedure (IGYWPL)

The IGYWPL procedure is a two-step procedure for prelinking and link-editing a program.

The following statements make up the IGYWPL cataloged procedure.

```
//IGYWPL PROC  PLANG=EDCPMSG,SYSLBLK=3200,
//              LIBPRFX='CEE',
//              PGMLIB='&&GOSET',GOPGM=GO
//*
//*  PRELINK AND LINK EDIT A COBOL PROGRAM
//*
//*  PARAMETER  DEFAULT VALUE  USAGE
//*  PLANG      EDCPMSG        PRELINK MESSAGES MEMBER NAME
//*  SYSLBLK    3200           BLKSIZE FOR OBJECT DATA SET
//*  LIBPRFX    CEE            PREFIX FOR LIBRARY DATA SET NAMES
//*  PGMLIB     &&GOSET        DATA SET NAME FOR LOAD MODULE
//*  GOPGM      GO             MEMBER NAME FOR LOAD MODULE
//*
//*  CALLER MUST SUPPLY //PLKED.SYSIN DD . . .
//*
//PLKED      EXEC PGM=EDCPRLK,PARM='',
//              REGION=2048K
//STEPLIB DD  DSNAME=&LIBPRFX..SCEERUN,                (1)
//              DISP=SHR
//SYSMSGSD  DD  DSNAME=&LIBPRFX..SCEEMSGP(&PLANG),
//              DISP=SHR
//SYSLIB DD  DUMMY
//SYSMOD DD  DSNAME=&&PLKSET,UNIT=SYSDA,DISP=(NEW,PASS),
//              SPACE=(32000,(100,50)),
//              DCB=(RECFM=FB,LRECL=80,BLKSIZE=&SYSLBLK)
//SYSDEFSD DD  DUMMY
//SYSOUT DD  SYSOUT=*
//SYSPRINT DD  SYSOUT=*
//*
//LKED      EXEC PGM=HEWL,COND=(4,LT,PLKED),REGION=1024K
//SYSLIB DD  DSNAME=&LIBPRFX..SCEELKED,                (2)
//              DISP=SHR
//SYSPRINT DD  SYSOUT=*
//SYSLIN DD  DSNAME=*.PLKED.SYSMOD,DISP=(OLD,DELETE)
//              DD DDNAME=SYSIN
//SYSLMOD DD  DSNAME=&PGMLIB(&GOPGM),SPACE=(TRK,(10,10,1)),
//              UNIT=SYSDA,DISP=(MOD,PASS)
//SYSUT1 DD  UNIT=SYSDA,SPACE=(TRK,(10,10))
//SYSIN DD  DUMMY
```

- (1) STEPLIB can be installation-dependent.
- (2) SYSLIB can be installation-dependent.

Compile, prelink, load, and run procedure (IGYWCPG)

The IGYWCPG procedure is a four-step procedure for compiling, prelinking, loading, and running a program.

You must supply the following DD statement, indicating the location of the source program, in the input stream.

```
//COBOL.SYSIN DD *          (or appropriate parameters)
```

If you use copybooks in the program that you are compiling, you must also supply a DD statement for SYSLIB or other libraries that you specify in COPY statements. For example:

```
//COBOL.SYSLIB DD DISP=SHR,DSN=DEPT88.BOBS.COBLIB
```

The following statements make up the IGYWCPG cataloged procedure.

```
//IGYWCPG PROC LNGPRFX='IGY.V3R3M0',SYSLBLK=3200,
//          PLANG=EDCPMSG,
//          LIBPRFX='CEE'
//*
/* COMPILE, PRELINK, LOAD, AND RUN A COBOL PROGRAM
/*
/*  PARAMETER  DEFAULT VALUE  USAGE
/*  LNGPRFX   IGY.V3R3M0      PREFIX FOR LANGUAGE DATA SET NAMES
/*  SYSLBLK    3200            BLKSIZE FOR OBJECT DATA SET
/*  PLANG      EDCPMSG         PRELINKER MESSAGES MODULE
/*  LIBPRFX    CEE             PREFIX FOR LIBRARY DATA SET NAMES
/*
/* CALLER MUST SUPPLY //COBOL.SYSIN DD . . .
/*
//COBOL EXEC PGM=IGYCRCTL,REGION=2048K
//STEPLIB DD DSN=IGYV3R3M0.SIGYCOMP,          (1)
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSLIN DD DSN=IGYV3R3M0.SYSDA,
//          DISP=(MOD,PASS),SPACE=(TRK,(3,3)),
//          DCB=(BLKSIZE=IGYV3R3M0.SYSLBLK)
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=SYSDA,SPACE=(CYL,(1,1))          (2)
//SYSUT6 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//PLKED EXEC PGM=EDCPRLK,PARM=' ',COND=(8,LT,COBOL),
//          REGION=2048K
//STEPLIB DD DSN=IGYV3R3M0.SCEERUN,
//          DISP=SHR
//SYSMMSG DD DSN=IGYV3R3M0.SCEMSGP(PLANG),
//          DISP=SHR
//SYSLIB DD DUMMY
//SYSIN DD DSN=IGYV3R3M0.SYSDA,DISP=(OLD,DELETE)
//SYSMOD DD DSN=IGYV3R3M0.SYSDA,DISP=(NEW,PASS), (3)
//          SPACE=(32000,(100,50)),
//          DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//SYSDEFSD DD DUMMY
//SYSOUT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
/*
//GO EXEC PGM=LOADER,COND=(8,LT,COBOL),REGION=2048K
//SYSLIB DD DSN=IGYV3R3M0.SCEELKED,          (4)
//          DISP=SHR
//SYSLOUT DD SYSOUT=*
//SYSLIN DD DSN=IGYV3R3M0.SYSDA,DISP=(OLD,DELETE)
//STEPLIB DD DSN=IGYV3R3M0.SCEERUN,
//          DISP=SHR
//SYSPRINT DD SYSOUT=*
//CEEDUMP DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
```

- (1) STEPLIB can be installation-dependent.
- (2) SYSUT5 is needed only if the LIB option is used.
- (3) SYSMOD can reside in the HFS.
- (4) SYSLIB can be installation-dependent.

Writing JCL to compile programs

If the cataloged procedures do not give you the z/OS programming flexibility you need for more complex programs, write your own job control statements. The following JCL shows the general format used to compile a program:

```
//jobname JOB acctno,name,MSGCLASS=1 (1)
//stepname EXEC PGM=IGYCRCTL,PARM=(options) (2)
//STEPLIB DD DSN=IGY.V3R3M0.SIGYCOMP,DISP=SHR (3)
//SYSUT1 DD UNIT=SYSDA,SPACE=(subparms) (4)
//SYSUT2 DD UNIT=SYSDA,SPACE=(subparms)
//SYSUT3 DD UNIT=SYSDA,SPACE=(subparms)
//SYSUT4 DD UNIT=SYSDA,SPACE=(subparms)
//SYSUT5 DD UNIT=SYSDA,SPACE=(subparms)
//SYSUT6 DD UNIT=SYSDA,SPACE=(subparms)
//SYSUT7 DD UNIT=SYSDA,SPACE=(subparms)
//SYSPRINT DD SYSOUT=A (5)
//SYSLIN DD DSN=MYPROG,UNIT=SYSDA, (6)
// DISP=(MOD,PASS),SPACE=(subparms)
//SYSIN DD DSN=dsname,UNIT=device, (7)
// VOLUME=(subparms),DISP=SHR
```

- (1) The JOB statement indicates the beginning of a job.
- (2) The EXEC statement specifies that the Enterprise COBOL compiler (IGYCRCTL) is to be invoked.
- (3) This DD statement defines the data set where the Enterprise COBOL compiler resides.
- (4) The SYSUT DD statements define the utility data sets that the compiler will use to process the source program. All SYSUT files must be on direct-access storage devices.
- (5) The SYSPRINT DD statement defines the data set that receives output from options such as LIST and MAP. SYSOUT=A is the standard designation for data sets whose destination is the system output device.
- (6) The SYSLIN DD statement defines the data set that receives output from the OBJECT option (the object module).
- (7) The SYSIN DD statement defines the data set to be used as input to the job step (source code).

You can use a mixture of HFS (PATH=*'hfs-directory-path'*) and MVS data sets (DSN=*traditional-data-set-name*) on the compilation DD statements for the following data sets:

- Sources files
- Object files
- Listings
- ADATA files
- Debug files
- Executable modules

However, the compiler utility files (DD statements SYSUTx) and COPY libraries (DD statement SYSLIB) must be MVS data sets.

“Example: user-written JCL for compiling”

“Example: sample JCL for a procedural DLL application” on page 428

RELATED REFERENCES

MVS JCL Reference

Example: user-written JCL for compiling

This example shows a few possibilities for adapting the basic JCL.

```
//JOB1      JOB                                     (1)
//STEP1     EXEC PGM=IGYCRCTL,PARM='OBJECT'        (2)
//STEPLIB   DD  DSNAME=IGY.V3R3M0.SIGYCOMP,DISP=SHR
//SYSUT1    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT4    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT5    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT6    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT7    DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSPRINT  DD  SYSOUT=A
//SYSLIN    DD  DSNAME=MYPROG,UNIT=SYSDA,
//           DISP=(MOD,PASS),SPACE=(TRK,(3,3))
//SYSIN     DD  *                                  (3)
000100 IDENTIFICATION DIVISION.
. . .
/*                                                (4)
```

- (1) JOB1 is the name of the job.
- (2) STEP1 is the name of the single job step in the job. The EXEC statement also specifies that the generated object code be placed on disk or tape to be used later as input to the link step.
- (3) The asterisk indicates that the input data set follows in the input stream.
- (4) The delimiter statement /* separates data from subsequent control statements in the input stream.

Compiling under TSO

Under TSO, you can use TSO commands, command lists (CLISTs), REXX execs, or ISPF to compile your program using traditional MVS data sets. You can use TSO commands or REXX execs to compile your program using HFS files. With each method, you need to allocate the data sets and request the compilation.

1. Use the ALLOCATE command to allocate data sets.

For any compilation, allocate the work data sets (SYSUT n), and the SYSIN and SYSPRINT data sets. If you specify certain compiler options, allocate the following data sets:

- If you specified the OBJECT compiler option, allocate the SYSLIN data set to produce an object module.
- If you specified the TERMINAL option, allocate the SYSTERM data set to get compiler messages at your terminal.
- If you specified the LIB option and if you have used COPY or REPLACE statements in your Enterprise COBOL program, allocate the SYSLIB data set. This must be a traditional MVS data set, not an HFS path.
- If you specified the LIB option in your program, allocate SYSUT5. This utility data set must be a traditional MVS data set, not an HFS path.

You can allocate data sets in any order. However, you must allocate all needed data sets before you start to compile.

2. Use the CALL command at the READY prompt to request compilation:

```
CALL 'IGY.V3R3M0.SIGYCOMP(IGYCRCTL)'
```

You can specify the ALLOCATE and CALL commands on the TSO command line, or, if you are not using HFS files, include them in a CLIST.

You can allocate HFS files for all the compiler data sets except the SYSUTx utility data sets and the SYSLIB libraries. Your ALLOCATE statements have the following form:

```
Allocate File(SYSIN) Path('/u/myu/myap/std/prog2.cb1')
Pathopts(ORDONLY) Filedata(TEXT)
```

“Example: ALLOCATE and CALL for compiling under TSO”

“Example: CLIST for compiling under TSO”

Example: ALLOCATE and CALL for compiling under TSO

The following example shows how to specify ALLOCATE and CALL commands when you are compiling under TSO.

```
READY
ALLOCATE FILE(SYSUT1) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSUT2) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSUT3) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSUT4) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSUT5) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSUT6) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSUT7) CYLINDERS SPACE(1 1)
READY
ALLOCATE FILE(SYSPRINT) SYSOUT
READY
ALLOCATE FILE(SYSTEM) DATASET(*)
READY
ALLOCATE FILE(SYSLIN) DATASET(PROG2.OBJ) NEW TRACKS SPACE(3,3)
READY
ALLOCATE FILE(SYSIN) DATASET(PROG2.COBOL) SHR
READY
CALL 'IGY.V3R3M0.SIGYCOMP(IGYCRCTL)' 'LIST,NOCOMPILE(S),OBJECT,FLAG(E,E),TERMINAL'
.
(COBOL listings and messages)
.
READY
FREE FILE(SYSUT1,SYSUT2,SYSUT3,SYSUT4,SYSUT5,SYSUT6,SYSUT7,SYSPRINT,SYSTEM,+,
SYSIN,SYSLIN)
READY
```

Example: CLIST for compiling under TSO

In the following sample CLIST for compiling under TSO, the FREE commands are not required. However, good programming practice dictates that you free your files before you allocate them.

```
PROC 1 MEM
CONTROL LIST
FREE (SYSUT1)
FREE (SYSUT2)
FREE (SYSUT3)
FREE (SYSUT4)
```

```

FREE (SYSUT5)
FREE (SYSUT6)
FREE (SYSUT7)
FREE (SYSPRINT)
FREE (SYSIN)
FREE (SYSLIN)
ALLOC F(SYSPRINT) SYSOUT
ALLOC F(SYSIN) DA(COBOL.SOURCE(&MEM)) SHR REUSE
ALLOC F(SYSLIN) DA(COBOL.OBJECT(&MEM)) OLD REUSE
ALLOC F(SYSUT1) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
ALLOC F(SYSUT2) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
ALLOC F(SYSUT3) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
ALLOC F(SYSUT4) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
ALLOC F(SYSUT5) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
ALLOC F(SYSUT6) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
ALLOC F(SYSUT7) NEW SPACE(5,5) TRACKS UNIT(SYSDA)
CALL 'IGY.V3R3M0.SIGYCOMP(IGYCRCTL)'

```

Starting the compiler from an assembler program

An assembler program can start the Enterprise COBOL compiler by using the `ATTACH` or the `LINK` macro instruction by dynamic invocation. Using dynamic invocation, you must supply the following information to the Enterprise COBOL compiler:

- Options to be specified for the compilation
- ddnames of the data sets to be used during processing by the Enterprise COBOL compiler

For example:

```
symbol {LINK|ATTACH} EP=IGYCRCTL,PARAM=(optionlist [, ddnamelist]),VL=1
```

where:

EP Specifies the symbolic name of the Enterprise COBOL compiler. The control program (from the library directory entry) determines the entry point at which the program should begin running.

PARAM Specifies, as a sublist, address parameters to be passed from the assembler program to the Enterprise COBOL compiler. The first fullword in the address parameter list contains the address of the COBOL *optionlist*. The second fullword contains the address of the *ddnamelist*.

The third and fourth fullwords contain the addresses of null parameters, or zero.

optionlist

Specifies the address of a variable-length list containing the COBOL options specified for compilation. This address must be written although no list is provided.

The *optionlist* must begin on a halfword boundary. The 2 high-order bytes contain a count of the number of bytes in the remainder of the list. If no options are specified, the count must be zero. The *optionlist* is free form, with each field separated from the next by a comma. No blanks or zeros should appear in the list. The compiler recognizes only the first 100 characters in the list.

ddnamelist

Specifies the address of a variable-length list containing alternative ddnames for the data sets used during COBOL compiler processing. If standard ddnames are used, the *ddnamelist* can be omitted.

The *ddnamelist* must begin on a halfword boundary. The 2 high-order bytes contain a count of the number of bytes in the remainder of the list. Each name of less than 8 bytes must be left justified and padded with blanks. If an alternate *ddname* is omitted from the list, the standard name will be assumed. If the name is omitted within the list, the 8-byte entry must contain binary zeros. You can omit names from the end by shortening the list.

All *SYSUT_n* data sets specified must be on direct-access storage devices and have physical sequential organization. They must not reside in the HFS.

The following table shows the sequence of the 8-byte entries in the *ddnamelist*.

ddname 8-byte entry	Name for which substituted
1	SYSLIN
2	Not applicable
3	Not applicable
4	SYSLIB
5	SYSIN
6	SYSPRINT
7	SYSPUNCH
8	SYSUT1
9	SYSUT2
10	SYSUT3
11	SYSUT4
12	SYSTEM
13	SYSUT5
14	SYSUT6
15	SYSUT7
16	SYSADATA
17	SYSJAVA
18	SYSDEBUG

VL Specifies that the sign bit is to be set to 1 in the last fullword of the address parameter list.

When the Enterprise COBOL compiler completes processing, it puts a return code in register 15.

Defining compiler input and output

You need to define several kinds of data sets that the compiler uses to do its work. The compiler takes input data sets and libraries and produces various types of output, including object code, listings, and messages. The compiler also uses utility data sets during compilation.

RELATED TASKS

“Defining the source code data set (SYSIN)” on page 235

“Specifying source libraries (SYSLIB)” on page 235

“Defining the output data set (SYSPRINT)” on page 236

“Directing compiler messages to your terminal (SYSTEM)” on page 236

“Creating object code (SYSLIN or SYSPUNCH)” on page 236

“Creating an associated data file (SYSADATA)” on page 237

“Defining the debug data set (SYSDEBUG)” on page 237

Data sets used by the compiler under z/OS

The following table lists the function, device requirements, and allowable device classes for each data set that the compiler uses.

Table 35. Compiler data sets

Type	ddname	Function	Required?	Device requirements	Allowable device classes	Reside in HFS?
Input	SYSIN ¹	Reads source program	Yes	Card reader; intermediate storage	Any	Yes
	SYSLIB or other copy libraries ¹	Reads user source libraries (PDSs)	If program has COPY or BASIS statements (LIB is required)	Direct access	SYSDA	No
Utility	SYSUT1, SYSUT2, SYSUT3, SYSUT4, SYSUT6 ²	Work data set used by compiler during compilation	Yes	Direct access	SYSDA	No
	SYSUT5 ²	Work data set used by compiler during compilation	If program has COPY, REPLACE, or BASIS statements (LIB is required)	Direct access	SYSDA	No
	SYSUT7 ²	Work data set used by compiler to create listing	Yes	Direct access	SYSDA	No

Table 35. Compiler data sets (continued)

Type	ddname	Function	Required?	Device requirements	Allowable device classes	Reside in HFS?
Output	SYSPRINT ¹	Writes storage map, listings, and messages	Yes	Printer; intermediate storage	SYSSQ, SYSDA, standard output class A	Yes
	SYSTEM	Writes progress and diagnostic messages	If TERM is in effect	Output device; TSO terminal		Yes
	SYSPUNCH	Creates object code	If DECK is in effect	Card punch; direct access	SYSSQ, SYSDA	Yes
	SYSLIN	Creates object module data set as output from compiler and input to linkage editor or binder	If OBJECT is in effect	Direct access	SYSSQ, SYSDA	Yes
	SYSADATA	Writes associated data file records	If ADATA or EVENTS is in effect	Output device		Yes
	SYSJAVA	Creates generated Java source file for a class definition	If compiling a class definition	(Must be an HFS file)		Yes
	SYSUDUMP, SYSABEND, or SYSMDUMP	Writes dump	If DUMP is in effect (should be rarely used)	Direct access	SYSDA	Yes
	SYSDEBUG	Writes symbolic debug information tables to a data set separate from the object module	If TEST(. . . ,SYM,SEPARATE) is in effect	Direct access	SYSDA	Yes
1. You can use the EXIT option to provide user exits from these data sets. 2. These data sets must be single volume.						

RELATED REFERENCES

“Logical record length and block size”

“EXIT” on page 283

Logical record length and block size

For compiler data sets other than the work data sets (SYSUT n) and HFS files, you can set the block size using the BLKSIZE subparameter of the DCB parameter. The value must be permissible for the device on which the data set resides. The values you set depend on whether the data sets are fixed length or variable length.

For fixed-length records (RECFM=F or RECFM=FB), LRECL is the logical record length, and BLKSIZE equals LRECL multiplied by n where n is equal to the blocking factor. The following table shows the defined values for the fixed-length data sets. In general, you should not change these values, but you can change the value for:

- SYSDEBUG: You can specify any LRECL in the listed range, with 1024 recommended.
- SYSPRINT, SYSDEBUG: You can specify BLKSIZE=0, which results in a system-determined block size.

Table 36. Block size of fixed-length compiler data sets

Data set	RECFM	LRECL (bytes)	BLKSIZE ¹
SYSIN	F or FB	80	80 x <i>n</i>
SYSLIN	F or FB	80	80 x <i>n</i>
SYSPUNCH	F or FB	80	80 x <i>n</i>
SYSLIB or other copy libraries	F or FB	80	80 x <i>n</i>
SYSPRINT ²	F or FB	133	133 x <i>n</i>
SYSTEM	F or FB	80	80 x <i>n</i>
SYSDEBUG ²	F or FB	80 to 1024	LRECL x <i>n</i>
1. <i>n</i> = blocking factor 2. If you specify BLKSIZE=0, the system will determine the block size.			

For variable-length records (RECFM=V), LRECL is the logical record length, and BLKSIZE equals LRECL plus 4.

Table 37. Block size of variable-length compiler data sets

Data set	RECFM	LRECL (bytes)	BLKSIZE (bytes) minimum acceptable value
SYSADATA	VB	1020	1024

Defining the source code data set (SYSIN)

Define the data set that contains your source code with the SYSIN DD statement, as in:

```
//SYSIN DD DSN=dsname,UNIT=SYSSQ,
//          VOLUME=(subparms),DISP=SHR
```

You can place your source code or BASIS statement directly in the input stream. If you do, use this SYSIN DD statement:

```
//SYSIN DD *
```

When you use the DD * convention, the source code or BASIS statement must follow the statement. If another job step follows the compilation, the EXEC statement for that step follows the /* statement or the last source statement.

Specifying source libraries (SYSLIB)

Add the SYSLIB DD statements if your program contains COPY or BASIS statements. These DD statements define the libraries (partitioned data sets) that contain the data requested by COPY statements (in the source code) or by a BASIS statement in the input stream.

```
//SYSLIB DD DSN=copylibname,DISP=SHR
```

Concatenate multiple DD statements if you have multiple copy or basis libraries.

```
//SYSLIB DD DSN=PROJECT.USERLIB,DISP=SHR
//          DD DSN=SYSTEM.COPYX,DISP=SHR
```

Libraries are on direct-access storage devices. They cannot be in the hierarchical file system when you compile using JCL or under TSO.

You do not need the SYSLIB DD statement if the NOLIB option is in effect.

Defining the output data set (SYSPRINT)

You can use SYSPRINT to produce a listing, as in:

```
//SYSPRINT DD   SYSOUT=A
```

You can direct the output to a SYSOUT data set, a printer, a direct-access storage device, or a magnetic-tape device. The listing includes the results of the default or requested options of the PARM parameter (that is, diagnostic messages, the object code listing).

Specify the following for the data set that you define:

- The name of a sequential data set, the name of a PDS or PDSE member, or an HFS path.
- A data set LRECL of 133.
- A data set RECFM of F or B.
- A block size, using the BLKSIZE subparameter of the DCB parameter, or let the system set the system-determined default block size.

Directing compiler messages to your terminal (SYSTEM)

If you are compiling under TSO, you can define the SYSTEM data set to send compiler messages to your terminal, as in:

```
ALLOC F(SYSTEM) DA(*)
```

You can define SYSTEM in various ways, including as a SYSOUT data set, a data set on disk, a file in the HFS, or to another print class.

Creating object code (SYSLIN or SYSPUNCH)

When using the OBJECT compiler option, you can store the object code on disk as a traditional MVS data set or an HFS file or on tape. The compiler uses the file that you define in the SYSLIN or SYSPUNCH DD statement to store the object code.

```
//SYSLIN DD   DSN=dsname,UNIT=SYSDA,  
//           SPACE=(subparms),DISP=(MOD,PASS)
```

Use the DISP parameter of the SYSLIN DD statement to indicate whether the object code data set is to be:

- Passed to the linkage editor or binder
- Cataloged
- Kept
- Added to an existing cataloged library

In the example above, the data is created and passed to another job step, the linkage editor or binder job step.

Your installation might use the DECK option and the SYSPUNCH DD statement.

```
//SYSPUNCH DD   SYSOUT=B
```

B is the standard output class for punch data sets.

You do not need the SYSLIN DD statement if the NOOBJECT option is in effect. You do not need the SYSPUNCH DD statement if the NODECK option is in effect.

RELATED REFERENCES

“OBJECT” on page 294

“DECK” on page 279

Creating an associated data file (SYSADATA)

Define a SYSADATA data set if you use either the ADATA compiler option or the EVENTS compiler option.

```
//SYSADATA DD DSNAME=dsname,UNIT=SYSDA
```

The file defined in the SYSADATA DD statement will be a sequential file containing specific record types that have information about the program collected during compilation. The file can be a traditional MVS data set or an HFS file.

RELATED REFERENCES

“ADATA” on page 270

Defining the output Java data set (SYSJAVA)

Add the SYSJAVA DD statement if you are compiling OO programs. The generated Java source file is written to the SYSJAVA ddname.

```
//SYSJAVA DD PATH='/u/userid/java/Classname.java',  
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),  
// PATHMODE=SIRWXU,  
// FILEDATA=TEXT
```

The file must be an HFS file.

RELATED TASKS

“Compiling OO applications using JCL or TSO/E” on page 261

Defining the debug data set (SYSDEBUG)

When you compile from JCL or from TSO and specify the TEST(. . .,SYM,SEPARATE) compiler option, the symbolic debug information tables are written to the data set that you specify on the SYSDEBUG DD statement, as in:

```
//SYSDEBUG DD DSNAME=dsname,UNIT=SYSDA
```

Specify the following for the data set that you define:

- The name of a sequential data set, the name of a PDS or PDSE member, or an HFS path.
- A data set LRECL greater than or equal to 80 and less than or equal to 1024. The default LRECL for SYSDEBUG is 1024.
- A data set RECFM of F or FB.
- A block size, using the BLKSIZE subparameter of the DCB parameter, or let the system set the system-determined default block size.

The data set name that you provide on SYSDEBUG is used by Language Environment dump services. You cannot change the name of the data set at run time. If you want to have a name for this data set that follows the naming conventions for your production data sets, use that name when you compile your program. You can direct Debug Tool to a renamed data set.

RELATED REFERENCES

“TEST” on page 306

Specifying compiler options under z/OS

The compiler is installed and set up with default compiler options. While installing the compiler, the system programmers for a site can fix compiler option settings to, for example, ensure better performance or maintain certain standards. You cannot override any compiler options that your site has set as fixed. For options that are not fixed, you can override the default settings by specifying compiler options in either of these ways:

- Code them on the `PROCESS` or `CBL` statement in your COBOL source.
- Include them when you start the compiler, either on the `PARM` parameter on the `EXEC` statement in your JCL or on the command line under TSO.

The compiler recognizes the options in the following order of precedence from highest to lowest:

1. Installation defaults that are fixed by your site
2. Values of the `BUFSIZE`, `LIB`, `OUTDD`, `SIZE`, and `SQL` compiler options in effect for the first program in a batch
3. Options specified on `PROCESS` (or `CBL`) statements, preceding the `IDENTIFICATION DIVISION`
4. Options specified on the compiler invocation (JCL `PARM` parameter or the TSO `CALL` command)
5. Installation defaults that are not fixed

This order of precedence also determines which options are in effect when conflicting or mutually exclusive options are specified.

Most of the options come in pairs; you select one or the other. For example, the option pair for a cross-reference listing is `XREF|NOXREF`. If you want a cross-reference listing, specify `XREF`. If you do not want one, specify `NOXREF`.

Some options have subparameters. For example, if you want 44 lines per page on your listings, specify `LINECOUNT(44)`.

“Example: specifying compiler options using JCL” on page 239

“Example: specifying compiler options under TSO” on page 239

RELATED TASKS

“Specifying compiler options with the `PROCESS` (`CBL`) statement”

“Specifying compiler options in a batch compilation” on page 242

RELATED REFERENCES

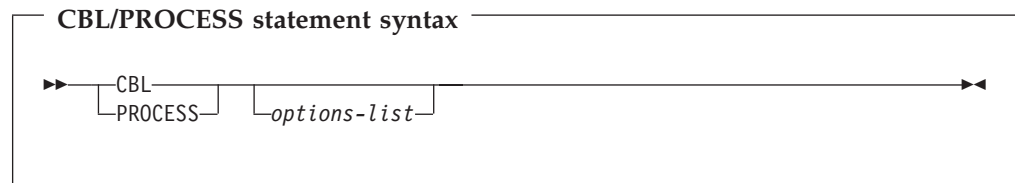
“Compiler options and compiler output under z/OS” on page 239

“Conflicting compiler options” on page 269

Chapter 17, “Compiler options,” on page 267

Specifying compiler options with the `PROCESS` (`CBL`) statement

You can code compiler options on the `PROCESS` statement in your COBOL source programs.



Place the PROCESS statement before the IDENTIFICATION DIVISION header and before any comment lines or compiler-directing statements.

You can start PROCESS in columns 1 through 66. A sequence field is allowed in columns 1 through 6. When used with a sequence field, PROCESS can start in columns 8 through 66. If used, the sequence field must contain six characters, and the first character must be numeric.

You can use CBL as a synonym for PROCESS. CBL can start in columns 1 through 70. When used with a sequence field, CBL can start in columns 8 through 70.

Use one or more blanks to separate PROCESS from the first option in *options-list*. Separate options with a comma or a blank. Do not insert spaces between individual options and their suboptions.

You can use more than one PROCESS statement. If multiple PROCESS statements are used, they must follow one another with no intervening statement of any other type. You cannot continue options across multiple PROCESS statements.

Your programming organization can inhibit the use of PROCESS statements with the default options module of the COBOL compiler. When PROCESS statements are found in a COBOL program where not allowed by the organization, the COBOL compiler generates error diagnostics.

Example: specifying compiler options using JCL

The following example shows how to specify compiler options under z/OS using JCL:

```

.. .
//STEP1      EXEC PGM=IGYCRCTL,
//              PARM='LIST,NOCOMPILE(S),OBJECT,FLAG(E,E)'
```

Example: specifying compiler options under TSO

The following example shows how to specify compiler options under TSO:

```

. . .

READY

CALL 'SYS1.LINKLIB(IGYCRCTL)' 'LIST,NOCOMPILE(S),OBJECT,FLAG(E,E)'
```

Compiler options and compiler output under z/OS

When the compiler finishes processing your source program, it will have produced one or more of the following, depending on the compiler options you selected:

Table 38. Types of compiler output under z/OS

Compiler option	Compiler output	Type of output
ADATA or EVENTS	Information about the program being compiled	Associated data file

Table 38. Types of compiler output under z/OS (continued)

Compiler option	Compiler output	Type of output
DLL	Object module that is enabled for DLL support	Object
DUMP	System dump, if compilation ended with abnormal termination (requires SYSUDUMP, SYSABEND, or SYSMDUMP DD statement); should be used rarely	Listing
EXPORTALL	Exported symbols for a DLL	Object
FLAG	List of errors that the compiler found in your program	Listing
LIST	Listing of object code in machine and assembler language	Listing
MAP	Map of the data items in your program	Listing
NUMBER	User-supplied line numbers shown in listing	Listing
OBJECT or DECK with COMPILE	Your object code	Object
OFFSET	Map of the relative addresses in your object code	Listing
OPTIMIZE	Optimized object code if OBJECT in effect	Object
RENT	Reentrant object code if OBJECT in effect	Object
SOURCE	Listing of your source program	Listing
SQL	SQL statements and host variable information for DB2 bind process	Database request module
SSRANGE	Extra code for checking references within tables	In object
TERMINAL	Progress and diagnostic messages sent to terminal	Terminal
TEST(<i>hook location suboption</i>)	Compiled-in hooks for Debug Tool	Extra code in object
TEST(SYM,NOSEP)	Information tables for Debug Tool and for formatted dumps	Object
TEST(SYM,SEP)	Information tables for Debug Tool and for formatted dumps	Debug information side file
VBREF	Cross-reference listing of verbs in your source program	Listing
XREF	Sorted cross-reference listing of names of procedures, programs, and data	Listing

Listing output from compilation will be in the data set defined by SYSPRINT; object output will be in SYSLIN or SYSPUNCH. Progress and diagnostic messages can be directed to the SYSTEM data set as well as included in the SYSPRINT data set. Associated data file records will be in the data set defined by SYSADATA. The database request module (DBRM) will be the data set defined in DBRMLIB. The debug information side file will be the data set defined in SYSDEBUG.

Save the listings you produced during compilation. You can use them during the testing of your work if you need to debug or tune.

After compilation, your next step will be to fix any errors that the compiler found in your program.

If no errors are detected, you can go to the next step in the process: link-editing, or binding, your program. (If you used compiler options to suppress object code generation, you must recompile to obtain object code.)

RELATED REFERENCES

“Messages and listings for compiler-detected errors” on page 246
Chapter 17, “Compiler options,” on page 267

RELATED TASKS

Preparing to link-edit and run under Language Environment (*Language Environment Programming Guide*)

Compiling multiple programs (batch compilation)

You can compile a sequence of separate COBOL programs with a single invocation of the compiler. You can link the object program produced from this compilation into one load module or separate load modules, controlled by the NAME compiler option.

When you compile several programs as part of a batch job, you need to:

- Determine whether you want to create one or more load modules.
- Terminate each program in the sequence.
- Specify compiler options, with an awareness of the effect of compiler options specified in programs within the batch job.

To create separate load modules, precede each set of modules with the NAME option. When the compiler encounters a NAME compiler option, the first program in the sequence and all subsequent programs are link-edited into a single load module, until the next NAME compiler option is encountered. Then, each successive program that is compiled with the NAME option is included in a separate load module.

Use the END PROGRAM marker to terminate each program in the sequence (except the last program in the batch for which the END PROGRAM marker is optional). Alternatively, you can precede each program in the sequence with a CBL or PROCESS statement.

If you omit the END PROGRAM marker from a program (other than the last program in a sequence of separate programs), the next program in the sequence will be nested in the preceding program. An error can occur in either of the following situations:

- A PROCESS statement is in a program that is now nested.
- A CBL statement is not coded entirely in the sequence number area (columns 1 through 6).

If a CBL statement is coded entirely in the sequence number area (columns 1 through 6), no error message is issued for the CBL statement because it is considered a label for the source statement line.

“Example: batch compilation” on page 242

RELATED TASKS

“Specifying compiler options in a batch compilation” on page 242

RELATED REFERENCES

“NAME” on page 291

Example: batch compilation

The following example shows a batch compilation for three programs (PROG1, PROG2, and PROG3) creating two load modules, using one invocation of the IGYWCL cataloged procedure:

- PROG1 and PROG2 are link-edited together to form one load module with a name of PROG2. The entry point of this load module defaults to the first program in the load module, PROG1.
- PROG3 is link-edited by itself into a load module with the name PROG3. Because it is the only program in the load module, the entry point is also PROG3.

```
//jobname JOB acctno,name,MSGLEVEL=1
//stepname EXEC IGYWCL
//COBOL.SYSIN DD *
010100 IDENTIFICATION DIVISION.
010200 PROGRAM-ID PROG1.

      . . .
019000 END PROGRAM PROG1.
020100 IDENTIFICATION DIVISION.
020200 PROGRAM-ID PROG2.

      . . .
029000 END PROGRAM PROG2.
      CBL NAME
030100 IDENTIFICATION DIVISION.
030200 PROGRAM-ID PROG3.

      . . .
039000 END PROGRAM PROG3.
/*
//LKED.SYSLMOD DD DSN=&&GOSET                                (1)
/*
//P2          EXEC PGM=PROG2
//STEPLIB DD   DSN=&&GOSET,DISP=(SHR,PASS)                    (2)
. . .                                                  (3)
/*
//P3          EXEC PGM=PROG3
//STEPLIB DD   DSN=&&GOSET,DISP=(SHR,PASS)                    (2)
. . .                                                  (3)
/*
//
```

- (1) The data set name for the LKED step SYSLMOD is changed to the temporary name &&GOSET, without any member name.
- (2) The temporary data set &&GOSET is used as the STEPLIB for steps P2 and P3 to run the compiled programs. If the Language Environment library does not reside in shared storage, you must also add the library data set as a DD statement for STEPLIB.
- (3) Other DD statements and input that are required to run PROG1 and PROG2 must be added.
- (4) Other DD statements and input that are required to run PROG3 must be added.

RELATED REFERENCES

IBM-supplied cataloged procedures (*Language Environment Programming Guide*)

Specifying compiler options in a batch compilation

You can specify compiler options for each program in the batch sequence in either of the usual ways:

- CBL or PROCESS statements preceding a program
- Invocation of the compiler

If a CBL or PROCESS statement is specified in the current program, the compiler resolves the CBL or PROCESS statements together with the options in effect before the first program. If the current program does not contain CBL or PROCESS statements, the compiler uses the settings of options in effect for the previous program.

You should be aware of the effect of certain compiler options on the precedence of compiler option settings for each program in the sequence:

1. Installation defaults that are fixed at your site
2. Values of the BUFSIZE, LIB, OUTDD, SIZE, and SQL compiler options in effect for the first program in the batch
3. Options on CBL or PROCESS statements, if any, for the current program
4. Options specified on the compiler invocation (JCL PARM or TSO CALL)
5. Installation defaults that are not fixed

If any program in the sequence requires the BUF, LIB, OUTDD, SIZE, or SQL option, that option must be in effect for the first program in the batch sequence. (When processing BASIS, COPY, or REPLACE statements, the compiler handles all programs in the batch as a single input file.)

If you specify the LIB option for the batch, you cannot change the NUMBER and SEQUENCE options during the batch compilation. The compiler treats all programs in the batch as a single input file during NUMBER and SEQUENCE processing under the LIB option; therefore, the sequence numbers of the entire input file must be in ascending order.

If the compiler diagnoses the LANGUAGE option on the CBL or PROCESS statement as an error, the language selection reverts to what was in effect before the compiler encountered the first CBL or PROCESS statement. The language in effect during a batch compilation conforms to the rules of processing CBL or PROCESS statements in that environment.

“Example: precedence of options in a batch compilation”

“Example: LANGUAGE option in a batch compilation” on page 244

Example: precedence of options in a batch compilation

The following listing shows the compiler options precedence for batch compilation.

PP 5655-G53 IBM Enterprise COBOL for z/OS 3.3.0 Date 02/27/2004. . .

INVOCATION PARAMETERS:

NOTERM

PROCESS(CBL) statements:

CBL CURRENCY,FLAG(I,I)

Options in effect: All options are installation defaults unless otherwise noted:

NOADATA

ADV

QUOTE

NOAWO

BUFSIZE(4096)

CURRENCY Process option PROGRAM 1

.

.

FLAG(I,I) Process option PROGRAM 1

.

.

```

NOTERM          INVOCATION option
.
.
End of compilation for program 1
.
.
PP 5655-G53 IBM Enterprise COBOL for z/OS  3.3.0  Date 02/27/2004. . .
PROCESS(CBL) statements:
  CBL APOST
Options in effect:
  NOADATA
  ADV
  APOST          Process option PROGRAM 2
  NOAWO
  BUFSIZE(4096)
  NOCURRENCY     Installation default option for PROGRAM 2
.
.
  FLAG(I)       Installation default option
.
.
NOTERM          INVOCATION option remains in effect
.
.
End of compilation for program 2

```

Example: LANGUAGE option in a batch compilation

The following example shows the behavior of the LANGUAGE compiler option in a batch environment. The default installation option is ENGLISH (abbreviated EN), and the invocation option is XX, a nonexistent language.

Source	Language
CBL LANG(JP),FLAG(I,I),APOST,SIZE(MAX)	EN (1)
IDENTIFICATION DIVISION.	JP (2)
PROGRAM-ID. COMPILE1.	"
..	"
END PROGRAM COMPILE1.	"
CBL LANGUAGE(YY)	EN (3)
CBL SIZE(2048K),LANGUAGE(JP),LANG(!!)	" (4)
IDENTIFICATION DIVISION.	JP
PROGRAM-ID. COMPILE2.	"
..	"
END PROGRAM COMPILE2.	"
IDENTIFICATION DIVISION.	"
PROGRAM-ID. COMPILE3.	"
..	"
END PROGRAM COMPILE3.	"
CBL LANGUAGE(JP),LANGUAGE(YY)	EN (5)
..	"

- (1) The installation default is EN. The invocation option was XX.
- (2) After the CBL statement is scanned, JP is the language in effect.
- (3) CBL resets the language to EN. YY is ignored because it is superseded by JP.
- (4) !! is not alphanumeric and is discarded.
- (5) CBL resets the language to EN. YY supersedes JP but is nonexistent.

For the program COMPILE1, the default language English (EN) is in effect when the compiler scans the invocation options. A diagnostic message is issued in mixed-case English because XX is a nonexistent language identifier. The default EN remains in effect when the compiler scans the CBL statement. The unrecognized option APOST in the CBL statement is diagnosed in mixed-case English because the

CBL statement has not completed processing and EN was the last valid language option. After the compiler processes the CBL options, the language in effect becomes Japanese (JP).

In the program COMPILE2, the compiler diagnoses CBL statement errors in mixed-case English because English is the language in effect before the first program is used. If more than one LANGUAGE option is specified, only the last valid language specified is used. In this example, the last valid language is Japanese (JP). Therefore Japanese becomes the language in effect when the compiler finishes processing the CBL options. If you want diagnostics in Japanese for the options in the CBL and PROCESS statements, the language in effect before COMPILE1 must be Japanese.

The program COMPILE3 has no CBL statement. It inherits the language in effect, Japanese (JP), from the previous compilation.

After compiling COMPILE3, the compiler resets the language in effect to English (EN) because of the CBL statement. The language option in the CBL statement resolves the last-specified two-character alphanumeric language identifier, YY. Because YY is nonexistent, the language in effect remains English.

Correcting errors in your source program

Messages about source code errors indicate where the error happened (LINEID), and the text of the message tells you what the problem is. With this information, you can correct the source program and recompile.

Although you should try to correct errors, it is not necessary to fix all of them. A warning-level or informational-level message can be left in a program without much risk, and you might decide that the recoding and compilation needed to remove the error are not worth the effort. Severe-level and error-level errors, however, indicate probable program failure and should be corrected.

Unrecoverable-level errors are in a class by themselves. In contrast with the four lower levels of errors, a U-level error might not result from a mistake in your source program. It could come from a flaw in the compiler itself or in the operating system. In any case, the problem must be resolved, because the compiler is forced to end early and does not produce complete object code and listing. If the message is received for a program with many S-level syntax errors, correct those errors and compile the program again. You can also resolve job set-up cases yourself (problems such as missing data set definitions or insufficient storage for compiler processing) by making changes to the compile job. If your compile job set-up is correct and you have corrected the S-level syntax errors, you need to call IBM to investigate other U-level errors.

After correcting the errors in your source program, recompile the program. If this second compilation is successful, go on to the link-editing step. If the compiler still finds problems, repeat the above procedure until only informational messages are returned.

RELATED TASKS

“Generating a list of compiler error messages” on page 246

RELATED REFERENCES

“Messages and listings for compiler-detected errors” on page 246

Generating a list of compiler error messages

You can generate a complete listing of compiler diagnostic messages, with their explanations, by compiling a program with a program name of ERRMSG specified in the PROGRAM-ID paragraph, like this:

```
Identification Division.  
Program-ID. ErrMsg.
```

You can omit the rest of the program.

Messages and listings for compiler-detected errors

As the compiler processes your source program, it checks for COBOL language errors that you might have made. For each error found, the compiler issues a message. These messages are collated in the compiler listing (subject to the FLAG option).

Each message in the listing gives the following information:

- Nature of the error
- Compiler phase that detected the error
- Severity level of the error

Wherever possible, the message provides specific instructions for correcting the error.

The messages for errors found during processing of compiler options, CBL and PROCESS statements, or BASIS, COPY, and REPLACE statements are displayed near the top of your listing.

The messages for compilation errors found in your program (ordered by line number) are displayed near the end of the listing for each program.

A summary of all errors found during compilation is displayed near the bottom of your listing.

RELATED TASKS

“Correcting errors in your source program” on page 245

“Generating a list of compiler error messages”

RELATED REFERENCES

“Format of compiler error messages”

“Severity codes for compiler error messages” on page 247

“FLAG” on page 284

Format of compiler error messages

Each message issued by the compiler has the following form:

```
nnnnnn IGYppxxx-l message-text
```

nnnnnn

The number of the source statement of the last line the compiler was processing. Source statement numbers are listed on the source printout of your program. If you specified the NUMBER option at compile time, these are your original source program numbers. If you specified NONUMBER, the numbers are those generated by the compiler.

IGY The prefix that identifies this message as coming from the COBOL compiler.

pp Two characters that identify which phase or subphase of the compiler discovered the error. As an application programmer, you can ignore this information. If you are diagnosing a suspected compiler error, contact IBM for support.

xxxx A four-digit number that identifies the error message.

l A character that indicates the severity level of the error: I, W, E, S, or U.

message-text

The message text itself which, in the case of an error message, is a short explanation of the condition that caused the error.

Tip: If you used the FLAG option to suppress messages, there might be additional errors in your program.

RELATED REFERENCES

“Severity codes for compiler error messages”

“FLAG” on page 284

Severity codes for compiler error messages

Errors the compiler can detect fall into the following five categories of severity:

Table 39. Severity codes for compiler error messages

Level of message	Purpose
Informational (I) (return code=0)	To inform you. No action is required and the program executes correctly.
Warning (W) (return code=4)	To indicate a possible error. The program probably executes correctly as written.
Error (E) (return code=8)	To indicate a condition that is definitely an error. The compiler attempted to correct the error, but the results of program execution might not be what you expect. You should correct the error.
Severe (S) (return code=12)	To indicate a condition that is a serious error. The compiler was unable to correct the error. The program does not execute correctly, and execution should not be attempted. Object code might not be created.
Unrecoverable (U) (return code=16)	To indicate an error condition of such magnitude that the compilation was terminated.

Chapter 15. Compiling under UNIX

You can compile Enterprise COBOL programs under UNIX using the `cob2` command. Under UNIX, you can compile any COBOL source program that you compile under z/OS. The object code generated under UNIX by the COBOL compiler can run under z/OS.

As part of the compilation step, you need to define the files needed for the compilation and specify any compiler options necessary for your program and for the output that you want.

The main job of the compiler is to translate your COBOL program into language that the computer can process (object code). The compiler also lists errors in your source statements and provides supplementary information to help you debug and tune your program. Use compiler-directing statements and compiler options to control your compilation.

RELATED TASKS

"Setting environment variables under UNIX"

"Specifying compiler options under UNIX" on page 250

"Compiling and linking with the `cob2` command" on page 251

"Compiling using scripts" on page 255

"Compiling, linking, and running OO applications under UNIX" on page 257

RELATED REFERENCES

"Data sets used by the compiler under z/OS" on page 233

"Compiler options and compiler output under z/OS" on page 239

Setting environment variables under UNIX

An *environment variable* is a name that is associated with a string of characters, and defines some aspect of a program environment that can vary. You use environment variables to set values that programs, including the compiler, need. Set the environment variables for the compiler by using the `export` shell command. For example, to set the `SYSLIB` variable, issue the `export` command from the shell or from a script file:

```
export SYSLIB=/u/mystuff/copybooks
```

The value that you assign to an environment variable can include other environment variables or the variable itself. The values of these variables apply only when you compile from the shell where you issue the `export` command. If you do not set an environment variable, either a default value is applied or the variable is not defined. The environment variable names must be uppercase.

The environment variables that you can set for use by the compiler are as follows:

COBOPT

Specify compiler options separated by blanks or commas. Separate suboptions with commas. Blanks at the beginning or the end of the variable value are ignored. Delimit the list of options with quotation marks if it contains blanks or characters significant to the UNIX shell. For example:

```
export COBOPT="TRUNC(OPT) XREF"
```

SYSLIB

Specify paths to directories to be used in searching for COBOL copybooks when you do not specify an explicit library-name on the COPY statement. Separate multiple paths with a colon. The paths are evaluated in order, from the first path to the last in the export command. If you set the variable with multiple files of the same name, the first located copy of the file is used.

For COPY statements in which you have not coded an explicit library-name, the compiler searches for copybooks in this order:

1. In the current directory
2. In the paths you specify with the -I cob2 option
3. In the paths you specify in the SYSLIB environment variable

library-name

Specify the directory path from which to copy when you specify an explicit library-name on the COPY statement. The environment variable name is identical to the *library-name* in your program. You must set an environment variable for each library; an error will occur otherwise. The environment variable name *library-name* must be uppercase.

text-name

Specify the name of the file from which to copy text. The environment variable name is identical to the *text-name* in your program. The environment variable name *text-name* must be uppercase.

RELATED TASKS

“Specifying compiler options under UNIX”

“Compiling and linking with the cob2 command” on page 251

“Setting and accessing environment variables” on page 384

RELATED REFERENCES

Chapter 18, “Compiler-directing statements,” on page 317

Chapter 17, “Compiler options,” on page 267

COPY statement (*Enterprise COBOL Language Reference*)

Specifying compiler options under UNIX

The compiler is installed and set up with default compiler options. While installing the compiler, the system programmers for a site can fix compiler option settings to, for example, ensure better performance or maintain certain standards. You cannot override any compiler options that your site has set as fixed. For options that are not fixed, you can override the default settings by specifying compiler options in any of three ways:

1. Code them on the PROCESS or CBL statement in your COBOL source.
2. Specify the -q option of the cob2 command.
3. Set the COBOPT environment variable.

The compiler recognizes the options in the above order of precedence.

The order of precedence also determines which options are in effect when conflicting or mutually exclusive options are specified. When you compile using the cob2 command, compiler options are recognized in the following order of precedence from highest to lowest:

1. Installation defaults fixed as nonoverridable

2. The values of BUFSIZE, LIB, SQL, OUTDD, and SIZE options in effect for the first program in a batch compilation
3. The values that you specify on PROCESS or CBL statements within your COBOL source programs
4. The values that you specify in the cob2 command's -q option string
5. The values that you specify in the COBOPT environment variable
6. Installation defaults that are not fixed

Restriction: Do not use the SQL option under UNIX. Neither the separate SQL precompiler nor the integrated SQL coprocessor run under UNIX.

RELATED TASKS

"Specifying compiler options with the PROCESS (CBL) statement" on page 238

"Setting environment variables under UNIX" on page 249

"Compiling and linking with the cob2 command"

RELATED REFERENCES

"Conflicting compiler options" on page 269

Chapter 17, "Compiler options," on page 267

Compiling and linking with the cob2 command

Use the cob2 command to compile and link your COBOL programs from the UNIX shell. You can specify the options and input file names in any order, using spaces to separate options and names. Any options that you specify apply to all files on the command line.

To compile multiple files (batch compilation), specify multiple source file names.

When you compile COBOL programs for UNIX, the RENT option is required. The cob2 command automatically includes the COBOL compiler options RENT and TERM.

The cob2 command invokes the COBOL compiler that is found through the standard MVS search order. If the COBOL compiler is not installed in the LNKLIST, or if more than one level of IBM COBOL compiler is installed on your system, you can specify the compiler PDS that you want to use in the STEPLIB environment variable. For example:

```
export STEPLIB=IGY.V3R3M0.SIGYCOMP
```

The cob2 command implicitly uses the UNIX shell command c89 for the link step. c89 is the shell interface to the linker (the DFSMS program management binder).

Defining input and output

The default location for compiler input and output is the current directory.

Only files with the .cbl extension are passed to the compiler; cob2 passes all other files to the linker.

The linker causes execution to begin at the first main program.

Listing output that you request from the compilation of a COBOL source program *file.cbl* is written to *file.lst*. Listing output that you request from the linker is written to stdout.

Creating a DLL

To create a DLL, you must specify the cob2 option `-bdll`. The COBOL compiler options `DLL`, `EXPORTALL`, and `RENT` are required when you create a DLL and are included for you when you specify the `-bdll` cob2 option. For example:

```
cob2 -o mydll -bdll mysub.cbl
```

When you specify cob2 `-bdll`, the link step produces a DLL definition side file. This file contains `IMPORT` control statements for each of the names exported by the DLL. The name of the DLL definition side file is based on the output file name. If the output name has an extension, that extension is replaced with *x* to form the side file name. For example, if the output file name is `foo.dll`, the side file name is `foo.x`.

To use the DLL definition side files later when you create a module that calls the DLL, specify the side files with any other object files (*file.o*) that you specify for the linking. For example:

```
cob2 -o myappl -qdll myappl.cbl mydll.x
```

“Example: using cob2 to compile under UNIX”

RELATED TASKS

“Compiling programs to create DLLs” on page 426

“Preparing OO applications under UNIX” on page 258

Language Environment Programming Guide

UNIX System Services User's Guide

RELATED REFERENCES

“cob2” on page 253

“cob2 input and output files” on page 254

“Data sets used by the compiler under z/OS” on page 233

“Compiler options and compiler output under z/OS” on page 239

UNIX System Services Command Reference

Example: using cob2 to compile under UNIX

The following examples illustrate the use of cob2:

- To compile one file called `alpha.cbl`, enter:

```
cob2 -c alpha.cbl
```

The compiled file is named `alpha.o`.

- To compile two files called `alpha.cbl` and `beta.cbl`, enter:

```
cob2 -c alpha.cbl beta.cbl
```

The compiled files are named `alpha.o` and `beta.o`.

- To link two files, compile them without the `-c` option. For example, to compile and link `alpha.cbl` and `beta.cbl` and generate `gamma`, enter:

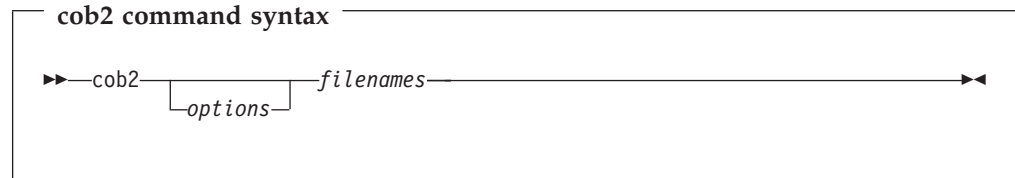
```
cob2 alpha.cbl beta.cbl -o gamma
```

This command creates `alpha.o` and `beta.o`, then links `alpha.o`, `beta.o`, and the COBOL libraries. If the link step is successful, it produces an executable program named `gamma`.

- To compile `alpha.cbl` with the `LIST` and `NODATA` options, enter:

```
cob2 -qlist,noadata alpha.cbl
```

cob2



Do not capitalize `cob2`.

The options for `cob2` are:

-bxxx Passes the string *xxx* to the linker as parameters. *xxx* is a list of linker options in *name=value* format, separated by commas. You must spell out both the name and the value in full. They are case insensitive. Do not use any spaces between `-b` and *xxx*.

If you do not specify a value for an option, a default value of YES is used, except for the following options, which have the indicated default values:

- LIST=NOIMPORT
- ALIASES=ALL
- COMPAT=CURRENT
- DYNAM=DLL

One special value for *xxx* is `dll`, which specifies that the executable module is to be a DLL. It is not passed to the linker.

-c Compiles programs but does not link them.

-comprc_ok=n

Controls `cob2` behavior on the return code from the compiler. If the return code is less than or equal to *n*, `cob2` continues to the link step or, in the compile-only case, exits with a zero return code. If the return code returned by the compiler is greater than *n*, `cob2` exits with the same return code. When the `c89` command is implicitly invoked by `cob2` for the link step, the exit value from the `c89` command is used as the return code from the `cob2` command.

The default is `-comprc_ok=4`.

-e xxx Specifies the name of a program to be used as the entry point of the module. If you do not specify `-e`, the default entry point is the first program (*file.cbl*) or object file (*file.o*) that you specify as a file name on the `cob2` command invocation.

-g Prepares the program for debugging. Equivalent to specifying the `TEST` option with no suboptions.

-Ixxx Adds a path *xxx* to the directories to be searched for copybooks for which you do not specify a *library-name*.

To specify multiple paths, either use multiple `-I` options, or use a colon to separate multiple path names within a single `-I` option value.

For `COPY` statements where you have not coded an explicit *library-name*, the compiler searches for copybooks in this order:

1. In the current directory

2. In the paths you specify with the `-I cob2` option
3. In the paths you specify in the SYSLIB environment variable

If you use the `COPY` statement, you must ensure that the LIB compiler option is in effect.

- L xxx** Specifies the directory paths to be used to search for archive libraries specified by the `-l` operand.
- l xxx** Specifies the name of an archive library for the linker. The `cob2` command searches for the name `libxxx.a` in the directories specified in the `-L` option, then in the usual search order. (This option is lowercase “el,” not uppercase “eye.”)
- o xxx** Names the object module `xxx`. If the `-o` option is not used, the name of the object module is `a.out`.
- qxxx** Passes `xxx` to the compiler, where `xxx` is a list of compiler options separated by blanks or commas.

Enclose `xxx` in quotation marks if a parenthesis is part of the option or suboption, or if you use blanks to separate options. Do not insert spaces between `-q` and `xxx`.
- v** Displays the generated commands that are issued by `cob2` for the compile and link steps, including the options being passed, and executes them. This is sample output:


```
cob2 -v -o mini -qssrange mini.cbl
compiler: ATTCRCTL PARM=RENT,TERM,SSRANGE /u/userid/cobol/mini.cbl
PP 5655-G53 IBM Enterprise COBOL for z/OS 3.3.0 in progress ...
End of compilation 1, program mini, no statements flagged.
linker: /bin/c89 -o mini -e // mini.o
```
- #** Displays compile and link steps, but does not execute them.

RELATED TASKS

“Compiling and linking with the `cob2` command” on page 251

“Setting environment variables under UNIX” on page 249

cob2 input and output files

You can specify the following files as input file names when you use the `cob2` command:

Table 40. Input files to the `cob2` command

File name	Description	Comments
<i>file.cbl</i>	COBOL source file to be compiled and linked	Will not be linked if you specify the <code>cob2</code> option <code>-c</code>
<i>file.a</i>	Archive file	Produced by the <code>ar</code> command, to be used during the link-edit phase
<i>file.o</i>	Object file to be link-edited	Can be produced by the COBOL compiler, the C/C++ compiler, or the assembler
<i>file.x</i>	DLL definition side file	Used during the link-edit phase of an application that references the dynamic link library (DLL)

When you use the `cob2` command, the following files are created in the current directory:

Table 41. Output files from the cob2 command

File name	Description	Comments
<i>file</i>	Executable module or DLL	Created by the linker if you specify the cob2 option <i>-o file</i>
<i>a.out</i>	Executable module or DLL	Created by the linker if you do not specify the cob2 option <i>-o</i>
<i>file.adt</i>	Associated data (ADATA) file corresponding to input COBOL source program <i>file.cbl</i>	Created by the compiler if you specify the compiler option ADATA
<i>file.dbg</i>	Symbolic information tables for Debug Tool corresponding to input COBOL source program <i>file.cbl</i>	Created by the compiler if you specify the compiler option TEST(<i>hook</i> ,SYM,SEPARATE)
<i>file.lst</i>	Listing file corresponding to input COBOL source program <i>file.cbl</i>	Created by the compiler
<i>file.o</i>	Object file corresponding to input COBOL source program <i>file.cbl</i>	Created by the compiler
<i>file.x</i>	DLL definition side file	Created during the cob2 linking phase when creating a DLL named <i>file.dll</i>
<i>class.java</i>	Java class definition (source)	Created when you compile a class definition

RELATED TASKS

“Compiling and linking with the cob2 command” on page 251

RELATED REFERENCES

“ADATA” on page 270

“TEST” on page 306

UNIX System Services Command Reference

Compiling using scripts

To use a shell script to automate your cob2 tasks, use the following syntax to prevent the shell from passing syntax to cob2 that is not valid:

- Use an equal sign and colon rather than left and right parentheses, respectively, to specify compiler suboptions. For example, code `-qOPT=FULL: ,XREF` instead of `-qOPT(FULL) ,XREF`.
- Use an underscore rather than a single quotation mark where a compiler option requires single quotation marks for delimiting a suboption.
- Do not use blanks in the option string.

Chapter 16. Compiling, linking, and running OO applications

It is recommended that you compile, link, and run object-oriented (OO) applications in a z/OS UNIX environment. However, with certain limitations discussed in the related tasks, it is possible to compile, link, and run OO COBOL applications by using standard batch JCL or TSO/E commands.

RELATED TASKS

“Compiling, linking, and running OO applications under UNIX”

“Compiling, linking, and running OO applications using JCL or TSO/E” on page 261

Compiling, linking, and running OO applications under UNIX

When you compile, link, and run OO applications in a z/OS UNIX environment:

- Application components reside in the HFS.
- You compile and link them by using UNIX shell commands.
- You run them at a UNIX shell command prompt or with the BPXBATCH utility from JCL or TSO/E.

RELATED TASKS

“Compiling OO applications under UNIX”

“Preparing OO applications under UNIX” on page 258

“Running OO applications under UNIX” on page 259

Compiling OO applications under UNIX

When you compile OO applications in a UNIX shell, use the following commands:

- `cob2` to compile COBOL client programs and class definitions
- `javac` to compile Java class definitions to produce *bytecode* (extension `.class`)

To compile COBOL source code that contains OO syntax such as `INVOKE` statements or class definitions, or that uses Java services, you must use these compiler options: `RENT`, `DLL`, `THREAD`, and `DBCS`. (The `RENT` and `DBCS` options are defaults.)

A COBOL source file that contains a class definition must not contain any other class or program definitions.

When you compile a COBOL class definition, two output files are generated:

- The object file (`.o`) for the class definition.
- A Java source program (`.java`) that contains a class definition that corresponds to the COBOL class definition. Do not edit this generated Java class definition in any way. If you change the COBOL class definition, you must regenerate both the object file and the Java class definition by recompiling the updated COBOL class definition.

If a COBOL client program or class definition includes the `JNI.cpy` file by using a `COPY` statement, specify the include subdirectory of the COBOL install directory (typically `/usr/lpp/cobol/include`) in the search order for copybooks. You can do this by using the `-I` option of the `cob2` command or by setting the `SYSLIB` environment variable.

RELATED TASKS

Chapter 15, “Compiling under UNIX,” on page 249

“Preparing OO applications under UNIX”

“Running OO applications under UNIX” on page 259

“Setting and accessing environment variables” on page 384

“Accessing JNI services” on page 527

RELATED REFERENCES

“cob2” on page 253

“DBCS” on page 279

“DLL” on page 281

“RENT” on page 299

“THREAD” on page 309

Preparing OO applications under UNIX

Use the cob2 command to link OO COBOL applications.

To prepare an OO COBOL client program for execution, link the object file with the following two DLL side files to create an executable module:

- libjvm.x, which is provided with the IBM Developer Kit for OS/390, Java 2 Technology Edition.
- igzcjava.x, which is provided in the lib subdirectory of the cobol directory in the HFS. The typical complete path name is /usr/lpp/cobol/lib/igzcjava.x. This DLL side file is also available as the member IGZCJAVA in the SCEELIB PDS (part of Language Environment).

To prepare a COBOL class definition for execution, process the following files:

1. Link the object file using the two DLL side files discussed above to create an executable DLL module.

You must name the resulting DLL module lib*Classname*.so, where *Classname* is the external class-name. If the class is part of a package and thus there are periods in the external class-name, you must change the periods to underscores in the DLL module name. For example, if class Account is part of the com.acme package, the external class-name (as defined in the REPOSITORY paragraph entry for the class) must be com.acme.Account, and the DLL module for the class must be libcom_acme_Account.so.

2. Compile the generated Java source with the Java compiler to create a class file (.class).

For a COBOL source file *Classname.cbl* that contains the class definition for *Classname*, you use the following commands to compile and link the components of the application:

Table 42. Commands for compiling and linking a class definition

Command	Input	Output
cob2 -c -qdll,thread <i>Classname.cbl</i>	<i>Classname.cbl</i>	<i>Classname.o</i> <i>Classname.java</i>
cob2 -bdll -o lib <i>Classname</i> .so <i>Classname.o</i> /usr/lpp/java/IBM/J1.3/bin/classic/libjvm.x /usr/lpp/cobol/lib/igzcjava.x	<i>Classname.o</i>	lib <i>Classname</i> .so
javac <i>Classname.java</i>	<i>Classname.java</i>	<i>Classname.class</i>

After you issue the `cob2` and `javac` commands successfully, you have the executable components for the program: the executable DLL module `libClassname.so` and the class file `Classname.class`.

All files from these commands are generated in the current working directory.

“Example: compiling and linking a COBOL class definition under UNIX”

RELATED TASKS

Chapter 15, “Compiling under UNIX,” on page 249

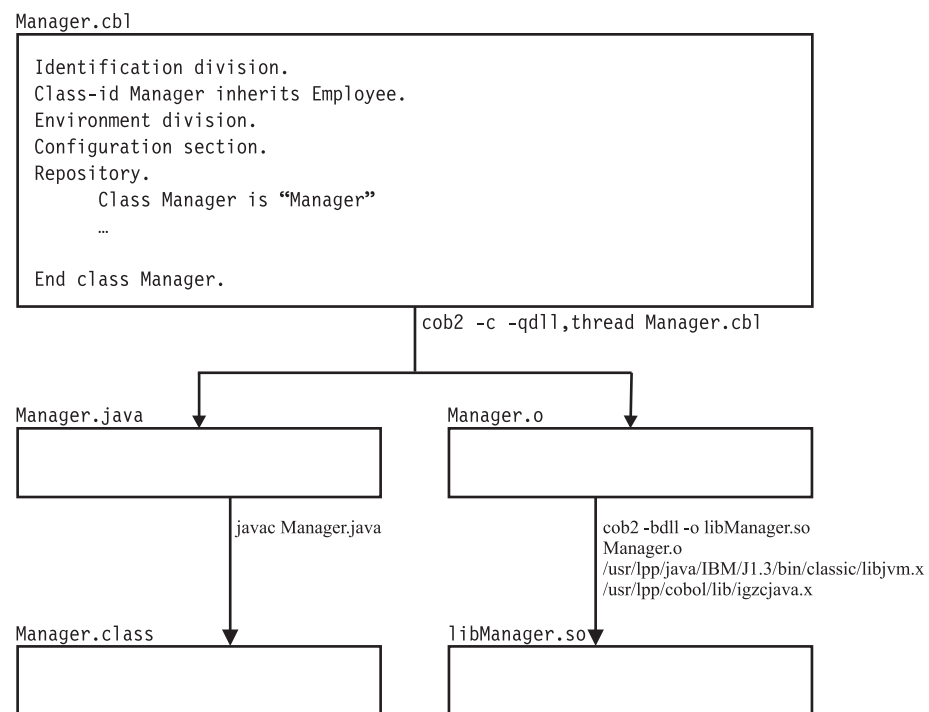
“REPOSITORY paragraph for defining a class” on page 490

RELATED REFERENCES

“cob2” on page 253

Example: compiling and linking a COBOL class definition under UNIX

This chart illustrates the commands that you use and the files that are produced when you compile and link a COBOL class definition, `Manager.cbl`, using UNIX shell commands:



The class file `Manager.class` and the DLL module `libManager.so` are the executable components of the application, and are generated in the current working directory.

Running OO applications under UNIX

It is recommended that you run object-oriented COBOL applications as UNIX applications. You must do so if an application begins with a Java program or the main factory method of a COBOL class.

Specify the directory that contains the DLLs for the COBOL classes in the LIBPATH environment variable. Specify the directory paths for the Java class files that are associated with the COBOL classes in the CLASSPATH environment variable as follows:

- For classes that are not part of a package, end the class path with the directory that contains the .class files.
- For classes that are part of a package, end the class path with the directory that contains the “root” package (the first package in the full package name).
- For a .jar file that contains .class files, end the class path with the name of the .jar file.

Separate multiple path entries with colons.

Running OO applications that start with a main method

If the first routine of a mixed COBOL and Java application is the main method of a Java class or the main factory method of a COBOL class, run the application by using the java command and by specifying the name of the class that contains the main method. The java command initializes the Java virtual machine (JVM).

To customize the initialization of the JVM, specify options on the java command as in the following examples:

Table 43. java command options for customizing the JVM

Purpose	Option
To set a system property	-Dname=value
To request that the JVM generate verbose messages about garbage collection	-verbose:gc
To request that the JVM generate verbose messages about class loading	-verbose:class
To request that the JVM generate verbose messages about native methods and other Java Native Interface activity	-verbose:jni
To set the initial Java heap size to value bytes	-Xmsvalue
To set the maximum Java heap size to value bytes	-Xmxvalue

See the output from the java -h command or the related references for details about the options that the JVM supports.

Running OO applications that start with a COBOL program

If the first routine of a mixed COBOL and Java application is a COBOL program, run the application by specifying the program name at the command prompt. If a JVM is not already running in the process of the COBOL program, the COBOL run time automatically initializes a JVM.

To customize the initialization of the JVM, specify options by setting the COBJVMINITOPTIONS environment variable. For example:

```
export COBJVMINITOPTIONS="-Xms100000000 -Xmx200000000 -verbose:gc"
```

Use blanks to separate options.

Running J2EE COBOL clients: You can use OO syntax in a COBOL program to implement a Java 2 Platform, Enterprise Edition (J2EE) client. You can, for example, invoke methods on enterprise beans that run in the WebSphere for z/OS or OS/390 environment.

Before you run a COBOL J2EE client, you must set the Java system property `java.naming.factory.initial` to access WebSphere naming services. For example:

```
export COBJVMINITOPTIONS  
="-Djava.naming.factory.initial=com.ibm.websphere.naming.WsnInitialContextFactory"
```

"Example: J2EE client written in COBOL" on page 539

RELATED TASKS

Chapter 23, "Running COBOL programs under UNIX," on page 383

"Setting and accessing environment variables" on page 384

Chapter 30, "Writing object-oriented programs," on page 485

"Structuring OO applications" on page 524

RELATED REFERENCES

JVM options (*New IBM Technology featuring Persistent Reusable Java Virtual Machines*)

Java Naming and Directory Interface (JNDI) (*WebSphere for z/OS: Assembling J2EE Applications*)

Compiling, linking, and running OO applications using JCL or TSO/E

It is recommended that you compile, link, and run applications that use OO syntax in a z/OS UNIX environment. However, in limited circumstances it is possible to compile, prepare, and run OO applications by using standard batch JCL or TSO/E commands. To do so, you must follow the guidelines discussed in the related tasks.

For example, you might follow this approach for applications that consist of a COBOL main program and subprograms that:

- Access objects that are all implemented in Java
- Access enterprise beans that run in a WebSphere server

RELATED TASKS

"Compiling OO applications using JCL or TSO/E"

"Preparing and running OO applications using JCL or TSO/E" on page 262

"Compiling, linking, and running OO applications under UNIX" on page 257

Compiling OO applications using JCL or TSO/E

If you use batch JCL or TSO/E to compile an OO COBOL program or class definition, the generated object file is written, as usual, to the data set that you identify with the `SYSLIN` or `SYSPUNCH` ddname. You must use the compiler options `RENT`, `DLL`, `THREAD`, and `DBCS`. (`RENT` and `DBCS` are defaults.)

If the COBOL program or class definition uses the JNI environment structure to access JNI callable services, copy the file `JNI.cpy` from the HFS to a PDS or PDSE member called `JNI`, identify that library with a `SYSLIB DD` statement, and use a `COPY` statement of the form `COPY JNI` in the COBOL source program.

A COBOL source file that contains a class definition must not contain any other class or program definitions.

When you compile a COBOL class definition, a Java source program that contains a class definition that corresponds to the COBOL class definition is generated in addition to the object file. Use the `SYSJAVA` ddname to write the generated Java source file to a file in the HFS. For example:

```
//SYSJAVA DD PATH='/u/userid/java/Classname.java',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
// PATHMODE=SIRWXU,
// FILEDATA=TEXT
```

Do not edit this generated Java class definition in any way. If you change the COBOL class definition, you must regenerate both the object file and the Java class definition by recompiling the updated COBOL class definition.

Compile Java class definitions by using the `javac` command from a UNIX shell command prompt, or by using the BPXBATCH utility.

“Example: compiling, linking, and running an OO application using JCL” on page 263

RELATED TASKS

- “Compiling with JCL” on page 217
- “Compiling under TSO” on page 229
- “Specifying source libraries (SYSLIB)” on page 235
- “Defining the output Java data set (SYSJAVA)” on page 237
- “Accessing JNI services” on page 527
- “Compiling OO applications under UNIX” on page 257
- “Preparing OO applications under UNIX” on page 258

RELATED REFERENCES

- “DBCS” on page 279
- “DLL” on page 281
- “RENT” on page 299
- “THREAD” on page 309
- Appendix F, “JNI.cpy,” on page 649
- The BPXBATCH utility (*UNIX System Services User's Guide*)

Preparing and running OO applications using JCL or TSO/E

It is recommended that you run OO applications in a z/OS UNIX environment. To run OO applications from batch JCL or TSO/E, you should therefore use the BPXBATCH utility.

In limited circumstances, however, you can run an OO application by using standard batch JCL (EXEC PGM=COBPROG) or the TSO/E CALL command. To do so, follow these requirements when preparing the application:

- Structure the application to start with a COBOL program, and link the load module for the COBOL program into a PDSE. (If an application starts with a Java program or with the main factory method of a COBOL class, you must run the application under UNIX, and the application components must reside in the HFS.)
- Ensure that the class files and DLLs associated with the COBOL or Java classes that are used by the application reside in the HFS. You must name the class files and DLLs as described in the related task on preparing OO applications under UNIX.
- Specify INCLUDE control statements for the DLL side files `libjvm.x` and `igzjava.x` when you bind the object deck for the main program. For example:


```
INCLUDE '/usr/lpp/java/IBM/J1.3/bin/classic/libjvm.x'
INCLUDE '/usr/lpp/cobol/lib/igzjava.x'
```
- Create a file that contains the environment variable settings that are required for Java. For example, a file `/u/userid/javaenv` might contain these three lines to set

the PATH, LIBPATH, and CLASSPATH environment variables. (The LIBPATH setting is shown below on two lines because of document length limitations, but you must specify the setting on one unbroken line that has no internal blanks.):

```
PATH=/bin:/usr/lpp/java/IBM/J1.3/bin
LIBPATH=/lib:/usr/lib:/usr/lpp/java/IBM/J1.3/bin:
      /usr/lpp/java/IBM/J1.3/bin/classic:/u/userid/applications
CLASSPATH=/u/userid/applications
```

To customize the initialization of the JVM that will be used by the application, you can set the COBJVMINITOPTIONS environment variable in the same file. For example, to access enterprise beans that run in a WebSphere server, you must set the Java system property java.naming.factory.initial. For details, see the related task on running OO applications under UNIX.

When you run an OO application that starts with a COBOL program by using standard batch JCL or the TSO/E CALL command, follow these guidelines:

- Use the _CEE_ENVFILE environment variable to indicate the location of the file that contains the environment variable settings required by Java. Set _CEE_ENVFILE by using the ENVAR run-time option.
- Specify the POSIX(ON) run-time option.
- Use DD statements to specify files in the HFS for the standard input, output, and error streams for Java:
 - JAVAIN DD for the input from statements such as `c=System.in.read();`
 - JAVAOUT DD for the output from statements such as `System.out.println(string);`
 - JAVAERR DD for the output from statements such as `System.err.println(string);`
- Ensure that the SCEERUN2 and SCEERUN load libraries are available in the system library search order, for example, by using a STEPLIB DD statement.

“Example: compiling, linking, and running an OO application using JCL”

RELATED TASKS

“Preparing OO applications under UNIX” on page 258

“Running OO applications under UNIX” on page 259

“Structuring OO applications” on page 524

The BPXBATCH utility (*UNIX System Services User's Guide*)

Program library definition and search order (*Language Environment Programming Guide*)

RELATED REFERENCES

_CEE_ENVFILE (*C/C++ Programming Guide*)

ENVAR (*Language Environment Programming Reference*)

Example: compiling, linking, and running an OO application using JCL

This example shows:

- The JCL to compile, link, and run an OO COBOL program, TSTHELLO
- A Java class definition, HelloJ, that contains a method invoked by the COBOL program
- An HFS file, ENV, that contains the environment variable settings required by Java

JCL for program TSTHELLO

```
//TSTHELLO JOB ,
// TIME=(1),MSGLEVEL=(1,1),MSGCLASS=H,CLASS=A,REGION=100M,
// NOTIFY=&SYSUID,USER=&SYSUID
//*
// SET COBPRFX='IGY.V3R3M0'
// SET LIBPRFX='CEE'
//*
//COMPILE EXEC PGM=IGYCRCTL,
// PARM='SIZE(5000K)'
//SYSLIN DD DSN=&&OBJECT(TSTHELLO),UNIT=VIO,DISP=(NEW,PASS),
// SPACE=(CYL,(1,1,1))
//SYSPRINT DD SYSOUT=*
//STEPLIB DD DSN=&COBPRFX..SIGYCOMP,DISP=SHR
// DD DSN=&LIBPRFX..SCEERUN,DISP=SHR
//SYSUT1 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSUT4 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSUT5 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSUT6 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSUT7 DD UNIT=VIO,SPACE=(CYL,(1,1))
//SYSIN DD *
    cbl dll,thread
    Identification division.
    Program-id. "TSTHELLO" recursive.
    Environment division.
    Configuration section.
    Repository.
        Class HelloJ is "HelloJ".
    Data Division.
    Procedure division.
        Display "COBOL program TSTHELLO entered"
        Invoke HelloJ "sayHello"
        Display "Returned from java sayHello to TSTHELLO"
        Goback.
    End program "TSTHELLO".
/*
//LKED EXEC PGM=IEWL,PARM='RENT,LIST,LET,DYNAM(DLL),CASE(MIXED)'
//SYSLIB DD DSN=&LIBPRFX..SCEELKED,DISP=SHR
// DD DSN=&LIBPRFX..SCEELKEX,DISP=SHR
//SYSPRINT DD SYSOUT=*
//SYSTEM DD SYSOUT=*
//SYSLMOD DD DSN=&&GOSET(TSTHELLO),DISP=(MOD,PASS),UNIT=VIO,
// SPACE=(CYL,(1,1,1)),DSNTYPE=LIBRARY
//SYSDEFSD DD DUMMY
//OBJMOD DD DSN=&&OBJECT,DISP=(OLD,DELETE)
//SYSLIN DD *
    INCLUDE OBJMOD(TSTHELLO)
    INCLUDE '/usr/lpp/java/IBM/J1.3/bin/classic/libjvm.x'
    INCLUDE '/usr/lpp/cobol/lib/igzcjava.x'
/*
//GO EXEC PGM=TSTHELLO,COND=(4,LT,LKED),
// PARM='/ENVAR("_CEE_ENVFILE=/u/userid/ootest/tsthello/ENV")'
// POSIX(ON)'
//STEPLIB DD DSN=*.LKED.SYSLMOD,DISP=SHR
// DD DSN=&LIBPRFX..SCEERUN2,DISP=SHR
// DD DSN=&LIBPRFX..SCEERUN,DISP=SHR
//SYSOUT DD SYSOUT=*
//CEEDUMP DD SYSOUT=*
//SYSUDUMP DD DUMMY
//JAVAOUT DD PATH='/u/userid/ootest/tsthello/javaout',
// PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
// PATHMODE=(SIRUSR,SIWUSR,SIRGRP)
```


Definition of class HelloJ

```
class HelloJ {  
    public static void sayHello() {  
        System.out.println("Hello World, from Java!");  
    }  
}
```

HelloJ.java is compiled with the `javac` command. The resulting `.class` file resides in the HFS directory `u/userid/octest/tsthello`, which is specified in the `CLASSPATH` environment variable in the environment variable settings file.

Environment variable settings file, ENV

```
PATH=/bin:/usr/lpp/java/IBM/J1.3/bin:.  
LIBPATH=/lib:/usr/lib:/usr/lpp/java/IBM/J1.3/bin:  
    /usr/lpp/java/IBM/J1.3/bin/classic:/u/userid/octest/tsthello  
CLASSPATH=/u/userid/octest/tsthello
```

(The `LIBPATH` setting is shown above on two lines because of document length limitations, but you must specify the setting on one unbroken line that has no internal blanks.)

The environment variable settings file also resides in directory `u/userid/octest/tsthello`, as specified in the `_CEE_ENVFILE` environment variable in the JCL.

Chapter 17. Compiler options

You can direct and control your compilation in two ways:

- By using compiler options
- By using compiler-directing statements (compiler directives)

Compiler options affect the aspects of your program that are listed in the table below. The linked-to information for each option provides the syntax for specifying the option and describes the option, its parameters, and its interaction with other parameters.

Table 44. Compiler options

Aspect of your program	Compiler option	Default	Abbreviations
Source language	"ARITH" on page 271	ARITH(COMPAT)	AR(C|E)
	"CICS" on page 273	NOCICS	None
	"CODEPAGE" on page 274	CODEPAGE(01140)	CP(ccsid)
	"CURRENCY" on page 276	NOCURRENCY	CURR|NOCURR
	"DBCS" on page 279	DBCS	None
	"LIB" on page 288	LIB	None
	"NSYMBOL" on page 291	NSYMBOL(NATIONAL)	NS(DBCS|NAT)
	"NUMBER" on page 292	NONUMBER	NUM|NONUM
	"QUOTE/APOST" on page 299	QUOTE	Q|APOST
	"SEQUENCE" on page 301	SEQUENCE	SEQ|NOSEQ
	"SQL" on page 303	NOSQL	None
	"WORD" on page 313	NOWORD	WD|NOWD
Date processing	"DATEPROC" on page 278	NODATEPROC, or DATEPROC(FLAG,NOTRIG) if only DATEPROC is specified	DP|NODP
	"INTDATE" on page 287	INTDATE(ANSI)	None
	"YEARWINDOW" on page 315	YEARWINDOW(1900)	YW
Maps and listings	"LANGUAGE" on page 287	LANGUAGE(ENGLISH)	LANG(EN|UE|JA|JP)
	"LINECOUNT" on page 289	LINECOUNT(60)	LC
	"LIST" on page 289	NOLIST	None
	"MAP" on page 290	NOMAP	None
	"OFFSET" on page 294	NOOFFSET	OFF|NOOFF
	"SOURCE" on page 302	SOURCE	S|NOS
	"SPACE" on page 303	SPACE(1)	None
	"TERMINAL" on page 305	NOTERMINAL	TERM|NOTERM
	"VBREF" on page 313	NOVBREF	None
	"XREF" on page 314	XREF(FULL)	X|NOX

Table 44. Compiler options (continued)

Aspect of your program	Compiler option	Default	Abbreviations
Object deck generation	"COMPILE" on page 275	NOCOMPILE(S)	C|NOC
	"DECK" on page 279	NODECK	D|NOD
	"NAME" on page 291	NONAME, or NAME(NOALIAS) if only NAME is specified	None
	"OBJECT" on page 294	OBJECT	OBJ|NOOBJ
	"PGMNAME" on page 297	PGMNAME (COMPAT)	PGMN(CO|LU|LM)
Object code control	"ADV" on page 271	ADV	None
	"AWO" on page 272	NOAWO	None
	"DLL" on page 281	NODLL	None
	"EXPORTALL" on page 283	NOEXPORTALL	EXP|NOEXP
	"FASTSRT" on page 284	NOFASTSRT	FSRT|NOFSRT
	"NUMPROC" on page 293	NUMPROC (NOPFD)	None
	"OPTIMIZE" on page 295	NOOPTIMIZE	OPT|NOOPT
	"OUTDD" on page 296	OUTDD(SYSOUT)	OUT
	"TRUNC" on page 310	TRUNC(STD)	None
Virtual storage usage	"ZWB" on page 316	ZWB	None
	"BUFSIZE" on page 273	4096	BUF
	"SIZE" on page 302	SIZE(MAX)	SZ
	"DATA" on page 277	DATA(31)	None
	"DYNAM" on page 282	NODYNAM	DYN|NODYN
	"RENT" on page 299	RENT	None
Debugging and diagnostics	"RMODE" on page 300	AUTO	None
	"DIAGTRUNC" on page 280	NODIAGTRUNC	DTR|NODTR
	"DUMP" on page 281	NODUMP	DU|NODU
	"FLAG" on page 284	FLAG(I,I)	F|NOF
	"FLAGSTD" on page 285	NOFLAGSTD	None
	"TEST" on page 306	NOTEST	None
Other	"SSRANGE" on page 304	NOSSRANGE	SSR|NOSSR
	"ADATA" on page 270	NOADATA	None
	"EXIT" on page 283	NOEXIT	EX(INX,LIBX,PRTX,ADX)
	"THREAD" on page 309	NOTHREAD	None

Installation defaults: The default options that were set up when your compiler was installed are in effect for your program unless you override them with other options. (In some installations, certain compiler options are set up as fixed so that you cannot override them. If you have problems, see your system administrator.) To find out the default compiler options in effect, run a test compilation without specifying any options. The output listing lists the default options specified by your installation.

Nonoverridable options: In some installations, certain compiler options are set up so that you cannot override them. If you have problems, see your system administrator.

Performance considerations: The DYNAM, FASTSRT, NUMPROC, OPTIMIZE, RENT, SSRANGE, TEST, and TRUNC compiler options can all affect run-time performance.

RELATED REFERENCES

“Conflicting compiler options”

Chapter 18, “Compiler-directing statements,” on page 317

“Option settings for COBOL 85 Standard conformance”

RELATED TASKS

Chapter 14, “Compiling under z/OS,” on page 217

“Compiling under TSO” on page 229

Chapter 15, “Compiling under UNIX,” on page 249

Chapter 34, “Tuning your program,” on page 579

Option settings for COBOL 85 Standard conformance

The following compiler options are required to conform to the COBOL 85 Standard specification:

ADV	NAME(ALIAS) or NAME(NOALIAS)
NOCICS	NUMPROC(NOPFD) or NUMPROC(MIG)
NODATEPROC	PGMNAME(COMPAT) or PGMNAME(LONGUPPER)
NODLL	QUOTE
DYNAM	NOTHREAD
NOEXPORTALL	TRUNC(STD)
NOFASTSRT	NOWORD
LIB	ZWB

The following run-time options are required to conform to the COBOL 85 Standard:

- AIXBLD
- CBLQDA(ON)
- TRAP(ON)

RELATED REFERENCES

Language Environment Programming Reference

Conflicting compiler options

The Enterprise COBOL compiler can encounter conflicting compiler options in two ways:

- Both the positive and negative form of a compiler option are specified on the same level in the hierarchy of precedence (such as specifying both DECK and NODECK in a PROCESS (or CBL) statement).

When conflicting options are specified at the same level in the hierarchy, the option specified last takes effect.

- Mutually exclusive options are specified at the same level in the hierarchy, regardless of order.

When you specify mutually exclusive options, any conflicting options that you specify are ignored. For example, if you specify both OFFSET and LIST in your PROCESS statement in any order, OFFSET takes effect and LIST is ignored.

However, options coded at a higher level of precedence override any options specified at a lower level of precedence. For example, if you code OFFSET in your JCL statement but LIST in your PROCESS statement, LIST will take effect because the options coded in the PROCESS statement and any options forced on by an option coded in the PROCESS statement have higher precedence.

The following table lists mutually exclusive compiler options.

Table 45. Mutually exclusive compiler options

Specified	Ignored ¹	Forced on ¹
CICS	NOLIB DYNAM NORENT	LIB NODYNAM RENT
DLL	DYNAM NORENT	NODYNAM RENT
EXIT	DUMP	NODUMP
EXPORTALL	NODLL DYNAM NORENT	DLL NODYNAM RENT
NSYMBOL(NATIONAL)	NODBCS	DBCS
OFFSET	LIST	NOLIST
SQL	NOLIB	LIB
TEST TEST(ALL) TEST(STMT) TEST(PATH) TEST(BLOCK)	NOOBJECT OPT(STD) or OPT(FULL)	OBJECT NOOPTIMIZE
THREAD	NORENT	RENT
WORD	FLAGSTD	NOFLAGSTD
1. Unless in conflict with a fixed installation default option.		

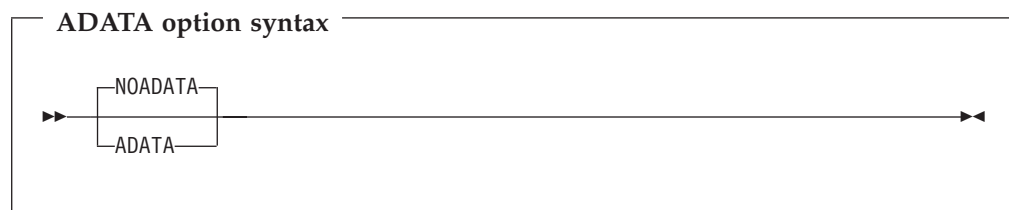
RELATED TASKS

“Specifying compiler options under z/OS” on page 238

“Specifying compiler options in a batch compilation” on page 242

“Specifying compiler options under UNIX” on page 250

ADATA



Default is: NOADATA

Abbreviations are: None

Use ADATA when you want the compiler to create a SYSADATA file, which contains records of additional compilation information. ADATA is required for remote compile using an IBM Windows COBOL compiler. On z/OS, this file is written to ddname SYSADATA. The size of this file generally grows with the size of the associated program.

You cannot specify ADATA in a PROCESS (CBL) statement. You can specify it only in one of the following ways:

- On invocation of the compiler using an option list
- On the PARM field of JCL
- As a command option
- As an installation default

RELATED REFERENCES

Appendix G, “COBOL SYSADATA file contents,” on page 655

ADV

ADV option syntax



Default is: ADV

Abbreviations are: None

ADV has meaning only if you use WRITE . . . ADVANCING in your source code.

With ADV in effect, the compiler adds 1 byte to the record length to account for the printer control character.

Use NOADV if you have already adjusted your record length to include 1 byte for the printer control character.

ARITH

ARITH option syntax



Default is: ARITH(COMPAT)

Abbreviations are: AR(C), AR(E)

When you specify ARITH(EXTEND):

- The maximum number of digit positions that you can specify in the PICTURE clause for packed-decimal, zoned-decimal, and numeric-edited data items is raised from 18 to 31.
- The maximum number of digits that you can specify in a fixed-point numeric literal is raised from 18 to 31. You can use numeric literals with large precision anywhere that numeric literals are currently allowed, including:
 - Operands of PROCEDURE DIVISION statements
 - VALUE clauses (on numeric data items with large-precision PICTURE)
 - Condition-name values (on numeric data items with large-precision PICTURE)
- The maximum number of digits that you can specify in the arguments to NUMVAL and NUMVAL-C is raised from 18 to 31.
- The maximum value of the integer argument to the FACTORIAL function is 29.
- Intermediate results in arithmetic statements use *extended mode*.

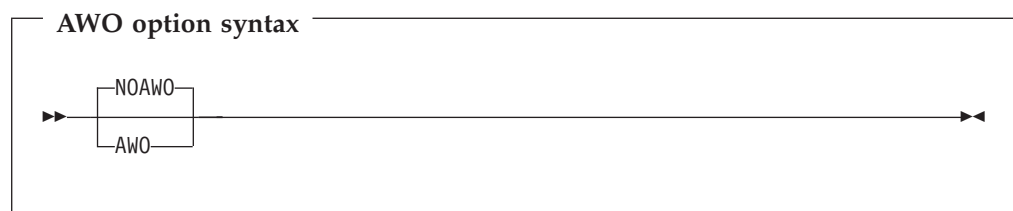
When you specify ARITH(COMPAT):

- The maximum number of digit positions in the PICTURE clause for packed-decimal, zoned-decimal, and numeric-edited data items is 18.
- The maximum number of digits in a fixed-point numeric literal is 18.
- The maximum number of digits in the arguments to NUMVAL and NUMVAL-C is 18.
- The maximum value of the integer argument to the FACTORIAL function is 28.
- Intermediate results in arithmetic statements use *compatibility mode*.

RELATED CONCEPTS

Appendix A, “Intermediate results and arithmetic precision,” on page 603

AWO



Default is: NOAWO

Abbreviations are: None

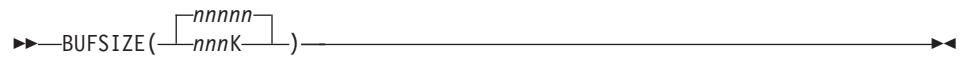
With AWO specified, an implicit APPLY WRITE-ONLY clause is activated for all files in the program that are eligible for this clause. To be eligible, a file must have physical sequential organization and blocked variable-length records.

RELATED TASKS

“Optimizing buffer and device space” on page 12

BUFSIZE

BUFSIZE option syntax



The diagram shows the syntax for the BUFSIZE option. It starts with a right-pointing arrow, followed by the text 'BUFSIZE(' in a monospace font. Then, there is a bracketed choice between two options: 'nnnnn' and 'nnnK'. The 'nnnnn' option has a bracket above it, and the 'nnnK' option has a bracket below it. This is followed by a closing parenthesis ')'. The entire sequence is enclosed in a box with a right-pointing arrow at the end.

```
➡➡BUFSIZE( nnnnn nnnK )➡➡
```

Default is: 4096

Abbreviations are: BUF

nnnnn specifies a decimal number that must be at least 256.

nnnK specifies a decimal number in 1-KB increments, where 1 KB = 1024 bytes.

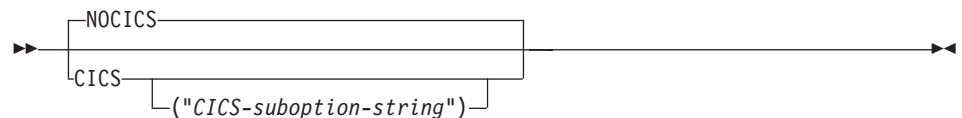
Use BUFSIZE to allocate an amount of main storage to the buffer for each compiler work data set. Usually, a large buffer size improves the performance of the compiler.

If you use both BUFSIZE and SIZE, the amount allocated to buffers is included in the amount of main storage available for compilation via the SIZE option.

BUFSIZE cannot exceed the track capacity for the device used, nor can it exceed the maximum allowed by data management services.

CICS

CICS option syntax



The diagram shows the syntax for the CICS option. It starts with a right-pointing arrow, followed by a bracketed choice between 'NOCICS' and 'CICS'. The 'CICS' option has a bracket below it pointing to a string literal '"CICS-suboption-string"'. The entire sequence is enclosed in a box with a right-pointing arrow at the end.

```
➡➡ NOCICS CICS ("CICS-suboption-string")➡➡
```

Default is: NOCICS

Abbreviations are: None

The CICS compiler option enables the integrated CICS translator capability and allows specification of CICS options. You must specify the CICS option if your COBOL source program contains EXEC CICS or EXEC DLI statements, and it has not been processed by the separate CICS translator.

Use the CICS option to compile CICS programs only. Programs compiled with the CICS option will not run in a non-CICS environment.

Note that the compiler needs access to CICS Transaction Server Version 2 or later.

If you specify the NOCICS option, any CICS statements found in the source program are diagnosed and discarded.

Use either quotation marks or single quotation marks to delimit the string of CICS suboptions.

You can partition a long suboption string into multiple suboption strings on multiple CBL statements. The CICS suboptions are concatenated in the order of their appearance. For example:

```
//STEP1 EXEC IGYWC, . . .
// PARM.COBOL='CICS("string1")'
//COBOL.SYSIN DD *
    CBL CICS('string2')
    CBL CICS("string3")
    IDENTIFICATION DIVISION.
    PROGRAM-ID. DRIVER1.
    . . .
```

The compiler passes the following suboption string to the integrated CICS translator:

```
"string1 string2 string3"
```

The concatenated strings are delimited with single spaces as shown. If multiple instances of the same CICS option are found, the last specification of each option prevails. The compiler limits the length of the concatenated CICS suboptions string to 4 KB.

RELATED CONCEPTS

“Integrated CICS translator” on page 364

RELATED TASKS

“Compiling with the CICS option” on page 362

RELATED REFERENCES

“Conflicting compiler options” on page 269

CODEPAGE

CODEPAGE option syntax

►►—CODEPAGE(*ccsid*)—————◄◄

Default is: CODEPAGE(1140)

Abbreviations are: CP(*ccsid*)

The CODEPAGE option specifies the code page used for encoding:

- The contents of alphanumeric and DBCS data items at run time
- Alphanumeric, national, and DBCS literals in the COBOL source program

The CODEPAGE option also specifies the default code page for parsing alphanumeric XML documents.

ccsid must be an integer that represents a valid coded character set identifier (CCSID) number for an EBCDIC code page.

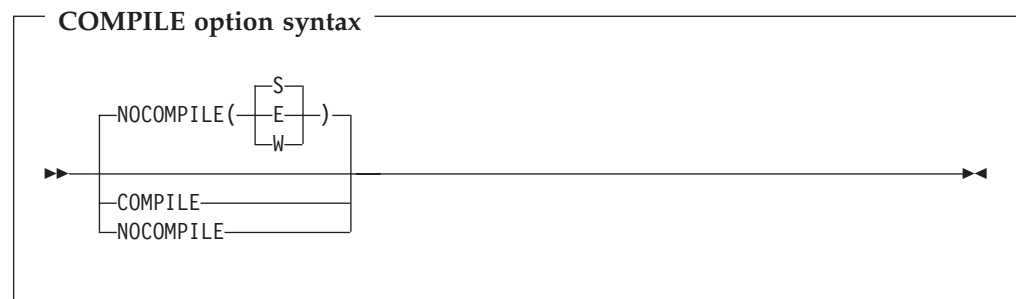
The default CCSID 1140 is an equivalent of CCSID 37 (EBCDIC Latin-1, USA) but includes the Euro symbol.

Important: The conversion image that was configured as part of the Unicode Conversion Services installation must include support for conversions of the specified CCSID to and from CCSID 1200. For applications that use object-oriented syntax, conversions from the specified CCSID to CCSID 1208 must also be included.

RELATED TASKS

Customizing Unicode support for COBOL (*Enterprise COBOL Customization Guide*)

COMPILE



Default is: NOCOMPILE(S)

Abbreviations are: C | NOC

Use the COMPILE option only if you want to force full compilation even in the presence of serious errors. All diagnostics and object code will be generated. Do not try to run the object code if the compilation resulted in serious errors: the results could be unpredictable or an abnormal termination could occur.

Use NOCOMPILE without any suboption to request a syntax check (only diagnostics produced, no object code).

Use NOCOMPILE with W, E, or S for conditional full compilation. Full compilation (diagnosis and object code) will stop when the compiler finds an error of the level you specify (or higher), and only syntax checking will continue.

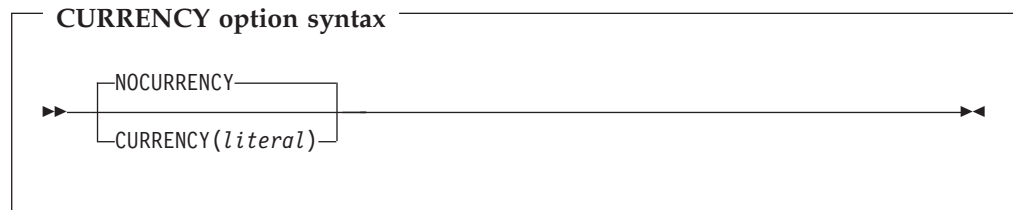
If you request an unconditional NOCOMPILE, the following options have no effect because no object code will be produced:

- LIST
- SSRANGE
- OPTIMIZE
- OBJECT
- TEST

RELATED REFERENCES

“Messages and listings for compiler-detected errors” on page 246

CURRENCY



Default is: NOCURRENCY

Abbreviations are: CURR | NOCURR

The default currency symbol is the dollar sign (\$). You can use the CURRENCY option to provide an alternate default currency symbol to be used for the COBOL program.

NOCURRENCY specifies that no alternate default currency symbol will be used.

To change the default currency symbol, use the CURRENCY(*literal*) option, where *literal* is a valid COBOL alphanumeric literal (including a hexadecimal literal) representing a single character that must not be any of the following:

- Digits zero (0) through nine (9)
- Uppercase alphabetic characters A B C D E G N P R S V X Z, or their lowercase equivalents
- The space
- Special characters * + - / , . ; () " ' =
- A figurative constant
- A null-terminated literal
- A DBCS literal
- A national literal

If your program processes only one currency type, you can use the CURRENCY option as an alternative to the CURRENCY SIGN clause for selecting the currency symbol you will use in the PICTURE clause of your program. If your program processes more than one currency type, you should use the CURRENCY SIGN clause with the WITH PICTURE SYMBOL phrase to specify the different currency sign types.

If you use both the CURRENCY option and the CURRENCY SIGN clause in a program, the CURRENCY option is ignored. Currency symbols specified in the CURRENCY SIGN clause or clauses can be used in PICTURE clauses.

When the NOCURRENCY option is in effect and you omit the CURRENCY SIGN clause, the dollar sign (\$) is used as the PICTURE symbol for the currency sign.

Delimiter: You can delimit the CURRENCY option literal with either quotation marks or single quotation marks, regardless of the QUOTE|APOST compiler option setting.

DATA

DATA option syntax

DATA(31
24)

Default is: DATA(31)

Abbreviations are: None

Affects the location of storage for dynamic data areas and other dynamic run-time storage: either above (DATA(31)) or below (DATA(24)) the 16-MB line. For reentrant programs, the DATA(24|31) compiler option and the HEAP run-time option control whether storage for dynamic data areas (such as WORKING-STORAGE and FD record areas) is obtained from below the 16-MB line or from unrestricted storage. (The DATA option does not affect the location of LOCAL-STORAGE data; the STACK run-time option controls that location instead, along with the AMODE of the program. It does affect the location of local WORKING-STORAGE data.)

When you specify the run-time option HEAP(, ,BELOW), the DATA(24|31) compiler option has no effect; the storage for all dynamic data areas is allocated from below the 16-MB line. However, with HEAP(, ,ANYWHERE) as the run-time option, storage for dynamic data areas is allocated from below the line if you compiled the program with the DATA(24) compiler option or from unrestricted storage if you compiled with the DATA(31) compiler option.

Specify the DATA(24) compiler option for programs running in 31-bit addressing mode that are passing data arguments to programs in 24-bit addressing mode. This ensures that the data will be addressable by the called program.

External data and QSAM buffers: The DATA option interacts with other compiler options and run-time options that affect storage and its addressability. See the related information for details.

RELATED CONCEPTS

“Storage and its addressability” on page 34

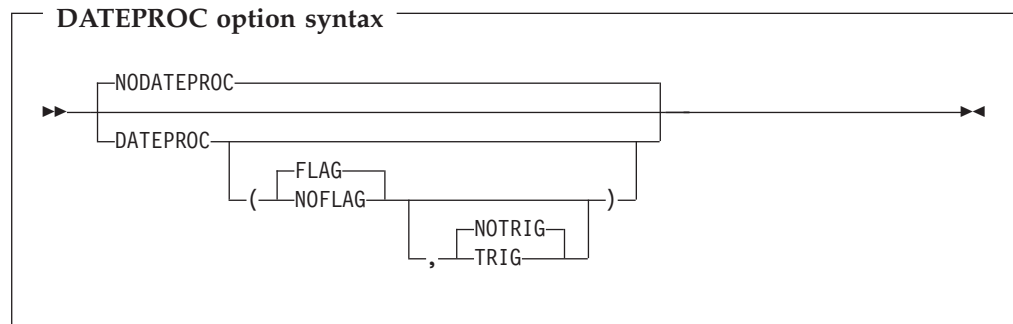
RELATED TASKS

Using run-time options (*Language Environment Programming Guide*)

RELATED REFERENCES

“Allocation of buffers for QSAM files” on page 140

DATEPROC



Default is: NODATEPROC, or DATEPROC(FLAG,NOTRIG) if only DATEPROC is specified

Abbreviations are: DP | NODP

Use the DATEPROC option to enable the millennium language extensions of the COBOL compiler.

DATEPROC(FLAG)

With DATEPROC(FLAG), the millennium language extensions are enabled, and the compiler produces a diagnostic message wherever a language element uses or is affected by the extensions. The message is usually an information-level or warning-level message that identifies statements that involve date-sensitive processing. Additional messages that identify errors or possible inconsistencies in the date constructs might be generated.

Production of diagnostic messages, and their appearance in or after the source listing, is subject to the setting of the FLAG compiler option.

DATEPROC(NOFLAG)

With DATEPROC(NOFLAG), the millennium language extensions are in effect, but the compiler does not produce any related messages unless there are errors or inconsistencies in the COBOL source.

DATEPROC(TRIG)

With DATEPROC(TRIG), the millennium language extensions are enabled, and the automatic windowing that the compiler applies to operations on windowed date fields is sensitive to specific trigger or limit values in the date fields and in other nondatetime fields that are stored into or compared with the windowed date fields. These special values represent invalid dates that can be tested for or used as upper or lower limits.

Performance: The DATEPROC(TRIG) option results in slower-performing code for windowed date comparisons.

DATEPROC(NOTRIG)

With DATEPROC(NOTRIG), the millennium language extensions are enabled, and the automatic windowing that the compiler applies to operations on windowed dates does not recognize any special trigger values in the operands. Only the value of the year part of dates is relevant to automatic windowing.

Performance: The DATEPROC(NOTRIG) option is a performance option that assumes valid date values in windowed date fields.

NODATEPROC

NODATEPROC indicates that the extensions are not enabled for this compilation unit. This affects date-related program constructs as follows:

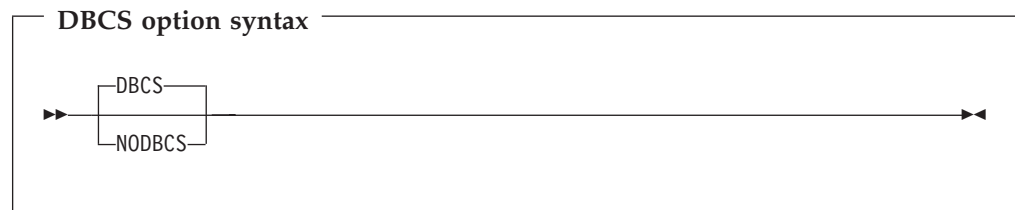
- The DATE FORMAT clause is syntax-checked, but has no effect on the execution of the program.
- The DATEVAL and UNDATE intrinsic functions have no effect. That is, the value returned by the intrinsic function is exactly the same as the value of the argument.
- The YEARWINDOW intrinsic function returns a value of zero.

Usage note: You can specify the FLAG|NOFLAG and TRIG|NOTRIG suboptions in any order. If you omit either suboption, it defaults to the current setting.

RELATED REFERENCES

“FLAG” on page 284

DBCS



Default is: DBCS

Abbreviations are: None

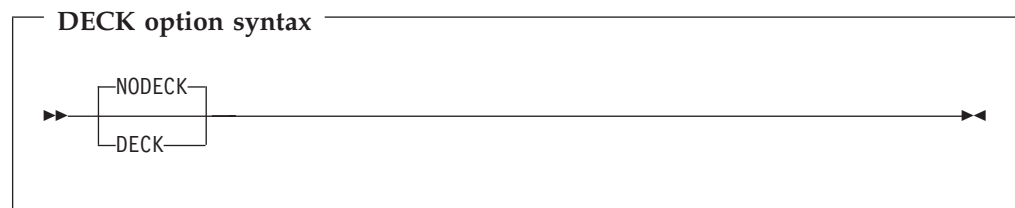
Using DBCS causes the compiler to recognize X'0E' (SO) and X'0F' (SI) as shift codes for the double-byte portion of an alphanumeric literal.

With DBCS selected, the double-byte portion of the literal is syntax-checked and the literal remains category alphanumeric.

RELATED REFERENCES

“Conflicting compiler options” on page 269

DECK

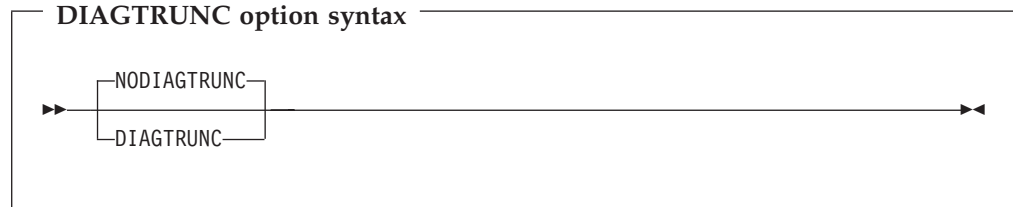


Default is: NODECK

Abbreviations are: D|NOD

Use DECK to produce object code in the form of 80-column card images. If you use the DECK option, be certain that SYSPUNCH is defined in your JCL for compilation.

DIAGTRUNC



Default is: NODIAGTRUNC

Abbreviations are: DTR, NODTR

DIAGTRUNC causes the compiler to issue a severity-4 (Warning) diagnostic message for MOVE statements with numeric receivers when the receiving data item has fewer integer positions than the sending data item or literal. In statements with multiple receivers, the message is issued separately for each receiver that could be truncated.

The diagnostic message is also issued for implicit moves associated with statements such as these:

- INITIALIZE
- READ . . . INTO
- RELEASE . . . FROM
- RETURN . . . INTO
- REWRITE . . . FROM
- WRITE . . . FROM

The diagnostic is also issued for moves to numeric receivers from alphanumeric data-names or literal senders, except when the sending field is reference modified.

There is no diagnostic for COMP-5 receivers, nor for binary receivers when you specify the TRUNC(BIN) option.

RELATED CONCEPTS

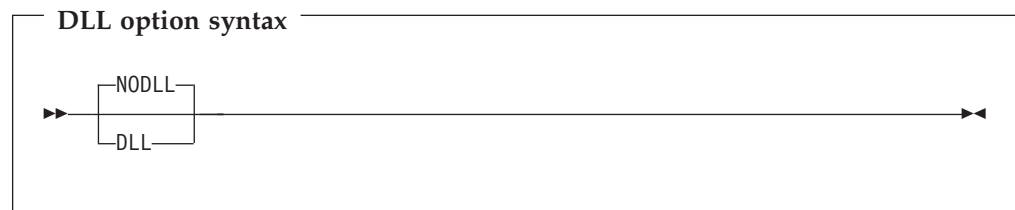
“Formats for numeric data” on page 40

“Reference modifiers” on page 94

RELATED REFERENCES

“TRUNC” on page 310

DLL



Default is: NODLL

Abbreviations are: None

Use DLL to instruct the compiler to generate an object module that is enabled for dynamic link library (DLL) support. DLL enablement is required if the program will be part of a DLL, will reference DLLs, or if the program contains object-oriented COBOL syntax such as INVOKE statements or class definitions.

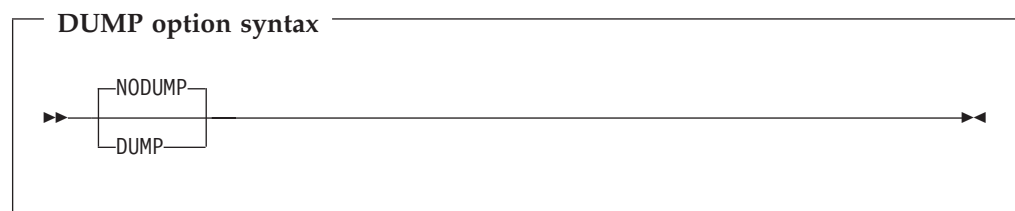
Specification of the DLL option requires that the RENT linkage-editor or binder option also be used.

NODLL instructs the compiler to generate an object module that is not enabled for DLL usage.

RELATED REFERENCES

“Conflicting compiler options” on page 269

DUMP



Default is: NODUMP

Abbreviations are: DU | NODU

Not for general use: The DUMP option should be used only at the request of an IBM representative.

Use DUMP to produce a system dump at compile time for an internal compiler error.

The dump, which consists of a listing of the compiler’s registers and a storage dump, is intended primarily for diagnostic personnel for determining errors in the compiler.

If you use the DUMP option, include a DD statement at compile time to define SYSABEND, SYSUDUMP, or SYSMDUMP.

If your COBOL program calls programs that have been linked as dynamic link libraries (DLLs), then you must not use the DYNAM option. You must instead compile the program with the NODYNAM and DLL options.

RELATED TASKS

“Making both static and dynamic calls” on page 401

RELATED REFERENCES

“Conflicting compiler options” on page 269

EXIT

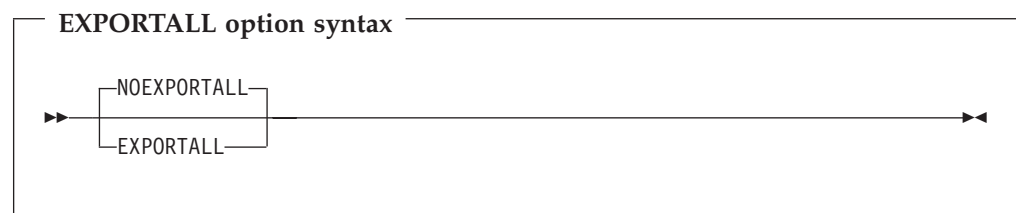
For information about the EXIT compiler option, see the first reference below.

RELATED REFERENCES

Appendix E, “EXIT compiler option,” on page 635

“Conflicting compiler options” on page 269

EXPORTALL



Default is: NOEXPORTALL

Abbreviations are: EXP | NOEXP

Use EXPORTALL to instruct the compiler to automatically export the PROGRAM-ID name and each alternate entry-point name from each program definition when the object deck is link-edited to form a DLL.

With these symbols exported from the DLL, the exported program and entry-point names can be called from programs in the root load module or in other DLL load modules in the application, as well as from programs that are linked into the same DLL.

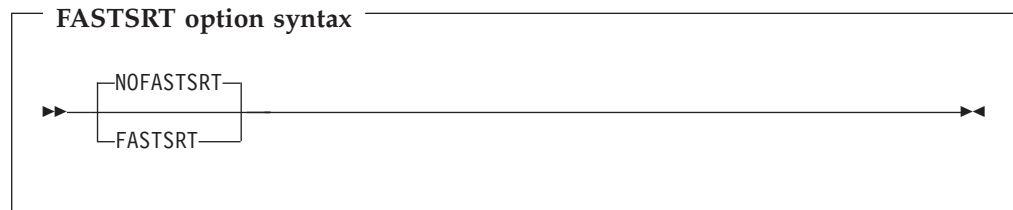
Specification of the EXPORTALL option requires that the RENT linker option also be used.

NOEXPORTALL instructs the compiler to not export any symbols. In this case the programs are accessible only from other routines that are link-edited into the same load module together with this COBOL program definition.

RELATED REFERENCES

“Conflicting compiler options” on page 269

FASTSRT



Default is: NOFASTSRT

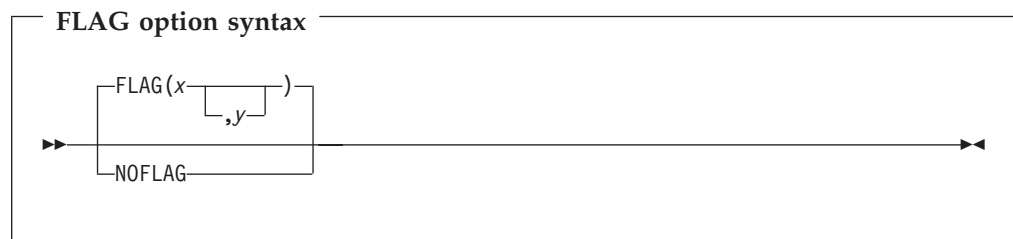
Abbreviations are: FSRT | NOFSRT

FASTSRT allows IBM DFSORT, or its equivalent, to perform the input and output instead of COBOL.

RELATED TASKS

"Improving sort performance with FASTSRT" on page 193

FLAG



Default is: FLAG(I,I)

Abbreviations are: F | NOF

x and y can be either I, W, E, S, or U.

Use FLAG(x) to produce diagnostic messages for errors of a severity level x or above at the end of the source listing.

Use FLAG(x,y) to produce diagnostic messages for errors of severity level x or above at the end of the source listing, with error messages of severity y and above to be embedded directly in the source listing. The severity coded for y must not be lower than the severity coded for x . To use FLAG(x,y), you must also specify the SOURCE compiler option.

Error messages in the source listing are set off by embedding the statement number in an arrow that points to the message code. The message code is then followed by the message text. For example:

```
000413      MOVE CORR WS-DATE TO HEADER-DATE
==000413==>  IGYPS2121-S      " WS-DATE " was not defined as a data-name. . . .
```


- N** Elements from segmentation module level 1 are *not* flagged as “nonconforming standard.”
- S** Elements from segmentation module level 2 are *not* flagged as “nonconforming standard.”

If S is specified, N is included (N is a subset of S).

0 specifies that obsolete language elements are flagged as “obsolete.”

Use FLAGSTD to get informational messages about the COBOL 85 Standard elements included in your program. You can specify any of the following items for flagging:

- A selected Federal Information Processing Standard (FIPS) COBOL subset
- Any of the optional modules
- Obsolete language elements
- Any combination of subset and optional modules
- Any combination of subset and obsolete elements
- IBM extensions (these are flagged any time FLAGSTD is specified, and identified as “nonconforming nonstandard”)

The informational messages appear in the source program listing, and identify:

- The element as “obsolete,” “nonconforming standard,” or “nonconforming nonstandard” (a language element that is both obsolete and nonconforming is flagged as obsolete only)
- The clause, statement, or header that contains the element
- The source program line and beginning location of the clause, statement, or header that contains the element
- The subset or optional module to which the element belongs

FLAGSTD requires the standard set of reserved words.

In the following example, the line number and column where a flagged clause, statement, or header occurred are shown, as well as the message code and text. At the bottom is a summary of the total of the flagged items and their type.

LINE	COL	CODE	FIPS MESSAGE TEXT
		IGYDS8211	Comment lines before "IDENTIFICATION DIVISION": nonconforming nonstandard, IBM extension to ANS/ISO 1985.
11.14		IGYDS8111	"GLOBAL clause": nonconforming standard, ANS/ISO 1985 high subset.
59.12		IGYPS8169	"USE FOR DEBUGGING statement": obsolete element in ANS/ISO 1985.
FIPS MESSAGES TOTAL			STANDARD NONSTANDARD OBSOLETE
		3	1 1 1

RELATED REFERENCES

“Conflicting compiler options” on page 269

INTDATE

INTDATE option syntax

The diagram shows the syntax for the INTDATE option. It starts with a double arrow pointing right, followed by the text 'INTDATE(' in a monospace font. Then, there is a bracketed choice between 'ANSI' and 'LILIAN', also in a monospace font. This is followed by a closing parenthesis ')'. A long horizontal line with double arrows at both ends extends to the right, indicating that the option can be followed by other code.

```
»»—INTDATE(—ANSI  
LILIAN—)—————»»
```

Default is: INTDATE(ANSI)

Abbreviations are: None

INTDATE(ANSI) instructs the compiler to use the Standard COBOL 85 starting date for integer dates used with date intrinsic functions. Day 1 is Jan 1, 1601.

INTDATE(LILIAN) instructs the compiler to use the Language Environment Liliian starting date for integer dates used with date intrinsic functions. Day 1 is Oct 15, 1582.

With INTDATE(LILIAN), the date intrinsic functions return results compatible with the Language Environment date callable services.

Usage note: When INTDATE(LILIAN) is in effect, CEECBLDY is not usable since you have no way to turn an ANSI integer into a meaningful date using either intrinsic functions or callable services. If you code a CALL *literal* statement with CEECBLDY as the target of the call with INTDATE(LILIAN) in effect, the compiler diagnoses this and converts the call target to CEEDAYS.

LANGUAGE

LANGUAGE option syntax

The diagram shows the syntax for the LANGUAGE option. It starts with a double arrow pointing right, followed by the text 'LANGUAGE(' in a monospace font. Then, there is a placeholder '(name)' in a monospace font. This is followed by a closing parenthesis ')'. A long horizontal line with double arrows at both ends extends to the right, indicating that the option can be followed by other code.

```
»»—LANGUAGE(name)—————»»
```

Default is: LANGUAGE(ENGLISH)

Abbreviations are: LANG(EN|UE|JA|JP)

Use the LANGUAGE option to select the language in which compiler output will be printed. The information that will be printed in the selected language includes diagnostic messages, source listing page and scale headers, FIPS message headers, message summary headers, compilation summary, and headers and notations that result from the selection of certain compiler options (MAP, XREF, VBREF, and FLAGSTD).

name specifies the language for compiler output messages. Possible values for the LANGUAGE option are shown in the table.

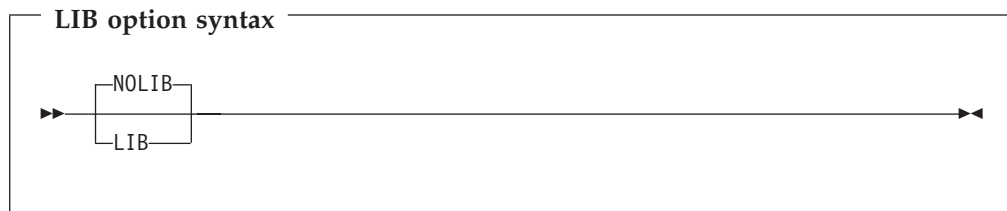
Table 46. Values of the LANGUAGE compiler option

Name	Abbreviation ¹	Output language
ENGLISH	EN	Mixed-case English (the default)
JAPANESE	JA, JP	Japanese, using the Japanese character set
UENGLISH ²	UE	Uppercase English
<ol style="list-style-type: none"> 1. If your installation's system programmer has provided a language other than those described, you must specify at least the first two characters of this other language's name. 2. To specify a language other than UENGLISH, the appropriate language feature must be installed. 		

If the LANGUAGE option is changed at compile time (using CBL or PROCESS statements), some initial text will be printed using the language that was in effect at the time the compiler was started.

NATLANG: The NATLANG run-time option allows you to control the national language to be used for the run-time environment, including error messages, month names, and day-of-the-week names. The LANGUAGE compiler option and the NATLANG run-time option act independently of each other. You can use them together with neither taking precedence over the other.

LIB



Default is: NOLIB

Abbreviations are: None

If your program uses COPY, BASIS, or REPLACE statements, the LIB compiler option must be in effect. In addition, for COPY and BASIS statements, you need to define the library or libraries from which the compiler can take the copied code. Define the libraries with DD statements, ALLOCATE commands, or environment variables, as appropriate for your environment. When using JCL, also include a DD statement to allocate SYSUT5.

RELATED REFERENCES

Chapter 18, "Compiler-directing statements," on page 317
 "Conflicting compiler options" on page 269

LINECOUNT

LINECOUNT option syntax

►—LINECOUNT(*nnn*)—◄

Default is: LINECOUNT(60)

Abbreviations are: LC

nnn must be an integer between 10 and 255, or 0.

Use LINECOUNT(*nnn*) to specify the number of lines to be printed on each page of the compilation listing, or use LINECOUNT(0) to suppress pagination.

If you specify LINECOUNT(0), no page ejects are generated in the compilation listing.

The compiler uses three lines of *nnn* for titles. For example, if you specify LINECOUNT(60), 57 lines of source code are printed on each page of the output listing.

LIST

LIST option syntax

►
┌ NOLIST
└ LIST
—◄

Default is: NOLIST

Abbreviations are: None

Use the LIST compiler option to produce a listing of the assembler-language expansion of your source code.

You will also get these in your output listing:

- Global tables
- Literal pools
- Information about WORKING-STORAGE and LOCAL-STORAGE
- Size of the program's WORKING-STORAGE and LOCAL-STORAGE and its location in the object code if the program is compiled with the NORENT option

The output is generated if:

- You specify the COMPILE option (or the NOCOMPILE(*x*) option is in effect and an error level *x* or higher does not occur).
- You do not specify the OFFSET option.

If you want to limit the assembler listing output, use `*CONTROL LIST` or `NOLIST` statements in your PROCEDURE DIVISION. Your source statements following a `*CONTROL NOLIST` are not included in the listing until a `*CONTROL LIST` statement switches the output back to normal LIST format.

RELATED TASKS

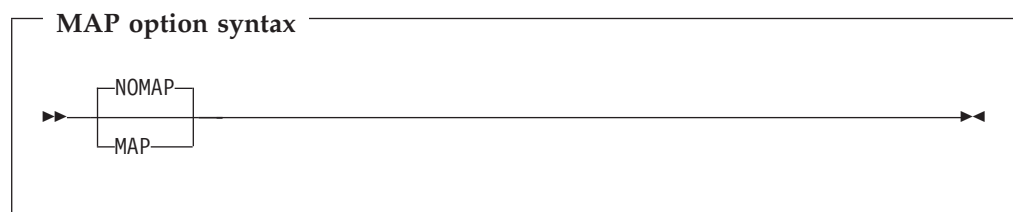
“Getting listings” on page 331

RELATED REFERENCES

“Conflicting compiler options” on page 269

`*CONTROL (*CBL)` statement (*Enterprise COBOL Language Reference*)

MAP



Default is: NOMAP

Abbreviations are: None

Use the MAP compiler option to produce a listing of the items defined in the DATA DIVISION. The output includes the following:

- DATA DIVISION map
- Global tables
- Literal pools
- Nested program structure map, and program attributes
- Size of the program’s WORKING-STORAGE and LOCAL-STORAGE and its location in the object code if the program is compiled with the NORENT option

If you want to limit the MAP output, use `*CONTROL MAP` or `NOMAP` statements in the DATA DIVISION. Source statements following a `*CONTROL NOMAP` are not included in the listing until a `*CONTROL MAP` statement switches the output back to normal MAP format. For example:

<code>*CONTROL NOMAP</code>	<code>*CBL NOMAP</code>
<code>01 A</code>	<code>01 A</code>
<code>02 B</code>	<code>02 B</code>
<code>*CONTROL MAP</code>	<code>*CBL MAP</code>

By selecting the MAP option, you can also print an embedded MAP report in the source code listing. The condensed MAP information is printed to the right of data-name definitions in the FILE SECTION, LOCAL-STORAGE SECTION, and LINKAGE SECTION of the DATA DIVISION. When both XREF data and an embedded MAP summary are on the same line, the embedded summary is printed first.

“Example: MAP output” on page 336

RELATED CONCEPTS

Chapter 19, “Debugging,” on page 321

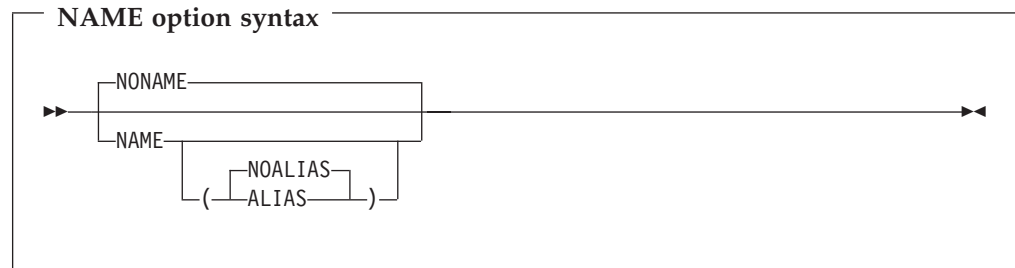
RELATED TASKS

“Getting listings” on page 331

RELATED REFERENCES

*CONTROL (*CBL) statement (*Enterprise COBOL Language Reference*)

NAME



Default is: NONAME, or NAME(NOALIAS) if only NAME is specified

Abbreviations are: None

Use NAME to generate a link-edit NAME card for each object module. You can also use NAME to generate names for each load module when doing batch compilations. When NAME is specified, a NAME card is appended to each object module that is created. Load module names are formed using the rules for forming module names from PROGRAM-ID statements.

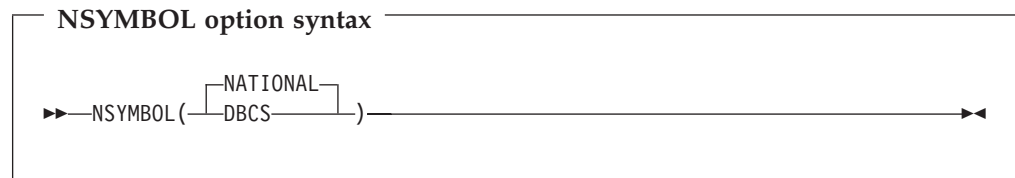
If you specify NAME(ALIAS) and if your program contains ENTRY statements, a link-edit ALIAS card is generated for each ENTRY statement.

The NAME or NAME(ALIAS) options cannot be used when compiling programs that will be prelinked with the Language Environment prelinker.

RELATED REFERENCES

PROGRAM-ID paragraph (*Enterprise COBOL Language Reference*)

NSYMBOL



Default is: NSYMBOL(NATIONAL)

Abbreviations are: NS(NAT|DBCS)

The NSYMBOL option controls the interpretation of the N symbol used in literals and PICTURE clauses, indicating whether national or DBCS processing is assumed.

With NSYMBOL(NATIONAL):

- Data items defined with the PICTURE clause consisting only of the symbol N without the USAGE clause are treated as if the USAGE NATIONAL clause is specified.
- Literals of the form N". . ." or N'. . .' are treated as national literals.

With NSYMBOL(DBCS):

- Data items defined with the PICTURE clause consisting only of the symbol N without the USAGE clause are treated as if the USAGE DISPLAY-1 clause is specified.
- Literals of the form N". . ." or N'. . .' are treated as DBCS literals.

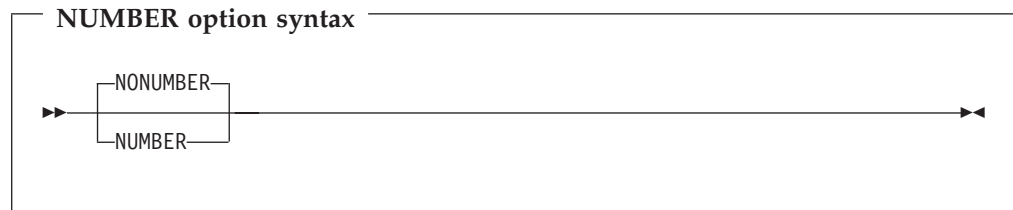
The NSYMBOL(DBCS) option provides compatibility with the previous releases of IBM COBOL, and the NSYMBOL(NATIONAL) option makes the handling of the above language elements consistent with the 2002 COBOL standard in this regard.

NSYMBOL(NATIONAL) is recommended for applications that use Unicode data or object-oriented syntax for Java interoperability.

RELATED REFERENCES

"Conflicting compiler options" on page 269

NUMBER



Default is: NONUMBER

Abbreviations are: NUM|NONUM

Use the NUMBER compiler option if you have line numbers in your source code and want those numbers to be used in error messages and SOURCE, MAP, LIST, and XREF listings.

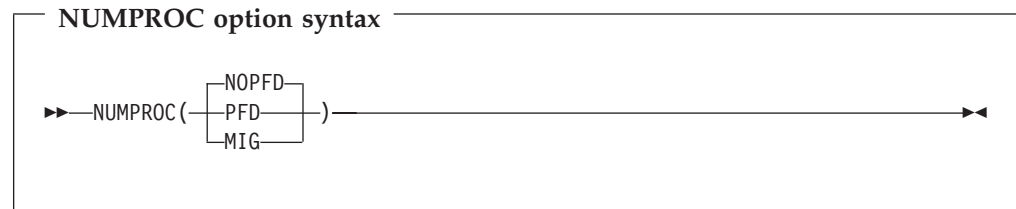
If you request NUMBER, the compiler checks columns 1 through 6 to make sure that they contain only numbers and that the numbers are in numeric collating sequence. (In contrast, SEQUENCE checks the characters in these columns according to EBCDIC collating sequence.) When a line number is found to be out of sequence, the compiler assigns to it a line number with a value one higher than the line number of the preceding statement. The compiler flags the new value with two asterisks and includes in the listing a message indicating an out-of-sequence error. Sequence-checking continues with the next statement, based on the newly assigned value of the previous line.

If you use COPY statements and NUMBER is in effect, be sure that your source program line numbers and the copybook line numbers are coordinated.

If you are doing a batch compilation and LIB and NUMBER are in effect, all programs in the batch compile will be treated as a single input file. The sequence numbers of the entire input file must be in ascending order.

Use NONUMBER if you do not have line numbers in your source code, or if you want the compiler to ignore the line numbers you do have in your source code. With NONUMBER in effect, the compiler generates line numbers for your source statements and uses those numbers as references in listings.

NUMPROC



Default is: NUMPROC(NOPFD)

Abbreviations are: None

Use NUMPROC(NOPFD) if you want the compiler to perform invalid sign processing. This option is not as efficient as NUMPROC(PFD); object code size will be increased, and there could be an increase in run-time overhead to validate all signed data.

NUMPROC(PFD) is a performance option that can be used to bypass invalid sign processing. Use this option *only* if your program data agrees exactly with the following IBM system standards:

External decimal, unsigned: High-order 4 bits of the sign byte contain X'F'.

External decimal, signed overpunch: High-order 4 bits of the sign byte contain X'C' if the number is positive or 0, and X'D' if it is not.

External decimal, separate sign: Separate sign contains the character '+' if the number is positive or 0, and '-' if it is not.

Internal decimal, unsigned: Low-order 4 bits of the low-order byte contain X'F'.

Internal decimal, signed: Low-order 4 bits of the low-order byte contain X'C' if the number is positive or 0, and X'D' if it is not.

Data produced by COBOL arithmetic statements conforms to the above IBM system standards. However, using REDEFINES and group moves could change data so that it no longer conforms. If you use NUMPROC(PFD), use the INITIALIZE statement to initialize data fields, rather than using group moves.

Using NUMPROC(PFD) can affect class tests for numeric data. You should use NUMPROC(NOPFD) or NUMPROC(MIG) if a COBOL program calls programs written in PL/I or FORTRAN.

Sign representation is affected not only by the NUMPROC option, but also by the installation-time option NUMCLS.

Use NUMPROC(MIG) to aid in migrating OS/VS COBOL programs to Enterprise COBOL. When NUMPROC(MIG) is in effect, the following processing occurs:

- Preferred signs are created only on the output of MOVE statements and arithmetic operations.
- No explicit sign repair is done on input.
- Some implicit sign repair might occur during conversion.
- Numeric comparisons are performed by a decimal comparison, not a logical comparison.

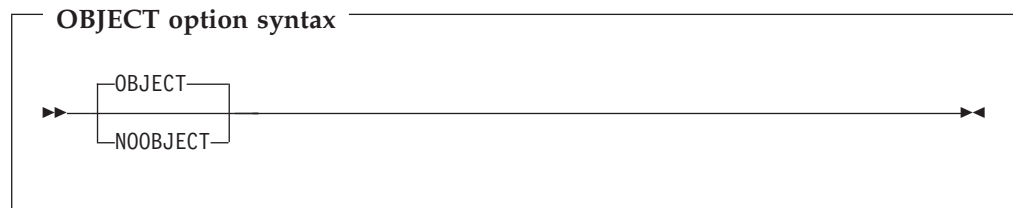
RELATED TASKS

“Checking for incompatible data (numeric class test)” on page 46

RELATED REFERENCES

“Sign representation and processing” on page 45

OBJECT



Default is: OBJECT

Abbreviations are: OBJ | NOOBJ

Use OBJECT to place the generated object code on disk or tape to be later used as input for the linkage editor or binder.

If you specify OBJECT, include a SYSLIN DD statement in your JCL for compilation.

The only difference between DECK and OBJECT is in the routing of the data sets:

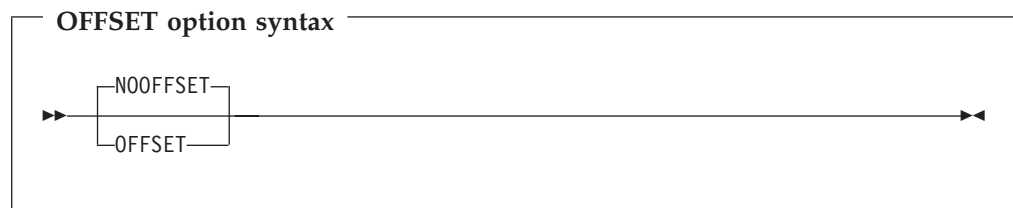
- DECK output goes to the data set associated with ddname SYSPUNCH.
- OBJECT output goes to the data set associated with ddname SYSLIN.

Use the option that your installation guidelines recommend.

RELATED REFERENCES

“Conflicting compiler options” on page 269

OFFSET



Default is: NOOFFSET

Abbreviations are: OFF | NOOFF

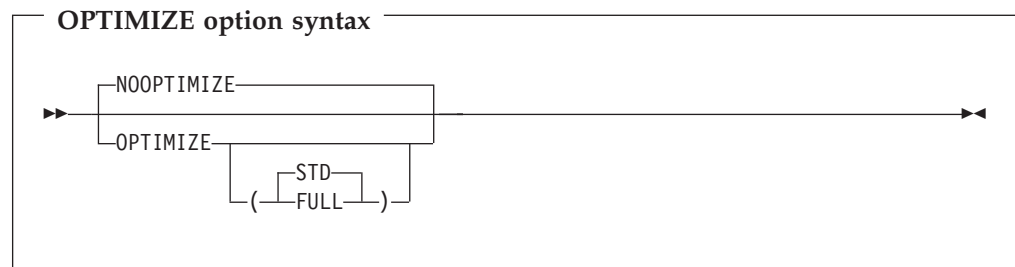
Use OFFSET to produce a condensed PROCEDURE DIVISION listing. With OFFSET, the condensed PROCEDURE DIVISION listing will contain line numbers, statement references, and the location of the first instruction generated for each statement. In addition, the following are produced:

- Global tables
- Literal pools
- Size of the program's working storage, and its location in the object code if the program is compiled with the NORENT option

RELATED REFERENCES

"Conflicting compiler options" on page 269

OPTIMIZE



Default is: NOOPTIMIZE

Abbreviations are: OPT | NOOPT

Use OPTIMIZE to reduce the run time of your object program. Optimization might also reduce the amount of storage your object program uses. Because OPTIMIZE increases compile time and can change the order of statements in your program, you should not use it when debugging.

If OPTIMIZE is specified without any suboptions, OPTIMIZE(STD) will be in effect.

The FULL suboption requests that, in addition to the optimizations performed with OPT(STD), the compiler discard unreferenced data items from the DATA DIVISION and suppress generation of code to initialize these data items to the values in their VALUE clauses. When OPT(FULL) is in effect, all unreferenced 77-level items and elementary 01-level items are discarded. In addition, 01-level group items are discarded if none of their subordinate items are referenced. The deleted items are shown in the listing. If the MAP option is in effect, a BL number of XXXXX in the data map information indicates that the data item was discarded.

Unused data items: Do not use OPT(FULL) if your programs depend on making use of unused data items. In the past, this was commonly done in two ways:

- A technique sometimes used in old OS/VS COBOL programs was to place an unreferenced table after a referenced table and use out-of-range subscripts on the first table to access the second table. To see if your programs use this technique, use the SSRANGE compiler option with the CHECK(ON) run-time option. To work around this problem, use the ability of newer COBOL to code large tables and use just one table.

- Place eye-catcher data items in the WORKING-STORAGE SECTION to identify the beginning and end of the program data or to mark a copy of a program for a library tool that uses the data to identify the version of a program. To solve this problem, initialize these items with PROCEDURE DIVISION statements rather than VALUE clauses. With this method, the compiler will consider these items used and will not delete them.

The OPTIMIZE option is turned off in the case of a severe-level error or higher.

RELATED CONCEPTS

“Optimization” on page 586

RELATED REFERENCES

“Conflicting compiler options” on page 269

OUTDD

OUTDD option syntax

►►—OUTDD(*ddname*)—◄◄

Default is: OUTDD(SYSOUT)

Abbreviations are: OUT

Use OUTDD to specify that you want DISPLAY output that is directed to the system logical output device to go to a specific *ddname*. Note that you can specify a file in the hierarchical file system (HFS) with the *ddname* named in OUTDD. See the discussion of the DISPLAY statement for defaults and for behavior when this *ddname* is not allocated.

The MSGFILE run-time option allows you to specify the *ddname* of the file to which all run-time diagnostics and reports generated by the RPTOPTS and RPTSTG run-time options are written. The IBM-supplied default is MSGFILE(SYSOUT). If the OUTDD compiler option and the MSGFILE run-time option both specify the same *ddname*, the error message information and DISPLAY output directed to the system logical output device are routed to the same destination.

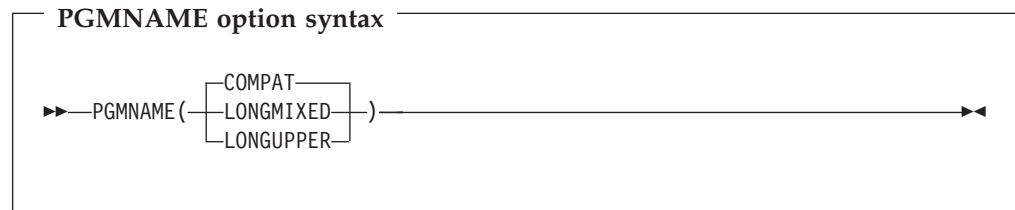
RELATED TASKS

“Displaying values on a screen or in a file (DISPLAY)” on page 30

RELATED REFERENCES

MSGFILE (*Language Environment Programming Reference*)

PGMNAME



Default is: PGMNAME (COMPAT)

Abbreviations are: PGMN (LM | LU | CO)

LONGUPPER can be abbreviated as UPPER, LU, or U. LONGMIXED can be abbreviated as MIXED, LM, or M.

The PGMNAME option controls the handling of names used in the following contexts:

- Program-names defined in the PROGRAM-ID paragraph
- Program entry point names on the ENTRY statement
- Program-name references in:
 - Calls to nested programs
 - Static calls to separately compiled programs
 - Static SET *procedure-pointer* TO ENTRY *literal* statement
 - Static SET *function-pointer* TO ENTRY *literal* statement
 - CANCEL of a nested program

PGMNAME (COMPAT)

With PGMNAME (COMPAT), program-names are handled in a manner compatible with older versions of COBOL compilers, namely:

- The program-name can be up to 30 characters in length.
- All the characters used in the name must be alphabetic, digits, or the hyphen, except that if the program-name is entered in the literal format and is in the outermost program, then the literal can also contain the extension characters @, #, and \$.
- At least one character must be alphabetic.
- The hyphen cannot be used as the first or last character.

External program-names are processed by the compiler as follows:

- They are folded to uppercase.
- They are truncated to eight characters.
- Hyphens are translated to zero (0).
- If the first character is not alphabetic, it is converted as follows:
 - 1-9 are translated to A-I.
 - Anything else is translated to J.

PGMNAME(LONGUPPER)

With PGMNAME(LONGUPPER), program-names that are specified in the PROGRAM-ID paragraph as COBOL user-defined words must follow the normal COBOL rules for forming a user-defined word:

- The program-name can be up to 30 characters in length.
- All the characters used in the name must be alphabetic, digits, or the hyphen.
- At least one character must be alphabetic.
- The hyphen cannot be used as the first or last character.

When a program is specified as a literal, in either a definition or a reference, then:

- The program-name can be up to 160 characters in length.
- All the characters used in the name must be alphabetic, digits, or the hyphen.
- At least one character must be alphabetic.
- The hyphen cannot be used as the first or last character.

External program-names are processed by the compiler as follows:

- They are folded to uppercase.
- Hyphens are translated to zero (0).
- If the first character is not alphabetic, it is converted as follows:
 - 1-9 are translated to A-I.
 - Anything else is translated to J.

Nested-program names are folded to uppercase by the compiler but otherwise are processed as is, without truncation or translation.

PGMNAME(LONGMIXED)

With PGMNAME(LONGMIXED), program-names are processed as is, without truncation, translation, or folding to uppercase.

With PGMNAME(LONGMIXED), all program-name definitions must be specified using the literal format of the program-name in the PROGRAM-ID paragraph or ENTRY statement.

The literal used for a program-name (in any of the contexts listed above as affected by the PGMNAME option) can contain any character in the range X'41'-X'FE'.

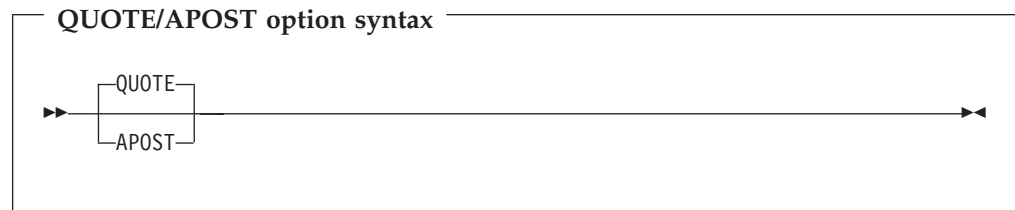
Usage notes

- The following are not affected by the PGMNAME option:
 - Class-names and method-names.
 - System-names (assignment-names in SELECT . . . ASSIGN, and text-names or library-names on COPY statements).
 - Dynamic calls. Dynamic calls are resolved with the target program-name truncated to eight characters, folded to uppercase, and translation of embedded hyphens or a leading digit.
 - CANCEL of nonnested programs. Name resolution uses the same mechanism as for a dynamic call.
- The PGMNAME option does affect nested-program calls and static calls to programs that are linked together with the caller.
- Dynamic calls are not permitted to COBOL programs compiled with the PGMNAME(LONGMIXED) or PGMNAME(LONGUPPER) options unless the program-name is

less than or equal to 8 bytes and all uppercase. In addition, the name of the program must be identical to the name of the module that contains it.

- When using the extended character set supported by `PGMNAME(LONGMIXED)`, be sure to use names that conform to the linkage-editor, binder, prelinker, or system conventions that apply, depending on the mechanism used to resolve the names. Using characters such as commas or parentheses is not recommended, because these characters are used in the syntax of linkage-editor and binder control statements.

QUOTE/APOST



Default is: QUOTE

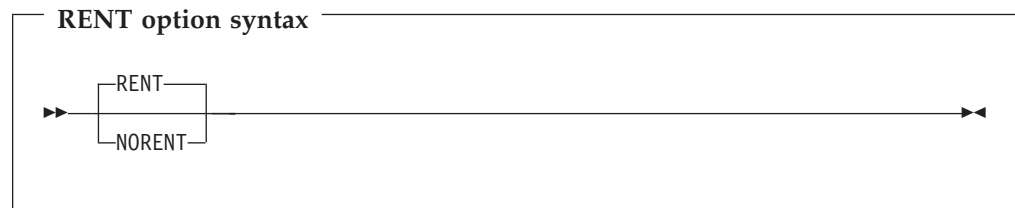
Abbreviations are: Q | APOST

Use QUOTE if you want the figurative constant [ALL] QUOTE or [ALL] QUOTES to represent one or more quotation mark (") characters.

Use APOST if you want the figurative constant [ALL] QUOTE or [ALL] QUOTES to represent one or more single quotation mark (') characters.

Delimiters: You can use either quotation marks or single quotation marks as literal delimiters regardless of whether the APOST or QUOTE option is in effect. The delimiter character used as the opening delimiter for a literal must be used as the closing delimiter for that literal.

RENT



Default is: RENT

Abbreviations are: None

A program compiled as RENT is generated as a reentrant object program. A program compiled as NORENT is generated as a nonreentrant object program. Either can be invoked as a main program or subprogram.

DATA and RMODE settings: The RENT option interacts with other compiler options that affect storage and its addressability. When a reentrant program is to be run with extended addressing, you can use the DATA(24|31) option to control whether dynamic data areas are allocated in unrestricted storage or in storage obtained from below 16 MB. Compile programs with RENT or RMODE(ANY) if they will be run with extended addressing in virtual storage addresses above 16 MB.

RENT also affects the RMODE (residency mode) of your generated object program. All Enterprise COBOL programs are AMODE ANY.

DATA: The setting of the DATA option does not affect programs compiled with NORENT.

CICS: You must use RENT for programs to be run under CICS.

UNIX: You must use RENT for programs to be run in the UNIX environment.

DB2: RENT is recommended for DB2 stored procedures, especially programs designated as main.

Link-edit considerations: If all programs in a load module are compiled with RENT, it is recommended that the load module be link-edited with the RENT linkage-editor or binder option. (Use the REUS linkage-editor or binder option instead if the load module will also contain any non-COBOL programs that are serially reusable.)

If any program in a load module is compiled with NORENT, the load module must not be link-edited with the RENT or REUS link-edit attributes. The NOREUS linkage-editor or binder option is needed to ensure that the CANCEL statement will guarantee a fresh copy of the program on a subsequent CALL.

RELATED CONCEPTS

“Storage and its addressability” on page 34

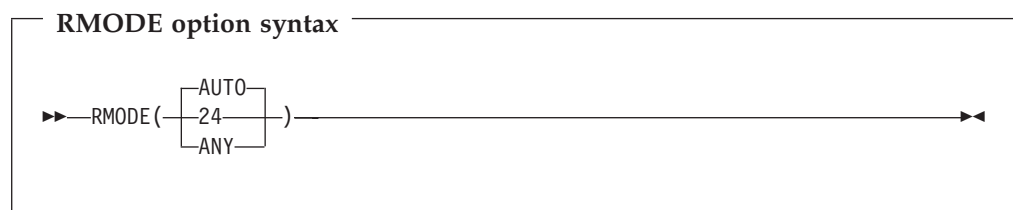
RELATED TASKS

Using reentrant code (*IBM DB2 Application Programming and SQL Guide*)

RELATED REFERENCES

“Conflicting compiler options” on page 269

RMODE



Default is: AUTO

Abbreviations are: None

The RMODE option setting influences the RMODE (residency mode) of your generated object program.

A program compiled with the `RMODE(AUTO)` option will have `RMODE 24` if `NORENT` is specified, and `RMODE ANY` if `RENT` is specified. `RMODE(AUTO)` is compatible with older compilers such as VS COBOL II, which produced `RMODE 24` for programs compiled with `NORENT` and `RMODE ANY` for programs compiled with `RENT`.

A program compiled with the `RMODE(24)` option will have `RMODE 24` whether `NORENT` or `RENT` is specified.

A program compiled with the `RMODE(ANY)` option will have `RMODE ANY` whether `NORENT` or `RENT` is specified.

DATA and RENT: The `RMODE` option interacts with other compiler options and run-time options that affect storage and its addressability. See the related concepts for information about passing data between programs with different modes.

RELATED CONCEPTS

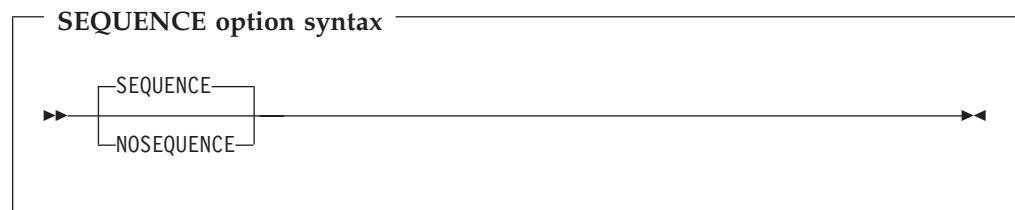
“Storage and its addressability” on page 34

RELATED REFERENCES

“Allocation of buffers for QSAM files” on page 140

“Conflicting compiler options” on page 269

SEQUENCE



Default is: `SEQUENCE`

Abbreviations are: `SEQ` | `NOSEQ`

When you use `SEQUENCE`, the compiler examines columns 1 through 6 of your source statements to check that the statements are arranged in ascending order according to their EBCDIC collating sequence. The compiler issues a diagnostic message if any statements are not in ascending sequence (source statements with blanks in columns 1 through 6 do not participate in this sequence check and do not result in messages).

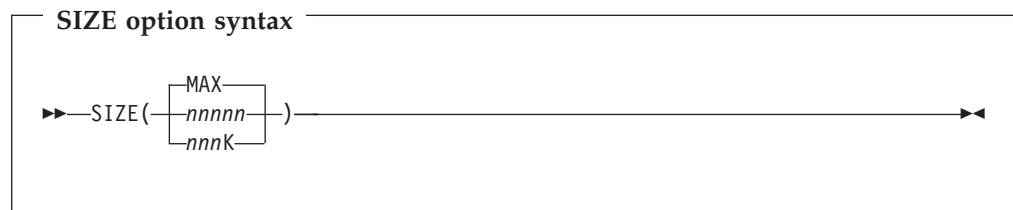
If you use `COPY` statements and `SEQUENCE` is in effect, be sure that your source program sequence fields and the copybook sequence fields are coordinated.

If you use `NUMBER` and `SEQUENCE`, the sequence is checked according to numeric, rather than EBCDIC, collating sequence.

If you are doing a batch compilation and `LIB` and `SEQUENCE` are in effect, all programs in the batch compile will be treated as a single input file. The sequence numbers of the entire input file must be in ascending order.

Use `NOSEQUENCE` to suppress this checking and the diagnostic messages.

SIZE



Default is: SIZE(MAX)

Abbreviations are: SZ

Use SIZE to indicate the amount of main storage available for compilation.

nnnnn specifies a decimal number that must be at least 851968.

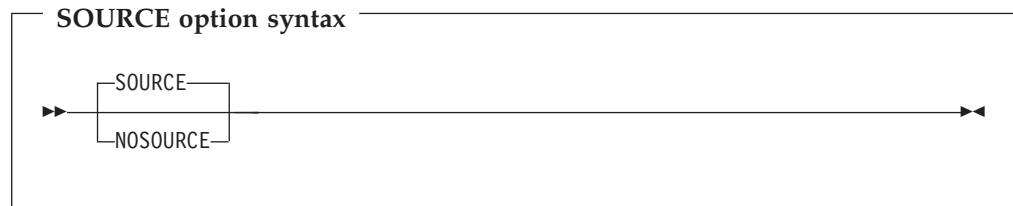
nnnK specifies a decimal number in 1-KB increments, where 1 KB = 1024 bytes. The minimum acceptable value is 832K.

MAX requests the largest available block of storage in the user region for use during compilation.

Do not use SIZE(MAX) if, when you invoke the compiler, you require it to leave a specific amount of unused storage available in the user region. For example, if you are using the CICS or SQL compiler option, use a value such as SIZE(4000K), which should work for most programs. If you compile in 31-bit mode and specify SIZE(MAX), the compiler uses storage as follows:

- Above the 16-MB line: all the storage in the user region
- Below the 16-MB line: storage for:
 - Work file buffers
 - Compiler modules that must be loaded below the line

SOURCE



Default is: SOURCE

Abbreviations are: S | NOS

Use SOURCE to get a listing of your source program. This listing will include any statements embedded by PROCESS or COPY statements.

You must specify SOURCE if you want embedded messages in the source listing.

Use NOSOURCE to suppress the source code from the compiler output listing.

If you want to limit the SOURCE output, use *CONTROL SOURCE or NOSOURCE statements in your PROCEDURE DIVISION. Your source statements following a *CONTROL NOSOURCE are not included in the listing at all, unless a *CONTROL SOURCE statement switches the output back to normal SOURCE format.

“Example: MAP output” on page 336

RELATED REFERENCES

*CONTROL (*CBL) statement (*Enterprise COBOL Language Reference*)

SPACE

SPACE option syntax



Default is: SPACE(1)

Abbreviations are: None

Use SPACE to select single-, double-, or triple-spacing in your source code listing.

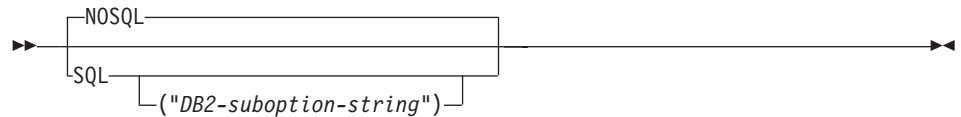
SPACE has meaning only when the SOURCE compiler option is in effect.

RELATED REFERENCES

“SOURCE” on page 302

SQL

SQL option syntax



Default is: NOSQL

Abbreviations are: None

Use the SQL compiler option to enable the DB2 coprocessor capability and to specify DB2 suboptions. You must specify the SQL option if your COBOL source program contains SQL statements and it has not been processed by the DB2 precompiler.

When you use the SQL option, the compiler writes the database request module (DBRM) to ddname DBRMLIB. Note that the compiler needs access to DB2 Version 7 or later.

If you specify the NOSQL option, any SQL statements found in the source program are diagnosed and discarded.

Use either quotation marks or single quotation marks to delimit the string of DB2 suboptions.

You can partition a long suboption string into multiple suboption strings on multiple CBL statements. The DB2 suboptions are concatenated in the order of their appearance. For example:

```
//STEP1 EXEC IGYWC, . . .
// PARM.COBOL='SQL("string1")'
//COBOL.SYSIN DD *
    CBL SQL("string2")
    CBL SQL('string3')
    IDENTIFICATION DIVISION.
    PROGRAM-ID. DRIVER1.
    . . .
```

The compiler passes the following suboption string to the DB2 coprocessor:

"string1 string2 string3"

The concatenated strings are delimited with single spaces as shown. If multiple instances of the same DB2 option are found, the last specification of each option prevails. The compiler limits the length of the concatenated DB2 suboptions string to 4 KB.

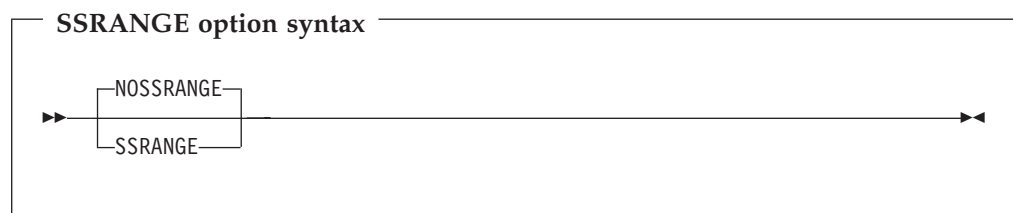
RELATED TASKS

"Compiling with the SQL option" on page 373

RELATED REFERENCES

"Conflicting compiler options" on page 269

SSRANGE



Default is: NOSSRANGE

Abbreviations are: SSR|NOSSR

Use SSRANGE to generate code that checks if subscripts (including ALL subscripts) or indexes try to reference an area outside the region of the table. Each subscript or index is not individually checked for validity; rather, the effective address is

checked to ensure that it does not cause a reference outside the region of the table. Variable-length items will also be checked to ensure that the reference is within their maximum defined length.

Reference modification expressions will be checked to ensure that:

- The reference modification starting position is greater than or equal to 1.
- The reference modification starting position is not greater than the current length of the subject data item.
- The reference modification length value (if specified) is greater than or equal to 1.
- The reference modification starting position and length value (if specified) do not reference an area beyond the end of the subject data item.

If SSRANGE is in effect at compile time, the range-checking code is generated. You can inhibit range checking by specifying CHECK(OFF) as a run-time option. This leaves range-checking code dormant in the object code. Optionally, the range-checking code can be used to aid in resolving any unexpected errors without recompilation.

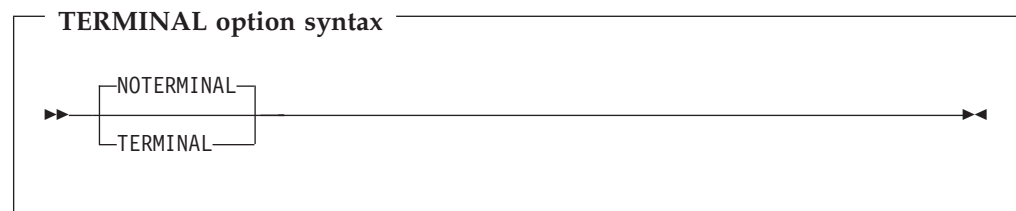
If an out-of-range condition is detected, an error message is displayed and the program is terminated.

Remember: You will get range checking only if you compile your program with the SSRANGE option and run it with the CHECK(ON) run-time option.

RELATED CONCEPTS

“Reference modifiers” on page 94

TERMINAL



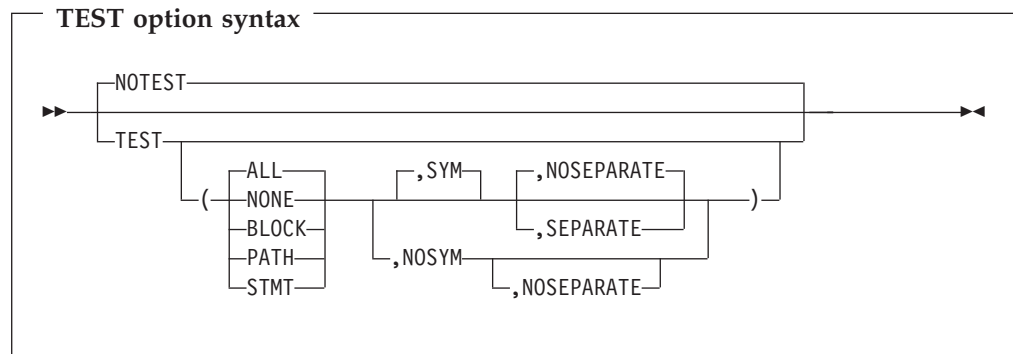
Default is: NOTERMINAL

Abbreviations are: TERM|NOTERM

Use TERMINAL to send progress and diagnostic messages to the ddname SYSTERM.

Use NOTERMINAL if you do not want this additional output.

TEST



Default is: NOTEST

Abbreviations are: SEP for SEPARATE and NOSEP for NOSEPARATE.

Use TEST to produce object code that enables Debug Tool to perform batch and interactive debugging. The amount of debugging support available depends on which TEST suboptions you use. The TEST option also allows you to request that symbolic variables be included in the formatted dump produced by Language Environment.

Use NOTEST if you do not want to generate object code with debugging information and do not want the formatted dump to include symbolic variables.

TEST has three suboptions. You can specify any combination of suboptions (one, two, or all), but you can specify SEPARATE only when SYM is in effect.

If you specify TEST without any suboptions, TEST(ALL,SYM,NOSEP) will be in effect.

Hook location suboptions

- NONE** No hooks will be generated.
- BLOCK** Hooks will be generated at all program entry and exit points.
- PATH** Hooks will be generated at all program entry and exit points and at all path points. A path point is any location in a program where the logic flow is not necessarily sequential or can change. Some examples of path points are IF-THEN-ELSE constructs, PERFORM loops, ON SIZE ERROR phrases, and CALL statements.
- STMT** Hooks will be generated at every statement and label, and at all program entry and exit points. In addition, if the DATEPROC option is in effect, hooks will be generated at all date-processing statements.
- ALL** Hooks will be generated at all statements, all path points, and at all program entry and exit points (both outermost and in contained programs). In addition, if the DATEPROC option is in effect, hooks will be generated at all date-processing statements.

Symbolic information suboptions

- SYM** When you specify the SYM suboption, the compiler generates symbol information tables. These tables are required if you:
- Refer to COBOL identifiers, such as data-names, file-names, and special registers, in Debug Tool commands such as LIST, MOVE, SET, IF, PERFORM, and EVALUATE
 - Use the automonitor and the playback (saving the application data value history) features of Debug Tool
 - Specify that the Language Environment dump of the program include a formatted dump of the data items that are declared in the program
- NOSYM** The compiler does not generate symbol information tables.

Symbolic information location suboptions

SEPARATE

Specify the SEPARATE suboption to control module size while retaining debugging capability. Symbolic information is written to the SYSDEBUG file instead of to the object module. See the additional information below about controlling module size while retaining debug capability.

NOSEPARATE

When you do not specify the SEPARATE suboption, the symbolic information is included in the object module.

Controlling module size while retaining debugging capability: For symbolic debugging, compile your programs with TEST(SYM). This option causes the compiler to generate debugging information tables that Debug Tool uses to resolve data-names, paragraph-names, and the like. This information can take a lot of storage. You can choose to either compile the information into the object program or write it to a separate file, the SYSDEBUG file. For smaller load modules, use the SEPARATE suboption and keep the separate debugging files to use for Debug Tool sessions. To avoid the management of separate debugging files, you can compile with the NOSEPARATE suboption, but this option will result in larger load modules.

When you invoke the COBOL compiler from JCL or from TSO and you specify TEST(. . .,SYM,SEPARATE), the symbolic debug information tables are written to the data set that is specified in the SYSDEBUG DD statement. The SYSDEBUG DD statement must specify the name of a sequential data set, the name of a PDS or PDSE member, or an HFS path. The data set LRECL must be greater than or equal to 80, and less than or equal to 1024. The default LRECL for SYSDEBUG is 1024. The data set RECFM can be F or FB. You can set the block size by using the BLKSIZE subparameter of the DCB parameter, or leave it to the system to set the system-determined default block size.

When you invoke the COBOL compiler from the UNIX shell and you specify TEST(. . .,SYM,SEPARATE), the symbolic debug information tables are written to *file.dbg* in the current directory, where *file* is the name of the COBOL source file.

Performance versus debugging capability: You can control the amount of debugging capability you get and so also the performance, as follows:

- For high performance and some restrictions on debugging, specify OPT and TEST(NONE,SYM).

When you use the dynamic debug facility of Debug Tool (SET DYNDEBUG ON), you can interactively debug your program even if the program has no compiled-in debug hooks. To use this function, compile with TEST(NONE,SYM). With this option, you can also compile with OPTIMIZE (either OPTIMIZE(STD) or OPTIMIZE(FULL)) for a more efficient program, but with some restrictions on debugging:

- The GOTO Debug Tool command is not supported.
- Except for the DESCRIBE ATTRIBUTES command, Debug Tool commands cannot refer to any data item that was discarded from your program by the OPTIMIZE(FULL) option.
- The AT CALL *entry-name* Debug Tool command is not supported.
- For medium performance and fewer restrictions on debugging, specify NOOPT and TEST(NONE,SYM).

This combination does not run as fast as optimized code, but it provides increased debugging capability. All Debug Tool commands are supported except the AT CALL *entry-name* command.

- For slow performance but maximum debugging capabilities, specify TEST(ALL). The TEST(ALL) option causes the compiler to put compiled-in hooks at every statement, resulting in much slower code, but all Debug Tool commands are supported.

Language Environment: The TEST option can improve your formatted dumps from Language Environment in two ways:

- Use the TEST option (with any suboptions) to have line numbers in the dump that indicate the failing statement, rather than just an offset.
- Use the SYM suboption of TEST to have the values of the program variables listed in the dump.

With NOTEST, the dump will not have program variables and will not have a line number for the failing statement.

Enterprise COBOL uses the Language Environment-provided dump services to produce dumps that are consistent in content and format with those that are produced by other Language Environment-conforming member languages. Whether Language Environment produces a dump for unhandled conditions depends on the setting of the run-time option TERMTHDACT. If you specify TERMTHDACT(DUMP), a dump is generated when a condition of severity 2 or greater goes unhandled.

SEPARATE suboption and Language Environment: For programs that are compiled with the SEPARATE suboption of TEST, Language Environment gets the data set name for the separate file (which is stored in DD SYSDEBUG by the compiler) from the object program. You cannot change the name of the data set at run time. Use the same data set name for SYSDEBUG at compile time that you want Language Environment to use at run time.

RELATED CONCEPTS

Considerations for setting TERMTHDACT options (*Language Environment Debugging Guide*)

RELATED TASKS

“Defining the debug data set (SYSDEBUG)” on page 237

Generating a dump (*Language Environment Debugging Guide*)

Invoking Debug Tool using the run-time TEST option (*Debug Tool User’s Guide*)

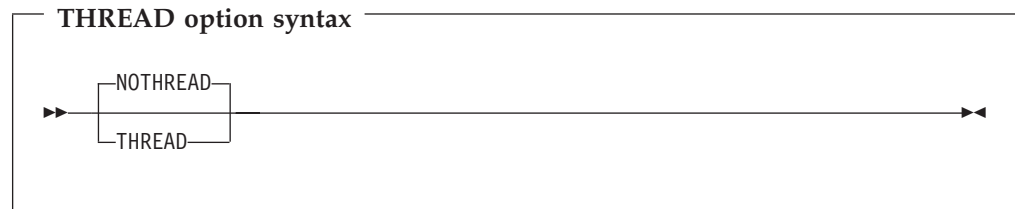
RELATED REFERENCES

“Conflicting compiler options” on page 269

“OPTIMIZE” on page 295

TEST | NOTEST (*Language Environment Programming Reference*)

THREAD



Default is: NOTHREAD

Abbreviations are: None

THREAD indicates that the COBOL program is to be enabled for execution in a Language Environment enclave with multiple POSIX threads or PL/I tasks.

A program that has been compiled with the THREAD option can also be used in a nonthreaded application. However, when a COBOL program is to be executed in a threaded application, all the COBOL programs in the Language Environment enclave must be compiled with the THREAD option.

NOTHREAD indicates that the COBOL program is not to be enabled for execution in an enclave with multiple POSIX threads or PL/I tasks.

Programs compiled with compilers earlier than Enterprise COBOL are treated as compiled with NOTHREAD.

When the THREAD option is in effect, the following language elements are not supported. If encountered, they are diagnosed as errors:

- ALTER statement
- DEBUG-ITEM special register
- GO TO statement without procedure-name
- RERUN
- STOP *literal* statement
- Segmentation module
- USE FOR DEBUGGING statement
- INITIAL phrase in PROGRAM-ID clause
- Nested programs
- SORT or MERGE statements

Additionally, some language constructs have different semantics than in the nonthreaded case.

Although threaded applications are subject to a number of programming and environment restrictions, the use of a program in nonthreaded applications is not so restricted. For example, a program compiled with the THREAD option can run in

the CICS and IMS environments, can run AMODE 24, and can call and be called by other programs that are not enabled for multithreading, as long as the application does not contain multiple POSIX threads or PL/I tasks at run time.

Programs compiled with the THREAD option are supported in a reusable environment created by calling the Language Environment preinitialization routine CEEPIPI. But a reusable environment created by calling IGZERRE or ILBOSTP0 or by using the RTEREUS run-time option is not supported for programs compiled with the THREAD option.

Performance: With the THREAD option, you can anticipate some run-time performance degradation due to the overhead of serialization logic that is automatically generated.

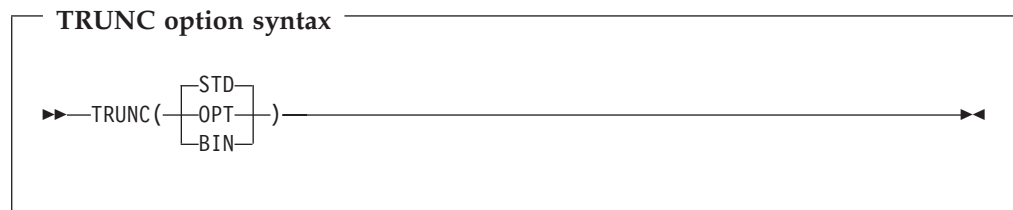
RELATED TASKS

Chapter 27, “Preparing COBOL programs for multithreading,” on page 437

RELATED REFERENCES

“Conflicting compiler options” on page 269

TRUNC



Default is: TRUNC(STD)

Abbreviations are: None

TRUNC has no effect on COMP-5 data items; COMP-5 items are handled as if TRUNC(BIN) were in effect regardless of the TRUNC suboption specified.

TRUNC(STD)

Use TRUNC(STD) to control the way arithmetic fields are truncated during MOVE and arithmetic operations. TRUNC(STD) applies only to USAGE BINARY receiving fields in MOVE statements and arithmetic expressions. When TRUNC(STD) is in effect, the final result of an arithmetic expression, or the sending field in the MOVE statement, is truncated to the number of digits in the PICTURE clause of the BINARY receiving field.

TRUNC(OPT)

TRUNC(OPT) is a performance option. When TRUNC(OPT) is in effect, the compiler assumes that data conforms to PICTURE specifications in USAGE BINARY receiving fields in MOVE statements and arithmetic expressions. The results are manipulated in the most optimal way, either truncating to the number of digits in the PICTURE clause, or to the size of the binary field in storage (halfword, fullword, or doubleword).

Tips:

- Use the TRUNC(OPT) option only if you are sure that the data being moved into the binary areas will not have a value with larger precision

than that defined by the PICTURE clause for the binary item. Otherwise, unpredictable results could occur. This truncation is performed in the most efficient manner possible; therefore, the results will be dependent on the particular code sequence generated. It is not possible to predict the truncation without seeing the code sequence generated for a particular statement.

- There are some cases when programs compiled with the TRUNC(OPT) option under Enterprise COBOL could give different results than the same programs compiled under OS/VS COBOL with NOTRUNC. You must actually lose nonzero high-order digits for this difference to appear. For statements where loss of high-order digits might cause a difference in results between Enterprise COBOL and OS/VS COBOL, Enterprise COBOL will issue a diagnostic message. If you receive this message, make sure that either the sending items will not contain large numbers or that the receivers are defined with enough digits in the PICTURE clause to handle the largest sending data items.

TRUNC(BIN)

The TRUNC(BIN) option applies to all COBOL language that processes USAGE BINARY data. When TRUNC(BIN) is in effect, all binary items (USAGE COMP, COMP-4, or BINARY) are handled as native hardware binary items, that is, as if they were each individually declared USAGE COMP-5:

- BINARY receiving fields are truncated only at halfword, fullword, or doubleword boundaries.
- BINARY sending fields are handled as halfwords, fullwords, or doublewords when the receiver is numeric; TRUNC(BIN) has no effect when the receiver is not numeric.
- The full binary content of fields is significant.
- DISPLAY will convert the entire content of binary fields with no truncation.

Recommendations: TRUNC(BIN) is the recommended option for programs that use binary values set by other products. Other products, such as IMS, DB2, C/C++, FORTRAN, and PL/I, might place values in COBOL binary data items that do not conform to the PICTURE clause of the data items. You can use TRUNC(OPT) with CICS programs as long as your data conforms to the PICTURE clause for your BINARY data items.

USAGE COMP-5 has the effect of applying TRUNC(BIN) behavior to individual data items. Therefore, you can avoid the performance overhead of using TRUNC(BIN) for every binary data item by specifying COMP-5 on only some of the binary data items, such as those data items that are passed to non-COBOL programs or other products and subsystems. The use of COMP-5 is not affected by the TRUNC suboption in effect.

Large literals in VALUE clauses: When you use the compiler option TRUNC(BIN), numeric literals specified in VALUE clauses for binary data items (COMP, COMP-4, or BINARY) can generally contain a value of magnitude up to the capacity of the native binary representation (2, 4, or 8 bytes) rather than being limited to the value implied by the number of 9s in the PICTURE clause.

TRUNC example 1

```
01 BIN-VAR      PIC 99 USAGE BINARY.  
  . . .  
  MOVE 123451 to BIN-VAR
```

The following table shows values of the data items after the MOVE:

Data item	Decimal	Hex	Display
Sender	123451	00|01|E2|3B	123451
Receiver TRUNC(STD)	51	00|33	51
Receiver TRUNC(OPT)	-7621	E2|3B	2J
Receiver TRUNC(BIN)	-7621	E2|3B	762J

A halfword of storage is allocated for BIN-VAR. The result of this MOVE statement if the program is compiled with the TRUNC(STD) option is 51; the field is truncated to conform to the PICTURE clause.

If you compile the program with TRUNC(BIN), the result of the MOVE statement is -7621. The reason for the unusual result is that nonzero high-order digits are truncated. Here, the generated code sequence would merely move the lower halfword quantity X'E23B' to the receiver. Because the new truncated value overflows into the sign bit of the binary halfword, the value becomes a negative number.

It is better not to compile this MOVE statement with TRUNC(OPT), because 123451 has greater precision than the PICTURE clause for BIN-VAR. With TRUNC(OPT), the results are again -7621. This is because the best performance was gained by not doing a decimal truncation.

TRUNC example 2

```
01 BIN-VAR      PIC 9(6)  USAGE BINARY  
  . . .  
  MOVE 1234567891 to BIN-VAR
```

The following table shows values of the data items after the MOVE:

Data item	Decimal	Hex	Display
Sender	1234567891	49|96|02|D3	1234567891
Receiver TRUNC(STD)	567891	00|08|AA|53	567891
Receiver TRUNC(OPT)	567891	53|AA|08|00	567891
Receiver TRUNC(BIN)	1234567891	49|96|02|D3	1234567891

When you specify TRUNC(STD), the sending data is truncated to six integer digits to conform to the PICTURE clause of the BINARY receiver.

When you specify TRUNC(OPT), the compiler assumes the sending data is not larger than the PICTURE clause precision of the BINARY receiver. The most efficient code sequence in this case is truncation as if TRUNC(STD) were in effect.

When you specify TRUNC(BIN), no truncation occurs because all of the sending data fits into the binary fullword allocated for BIN-VAR.

RELATED CONCEPTS

“Formats for numeric data” on page 40

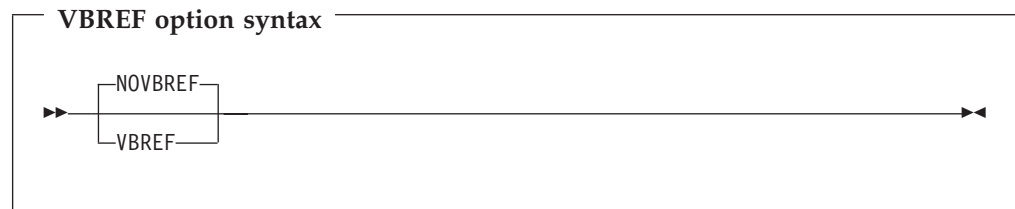
RELATED TASKS

“Compiling with the CICS option” on page 362

RELATED REFERENCES

VALUE clause (*Enterprise COBOL Language Reference*)

VBREF



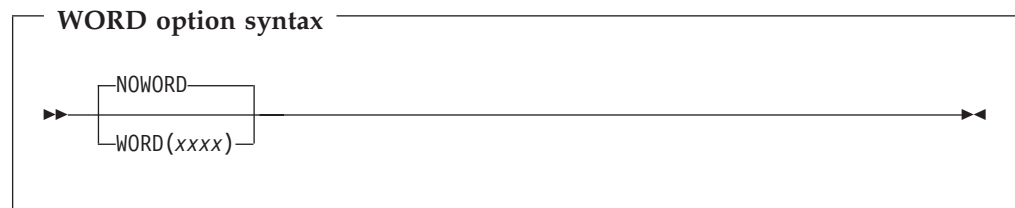
Default is: NOVBREF

Abbreviations are: None

Use VBREF to get a cross-reference among all verb types used in the source program and the line numbers in which they are used. VBREF also produces a summary of how many times each verb was used in the program.

Use NOVBREF for more efficient compilation.

WORD



Default is: NOWORD

Abbreviations are: WD | NOWD

xxxx specifies the ending characters of the name of the reserved-word table (IGYC*xxxx*) to be used in your compilation. IGYC are the first four standard characters of the name, and *xxxx* can be one to four characters in length.

Use WORD(*xxxx*) to specify that an alternate reserved-word table is to be used during compilation.

Alternate reserved-word tables provide changes to the IBM-supplied default reserved-word table. Your systems programmer might have created one or more alternate reserved-word tables for your site. See your systems programmer for the names of alternate reserved-word tables.

Enterprise COBOL provides an alternate reserved-word table (IGYCCICS) specifically for CICS applications. It is set up to flag COBOL words not supported under CICS with an error message. If you want to use this CICS reserved-word table during your compilation, specify the compiler option `WORD(CICS)`.

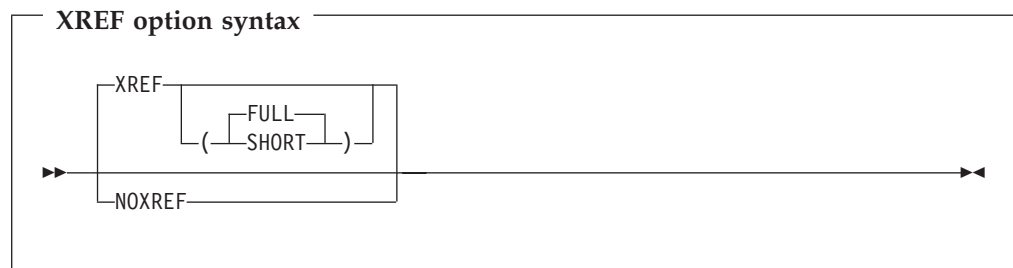
RELATED TASKS

“Compiling with the CICS option” on page 362

RELATED REFERENCES

“Conflicting compiler options” on page 269

XREF



Default is: `XREF(FULL)`

Abbreviations are: `X` | `NOX`

You can choose `XREF`, `XREF(FULL)`, or `XREF(SHORT)`. If you specify `XREF` without any suboptions, `XREF(FULL)` is in effect.

Use `XREF` to get a sorted cross-reference listing. EBCDIC data-names and procedure-names are listed in alphanumeric order. DBCS data-names and procedure-names are listed based on their physical order in the program, and appear before the EBCDIC data-names and procedure-names unless the `DBCSXREF` installation option is selected with a DBCS ordering program. In this case, DBCS data-names and procedure-names are ordered as specified by the DBCS ordering program.

Also included is a section listing all the program-names that are referenced in your program, and the line number where they are defined. External program-names are identified.

If you use `XREF` and `SOURCE`, cross-reference information is printed on the same line as the original source in the listing. Line number references or other information appears on the right-hand side of the listing page. On the right of source lines that reference an intrinsic function, the letters `IFN` are printed with the line numbers of the location where the function arguments are defined. Information included in the embedded references lets you know if an identifier is undefined or defined more than once (`UND` or `DUP`, respectively), if items are implicitly defined (`IMP`) (such as special registers or figurative constants), or if a program-name is external (`EXT`).

If you use XREF and NOSOURCE, you get only the sorted cross-reference listing.

XREF(SHORT) prints only the explicitly referenced data items in the cross-reference listing. XREF(SHORT) applies to DBCS data-names and procedure-names as well as to single-byte names.

NOXREF suppresses this listing.

Usage notes

- Group names used in a MOVE CORRESPONDING statement are in the XREF listing. In addition, the elementary names in those groups are also listed.
- In the data-name XREF listing, line numbers preceded by the letter M indicate that the data item is explicitly modified by a statement on that line.
- XREF listings take additional storage.

RELATED CONCEPTS

Chapter 19, “Debugging,” on page 321

RELATED TASKS

“Getting listings” on page 331

RELATED REFERENCES

COBOL compiler options (*Language Environment Debugging Guide*)

YEARWINDOW

YEARWINDOW option syntax

►►—YEARWINDOW(*base-year*)—◄◄

Default is: YEARWINDOW(1900)

Abbreviation is: YW

Use the YEARWINDOW option to specify the first year of the 100-year window (the *century window*) to be applied to windowed date field processing by the COBOL compiler.

base-year represents the first year of the 100-year window, and must be specified as one of the following:

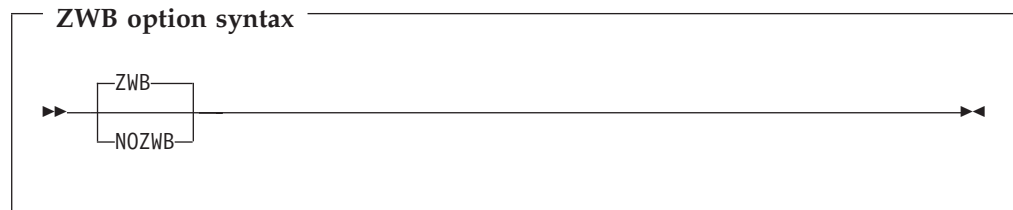
- An unsigned decimal number between 1900 and 1999.
This specifies the starting year of a fixed window. For example, YEARWINDOW(1930) indicates a century window of 1930-2029.
- A negative integer from -1 through -99.
This indicates a sliding window, where the first year of the window is calculated from the current run-time date. The number is subtracted from the current year to give the starting year of the century window. For example, YEARWINDOW(-80) indicates that the first year of the century window is 80 years before the current year at the time the program is run.

Usage notes

- The YEARWINDOW option has no effect unless the DATEPROC option is also in effect.
- At run time, two conditions must be true:
 - The century window must have its beginning year in the 1900s.
 - The current year must lie within the century window for the compilation unit.

For example, if the current year is 2004, the DATEPROC option is in effect, and you use the YEARWINDOW(1900) option, the program will terminate with an error message.

ZWB



Default is: ZWB

Abbreviations are: None

With ZWB, the compiler removes the sign from a signed external decimal (DISPLAY) field when comparing this field to an alphanumeric elementary field during execution.

If the external decimal item is a scaled item (contains the symbol P in its PICTURE character string), its use in comparisons is not affected by ZWB. Such items always have their sign removed before the comparison is made to the alphanumeric field.

ZWB affects how the program runs; the same COBOL source program can give different results, depending on the option setting.

Use NOZWB if you want to test input numeric fields for SPACES.

Chapter 18. Compiler-directing statements

Several statements help you to direct the compilation of your program.

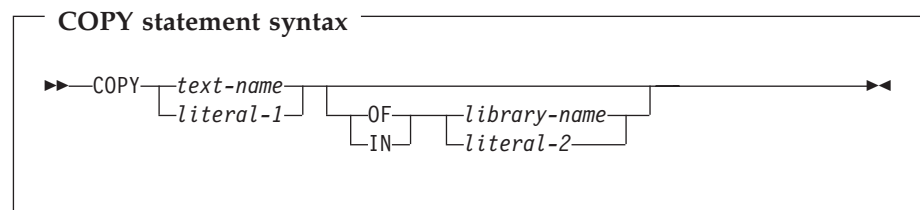
BASIS statement

This extended source program library statement provides a complete COBOL program as the source for a compilation. For rules of formation and processing, see the description of *text-name* for the COPY statement.

***CONTROL (*CBL) statement**

This compiler-directing statement selectively suppresses or allows output to be produced. The names *CONTROL and *CBL are synonymous.

COPY statement



This library statement places prewritten text into a COBOL program. A user-defined word can be the same as a *text-name* or a *library-name*. The uniqueness of *text-name* and *library-name* is determined after the formation and conversion rules for a system-dependent name have been applied. If *library-name* is omitted, SYSLIB is assumed.

When compiling with JCL:

text-name, *library-name*, and *literal* are processed as follows:

- The name (which can be one to 30 characters long) is truncated to eight characters. Only the first eight characters of *text-name* and *library-name* are used as the identifying name. These eight characters must be unique within one COBOL library.
- The name is folded to uppercase.
- Hyphens that are not the first or last character are translated to zero (0), and a warning message is given.
- If the first character is numeric, then the characters (1-9) are translated to A-I, and a warning message is given. An error message is given if the first or last character is a hyphen (or if it is a hyphen, @, #, or \$ for a literal).

For example:

```
COPY INVOICES1Q
COPY "Company-#Employees" IN Personellib
```

In the IN/OF phrase, *library-name* is the ddname that identifies the partitioned data set to be copied from. Use a DD statement such as in the following example to define *library-name*:

```
//COPYLIB DD DSN=ABC.COB,VOLUME=SER=111111,
//          DISP=SHR,UNIT=3380
```

To specify more than one copy library, use either JCL or a combination of JCL and the IN/OF phrase. Using just JCL, concatenate data sets on your DD statement for SYSLIB. Alternatively, define multiple DD statements and include the IN/OF phrase on your COPY statements.

The maximum block size for the copy library depends on the device on which your data set resides.

When compiling in the UNIX System Services shell:

When you compile with the cob2 command, copybooks are included from the HFS. *text-name*, *library-name*, and *literal* are processed as follows:

- User-defined words are folded to uppercase. Literals are not. Because UNIX is case sensitive, if your file name is lowercase or mixed case, you must specify it as a literal.
- When *text-name* is a literal and *library-name* is omitted, *text-name* is used directly: as a file name, a relative path name, or an absolute path name (if the first character is /). For example:

```
COPY "MyInc"  
COPY "x/MyInc"  
COPY "/u/user1/MyInc"
```

- When *text-name* is a user-defined word and an environment variable of that name is defined, the value of the environment variable is used as the name of the file containing the copybook.

If an environment variable of that name is not defined, the copybook is searched for as the following names, in the order given:

1. *text-name.cpy*
2. *text-name.CPY*
3. *text-name.cbl*
4. *text-name.CBL*
5. *text-name.cob*
6. *text-name.COB*
7. *text-name*

- When *library-name* is a literal, it is treated as the actual path, relative or absolute, from which to copy file *text-name*.
- When *library-name* is a user-defined word, it is treated as an environment variable. The value of the environment variable is used as the path. If the environment variable is not set, an error occurs.
- If both *library-name* and *text-name* are specified, the compiler forms the path name for the copybook by concatenating *library-name* and *text-name* with a path separator (/) inserted between the two values. For example, suppose you have the following setting for COPY MYCOPY OF MYLIB:

```
export MYCOPY=mystuff/today.cpy  
export MYLIB=/u/user1
```

These settings result in:

```
/u/user1/mystuff/today.cpy
```

When *library-name* is an environment variable that identifies the path from which copybooks are to be copied, use an export command such as the following example to define *library-name*:

```
export COPYLIB=/u/mystuff/copybooks
```

The name of the environment variable must be uppercase. To specify more than one copy library, set the environment variable to multiple path names delimited by colon (:).

When *library-name* is omitted and *text-name* is not an absolute path name, the copybook is searched for in this order:

1. In the current directory
2. In the paths specified on the -I cob2 option
3. In the paths specified in the SYSLIB environment variable

DELETE statement

This extended source library statement removes COBOL statements from the BASIS source program.

EJECT statement

This compiler-directing statement specifies that the next source statement is to be printed at the top of the next page.

ENTER statement

The compiler handles this statement as a comment.

INSERT statement

This library statement adds COBOL statements to the BASIS source program.

PROCESS (CBL) statement

This statement, which is placed before the IDENTIFICATION DIVISION header of an outermost program, indicates which compiler options are to be used during compilation of the program.

REPLACE statement

This statement is used to replace source program text.

SERVICE LABEL statement

This statement is generated by the CICS translator to indicate control flow. It is not intended for general use.

SKIP1/2/3 statement

These statements indicate lines to be skipped in the source listing.

TITLE statement

This statement specifies that a title (header) should be printed at the top of each page of the source listing.

USE statement

The USE statement provides *declaratives* to specify the following:

- Error-handling procedures: EXCEPTION/ERROR
- User label-handling procedures: LABEL
- Debugging lines and sections: DEBUGGING

RELATED TASKS

“Changing the header of a source listing” on page 7

“Eliminating repetitive coding” on page 595

“Specifying compiler options under z/OS” on page 238

“Specifying compiler options under UNIX” on page 250

“Setting environment variables under UNIX” on page 249

RELATED REFERENCES
"cob2" on page 253
Enterprise COBOL Language Reference

Chapter 19. Debugging

You can choose from two approaches to determine the cause of problems in program behavior of your application: source-language debugging or interactive debugging.

For source-language debugging, COBOL provides several language elements, compiler options, and listing outputs that make debugging easier.

If the problem with your program is not easily detected and you do not have a debugger available, you might need to analyze a storage dump of your program.

For interactive debugging, you can also use Debug Tool, which is available in the Full Function offering of this compiler.

Debug Tool offers these productivity enhancements:

- Interactive debugging (in full-screen or line mode), or debugging in batch mode
During an interactive full-screen mode session, you can use Debug Tool's full-screen services and session panel windows on a 3270 device to debug your program while it is running.
- COBOL-like commands
For each high-level language supported, commands for coding actions to be taken at breakpoints are provided in a syntax similar to that programming language.
- Mixed-language debugging
You can debug an application that contains programs written in a different language. Debug Tool automatically determines the language of the program or subprogram being run.
- COBOL-CICS debugging
Debug Tool supports the debugging of CICS applications in both interactive and batch mode.
- Support for remote debugging
Workstation users can use the Debug Perspective of WebSphere Studio Enterprise Developer for debugging programs that reside on z/OS.

RELATED TASKS

"Debugging with source language" on page 322

"Debugging using compiler options" on page 325

"Getting listings" on page 331

"Preparing to use the debugger" on page 355

Debug Tool User's Guide

RELATED REFERENCES

Debug Tool Reference and Messages

Formatting and analyzing system dumps (*Language Environment Debugging Guide*)

Debugging example COBOL programs (*Language Environment Debugging Guide*)

Debugging with source language

You can use several COBOL language features to pinpoint the cause of a failure in your program. If the program is part of a large application already in production (precluding source updates), write a small test case to simulate the failing part of the program. Code certain debugging features in the test case to help detect these problems:

- Errors in program logic
- Input-output errors
- Mismatches of data types
- Uninitialized data
- Problems with procedures

RELATED TASKS

“Tracing program logic”

“Finding and handling input-output errors” on page 323

“Validating data” on page 323

“Finding uninitialized data” on page 323

“Generating information about procedures” on page 324

RELATED REFERENCES

Source language debugging (*Enterprise COBOL Language Reference*)

Tracing program logic

Trace the logic of your program by adding DISPLAY statements. For example, if you determine that the problem is in an EVALUATE statement or in a set of nested IF statements, use DISPLAY statements in each path to see the logic flow. If you determine that the calculation of a numeric value is causing the problem, use DISPLAY statements to check the value of some interim results.

If you have used explicit scope terminators to end statements in your program, the logic of your program is more apparent and therefore easier to trace.

To determine whether a particular routine started and finished, you might insert code like this into your program:

```
DISPLAY "ENTER CHECK PROCEDURE"  
.  
  . (checking procedure routine)  
.  
DISPLAY "FINISHED CHECK PROCEDURE"
```

After you are sure that the routine works correctly, disable the DISPLAY statements in one of two ways:

- Put an asterisk in column 7 of each DISPLAY statement line to convert it to a comment line.
- Put a D in column 7 of each DISPLAY statement to convert it to a comment line. When you want to reactivate these statements, include a WITH DEBUGGING MODE clause in the ENVIRONMENT DIVISION; the D in column 7 is ignored and the DISPLAY statements are implemented.

Before you put the program into production, delete or disable the debugging aids you used and recompile the program. The program will run more efficiently and use less storage.

RELATED CONCEPTS

“Scope terminators” on page 21

RELATED REFERENCES

DISPLAY statement (*Enterprise COBOL Language Reference*)

Finding and handling input-output errors

File status keys can help you determine whether your program errors are due to input-output errors occurring on the storage media.

To use file status keys in debugging, include a test after each input-output statement to check for a nonzero value in the status key. If the value is nonzero (as reported in an error message), you should look at the coding of the input-output procedures in the program. You can also include procedures to correct the error based on the value of the status key.

If you have determined that a problem lies in an input-output procedure, include the USE EXCEPTION/ERROR declarative to help debug the problem. Then, when a file fails to open, the appropriate EXCEPTION/ERROR declarative is performed. The appropriate declarative might be a specific one for the file or one provided for the open attributes INPUT, OUTPUT, I-O, or EXTEND.

Code each USE AFTER STANDARD ERROR statement in a section immediately after the DECLARATIVE SECTION keyword of the PROCEDURE DIVISION.

RELATED TASKS

“Coding ERROR declaratives” on page 207

RELATED REFERENCES

Status key values and meanings (*Enterprise COBOL Language Reference*)

Status key (*Enterprise COBOL Language Reference*)

Validating data

If you suspect that your program is trying to perform arithmetic on nonnumeric data or is somehow receiving the wrong type of data on an input record, use the class test to validate the type of data. The class test checks whether data is alphabetic, alphabetic-lower, alphabetic-upper, DBCS, KANJI, or numeric.

RELATED REFERENCES

Class condition (*Enterprise COBOL Language Reference*)

Finding uninitialized data

Use INITIALIZE or SET statements to initialize a table or data item when you suspect that the problem might be caused by residual data left in those fields.

If the problem happens intermittently and not always with the same data, it could be that a switch is not initialized but generally is set to the right value (0 or 1) by accident. By including a SET statement to ensure that the switch is initialized, you can either determine that the uninitialized switch is the problem or remove that as a possible cause.

RELATED REFERENCES

INITIALIZE statement (*Enterprise COBOL Language Reference*)

SET statement (*Enterprise COBOL Language Reference*)

Generating information about procedures

Generate information about your program or test case and how it is running with the `USE FOR DEBUGGING` declarative. This declarative lets you include statements in the program and indicate when they should be performed when you run your program.

For example, to check how many times a procedure is run, you could include a debugging procedure in the `USE FOR DEBUGGING` declarative and use a counter to keep track of the number of times control passes to that procedure. You can use the counter technique to check items such as these:

- How many times a `PERFORM` runs and thus whether a particular routine is being used and whether the control structure is correct
- How many times a loop routine runs and thus whether the loop is executing and whether the number for the loop is accurate

You can have debugging lines or debugging statements or both in your program.

Debugging lines

Debugging lines are statements that are identified by a `D` in column 7. To make debugging lines in your program active, include the `WITH DEBUGGING MODE` clause on the `SOURCE-COMPUTER` line in the `ENVIRONMENT DIVISION`. Otherwise debugging lines are treated as comments.

Debugging statements

Debugging statements are the statements coded in the `DECLARATIVES SECTION` of the `PROCEDURE DIVISION`. Code each `USE FOR DEBUGGING` declarative in a separate section. Code the debugging statements as follows:

- Only in a `DECLARATIVES SECTION`.
- Following the header `USE FOR DEBUGGING`.
- Only in the outermost program; they are not valid in nested programs. Debugging statements are also never triggered by procedures contained in nested programs.

To use debugging statements in your program, you must include the `WITH DEBUGGING MODE` clause and use the `DEBUG` run-time option. However, you cannot use the `USE FOR DEBUGGING` declarative in a program that you compile with the `THREAD` option.

The `WITH DEBUGGING MODE` clause and the `TEST` compiler option (with any suboption value other than `NONE`) are mutually exclusive. If both are present, the `WITH DEBUGGING MODE` clause takes precedence.

“Example: `USE FOR DEBUGGING`”

RELATED REFERENCES

Debugging line (*Enterprise COBOL Language Reference*)

Coding debugging sections (*Enterprise COBOL Language Reference*)

`DEBUGGING` declarative (*Enterprise COBOL Language Reference*)

Example: `USE FOR DEBUGGING`

These program segments show what kind of statements are needed to use a `DISPLAY` statement and a `USE FOR DEBUGGING` declarative to test a program. The

DISPLAY statement generates information on the terminal or in the output data set. The USE FOR DEBUGGING declarative is used with a counter to show how many times a routine runs.

```
Environment Division.
...
Data Division.
...
Working-Storage Section.
... (other entries your program needs)
01 Trace-Msg    PIC X(30) Value " Trace for Procedure-Name : ".
01 Total        PIC 9(9) Value 1.
...
Procedure Division.
Declaratives.
Debug-Declaratives Section.
    Use For Debugging On Some-Routine.
Debug-Declaratives-Paragraph.
    Display Trace-Msg, Debug-Name, Total.
End Declaratives.

Main-Program Section.
... (source program statements)
Perform Some-Routine.
... (source program statements)
Stop Run.
Some-Routine.
... (whatever statements you need in this paragraph)
    Add 1 To Total.
Some-Routine-End.
```

In this example the DISPLAY statement in the DECLARATIVES SECTION issues this message every time the procedure Some-Routine runs:

```
Trace For Procedure-Name : Some-Routine 22
```

The number at the end of the message, 22, is the value accumulated in the data item Total; it shows the number of times Some-Routine has run. The statements in the debugging declarative are performed before the named procedure runs.

You can also use the DISPLAY statement to trace program execution and show the flow through the program. You do this by dropping Total from the DISPLAY statement and changing the USE FOR DEBUGGING declarative in the DECLARATIVES SECTION to:

```
USE FOR DEBUGGING ON ALL PROCEDURES.
```

Now a message is displayed before every nondebugging procedure in the outermost program is run.

Debugging using compiler options

Use certain compiler options to generate information to help you find errors in your program such as these:

- Syntax errors such as duplicate data names (NOCOMPILE)
- Missing sections (SEQUENCE)
- Invalid subscript values (SSRANGE)

In addition, you can use certain compiler options to help you find these elements in your program:

- Error messages and where the errors occurred (FLAG)

- Program entity definitions and references (XREF)
- Items you defined in the DATA DIVISION (MAP)
- Verb references (VBREF)
- Assembler-language expansion (LIST)

You can get a copy of your source (by using the SOURCE compiler option) or a listing of generated code (by using the LIST compiler option).

There is also a compiler option (TEST) that you need to use to prepare your program for debugging.

RELATED TASKS

- “Selecting the level of error to be diagnosed” on page 328
- “Finding coding errors”
- “Finding line sequence problems” on page 327
- “Checking for valid ranges” on page 327
- “Finding program entity definitions and references” on page 329
- “Listing data items” on page 330
- “Getting listings” on page 331
- “Preparing to use the debugger” on page 355

RELATED REFERENCES

- “COMPILE” on page 275
- “SEQUENCE” on page 301
- “SSRANGE” on page 304
- “FLAG” on page 284
- “XREF” on page 314
- “MAP” on page 290
- “VBREF” on page 313
- “LIST” on page 289
- “TEST” on page 306

Finding coding errors

Use the NOCOMPILE compiler option for compiling conditionally or for checking syntax only. When used with the SOURCE option, NOCOMPILE produces a listing that will help you find your COBOL coding mistakes such as missing definitions, improperly defined data items, and duplicate data-names.

If you are compiling in the TSO foreground, you can send the messages to your screen by defining your data set as the SYSTERM data set and using the TERM option when you compile your program.

Checking syntax only

Use NOCOMPILE without parameters to have the compiler only syntax-check the source program and produce no object code. If you also specify the SOURCE option, the compiler produces a listing after completing the syntax check.

The following compiler options are suppressed when you use NOCOMPILE without parameters: DECK, OFFSET, LIST, OBJECT, OPTIMIZE, SSRANGE, and TEST.

Compiling conditionally

When you use NOCOMPILE(*x*), where *x* is one of the severity levels for errors, your program is compiled if all the errors are of a lower severity than the *x* level. The severity levels (from highest to lowest) that you can use are S (severe), E (error), and W (warning).

If an error of x level or higher occurs, the compilation stops and your program is syntax-checked only. You receive a source listing if you have specified the `SOURCE` option.

RELATED REFERENCES

“`COMPILE`” on page 275

Finding line sequence problems

Use the `SEQUENCE` compiler option to find statements that are out of sequence. Breaks in sequence indicate that a section of your source program was moved or deleted.

When you use `SEQUENCE`, the compiler checks the source statement numbers you have supplied to see whether they are in ascending sequence. Two asterisks are placed beside statement numbers that are out of sequence. Also, the total number of these statements is printed as the first line of the diagnostics after the source listing.

RELATED REFERENCES

“`SEQUENCE`” on page 301

Checking for valid ranges

Use the `SSRANGE` compiler option to check the following ranges:

- Subscripted or indexed data references
Is the effective address of the desired element within the maximum boundary of the specified table?
- Variable-length data references (a reference to a data item that contains an `OCCURS DEPENDING ON` clause)
Is the actual length positive and within the maximum defined length for the group data item?
- Reference-modified data references
Are the offset and length positive? Is the sum of the offset and length within the maximum length for the data item?

When the `SSRANGE` option is specified, checking is performed at run time when both of the following are true:

- The COBOL statement containing the indexed, subscripted, variable-length, or reference-modified data item is performed.
- The `CHECK` run-time option is `ON`.

If a check finds that an address is generated outside the address range of the data item that contains the referenced data, an error message is generated and the program stops. The error message identifies the table or identifier that was referenced and the line number where the error occurred. Additional information is provided depending on the type of reference that caused the error.

If all subscripts, indices, or reference modifiers are literals in a given data reference and they result in a reference outside the data item, the error is diagnosed at compile time regardless of the setting of the `SSRANGE` compiler option.

Performance consideration: `SSRANGE` can degrade the performance of your program somewhat because of the extra overhead to check each subscripted or indexed item.

RELATED REFERENCES

“SSRANGE” on page 304

“Performance-related compiler options” on page 589

Selecting the level of error to be diagnosed

Use the FLAG compiler option to select the level of error to be diagnosed during compilation and to indicate whether syntax-error messages are embedded in the listing. Use FLAG(I) or FLAG(I,I) to be notified of all errors in your program.

Specify as the first parameter the lowest severity level of the syntax-error messages to be issued. Optionally, specify the second parameter as the lowest level of the syntax-error messages to be embedded in the source listing. This severity level must be the same or higher than the level for the first parameter. If you specify both parameters, you must also specify the SOURCE compiler option.

Table 47. Severity levels of compiler messages

Severity level	What you get when you specify the corresponding level
U (unrecoverable)	U messages only
S (severe)	All S and U messages
E (error)	All E, S, and U messages
W (warning)	All W, E, S, and U messages
I (informational)	All messages

When you specify the second parameter, each syntax-error message (except a U-level message) is embedded in the source listing at the point where the compiler had enough information to detect the error. All embedded messages (except those issued by the library compiler phase) directly follow the statement to which they refer. The number of the statement containing the error is also included with the message. Embedded messages are repeated with the rest of the diagnostic messages at the end of the source listing.

When you specify the NOSOURCE compiler option, the syntax-error messages are included only at the end of the listing. Messages for unrecoverable errors are not embedded in the source listing, because an error of this severity terminates the compilation.

“Example: embedded messages”

RELATED TASKS

“Generating a list of compiler error messages” on page 246

RELATED REFERENCES

“FLAG” on page 284

“Messages and listings for compiler-detected errors” on page 246

“Severity codes for compiler error messages” on page 247

Example: embedded messages

The following example shows the embedded messages generated by specifying a second parameter on the FLAG option. Some messages in the summary apply to more than one COBOL statement.


```

090671** /
090672** *****
090673** ***      I N I T I A L I Z E   P A R A G R A P H      **
090674** ***      Open files. Accept date, time and format header lines.  **
090675** ***      Load location-table.                               **
090676** *****
090677**      100-initialize-paragraph.
090678**      move spaces to ws-transaction-record                IMP 331
090679**      move spaces to ws-commuter-record                  IMP 307
090680**      move zeroes to commuter-zipcode                    IMP 318
090681**      move zeroes to commuter-home-phone                IMP 319
090682**      move zeroes to commuter-work-phone                IMP 320
090683**      move zeroes to commuter-update-date                IMP 324
090684**      open input update-transaction-file                  204
==090684==> IGYPS2052-S An error was found in the definition of file "LOCATION-FILE". The
                  reference to this file was discarded.
090685**      location-file                                      193
090686**      i-o commuter-file                                  181
090687**      output print-file                                  217
090688**      if commuter-file-status not = "00" and not = "97"  241
090689**      1      display "100-OPEN"
090690**      1      move 100 to comp-code                        231
090691**      1      perform 500-vsam-error                      91069
090692**      1      perform 900-abnormal-termination            91114
090693**      end-if
090694**      accept ws-date from date                            UND
==090694==> IGYPS2121-S "WS-DATE" was not defined as a data-name. The statement was discarded.
090695**      move corr ws-date to header-date                    UND 455
==090695==> IGYPS2121-S "WS-DATE" was not defined as a data-name. The statement was discarded.
090696**      accept ws-time from time                            UND
==090696==> IGYPS2121-S "WS-TIME" was not defined as a data-name. The statement was discarded.
090697**      move corr ws-time to header-time                    UND 449
==090697==> IGYPS2121-S "WS-TIME" was not defined as a data-name. The statement was discarded.
090698**      read location-file                                  193
==090698==> IGYPS2053-S An error was found in the definition of file "LOCATION-FILE". This
                  input/output statement was discarded.
090699**      at end
090700**      1      set location-eof to true                      256
090701**      end-read

```

```

LineID Message code Message text
IGYSC0090-W 1700 sequence errors were found in this program.
IGYSC3002-I A severe error was found in the program. The "OPTIMIZE" compiler option was cancelled.
160 IGYDS1089-S "ASSIGN" was invalid. Scanning was resumed at the next area "A" item, level-number, or
the start of the next clause.
193 IGYGR1207-S The "ASSIGN" clause was missing or invalid in the "SELECT" entry for file "LOCATION-FILE".
The file definition was discarded.
269 IGYDS1066-S "REDEFINES" object "WS-DATE" was not the immediately preceding level-1 data item.
The "REDEFINES" clause was discarded.
90602 IGYPS2052-S An error was found in the definition of file "LOCATION-FILE". The reference to this file
was discarded. Same message on line: 90684
90694 IGYPS2121-S "WS-DATE" was not defined as a data-name. The statement was discarded.
Same message on line: 90695
90696 IGYPS2121-S "WS-TIME" was not defined as a data-name. The statement was discarded.
Same message on line: 90697
90698 IGYPS2053-S An error was found in the definition of file "LOCATION-FILE". This input/output statement
was discarded. Same message on line: 90709

Messages Total Informational Warning Error Severe Terminating
Printed: 13 1 1 11
* Statistics for COBOL program IGYTCARA:
* Source records = 1735
* Data Division statements = 287
* Procedure Division statements = 471
End of compilation 1, program IGYTCARA, highest severity 12.
Return code 12

```

Finding program entity definitions and references

Use the XREF(FULL) compiler option to find out where a data-name, procedure-name, or program-name is defined and referenced. The sorted cross-reference includes the line number where the entity was defined and the line numbers of all references to it.

To include only the explicitly referenced data items, use the XREF(SHORT) option.

Use both the XREF (with FULL or SHORT) and the SOURCE options to get a modified cross-reference printed to the right of the source listing. This embedded cross-reference gives the line number where the data-name or procedure-name was defined.

If your program contains DBCS user-defined words, these user-defined words are listed before the alphabetic list of EBCDIC user-defined words.

If a DBCS ordering program is specified in the DBCSXREF installation option, the DBCS user-defined words are listed in order according to the specified DBCS collating sequence. Otherwise, the DBCS user-defined words are listed in physical order according to their appearance in the source program.

Group names in a MOVE CORRESPONDING statement are listed in the XREF listing. The cross-reference listing includes the group names and all the elementary names involved in the move.

"Example: XREF output - data-name cross-references" on page 352

"Example: XREF output - program-name cross-references" on page 353

"Example: embedded cross-reference" on page 353

RELATED TASKS

"Getting listings" on page 331

RELATED REFERENCES

"XREF" on page 314

Listing data items

Use the MAP compiler option to produce a listing of the items you defined in the DATA DIVISION, plus all items implicitly declared. Use the MAP output to locate the contents of a data item in a system dump.

In addition, when you use the MAP option, an embedded MAP summary (which contains condensed data MAP information) is generated to the right of the COBOL source data declaration. When both XREF data and an embedded MAP summary are on the same line, the embedded summary is printed first.

You can select or inhibit parts of the MAP listing and embedded MAP summary by using *CONTROL MAP or *CONTROL NOMAP statements (*CBL MAP or *CBL NOMAP statements) throughout the source. For example:

*CONTROL NOMAP	*CBL NOMAP
01 A	01 A
02 B	02 B
*CONTROL MAP	*CBL MAP

"Example: MAP output" on page 336

RELATED TASKS

"Getting listings" on page 331

RELATED REFERENCES

"MAP" on page 290

Getting listings

Get the information that you need for debugging by requesting the appropriate compiler listing with the use of compiler options.

Attention: The listings produced by the compiler are not a programming interface and are subject to change.

Table 48. Using compiler options to get listings

Use	Listing	Contents	Compiler option
To check diagnostic messages about the compilation, a list of the options in effect for the program, and statistics about the content of the program	Short listing	Diagnostic messages about the compilation ¹ (page 332); list of options in effect for the program; statistics about the content of the program	NOSOURCE, NOXREF, NOVBREF, NOMAP, NOOFFSET, NOLIST
To aid in testing and debugging your program; to have a record after the program has been debugged	Source listing	Copy of your source	"SOURCE" on page 302
To find certain data items in a storage dump; to see the final storage allocation after reentrancy or optimization has been accounted for; to see where programs are defined and check their attributes	Map of DATA DIVISION items	All DATA DIVISION items and all implicitly declared items Embedded map summary (in the right margin of the listing for lines in the DATA DIVISION that contain data declarations) Nested program map (if the program contains nested programs)	"MAP" on page 290 ²
To find where a name is defined, referenced, or modified; to determine the context (such as whether a verb was used in a PERFORM block) in which a procedure is referenced	Sorted cross-reference listing of names	Data-names, procedure-names, and program-names; references to these names Embedded modified cross-reference: provides the line number where the data-name or procedure-name was defined	"XREF" on page 314 ^{2 3} (page 332)
To find the failing verb in a program or the address in storage of a data item that was moved during the program	PROCEDURE DIVISION code and assembler code produced by the compiler ³ (page 332)	Generated code	"LIST" on page 289 ^{2 4} (page 332)
To verify you still have a valid logic path after you move or add PROCEDURE DIVISION sections	Condensed PROCEDURE DIVISION listing	Condensed verb listing, global tables, WORKING-STORAGE information, and literals	"OFFSET" on page 294

Table 48. Using compiler options to get listings (continued)

Use	Listing	Contents	Compiler option
To find an instance of a certain verb	Alphabetic listing of verbs	Each verb used, number of times each verb was used, line numbers where each verb was used	"VBREF" on page 313
<ol style="list-style-type: none"> 1. To eliminate messages, turn off the options (such as FLAG) that govern the level of compile diagnostic information. 2. To use your line numbers in the compiled program, use the NUMBER compiler option. The compiler checks the sequence of your source statement line numbers in columns 1 through 6 as the statements are read in. When it finds a line number out of sequence, the compiler assigns to it a number with a value one higher than the line number of the preceding statement. The new value is flagged with two asterisks. A diagnostic message indicating an out-of-sequence error is included in the compilation listing. 3. The context of the procedure reference is indicated by the characters preceding the line number. 4. You can control the selective listing of generated object code by placing *CONTROL LIST and *CONTROL NOLIST statements (*CBL LIST and *CBL NOLIST) in your source. Note that the *CONTROL statement is different from the PROCESS (or CBL) statement. <p>The output is generated if:</p> <ul style="list-style-type: none"> • You specify the COMPILE option (or the NOCOMPILE(x) option is in effect and an error level x or higher does not occur). • You do not specify the OFFSET option. OFFSET and LIST are mutually exclusive options with OFFSET taking precedence. 			

"Example: short listing"

"Example: SOURCE and NUMBER output" on page 335

"Example: MAP output" on page 336

"Example: embedded map summary" on page 337

"Example: nested program map" on page 340

"Example: XREF output - data-name cross-references" on page 352

"Example: XREF output - program-name cross-references" on page 353

"Example: embedded cross-reference" on page 353

"Example: OFFSET compiler output" on page 354

"Example: VBREF compiler output" on page 355

RELATED TASKS

"Generating a list of compiler error messages" on page 246

"Reading LIST output" on page 340

Debugging COBOL programs (*Language Environment Debugging Guide*)

RELATED REFERENCES

"Messages and listings for compiler-detected errors" on page 246

Example: short listing

The note numbers shown in the listing correspond to the numbers shown in the explanations that follow the listing. For illustrative purposes, some errors that cause diagnostic messages were deliberately introduced.

(Note 1)

Invocation parameters: (Note 2)

C,NODU,FLAG(I),X,MAP,NOLIST,RENT,OPT,SSR,TEST(NONE,SYM),

PROCESS(CBL) statements:

CBL NODECK (Note 3)

CBL NOADV,NODYN,NONAME,NONUMBER,QUOTE,SEQ,DUMP

CBL NOSOURCE, NOXREF, NOVBREF, NOMAP, NOOFFSET, NOLIST IGY00010

Options in effect: (Note 4)

NOADATA
NOADV
QUOTE
ARITH(COMPAT)
NOAWO
BUFSIZE(4096)
NOCICS
CODEPAGE(1140)
COMPILE
NOCURRENCY
DATA(31)
NODATEPROC
DBCS
NODECK
NODIAGTRUNC
NODLL
NODUMP
NODYNAM
NOEXIT
NOEXPORTALL
NOFASTSRT
FLAG(I)
NOFLAGSTD
INTDATE(ANSI)
LANGUAGE(EN)
NOLIB
LINECOUNT(60)
NOLIST
NOMAP
NONAME
NSYMBOL(NATIONAL)
NONUMBER
NUMPROC(NOPFD)
OBJECT
NOOFFSET
OPTIMIZE(STD)
OUTDD(SYSOUT)
PGMNAME(COMPAT)
RENT
RMODE(AUTO)
SEQUENCE
SIZE(MAX)
NOSOURCE
SPACE(1)
NOSQL
SSRANGE
NOTERM
TEST(NONE,SYM,NOSEPARATE)
NOTHREAD
TRUNC(STD)
NOVBREF
NOWORD
NOXREF
YEARWINDOW(1900)
ZWB

(Note 5)

LineID	Message code	Message text (Note 6)
	IGYDS0139-W	Diagnostic messages were issued during processing of compiler options. These messages are located at the beginning of the listing.
	IGYSC0090-W	3 sequence errors were found in this program.
160	IGYDS1089-S	"ASSIGNN" was invalid. Scanning was resumed at the next area "A" item, level-number, or the start of the next clause.
193	IGYGR1207-S	The "ASSIGN" clause was missing or invalid in the "SELECT" entry for file "LOCATION-FILE". The file definition was discarded.
269	IGYDS1066-S	"REDEFINES" object "WS-DATE" was not the immediately preceding level-1 data item. The "REDEFINES" clause was discarded.
901	IGYPS2052-S	An error was found in the definition of file "LOCATION-FILE". The reference to this file was discarded. Same message on line: 983
993	IGYPS2121-S	"WS-DATE" was not defined as a data-name. The statement was discarded. Same message on line: 994
995	IGYPS2121-S	"WS-TIME" was not defined as a data-name. The statement was discarded. Same message on line: 996
997	IGYPS2053-S	An error was found in the definition of file "LOCATION-FILE". This input/output statement was discarded. Same message on line: 1008

Messages	Total	Informational	Warning	Error	Severe	Terminating	(Note 7)
Printed:	14		3		11		

* Statistics for COBOL program IGYTCARA: (Note 8)

* Source records = 1735

* Data Division statements = 287

* Procedure Division statements = 471

End of compilation 1, program IGYTCARA, highest severity 12. (Note 9)

Return code 12

- (1) COBOL default page header, including compiler-level information from the LVLINFO installation-time compiler option.
- (2) Message about options passed to the compiler at compiler invocation. This message does not appear if no options were passed.

LIST Produces an assembler-language expansion of the source code.

- (3) Options coded in the PROCESS (or CBL) statement.

TEST(NONE,SYM,SEPARATE)

The program was compiled for use with Debug Tool or formatted dumps.

OFFSET

Produces a condensed listing of the PROCEDURE DIVISION.

MAP

Produces a map report of the items in the DATA DIVISION.

- (4) Status of options at the start of this compilation.
- (5) Customized page header resulting from the COBOL program TITLE statement.
- (6) Program diagnostics. The first message refers you to any library phase diagnostics. Diagnostics for the library phase are presented at the beginning of the listing.
- (7) Count of diagnostic messages in this program, grouped by severity level.
- (8) Program statistics for the program IGYTCARA.
- (9) Program statistics for the compilation unit. When you perform a batch compilation, the return code is the highest message severity level for the entire compilation.

Example: SOURCE and NUMBER output

In the portion of the listing shown below, the programmer numbered two of the statements out of sequence. The note numbers shown in the listing correspond to the numbers shown in the explanations that follow the listing.

```

DATA VALIDATION AND UPDATE PROGRAM (1)                                IGYTCARA Date 11/24/2003 Time 12:26:53 Page 22
LineID  PL SL  ----+*A-1-B--+-----2-----+-----3-----+-----4-----+-----5-----+-----6-----+-----7-|-+-----8 Cross-Reference (2)
(3)      (4)      (5)
087000*****
087100***                               D O  M A I N  L O G I C                               * *
087200***                               * *
087300*** Initialization. Read and process update transactions until * *
087400*** EOF. Close files and stop run.                               * *
087500*****
087600 procedure division.
087700 000-do-main-logic.
087800 display "PROGRAM IGYTCARA - Beginning"
087900 perform 050-create-vsam-master-file.                               90633
088150 display "perform 050-create-vsam-master finished".
088151** perform 100-initialize-paragraph                               90677
088200 display "perform 100-initialize-paragraph finished"
088300 read update-transaction-file into ws-transaction-record          204 331
088400 at end
1 088500 set transaction-eof to true                                     254
088600 end-read
088700 display "READ completed"
088800 perform until transaction-eof                                     254
1 088900 display "inside perform until loop"
1 089000 perform 200-edit-update-transaction                             90733
1 089100 display "After perform 200-edit "
1 089200 if no-errors                                                  365
2 089300 perform 300-update-commuter-record                             90842
2 089400 display "After perform 300-update "
1 089650 else
089651** perform 400-print-transaction-errors                             90995
2 089700 display "After perform 400-errors "
1 089800 end-if
1 089900 perform 410-re-initialize-fields                               91056
1 090000 display "After perform 410-reinitialize"
1 090100 read update-transaction-file into ws-transaction-record        204 331
1 090200 at end
2 090300 set transaction-eof to true                                     254
1 090400 end-read
1 090500 display "After '2nd READ' "
090600 end-perform

```

- (1) Customized page header resulting from the COBOL program TITLE statement
- (2) Scale line, which labels Area A, Area B, and source code column numbers
- (3) Source code line number assigned by the compiler
- (4) Program (PL) and statement (SL) nesting level
- (5) Columns 1 through 6 of program (the sequence number area)

Example: MAP output

The following example shows output from the MAP option. The numbers used in the explanation below correspond to the numbers annotating the output.

Data Division Map

(1)

Data Definition Attribute codes (rightmost column) have the following meanings:

D = Object of OCCURS DEPENDING	G = GLOBAL	S = Spanned file
E = EXTERNAL	O = Has OCCURS clause	U = Undefined format file
F = Fixed-length file	OG= Group has own length definition	V = Variable-length file
FB= Fixed-length blocked file	R = REDEFINES	VB= Variable-length blocked file

(2)	(3) (4)	(5)	(6) (7)	(8)	(9)	(10)
Source LineID	Hierarchy and Data Name	Base Locator	Hex-Displacement Blk Structure	Asmblr Data Definition	Data Type	Data Def Attributes
4	PROGRAM-ID IGYTCARA-----*					
181	FD COMMUTER-FILE				VSAM	F
183	1 COMMUTER-RECORD	BLF=00000	000	DS 0CL80	Group	
184	2 COMMUTER-KEY.	BLF=00000	000 0 000 000	DS 16C	Display	
185	2 FILLER.	BLF=00000	010 0 000 010	DS 64C	Display	
187	FD COMMUTER-FILE-MST				VSAM	F
189	1 COMMUTER-RECORD-MST	BLF=00001	000	DS 0CL80	Group	
190	2 COMMUTER-KEY-MST.	BLF=00001	000 0 000 000	DS 16C	Display	
191	2 FILLER.	BLF=00001	010 0 000 010	DS 64C	Display	
193	FD LOCATION-FILE				QSAM	FB
198	1 LOCATION-RECORD	BLF=00002	000	DS 0CL80	Group	
199	2 LOC-CODE.	BLF=00002	000 0 000 000	DS 2C	Display	
200	2 LOC-DESCRIPTION	BLF=00002	002 0 000 002	DS 20C	Display	
201	2 FILLER.	BLF=00002	016 0 000 016	DS 58C	Display	
204	FD UPDATE-TRANSACTION-FILE				QSAM	FB
209	1 UPDATE-TRANSACTION-RECORD	BLF=00003	000	DS 80C	Display	
217	FD PRINT-FILE.				QSAM	FB
222	1 PRINT-RECORD.	BLF=00004	000	DS 121C	Display	
229	1 WORKING-STORAGE-FOR-IGYTCARA	BLW=00000	000	DS 1C	Display	
231	77 COMP-CODE	BLW=00000	008	DS 2C	Binary	
232	77 WS-TYPE	BLW=00000	010	DS 3C	Display	
235	1 I-F-STATUS-AREA	BLW=00000	018	DS 0CL2	Group	
236	2 I-F-FILE-STATUS	BLW=00000	018 0 000 000	DS 2C	Display	
237	88 I-O-SUCCESSFUL.					
240	1 STATUS-AREA	BLW=00000	020	DS 0CL8	Group	
241	2 COMMUTER-FILE-STATUS.	BLW=00000	020 0 000 000	DS 2C	Display	
242	88 I-O-OKAY.					
243	2 COMMUTER-VSAM-STATUS.	BLW=00000	022 0 000 002	DS 0CL6	Group	
244	3 VSAM-R15-RETURN-CODE.	BLW=00000	022 0 000 002	DS 2C	Binary	
245	77 UNUSED-DATA-ITEM.	BLW=XXXXX	022	DS 10C	Display	(11)

- (1) Explanations of the data definition attribute codes.
- (2) Source line number where the data item was defined.
- (3) Level definition or number. The compiler generates this number in the following way:
 - First level of any hierarchy is always 01. Increase 1 for each level; any item you coded as 02 through 49.
 - Level numbers 66, 77, and 88, and the indicators FD and SD, are not changed.
- (4) Data-name that is used in the source module in source order.
- (5) Base locator used for this data item.
- (6) Hexadecimal displacement from the beginning of the base locator value.
- (7) Hexadecimal displacement from the beginning of the containing structure.
- (8) Pseudoassembler code showing how the data is defined. When a structure contains variable-length fields, the maximum length of the structure is shown.
- (9) Data type and usage.
- (10) Data definition attribute codes. The definitions are explained at the top of the DATA DIVISION map.

- (11) UNUSED-DATA-ITEM was not referenced in the PROCEDURE DIVISION. Because OPTIMIZE(FULL) was specified, UNUSED-DATA-ITEM was deleted, resulting in the base locator being set to XXXXX.

RELATED REFERENCES

“Terms used in MAP output” on page 338

“Symbols used in LIST and MAP output” on page 338

Example: embedded map summary

The following example shows an embedded map summary from specifying the MAP option. The summary appears in the right margin of the listing for lines in the DATA DIVISION that contain data declarations.

```

000002 Identification Division.
000003
000004 Program-id. IGYTCARA.
. . .
000177 Data division.
000178 File section.
000179
000180
000181 FD COMMUTER-FILE
000182 record 80 characters.
. . .
000222 01 print-record pic x(121). BLF=00004+000 121C
. . .
000228 Working-storage section.
000229 01 Working-storage-for-IGYCARA pic x. BLW=00000+000 1C
000230
000231 77 comp-code pic S9999 comp. BLW=00000+008 2C
000232 77 ws-type pic x(3) value spaces. BLW=00000+010 3C
000233
000234
000235 01 i-f-status-area. BLW=00000+018 0CL2
000236 05 i-f-file-status pic x(2). BLW=00000+018,0000000 2C
000237 88 i-o-successful value zeroes.
000238
000239
000240 01 status-area. BLW=00000+020 0CL8
000241 05 commuter-file-status pic x(2). BLW=00000+020,0000000 2C
000242 88 i-o-okay value zeroes.
000243 05 commuter-vsam-status. BLW=00000+022,0000002 0CL6
000244 10 vsam-r15-return-code pic 9(2) comp. BLW=00000+022,0000002 2C
000245 10 vsam-function-code pic 9(1) comp. BLW=00000+024,0000004 2C
000246 10 vsam-feedback-code pic 9(3) comp. BLW=00000+026,0000006 2C
000247
000248 77 update-file-status pic xx. BLW=00000+028 2C
000249 77 loccode-file-status pic xx. BLW=00000+030 2C
000250 77 updpriint-file-status pic xx. BLW=00000+038 2C
000251
000252 01 flags. BLW=00000+040 0CL3
000253 05 transaction-eof-flag pic x value space. BLW=00000+040,0000000 1C
000254 88 transaction-eof value "Y".
000255 05 location-eof-flag pic x value space. BLW=00000+041,0000001 1C
000256 88 location-eof value "Y".
000257 05 transaction-match-flag pic x. BLW=00000+042,0000002 1C
. . .
000876 procedure division.
000877 000-do-main-logic.
000878 display "PROGRAM IGYTCARA - Beginning"
000879 perform 050-create-vsam-master-file.

```

- (1) Base locator used for this data item
- (2) Hexadecimal displacement from the beginning of the base locator value
- (3) Hexadecimal displacement from the beginning of the containing structure
- (4) Pseudoassembler code showing how the data is defined

Terms used in MAP output

This table describes the terms used in the listings produced by the MAP option.

Table 49. Terms used in MAP output

Term	Definition	Description
GROUP	DS 0CLn ¹	Fixed-length group data item
ALPHABETIC	DS nC	Alphabetic data item (PICTURE A)
ALPHA-EDIT	DS nC	Alphabetic-edited data item
DISPLAY	DS nC	Alphanumeric data item (PICTURE X)
AN-EDIT	DS nC	Alphanumeric-edited data item
GRP-VARLEN	DS 0LCn ¹	Variable-length group data item
NUM-EDIT	DS nC	Numeric-edited data item
DISP-NUM	DS nC	External decimal data item (USAGE DISPLAY)
BINARY	DS 1H ² , 1F ² , 2F ² , 2C, 4C, or 8C	Binary data item (USAGE BINARY or USAGE COMPUTATIONAL or USAGE COMPUTATIONAL-5)
COMP-1	DS 4C	Single-precision floating-point data item (USAGE COMPUTATIONAL-1)
COMP-2	DS 8C	Double-precision floating-point data item (USAGE COMPUTATIONAL-2)
PACKED-DEC	DS nP	Internal decimal data item (USAGE PACKED-DECIMAL or USAGE COMPUTATIONAL-3)
DBCS	DS nC	DBCS data item (USAGE DISPLAY-1)
DBCS-EDIT	DS nC	DBCS edited data item (USAGE DISPLAY-1)
INDX-NAME		Index name
INDEX		Index data item (USAGE INDEX)
NATIONAL	DS nC	National data item (USAGE NATIONAL)
OBJECT-REF		Object-reference data item (USAGE OBJECT-REFERENCE)
POINTER		Pointer data item (USAGE POINTER)
FD		File definition
VSAM, QSAM, LINESEQ		File processing method
1-49, 77		Level numbers for data descriptions
66		Level number for RENAMES
88		Level number for condition-names
SD		Sort file definition
1. <i>n</i> is the size in bytes for fixed-length groups and the maximum size in bytes for variable-length groups. 2. If the SYNCHRONIZED clause appears, these fields are used.		

Symbols used in LIST and MAP output

This table describes the symbols used in the listings produced by the LIST or MAP option.

Table 50. Symbols used in LIST and MAP output

Symbol	Definition
APBdisp=n ¹	ALL subscript parameter block displacement

Table 50. Symbols used in LIST and MAP output (continued)

Symbol	Definition
AVN=n ¹	Variable name cell for ALTER statement
BL=n ¹	Base locator for special registers
BLA=n ¹	Base locator for alphanumeric temporaries ⁴
BLF=n ¹	Base locator for files
BLK=n ¹	Base locator for LOCAL-STORAGE
BLL=n ¹	Base locator for LINKAGE SECTION
BLM=n ¹	Base locator for factory data
BLO=n ¹	Base locator for object instance data
BLS=n ¹	Base locator for sort items
BLT=n ¹	Base locator for XML-TEXT and XML-NTEXT
BLV=n ¹	Base locator for variably located data
BLW=n ¹	Base locator for WORKING-STORAGE
BLX=n ¹	Base locator for external data
CBL=n ¹	Base locator for constant global table (CGT)
CLLE=@=n ¹	Load list entry address in TGT
CLO=n ¹	Class object cell
DOV=n ¹	DSA overflow cell
EVALUATE=n ¹	Evaluate boolean cell
FCB=n ¹	File control block (FCB) address
GN=n(hhhh) ²	Generated procedure name and its offset in hexadecimal
IDX=n ¹	Base locator for index names
IDX=n ¹	Index cell number
ILS=n ¹	Index cell for LOCAL-STORAGE table or instance variable
ODOSAVE=n ¹	OD0 save cell number
OPT=nnnn ³	Optimizer temporary storage cell
PBL=n ¹	Base locator for procedure code
PFM=n ¹	PERFORM n times cells
PGMLIT AT + nnnn ³	Displacement for program literal from beginning of literal pool
PSV=n ¹	Perform save cell number
PVN=n ¹	Variable name cell for PERFORM statement
RBKST=n ¹	Register backstore cell
SFCB=n ¹	Secondary file control block for external file
SYSLIT AT + nnnn ³	Displacement for system literal from beginning of system literal pool
TGT FDMP TEST INFO. AREA + nnnn ³	FDUMP/TEST information area
TGTFIXD + nnnn ³	Offset from beginning of fixed portion of task global table (TGT)
TOV=n ¹	TGT overflow cell number
TS1=aaaa	Temporary storage cell number in subpool 1
TS2=aaaa	Temporary storage cell number in subpool 2
TS3=aaaa	Temporary storage cell number in subpool 3

Table 50. Symbols used in LIST and MAP output (continued)

Symbol	Definition
TS4=aaaa	Temporary storage cell number in subpool 4
V(routine name)	Assembler VCON for external routine
VLC=n ¹	Variable length name cell number (ODO)
VNI=n ¹	Variable name initialization
WHEN=n ¹	Evaluate WHEN cell number
<ol style="list-style-type: none"> 1. n is the number of the entry. For base locators, it can also be XXXXX, indicating a data item that was deleted by OPTIMIZE(FULL) processing. 2. (hhhhh) is the program offset in hexadecimal. 3. nnnn is the offset in decimal from the beginning of the entry. 4. Alphanumeric temporaries are temporary data values used in processing alphanumeric intrinsic function and alphanumeric EVALUATE statement subjects. 	

Example: nested program map

This example shows a map of nested procedures produced by specifying the MAP compiler option. Numbers in parentheses refer to notes that follow the example.

Nested Program Map

Program Attribute codes (rightmost column) have the following meanings:

C = COMMON

I = INITIAL (1)

U = PROCEDURE DIVISION USING...

(5)

Source Nesting

LineID	Level	Program Name from PROGRAM-ID paragraph	Program Attributes
2	0	NESTMAIN.	U
120	1 (4)	SUBPRO1	I,C,U
(2)199	2	NESTED1	I,C,U
253	1	SUBPRO2	U
335	2	NESTED2	C,U

(3)

- (1) Explanations of the program attribute codes
- (2) Source line number where the program was defined
- (3) Depth of program nesting
- (4) Program name
- (5) Program attribute codes

Reading LIST output

Parts of the LIST compiler output might be useful to you for debugging your program. You do not need to be able to program in assembler language to understand the output produced by LIST. The comments that accompany most of the assembler code provide you with a conceptual understanding of the functions performed by the code.

The LIST compiler option produces seven pieces of output:

- An assembler listing of the initialization code for the program (program signature information bytes) from which you can verify program characteristics such as these:
 - Compiler options in effect
 - Types of data items present

– Verbs used in the PROCEDURE DIVISION

- An assembler listing of the source code for the program

From the address in storage of the instruction that was executing when an abend occurred, you can find the COBOL verb corresponding to that instruction. After you have found the address of the failing instruction, go to the assembler listing and find the verb for which that instruction was generated.

- Location of compiler-generated tables in the object module
- Map of the task global table (TGT), including information about the program global table (PGT) and constant global table (CGT)

Use the TGT to find information about the environment in which your program is running.

- Information about the location and size of WORKING-STORAGE and control blocks

You can use the WORKING-STORAGE piece of LIST output to find the location of data items defined in WORKING-STORAGE. (The beginning location of WORKING-STORAGE is not shown for programs compiled with the RENT option.)

- Map of the dynamic save area (DSA)

The map of the DSA (also known as the stack frame) contains information about the contents of the storage acquired every time a separately compiled procedure is entered.

- Information about the location of literals and code for dynamic storage usage

“Example: program initialization code”

“Example: assembler code generated from source code” on page 349

“Example: TGT memory map” on page 350

“Example: DSA memory map” on page 351

“Example: location and size of WORKING-STORAGE” on page 352

RELATED TASKS

Interpret a particular instruction (*Principles of Operation*)

RELATED REFERENCES

Stack storage overview (*Language Environment Programming Guide*)

Example: program initialization code

A listing of the program initialization code gives you information about the characteristics of the COBOL source program. Interpret the program signature information bytes to verify characteristics of your program.

IBM Enterprise COBOL for z/OS 3.3.0			IMIN	Date 02/27/2004 Time 10:48:16 Page 5
(1)	(2)	(3)	(4)	
000000		IMIN DS OH	PROGRAM: IMIN	
		USING *,15		
000000	47F0 F028	B 40(,15)	BYPASS CONSTANTS. BRANCH TO @STM	
000004	00	DC AL1(0)	ZERO NAME LENGTH FOR DUMPS	
000005	C3C5C5	DC CL3'CEE'	CEE EYE CATCHER	(5)
000008	000000E8	DC X'000000E8'	STACK FRAME SIZE	
00000C	00000014	DC A(@PPA1-IMIN)	OFFSET TO PPA1 FROM PRIMARY ENTRY	
000010	47F0 F001	B 1(,15)	RESERVED	
000014		@PPA1 DS OH	PPA1 STARTS HERE	
000014	98	DC X'98'	OFFSET TO LENGTH OF NAME FROM PPA1	
000015	CE	DC X'CE'	CEL SIGNATURE	
000016	AC	DC X'AC'	CEL FLAGS: '10101100'B	
000017	00	DC X'00'	MEMBER FLAGS FOR COBOL	
000018	000000B6	DC A(@PPA2)	ADDRESS OF PPA2	
00001C	00000000	DC F'0'	OFFSET TO THE BDI (NONE)	
000020	00000000	DC F'0'	ADDRESS OF ENTRY POINT DESCRIPTORS	
000024	0000	DC X'0000'	RESERVED	
000026	00	DC X'00'	DSA FPR 8-15 SAVE AREA OFFSET/16	
000027	00	DC X'00'	DSA FPR 8-15 SAVE AREA BIT MASK	
000028		@STM DS OH	STM STARTS HERE	
000028	90EC D00C	STM 14,12,12(13)	SAVE CALLER'S REGISTERS	
00002C	4110 F038	LA 1,56(,15)	GET ADDRESS OF PARMLIST INTO R1	
000030	98EF F04C	LM 14,15,76(15)	LOAD ADDRESSES FROM @BRVAL	
000034	07FF	BR 15	DO ANY NECESSARY INITIALIZATION	
000036	0000	DC AL2'0'	AVAILABLE HALF-WORD	
000038		@MAINENT DS OH	PRIMARY ENTRY POINT ADDRESS	
000038	00000000	DC A(IMIN)	@PARMS: 1) PRIMARY ENTRY POINT ADDRESS	
00003C	00000000	DC AL4'0'	2) Available	
000040	000002C8	DC A(TGT)	3) TGT ADDRESS	(6)
000044	000000AE	DC A(@EPNAM)	4) ENTRY POINT NAME ADDRESS	
000048	00000000	DC A(IMIN)	5) CURRENT ENTRY POINT ADDRESS	
00004C	000001A4	DC A(START)	@BRVAL: 6) PROCEDURE CODE ADDRESS	
000050	00000000	DC V(IGZCBS0)	7) INITIALIZATION ROUTINE	
000054	000000CA	DC A(@CEEPARM)	8) ADDRESS OF PARM LIST FOR CEEINT	
000058	00104001	DC X'00104001'	DSA WORD 0 CONSTANT	
00005C	00000000	DC AL4'0'	AVAILABLE WORD	
000060	00000000	DC AL4'0'	AVAILABLE WORD	
000064	00000000	DC AL4'0'	AVAILABLE WORD	
000068	F2F0F0F1	DC CL4'2004'	@TIMEVRS: YEAR OF COMPILATION	(7)
00006C	F0F8F2F1	DC CL4'0227'	MONTH/DAY OF COMPILATION	(8)
000070	F1F0F4F8	DC CL4'1048'	HOURS/MINUTES OF COMPILATION	(9)
000074	F1F6	DC CL2'16'	SECONDS FOR COMPILATION DATE	
000076	F0F3F0F1F0F0	DC CL6'030300'	VERSION/RELEASE/MOD LEVEL OF PROD	(10)
00007C	0474	DC X'0474'	UNSIGNED BINARY CODE PAGE CCSID VALUE	(11)
000080	0000	DC AL2'0'	AVAILABLE HALF-WORD	
000082	0000	DC X'0000'	INFO. BYTES 28-29	(12)
000084	076C	DC X'076C'	SIGNED BINARY YEARWINDOW OPTION VALUE	
000086	E0E83D440000	DC X'E0E83D440000'	INFO. BYTES 1-6	
00008C	000000004009	DC X'000000004009'	INFO. BYTES 7-12	
000092	000000000800	DC X'000000000800'	INFO. BYTES 13-18	(12)
000098	0000000004	DC X'0000000004'	INFO. BYTES 19-23	
00009D	00	DC X'00'	COBOL SIGNATURE LEVEL	
00009E	00000007	DC X'00000007'	# DATA DIVISION STATEMENTS	(13)
0000A2	00000004	DC X'00000004'	# PROCEDURE DIVISION STATEMENTS	(14)
0000A6	000000	DC X'000000'	INFO. BYTES 24-26	(12)
0000A9	00	DC X'00'	INFO. BYTE 27	
0000AA	40404040	DC C'	USER LEVEL INFO (LVINFO)	(15)
0000AE	0004	DC X'0004'	LENGTH OF PROGRAM NAME	
0000B0		@EPNAM DS OH	ENTRY POINT NAME	
0000B0	C9D4C9D540404040	DC C'IMIN	PROGRAM NAME	(16)
0000B8		@PPA2 DS OH	PPA2 STARTS HERE	
0000B8	05	DC X'05'	CEL MEMBER IDENTIFIER	
0000B9	00	DC X'00'	CEL MEMBER SUB-IDENTIFIER	
0000BA	00	DC X'00'	CEL MEMBER DEFINED BYTE	
0000BB	01	DC X'01'	CONTROL LEVEL OF PROLOG	
0000BC	00000000	DC V(CEESTART)	VCON FOR LOAD MODULE	
0000C0	00000000	DC F'0'	OFFSET TO THE CDI (NONE)	
0000C4	FFFFFFB2	DC A(@TIMEVRS-@PPA2)	OFFSET TO TIMESTAMP/VERSION INFO	
0000C8	00000000	DC A(IMIN)	ADDRESS OF CU PRIMARY ENTRY POINT	
0000CC		@CEEPARM DS OH	PARM LIST FOR CEEINT	
0000CC	00000038	DC A(@MAINENT)	POINTER TO PRIMARY ENTRY PT ADDR	
0000D0	00000008	DC A(@PARMCCE-@CEEPARM)	OFFSET TO PARAMETERS FOR CEEINT	
0000D4		@PARMCCE DS OH	PARAMETERS FOR CEEINT	
0000D4	00000006	DC F'6'	1) NUMBER OF ENTRIES IN PARM LIST	
0000D8	00000038	DC A(@MAINENT)	2) POINTER TO PRIMARY ENTRY PT ADDR	
0000DC	00000000	DC V(CEESTART)	3) ADDRESS OF CEESTART	
0000E0	00000000	DC V(CEEBETBL)	4) ADDRESS OF CEEBETBL	
0000E4	00000005	DC F'5'	5) CEL MEMBER IDENTIFIER	
0000E8	00000000	DC F'0'	6) FOR CEL MEMBER USE	
0000EC	00000000	DC AL4'0'	AVAILABLE WORD	
0000F0	00000000	DC AL4'0'	AVAILABLE WORD	
0000F4	00000000	DC AL4'0'	AVAILABLE WORD	
0000F8	00000000	DC AL4'0'	AVAILABLE WORD	
0000FC	0000	DC AL2'0'	AVAILABLE HALF-WORD	

(1) Offset from the start of the COBOL program.

- (2) Hexadecimal representation of assembler instructions.
- (3) Pseudoassembler code generated for the COBOL program.
- (4) Comments explaining the assembler code.
- (5) Eye-catcher indicating that the COBOL compiler is Language Environment-enabled.
- (6) Address of the task global table (TGT), or the address of the dynamic access block (DAB), if the program is reentrant.
- (7) Four-digit year when the program was compiled.
- (8) Month and the day when the program was compiled.
- (9) Time when the program was compiled.
- (10) Version, release, and modification level of the COBOL compiler used to compile this program (each represented in two digits).
- (11) Code page CCSID value (from CODEPAGE compiler option).
- (12) Program signature information bytes. These provide information about the following for this program:
 - Compiler options
 - DATA DIVISION
 - ENVIRONMENT DIVISION
 - PROCEDURE DIVISION
- (13) Number of statements in the DATA DIVISION.
- (14) Number of statements in the PROCEDURE DIVISION.
- (15) Four-byte user-controlled level information field. The value of this field is controlled by the LVLINF0.
- (16) Program name as used in the IDENTIFICATION DIVISION of the program.

RELATED REFERENCES

"Signature information bytes: compiler options"

"Signature information bytes: DATA DIVISION" on page 345

"Signature information bytes: ENVIRONMENT DIVISION" on page 346

"Signature information bytes: PROCEDURE DIVISION verbs" on page 346

"Signature information bytes: more PROCEDURE DIVISION items" on page 348

Signature information bytes: compiler options

This table shows program signature information that is part of the listing of program initialization code provided when you use the LIST compiler option.

Table 51. Signature information bytes for compiler options

Byte	Bit	On	Off
1	0	ADV	NOADV
	1	APOST	QUOTE
	2	DATA(31)	DATA(24)
	3	DECK	NODECK
	4	DUMP	NODUMP
	5	DYNAM	NODYNAM
	6	FASTSRT	NOFASTSRT
	7	Reserved	
2	0	LIB	NOLIB
	1	LIST	NOLIST
	2	MAP	NOMAP
	3	NUM	NONUM
	4	OBJ	NOOBJ
	5	OFFSET	NOOFFSET
	6	OPTIMIZE	NOOPTIMIZE
	7	ddname supplied in OUTDD option will be used	OUTDD(SYSOUT) is in effect.
3	0	NUMPROC(PFD)	NUMPROC(NOPFD)
	1	RENT	NORENT
	2	Reserved	
	3	SEQUENCE	NOSEQUENCE
	4	SIZE(MAX)	SIZE(value)
	5	SOURCE	NOSOURCE
	6	SSRANGE	NOSSRANGE
	7	TERM	NOTERM
4	0	TEST	NOTEST
	1	TRUNC(STD)	TRUNC(OPT)
	2	WORD option was specified.	NOWORD
	3	VBREF	NOVBREF
	4	XREF	NOXREF
	5	ZWB	NOZWB
	6	NAME	NONAME
5	0	NUMPROC(MIG)	
	1	NUMCLS(ALT)	NUMCLS(PRIM)
	2	DBCS	NODBCS
	3	AWO	NOAWO
	4	TRUNC(BIN)	Not TRUNC(BIN)
	6	CURRENCY	NOCURRENCY
	7	Compilation unit is a class.	Compilation unit is a program.

Table 51. Signature information bytes for compiler options (continued)

Byte	Bit	On	Off
26	0	RMODE(ANY)	RMODE(24)
	1	TEST(STMT)	Not TEST(STMT)
	2	TEST(PATH)	Not TEST(PATH)
	3	TEST(BLOCK)	Not TEST(BLOCK)
	4	OPT(FULL)	OPT(STD) or NOOPT
	5	INTDATE(LILIAN)	INTDATE(ANSI)
	6	TEST(SEPARATE)	Not TEST(SEPARATE)
27	0	PGMNAME(LONGUPPER)	Not PGMNAME(LONGUPPER)
	1	PGMNAME(LONGMIXED)	Not PGMNAME(LONGMIXED)
	2	DLL	NODLL
	3	EXPORTALL	NOEXPORTALL
	4	DATEPROC	NODATEPROC
	5	ARITH(EXTEND)	ARITH(COMPAT)
	6	THREAD	NOTHREAD

Signature information bytes: DATA DIVISION

This table shows program signature information that is part of the listing of program initialization code provided when you use the LIST compiler option.

Table 52. Signature information bytes for the DATA DIVISION

Byte	Bit	Item
6	0	QSAM file descriptor
	1	VSAM sequential file descriptor
	2	VSAM indexed file descriptor
	3	VSAM relative file descriptor
	4	CODE-SET clause (ASCII files) in file descriptor
	5	Spanned records
	6	PIC G or PIC N (DBCS data item)
	7	OCCURS DEPENDING ON clause in data description entry
7	0	SYNCHRONIZED clause in data description entry
	1	JUSTIFIED clause in data description entry
	2	USAGE IS POINTER item
	3	Complex OCCURS DEPENDING ON clause
	4	External floating-point items in the DATA DIVISION
	5	Internal floating-point items in the DATA DIVISION
	6	Line-sequential file
	7	USAGE IS PROCEDURE-POINTER or FUNCTION-POINTER item

RELATED REFERENCES

“LIST” on page 289

Signature information bytes: ENVIRONMENT DIVISION

This table shows program signature information that is part of the listing of program initialization code provided when you use the LIST compiler option.

Table 53. Signature information bytes for the ENVIRONMENT DIVISION

Byte	Bit	Item
8	0	FILE STATUS clause in FILE-CONTROL paragraph
	1	RERUN clause in I-O-CONTROL paragraph of INPUT-OUTPUT SECTION
	2	UPSI switch defined in SPECIAL-NAMES paragraph

Signature information bytes: PROCEDURE DIVISION verbs

This table shows program signature information that is part of the listing of program initialization code provided when you use the LIST compiler option.

Table 54. Signature information bytes for PROCEDURE DIVISION verbs

Byte	Bit	Item
9	0	ACCEPT
	1	ADD
	2	ALTER
	3	CALL
	4	CANCEL
	6	CLOSE
10	0	COMPUTE
	2	DELETE
	4	DISPLAY
	5	DIVIDE
11	1	END-PERFORM
	2	ENTER
	3	ENTRY
	4	EXIT
	5	EXEC
	6	GO TO
	7	IF
12	0	INITIALIZE
	1	INVOKE
	2	INSPECT
	3	MERGE
	4	MOVE
	5	MULTIPLY
	6	OPEN
	7	PERFORM

Table 54. Signature information bytes for PROCEDURE DIVISION verbs (continued)

Byte	Bit	Item
13	0	READ
	2	RELEASE
	3	RETURN
	4	REWRITE
	5	SEARCH
	7	SET
14	0	SORT
	1	START
	2	STOP
	3	STRING
	4	SUBTRACT
	7	UNSTRING
15	0	USE
	1	WRITE
	2	CONTINUE
	3	END-ADD
	4	END-CALL
	5	END-COMPUTE
	6	END-DELETE
	7	END-DIVIDE
16	0	END-EVALUATE
	1	END-IF
	2	END-MULTIPLY
	3	END-READ
	4	END-RETURN
	5	END-REWRITE
	6	END-SEARCH
	7	END-START
17	0	END-STRING
	1	END-SUBTRACT
	2	END-UNSTRING
	3	END-WRITE
	4	GOBACK
	5	EVALUATE
	7	SERVICE
18	0	END-INVOKE
	1	END-EXEC
	2	XML
	3	END-XML

Check return code: A return code greater than 4 from the compiler could mean that some of the verbs shown as being in the program in information bytes might have been discarded because of an error.

Signature information bytes: more PROCEDURE DIVISION items

This table shows program signature information that is part of the listing of program initialization code provided when you use the LIST compiler option.

Table 55. Signature information bytes for more PROCEDURE DIVISION items

Byte	Bit	Item
21	0	Hexadecimal literal
	1	Altered GO TO
	2	I-O ERROR declarative
	3	LABEL declarative
	4	DEBUGGING declarative
	5	Program segmentation
	6	OPEN . . . EXTEND
	7	EXIT PROGRAM
22	0	CALL literal
	1	CALL identifier
	2	CALL . . . ON OVERFLOW
	3	CALL . . . LENGTH OF
	4	CALL . . . ADDRESS OF
	5	CLOSE . . . REEL/UNIT
	6	Exponentiation used
	7	Floating-point items used
23	0	COPY
	1	BASIS
	2	DBCS name in program
	3	Shift-out and Shift-in in program
	4-7	Highest error severity at entry to ASM2 module IGYBINIT
24	0	DBCS literal
	1	REPLACE
	2	Reference modification was used.
	3	Nested program
	4	INITIAL
	5	COMMON
	6	SELECT . . . OPTIONAL
	7	EXTERNAL

Table 55. Signature information bytes for more PROCEDURE DIVISION items (continued)

Byte	Bit	Item
25	0	GLOBAL
	1	RECORD IS VARYING
	2	ACCEPT FROM SYSIPT used in LABEL declarative
	3	DISPLAY UPON SYSLST used in LABEL declarative
	4	DISPLAY UPON SYSPCH used in LABEL declarative
	5	Intrinsic function was used
29	0	Java-based OO syntax in program
	1	FUNCTION RANDOM used in program
	2	NATIONAL data used in program

RELATED REFERENCES

“LIST” on page 289

Example: assembler code generated from source code

The following example shows a listing of the assembler code that is generated from source code when you use the LIST compiler option. You can use this listing to find the COBOL verb corresponding to the instruction that failed.

DATA VALIDATION AND UPDATE PROGRAM IGYTCARA Date 02/27/2004 Time 10:48:16

000433 MOVE

000435 READ

000436 SET (1)

(2)	(3)		(5)	(6)
000F26	92E8 A00A		MVI 10(10),X'E8'	LOCATION-EOF-FLAG
000F2A		GN=13	EQU *	
000F2A	47F0 B426		BC 15,1062(0,11)	GN=75(000EFA)
000F2E		GN=74	EQU *	
000439	IF			
000F2E	95E8 A00A		CLI 10(10),X'E8'	LOCATION-EOF-FLAG
000F32	4780 B490		BC 8,1168(0,11)	GN=14(000F64)
000440	DISPLAY			
000F36	5820 D05C		L 2,92(0,13)	TGTFIXD+92
000F3A	58F0 202C		L 15,44(0,2)	V(IGZCDSP)
000F3E	4110 97FF		LA 1,2047(0,9)	PGMLIT AT +1999
000F42	05EF		BALR 14,15	
000443	CALL			
000F44	4130 A012		LA 3,18(0,10)	COMP-CODE
000F48	5030 D21C		ST 3,540(0,13)	TS2=4
000F4C	9680 D21C		OI 540(13),X'80'	TS2=4
000F50	4110 D21C		LA 1,540(0,13)	TS2=4
000F54	58F0 9000		L 15,0(0,9)	V(ILBOABN0)
000F58	05EF		BALR 14,15	
000F5A	50F0 D078		ST 15,120(0,13)	TGTFIXD+120
000F5E	BF38 D089		ICM 3,8,137(13)	TGTFIXD+137
000F62	0430		SPM 3,0	
000F64		(4) GN=14	EQU *	
000F64	5820 D154		L 2,340(0,13)	VN=3
000F68	07F2		BCR 15,2	

(1) Source line number and COBOL verb, paragraph name, or section name

In line 000436, SET is the COBOL verb. An asterisk (*) before a name indicates that the name is a paragraph name or a section name.

- (2) Relative location of the object code instruction in the module, in hexadecimal notation
- (3) Object code instruction, in hexadecimal notation
The first two or four hexadecimal digits are the instruction, and the remaining digits are the instruction operands. Some instructions have two operands.
- (4) Compiler-generated names (GN) for code sequences
- (5) Object code instruction in a form that closely resembles assembler language
- (6) Comments about the object code instruction:
 - One or two operands participating in the machine instructions are displayed on the right. An asterisk immediately follows the data-names that are defined in more than one structure (in that way made unique by qualification in the source program).
 - The relative location of any generated label appearing as an operand is displayed in parentheses.

RELATED REFERENCES

“Symbols used in LIST and MAP output” on page 338

Example: TGT memory map

The following example shows LIST output for the task global table (TGT) with information about the environment in which your program runs.

DATA VALIDATION AND UPDATE PROGRAM IGYTCARA Date 02/27/2004 Time 10:48:16

*** TGT MEMORY MAP ***

(1)	(2)
TGTLOC	
000000	RESERVED - 72 BYTES
000048	TGT IDENTIFIER
00004C	RESERVED - 4 BYTES
000050	TGT LEVEL INDICATOR
000051	RESERVED - 3 BYTES
000054	32 BIT SWITCH
000058	POINTER TO RUNCOM
00005C	POINTER TO COBVEC
000060	POINTER TO PROGRAM DYNAMIC BLOCK TABLE
000064	NUMBER OF FCB'S
000068	WORKING-STORAGE LENGTH
00006C	RESERVED - 4 BYTES
000070	ADDRESS OF IGZESMG WORK AREA
000074	ADDRESS OF 1ST GETMAIN BLOCK (SPACE MGR)
000078	RESERVED - 2 BYTES
00007A	RESERVED - 2 BYTES
00007C	RESERVED - 2 BYTES
00007E	MERGE FILE NUMBER
000080	ADDRESS OF CEL COMMON ANCHOR AREA
000084	LENGTH OF TGT
000088	RESERVED - 1 SINGLE BYTE FIELD
000089	PROGRAM MASK USED BY THIS PROGRAM
00008A	RESERVED - 2 SINGLE BYTE FIELDS
00008C	NUMBER OF SECONDARY FCB CELLS
000090	LENGTH OF THE ALTER VN(VNI) VECTOR
000094	COUNT OF NESTED PROGRAMS IN COMPILE UNIT
000098	DDNAME FOR DISPLAY OUTPUT
0000A0	RESERVED - 8 BYTES
0000A8	POINTER TO COM-REG SPECIAL REGISTER
0000AC	RESERVED - 52 BYTES
0000E0	ALTERNATE COLLATING SEQUENCE TABLE PTR.

```

0000E4 ADDRESS OF SORT G.N. ADDRESS BLOCK
0000E8 ADDRESS OF PGT
0000EC RESERVED - 4 BYTES
0000F0 POINTER TO 1ST IPCB
0000F4 ADDRESS OF THE CLLE FOR THIS PROGRAM
0000F8 POINTER TO ABEND INFORMATION TABLE
0000FC POINTER TO TEST INFO FIELDS IN THE TGT
000100 ADDRESS OF START OF COBOL PROGRAM
000104 POINTER TO ALTER VNI'S IN CGT
000108 POINTER TO ALTER VN'S IN TGT
00010C POINTER TO FIRST PBL IN THE PGT
000110 POINTER TO FIRST FCB CELL
000114 WORKING-STORAGE ADDRESS
000118 POINTER TO FIRST SECONDARY FCB CELL
00011C POINTER TO STATIC CLASS INFO BLOCK 1
000120 POINTER TO STATIC CLASS INFO BLOCK 2

```

*** VARIABLE PORTION OF TGT ***

```

000124 BASE LOCATORS FOR SPECIAL REGISTERS
00012C BASE LOCATORS FOR WORKING-STORAGE (3)
000134 BASE LOCATORS FOR LINKAGE-SECTION
000138 BASE LOCATORS FOR FILES
00014C CLLE ADDR. CELLS FOR CALL LIT. SUB-PGMS.
000170 INDEX CELLS
000194 FCB CELLS
0001A8 INTERNAL PROGRAM CONTROL BLOCKS

```

- (1) Hexadecimal offset of the TGT field from the start of the TGT
- (2) Explanation of the contents of the TGT field
- (3) TGT fields for the base locators of COBOL data areas

Example: DSA memory map

The following example shows LIST output for the dynamic save area (DSA), which contains information about the contents of the storage acquired when a separately compiled procedure is entered.

DATA VALIDATION AND UPDATE PROGRAM IGYTCARA Date 02/27/2004 Time 10:48:16

*** DSA MEMORY MAP ***

(1) (2)
DSALOC

```

000000 REGISTER SAVE AREA
00004C STACK NAB (NEXT AVAILABLE BYTE)
000058 ADDRESS OF INLINE-CODE PRIMARY DSA
00005C ADDRESS OF TGT
000060 ADDRESS OF CAA
000084 SWITCHES
000088 CURRENT INT. PROGRAM OR METHOD NUMBER
00008C ADDRESS OF CALL STATEMENT PROGRAM NAME
000090 CALC ROUTINE REGISTER SAVE AREA
0000C4 ADDRESS OF FILE MUTEX USE COUNT CELLS
0000C8 PROCEDURE DIVISION RETURNING VALUE

```

*** VARIABLE PORTION OF DSA ***

```

0000D0 BACKSTORE CELLS FOR SYMBOLIC REGISTERS
000158 BASE LOCATORS FOR ALPHANUMERIC TEMPS
00015C VARIABLE-LENGTH CELLS
000170 ODO SAVE CELLS
00017C VARIABLE NAME (VN) CELLS FOR PERFORM
0001EC PERFORM SAVE CELLS
000320 TEMPORARY STORAGE-1

```

```

000330  TEMPORARY STORAGE-2
000500  ALL PARAMETER BLOCK
000564  ALPHANUMERIC TEMPORARY STORAGE

```

- (1) Hexadecimal offset of the dynamic save area (DSA) field from the start of the DSA
- (2) Explanation of the contents of the DSA field

Example: location and size of WORKING-STORAGE

The following example shows LIST output about the WORKING-STORAGE for a RENT program.

(1) (2)

WRK-STOR WILL BE ALLOCATED FOR 000015B0 BYTES

- (1) WORKING-STORAGE identification
- (2) Length of WORKING-STORAGE in hexadecimal

RELATED CONCEPTS

“Storage and its addressability” on page 34

Example: XREF output - data-name cross-references

The following example shows a sorted cross-reference of data-names, produced by the XREF compiler option. Numbers in parentheses refer to notes that follow the example.

An "M" preceding a data-name reference indicates that the data-name is modified by this reference.

(1) Defined	(2) Cross-reference of data names	(3) References
264	ABEND-ITEM1	
265	ABEND-ITEM2	
347	ADD-CODE	1126 1192
381	ADDRESS-ERROR.	M1156
280	AREA-CODE.	1266 1291 1354 1375
382	CITY-ERROR	M1159

(4)

Context usage is indicated by the letter preceding a procedure-name reference. These letters and their meanings are:

A = ALTER (procedure-name)
 D = GO TO (procedure-name) DEPENDING ON
 E = End of range of (PERFORM) through (procedure-name)
 G = GO TO (procedure-name)
 P = PERFORM (procedure-name)
 T = (ALTER) TO PROCEED TO (procedure-name)
 U = USE FOR DEBUGGING (procedure-name)

(5) Defined	(6) Cross-reference of procedures	(7) References
877	000-DO-MAIN-LOGIC	
943	050-CREATE-STL-MASTER-FILE . .	P879
995	100-INITIALIZE-PARAGRAPH . . .	P881
1471	1100-PRINT-I-F-HEADINGS. . . .	P926
1511	1200-PRINT-I-F-DATA.	P928
1573	1210-GET-MILES-TIME.	P1540
1666	1220-STORE-MILES-TIME.	P1541
1682	1230-PRINT-SUB-I-F-DATA. . . .	P1562
1706	1240-COMPUTE-SUMMARY	P1563
1052	200-EDIT-UPDATE-TRANSACTION. .	P890


```

1154 210-EDIT-THE-REST. . . . . P1145
1189 300-UPDATE-COMMUTER-RECORD . . P893
1237 310-FORMAT-COMMUTER-RECORD . . P1194 P1209
1258 320-PRINT-COMMUTER-RECORD. . . P1195 P1206 P1212 P1222
1318 330-PRINT-REPORT . . . . . P1208 P1232 P1286 P1310 P1370
1342 400-PRINT-TRANSACTION-ERRORS . P896

```

Cross-reference of data-names:

- (1) Line number where the name was defined.
- (2) Data-name.
- (3) Line numbers where the name was used. If M precedes the line number, the data item was explicitly modified at the location.

Cross-reference of procedure references:

- (4) Explanations of the context usage codes for procedure references
- (5) Line number where the procedure-name is defined
- (6) Procedure-name
- (7) Line numbers where the procedure is referenced and the context usage code for the procedure

Example: XREF output - program-name cross-references

The following example shows a sorted cross-reference of program-names, produced by the XREF compiler option. Numbers in parentheses refer to notes that follow the example.

(1) Defined	(2) Cross-reference of programs	(3) References
EXTERNAL	EXTERNAL1.	25
2	X.	41
12	X1	33 7
20	X11.	25 16
27	X12.	32 17
35	X2	40 8

- (1) Line number where the program name was defined. If the program is external, the word EXTERNAL is displayed instead of a definition line number.
- (2) Program name.
- (3) Line numbers where the program is referenced.

Example: embedded cross-reference

The following example shows a modified cross-reference embedded in the source listing, produced by the XREF compiler option.

LineID	PL	SL	-----A-1-B-----2-----3-----4-----5-----6-----7-|-----8	Map	Cross Reference
000878			procedure division.		
000879			000-do-main-logic.		
000880			display "PROGRAM IGYTCARA - Beginning".		
000881			perform 050-create-vsam-master-file.	932	(1)
000882			perform 100-initialize-paragraph.	984	
000883			read update-transaction-file into ws-transaction-record	204	340
000884			at end		
000885	1		set transaction-eof to true	254	
000886			end-read.		
000984			100-initialize-paragraph.		
000985			move spaces to ws-transaction-record	IMP 340	(2)
000986			move spaces to ws-commuter-record	IMP 316	
000987			move zeroes to commuter-zipcode	IMP 327	
000988			move zeroes to commuter-home-phone	IMP 328	
000989			move zeroes to commuter-work-phone	IMP 329	
000990			move zeroes to commuter-update-date	IMP 333	
000991			open input update-transaction-file	204	
000992			location-file	193	
000993			i-o commuter-file	181	
000994			output print-file	217	
001442			1100-print-i-f-headings.		
001443					
001444			open output print-file.	217	
001445					
001446			move function when-compiled to when-comp.	IFN 698	(2)
001447			move when-comp (5:2) to compile-month.	698	640
001448			move when-comp (7:2) to compile-day.	698	642
001449			move when-comp (3:2) to compile-year.	698	644
001450					
001451			move function current-date (5:2) to current-month.	IFN 649	
001452			move function current-date (7:2) to current-day.	IFN 651	
001453			move function current-date (3:2) to current-year.	IFN 653	
001454					
001455			write print-record from i-f-header-line-1	222	635
001456			after new-page.	138	

Example: OFFSET compiler output

DATA VALIDATION AND UPDATE PROGRAM IGYTCARA Date 02/27/2004 Time 10:48:16

001395 002826 DISPLAY	000944 002830 DISPLAY	000945 00283A PERFORM
001403 00283A DISPLAY	001404 002844 DISPLAY	001405 00284E DISPLAY
001406 002858 DISPLAY	001407 002862 CALL	000947 002888 CLOSE

(1) Line number. Your line numbers or compiler-generated line numbers are listed.

(2) Offset, from the start of the program, of the code generated for this verb (in hexadecimal notation).

The verbs are listed in the order in which they occur and once for each time they are used.

(3) Verb used.

RELATED REFERENCES

"OFFSET" on page 294

Example: VBREF compiler output

The following example shows an alphabetic listing of all the verbs in a program and where each is referenced. The listing is produced by the VBREF compiler option.

(1)	(2)	(3)
2	ACCEPT	101 101
2	ADD	129 130
1	CALL	140
5	CLOSE	90 94 97 152 153
20	COMPUTE	150 164 164 165 166 166 166 166 167 168 168 169 169 170 171 171
		171 172 172 173
2	CONTINUE	106 107
2	DELETE	96 119
47	DISPLAY	88 90 91 92 92 93 94 94 94 95 96 96 97 99 99 100 100 100 100
		103 109 117 117 118 119 138 139 139 139 139 139 139 139 139 140 140 140
		140 143 148 148 149 149 149 152 152 152 153 162
2	EVALUATE	116 155
47	IF	88 90 93 94 94 95 96 96 97 99 100 103 105 105 107 107 107 109
		110 111 111 112 113 113 113 113 114 114 115 115 116 118 119 124
		124 126 127 129 132 133 134 135 136 148 149 152 152
183	MOVE	90 93 95 98 98 98 98 98 99 100 101 101 102 104 105 105 106 106
		107 107 108 108 108 108 108 108 109 110 111 112 113 113 113 114
		114 114 115 115 116 116 117 117 117 118 118 118 119 119 120 121
		121 121 121 121 121 121 121 121 122 122 122 122 122 122 123 123
		123 123 123 123 123 124 124 124 125 125 125 125 125 125 126
		126 126 126 126 127 127 127 127 128 128 129 129 130 130 130
		131 131 131 131 131 132 132 132 132 132 133 133 133 133 133
		134 134 134 134 134 135 135 135 135 135 135 136 136 137 137
		137 137 138 138 138 138 141 141 142 142 144 144 144 145 145
		145 145 146 149 150 150 150 151 151 155 156 156 157 157 158 158
		159 159 160 160 161 161 162 162 162 168 168 168 169 169 170 171
		171 172 172 173 173
5	OPEN	93 95 99 144 148
62	PERFORM	88 88 88 88 89 89 89 91 91 91 91 93 93 94 94 95 95 95 95 96
		96 96 97 97 97 100 100 101 102 104 109 109 111 116 116 117 117
		117 118 118 118 118 119 119 119 120 120 124 125 127 128 133 134
		135 136 136 137 150 151 151 153 153
8	READ	88 89 96 101 102 108 149 151
1	REWRITE	118
4	SEARCH	106 106 141 142
46	SET	88 89 101 103 104 105 106 108 108 136 141 142 149 150 151 152 154
		155 156 156 156 156 157 157 157 157 158 158 158 158 159 159 159
		159 160 160 160 160 161 161 161 161 162 162 164 164
2	STOP	92 143
4	STRING	123 126 132 134
33	WRITE	94 116 129 129 129 129 129 130 130 130 130 145 146 146 146 146 147
		147 151 165 165 166 166 167 174 174 174 174 174 174 175 175

(1) Number of times the verb is used in the program

(2) Verb

(3) Line numbers where the verb is used

Preparing to use the debugger

Use the TEST option to prepare your executable COBOL program for use with the debugger.

The Debug Tool debugger is provided with the Full Function feature of the Enterprise COBOL compiler. To use Debug Tool to step through a run of your program, use the TEST compiler option. For remote debugging, the Debug Perspective of WebSphere Studio Enterprise Developer provides the client graphical user interface to the debug information provided by the Debug Tool engine running under z/OS or UNIX.

You can specify the TEST suboption SEPARATE to have the symbolic information tables for Debug Tool generated in a data set separate from your object module. Also, you can enable your COBOL program for debugging using overlay hooks (*production debugging*), rather than compiled-in hooks, which have some performance degradation even when the run-time TEST option is off. To use this function, compile with TEST(NONE,SYM).

Specify the NOOPTIMIZE option to get the most debugging function.

Specify the OPTIMIZE(STD) or OPTIMIZE(FULL) option for a more efficient program, but with some restrictions on debugging:

- The GOTO Debug Tool command is not supported.
- Except for the DESCRIBE ATTRIBUTES command, Debug Tool commands cannot refer to any data item that was discarded from your program by the OPTIMIZE(FULL) option.

RELATED TASKS

Preparing your program for debugging (*Debug Tool User's Guide*)

RELATED REFERENCES

"TEST" on page 306

Part 3. Targeting COBOL programs for certain environments

Chapter 20. Developing COBOL programs for

CICS	359
Coding COBOL programs to run under CICS	359
Coding file input and output	360
Retrieving the system date and time.	360
Displaying the contents of data items	361
Calling to or from COBOL programs	361
Coding nested programs	361
Coding a COBOL program to run above the	
16-MB line	362
Determining the success of ECI calls.	362
Compiling with the CICS option	362
Compiling a sequence of programs	363
Separating CICS suboptions	364
Integrated CICS translator	364
Using the separate CICS translator	365
CICS reserved-word table	366
Handling errors by using CICS HANDLE	367
Example: handling errors by using CICS	
HANDLE	368

Chapter 21. Programming for a DB2

environment	371
Coding SQL statements	371
Using SQL INCLUDE with the DB2 coprocessor	371
Using character data	372
Using binary items	373
Determining the success of SQL statements	373
Compiling with the SQL option	373
Compiling in batch	374
Separating DB2 suboptions.	374
DB2 coprocessor	375

Chapter 22. Developing COBOL programs for

IMS	377
Compiling and linking COBOL programs for	
running under IMS	377
Using object-oriented COBOL and Java under IMS	378
Calling a COBOL method from an IMS Java	
application	378
Building a mixed COBOL and Java application	
that starts with COBOL	379
Writing mixed-language applications	380
Using the COBOL STOP RUN statement	380
Processing messages and synchronizing	
transactions	380
Accessing databases	380
Using the application interface block	381

Chapter 23. Running COBOL programs under

UNIX	383
Running in UNIX environments	383
Setting and accessing environment variables	384
Setting environment variables that affect	
execution.	384

Environment variables of interest for COBOL	
programs.	385
Resetting environment variables	385
Accessing environment variables	385
Example: accessing environment variables.	385
Calling UNIX/POSIX APIs	386
fork(), exec(), and spawn()	386
Samples	387
Accessing main program parameters	388
Example: accessing main program parameters	388

Chapter 20. Developing COBOL programs for CICS

COBOL programs that are written for CICS can run under CICS Transaction Server. CICS COBOL application programs that use CICS services must use the CICS command-level interface.

When you use the CICS compiler option, the Enterprise COBOL compiler handles both native COBOL and embedded CICS statements in the source program. Compilers before COBOL for OS/390 & VM Version 2 Release 2 require a separate translation step to convert EXEC CICS commands to COBOL code. You can still translate embedded CICS statements separately, but use of the integrated CICS translator is recommended.

To use the integrated CICS translator, CICS Transaction Server Version 2 is required.

After you compile and link-edit your program, you need to do some other steps such as updating CICS tables before you can run the COBOL program under CICS. However, these CICS topics are beyond the scope of this COBOL information. See the related references for further information about CICS.

You can determine how run-time errors are handled by setting the CBLPSHPOP run-time option. See the related tasks for information about CICS HANDLE and CBLPSHPOP.

RELATED CONCEPTS

"Integrated CICS translator" on page 364

RELATED TASKS

"Coding COBOL programs to run under CICS"

"Compiling with the CICS option" on page 362

"Using the separate CICS translator" on page 365

"Handling errors by using CICS HANDLE" on page 367

Using the CBLPSHPOP run-time option under CICS (*Language Environment Programming Guide*)

RELATED REFERENCES

"CICS" on page 273

CICS Application Programming Guide

Coding COBOL programs to run under CICS

To code your program, you need to know how to code CICS commands in the PROCEDURE DIVISION. They have the following basic format:

```
EXEC CICS command name and command options  
END-EXEC
```

Within EXEC commands, use the space as a word separator; do not use a comma or a semicolon.

COBOL class definitions and methods (object-oriented COBOL) cannot be run in a CICS environment.

In addition, when you code your programs to run under CICS, do not use the following code:

- FILE-CONTROL entry in the ENVIRONMENT DIVISION, unless the FILE-CONTROL entry is used for a SORT statement
- FILE SECTION of the DATA DIVISION, unless the FILE SECTION is used for a SORT statement
- User-specified parameters to the main program
- USE declaratives (except USE FOR DEBUGGING)
- These COBOL language statements:
 - ACCEPT format 1: data transfer (you can use format-2 ACCEPT to retrieve the system date and time)
 - CLOSE
 - DELETE
 - DISPLAY UPON SYSPUNCH
 - DISPLAY UPON CONSOLE
 - MERGE
 - OPEN
 - READ
 - RERUN
 - REWRITE
 - START
 - STOP *literal*
 - WRITE

If you plan to use the separate CICS translator, you must put any REPLACE statements that contain EXEC commands after the PROCEDURE DIVISION statement for the program, or they will not be translated.

Coding file input and output

You must use CICS commands for most input and output processing. Therefore, do not describe files or code any OPEN, CLOSE, READ, START, REWRITE, WRITE, or DELETE statements. Instead, use CICS commands to retrieve, update, insert, and delete data.

Retrieving the system date and time

You cannot use a format-1 ACCEPT statement in a CICS program.

You can use these format-2 ACCEPT statements in the CICS environment to get the system date:

- ACCEPT *identifier-2* FROM DATE
- ACCEPT *identifier-2* FROM DATE YYYYMMDD
- ACCEPT *identifier-2* FROM DAY
- ACCEPT *identifier-2* FROM DAY YYYYDDD
- ACCEPT *identifier-2* FROM DAY-OF-WEEK

You can use this format-2 ACCEPT statement in the CICS environment to get the system time:

- ACCEPT *identifier-2* FROM TIME

The recommended way to retrieve system date and time information is to use the ACCEPT statement, because it works in all environments (CICS and non-CICS).

Displaying the contents of data items

DISPLAY to the system logical output device (SYSOUT, SYSLIST, SYSLST) is supported under CICS. The DISPLAY output is written to the Language Environment message file (transient data queue CESE).

DISPLAY . . . UPON CONSOLE and DISPLAY . . . UPON SYSPUNCH, however, are not allowed.

Calling to or from COBOL programs

You can make calls to or from VS COBOL II, COBOL for MVS & VM, COBOL for OS/390 & VM, and Enterprise COBOL programs using the CALL statement. However, these programs cannot call or be called by OS/VS COBOL programs with the CALL statement. You must use EXEC CICS LINK instead. If you are calling a separately compiled COBOL program that was processed with either the separate CICS translator or the integrated CICS translator, you must pass DFHEIBLK and DFHCOMMAREA as the first two parameters in the CALL statement.

You can use CALL *identifier* with the NODYNAM compiler option to dynamically call a program. Called programs can contain any function supported by CICS for the language. You must define dynamically called programs in the CICS program processing table (PPT) if you are not using CICS autoinstall. Under CICS, COBOL programs do not support dynamic calls to subprograms that have the RELOAD=YES option coded in their CICS PROGRAM definition. Dynamic calls to programs that are defined with RELOAD=YES can cause a storage shortage. Use the RELOAD=NO option for programs that are to be dynamically called by COBOL.

Support for interlanguage communication (ILC) with other high-level languages is available. Where ILC is not supported, you can use CICS LINK, XCTL, and RETURN instead.

The following table shows the calling relationship between COBOL and assembler programs. In the table, assembler programs that conform to the interface described in the *Language Environment Programming Guide* are called *Language Environment-conforming* assembler programs. Those that do not conform to the interface are *non-Language Environment-conforming* assembler programs.

Table 56. Calls between COBOL and assembler under CICS

Calls between COBOL and assembler programs	Language Environment-conforming assembler program	Non-Language Environment-conforming assembler program
From an Enterprise COBOL program to the assembler program?	Yes	Yes
From the assembler program to an Enterprise COBOL program?	Yes, if the assembler program is not a main program	No

Coding nested programs

When you compile with the integrated CICS translator, the DFHEIBLK and DFHCOMMAREA control blocks are generated by the translator with the GLOBAL clause

in the outermost program. Therefore when you code nested programs, you do not have to pass these control blocks as arguments on calls to the nested programs.

When you code nested programs and you plan to use the separate CICS translator, pass DFHEIBLK and DFHCOMMAREA as parameters to the nested programs that contain EXEC commands or references to the EIB (EXEC interface block). You must pass the same parameters also to any program that forms part of the control hierarchy between such a program and its top-level program.

Coding a COBOL program to run above the 16-MB line

Under Enterprise COBOL, these restrictions apply when you code a COBOL program to run above the 16-MB line:

- If you use IMS/ESA Version 6 (or later) without DBCTL, DL/I CALL statements are supported only if all the data passed on the call resides below the 16-MB line. Therefore, you must specify the DATA(24) compiler option. However, if you use IMS/ESA Version 6 (or later) with DBCTL, you can use the DATA(31) compiler option instead and pass data that resides above the 16-MB line.
If you use EXEC DLI instead of DL/I CALL statements, you can specify DATA(31) regardless of the IMS product level.
- If the receiving program is link-edited with AMODE 31, addresses passed must be 31 bits long, or 24 bits long with the leftmost byte set to zeros.
- If the receiving program is link-edited with AMODE 24, addresses passed must be 24 bits long.

Determining the success of ECI calls

Following calls to the external CICS interface (ECI), the content of the RETURN-CODE special register is set to an unpredictable value. Therefore, even if your COBOL program terminates normally after successfully using the external CICS interface, the job step could end with an undefined return code. To ensure that a meaningful return code is given at termination, set the RETURN-CODE special register before terminating your program.

To make the job return code reflect the status of the last call to CICS, set the RETURN-CODE special register based on the response codes from the last call to the external CICS interface.

RELATED TASKS

“Handling errors when calling programs” on page 213
ILC under CICS (*Language Environment Writing ILC Applications*)

RELATED REFERENCES

CICS External Interfaces Guide

Compiling with the CICS option

Use the CICS compiler option to enable the integrated CICS translator and to specify CICS suboptions. If you specify the NOCICS option, the compiler diagnoses and discards any CICS statements that it finds in your source program. If you have already used the separate CICS translator, you must use the NOCICS compiler option.

You can specify the CICS option in any of the compiler option sources: compiler invocation, PROCESS or CBL statements, or installation default. When the CICS option is the COBOL installation default, you cannot specify CICS suboptions. However,

making the CICS option the installation default is not recommended, because the changes made by the integrated CICS translator are not appropriate for non-CICS applications.

All CBL or PROCESS statements must precede any comment lines, in accordance with the rules for Enterprise COBOL.

The CICS suboption string that you provide on the CICS compiler option is made available to the integrated CICS translator. Only that translator views the contents of the string.

When you use the integrated CICS translator, you must compile with these options:

Table 57. Compiler options required for the integrated CICS translator

Compiler option	Comment
CICS	If you specify NOLIB, DYNAM, or NORENT, the compiler forces on LIB, NODYNAM, and RENT.
LIB	Must be in effect with CICS
NODYNAM	Must be in effect with CICS
RENT	Must be in effect with CICS
SIZE(xxx)	xxx must be a size value (not MAX) that leaves enough storage in your user region for the integrated CICS translation process.

In addition, IBM recommends that you use the compiler option WORD(CICS) to have the compiler flag language elements that are not supported under CICS.

You can use the standard JCL procedural statements that are supplied with COBOL to compile your program with the integrated CICS translator. In addition to specifying the above compiler options, you must change your JCL to specify the STEPLIB override for the COBOL step and to add the data set that contains the integrated CICS translator services, unless these services are in the linklist. The default name of the data set for CICS Transaction Server V2R2 is CICSTS22.CICS.SDFHLOAD, but your installation might have changed the name. For example, you might have the following line in your JCL:

```
//STEPLIB DD DSN=CICSTS22.CICS.SDFHLOAD,DISP=SHR
```

The COBOL compiler listing includes the error diagnostics (such as syntax errors in the CICS statements) that the integrated CICS translator generates. The listing reflects the input source; it does not include the COBOL statements that the integrated CICS translator generates.

Compiling a sequence of programs

When you use the CICS option to compile a source file that contains a sequence of COBOL programs, the order of precedence of the options from highest to lowest is:

1. Options that are specified in the CBL or PROCESS card that initiates the unit of compilation
2. Options that are specified when the compiler is started
3. CICS default options

Separating CICS suboptions

Because of the concatenation of multiple CICS option specifications, you can separate CICS suboptions (which might not fit on a single CBL statement) into multiple CBL statements.

The CICS suboptions that you include in the suboption string are cumulative. The compiler concatenates these suboptions from multiple sources in the order that they are specified. For example, suppose that your JCL file has the following code:

```
//STEP1 EXEC IGYWC, . . .  
//PARM.COBOL="CICS("FLAG(I)")"  
//COBOL.SYSIN DD *  
  CBL CICS("DEBUG")  
  CBL CICS("LINKAGE")  
  IDENTIFICATION DIVISION.  
  PROGRAM-ID. COBOL1.
```

During compilation, the compiler passes the following suboption string to the integrated CICS translator:

```
"FLAG(I) DEBUG LINKAGE"
```

The concatenated strings are delimited with single spaces and with a quotation mark or single quotation mark around the group. When the compiler finds multiple instances of the same CICS suboption, the last specification of the suboption in the concatenated string takes effect. The compiler limits the length of the concatenated CICS suboption string to 4 KB.

RELATED CONCEPTS

“Integrated CICS translator”

RELATED TASKS

“Coding COBOL programs to run under CICS” on page 359

RELATED REFERENCES

“CICS” on page 273

CICS Application Programming Guide

Integrated CICS translator

When you use the CICS compiler option, the COBOL compiler works with the integrated CICS translator to handle both native COBOL and embedded CICS statements in the source program. When the compiler encounters CICS statements, and at other significant points in the source program, it interfaces with the integrated CICS translator. This translator takes appropriate actions on the CICS statements and then returns to the compiler, typically indicating what native language statements to generate. However, if you are using CICS Transaction Server 1.3, you must continue to use the separate translator.

Although the use of the separate CICS translator continues to be supported, use of the integrated CICS translator is recommended. Certain restrictions that apply when you use the separate translator do not apply when you use the integrated translator:

- You can use Debug Tool to debug the original source, instead of the expanded source that the separate CICS translator provides.
- You do not need to translate separately the EXEC CICS or EXEC DLI statements that are in copybooks.

- There is no intermediate data set for the translated but not compiled version of the source program.
- There is only one output listing instead of two.
- Using nested programs that contain EXEC CICS statements is simpler. DFHCOMAREA and DFHEIBLK are generated with the GLOBAL attribute in the outermost program. You do not need to pass them as arguments on calls to nested programs or specify them on the PROCEDURE DIVISION USING statement of nested programs.
- You can keep nested programs that contain EXEC CICS in separate files and include them through COPY statements.
- REPLACE statements can affect EXEC CICS statements.
- Because the compiler generates binary fields in CICS control blocks with format COMP-5 instead of BINARY, there is no dependency on the setting of the TRUNC compiler option. You can use any setting of the TRUNC option in CICS applications, subject only to the requirements of the application logic and use of user-defined binary fields.

RELATED TASKS

“Coding COBOL programs to run under CICS” on page 359

“Compiling with the CICS option” on page 362

RELATED REFERENCES

“TRUNC” on page 310

Using the separate CICS translator

To run a COBOL program under CICS, you can use the separate CICS translator to convert the CICS commands to COBOL statements and then compile and link the program to create the executable module. However, using the CICS translator that is integrated with the Enterprise COBOL compiler is recommended.

To translate CICS statements separately, use the COBOL3 translator option. This option causes the following line to be inserted:

```
CBL RENT,NODYNAM,LIB
```

You can suppress the insertion of a CBL statement by using the CICS translator option NOCBLCARD.

CICS provides the translator option ANSI85, which supports these language features (introduced by the COBOL 85 Standard):

- Blank lines intervening in literals
- Sequence numbers containing any character
- Lowercase characters supported in all COBOL words
- REPLACE statement
- Batch compilation
- Nested programs
- Reference modification
- GLOBAL variables
- Interchangeability of comma, semicolon, and space
- Symbolic character definition

After you use the separate CICS translator, use the following compiler options when you compile the program:

Table 58. Compiler options required for the separate CICS translator

Required compiler option	Condition
RENT	
NODYNAM	The program is translated by the CICS translator.
LIB	The program contains a COPY or BASIS statement.

In addition, IBM recommends that you use the compiler option `WORD(CICS)` to have the compiler flag language elements that are not supported under CICS.

The following TRUNC compiler option recommendations are based on expected values for binary data items:

Table 59. TRUNC compiler options recommended for the separate CICS translator

Recommended compiler option	Condition
TRUNC(OPT)	All binary data items conform to the PICTURE and USAGE clause for those data items.
TRUNC(BIN)	Not all binary data items conform to the PICTURE and USAGE clause for those data items.

For example, if you use the separate CICS translator and have a data item defined as `PIC S9(8) BINARY` that might receive a value greater than eight digits, use the `TRUNC(BIN)` compiler option, change the item to `USAGE COMP-5`, or change the `PICTURE` clause.

You might also want to avoid using options that have no effect:

- ADV
- FASTSRT
- OUTDD

The input data set for the compiler is the data set that you received as a result of translation, which is `SYSPUNCH` by default.

RELATED CONCEPTS

“Integrated CICS translator” on page 364

RELATED TASKS

“Compiling with the CICS option” on page 362

CICS reserved-word table

COBOL provides an alternate reserved-word table (`IGYCCICS`) for CICS application programs. If you use the compiler option `WORD(CICS)`, COBOL words that are not supported under CICS are flagged by the compiler with an error message.

In addition to the COBOL words restricted by the IBM-supplied default reserved-word table, the IBM-supplied CICS reserved-word table restricts the following COBOL words:

CLOSE	I-O-CONTROL	REWRITE
DELETE	MERGE	SD
FD	OPEN	SORT
FILE	READ	START
FILE-CONTROL	RERUN	WRITE
INPUT-OUTPUT		

If you intend to use the SORT statement under CICS (COBOL supports an interface for the SORT statement under CICS), you must change the CICS reserved-word table before using it. You must remove the words in **bold** above from the list of words marked as restricted, because they are required for the SORT function.

RELATED TASKS

“Compiling with the CICS option” on page 362

RELATED REFERENCES

“WORD” on page 313

Handling errors by using CICS HANDLE

The setting of the CBLPSHPOP run-time option affects the state of the HANDLE specifications when a program calls COBOL subprograms using a CALL statement.

When CBLPSHPOP is ON and a COBOL subprogram (not a nested program) is called with a CALL statement, the following actions occur:

1. As part of program initialization, the run time suspends the HANDLE specifications of the calling program (with an EXEC CICS PUSH HANDLE).
2. The default actions for HANDLE apply until the called program issues its own HANDLE commands.
3. As part of program termination, the run time reinstates the HANDLE specifications of the calling program (with an EXEC CICS POP HANDLE).

When CBLPSHPOP is OFF, the run time does not perform CICS PUSH or POP on a CALL to any COBOL subprogram. If the subprograms do not use any of the EXEC CICS condition-handling commands, you can run with CBLPSHPOP(OFF), eliminating the overhead of the PUSH HANDLE and POP HANDLE commands. As a result, performance can be improved compared to running with CBLPSHPOP(ON).

If you are migrating an application from the VS COBOL II run time to the Language Environment run time, see the related reference for information about the CBLPSHPOP option for additional considerations.

If you use the CICS HANDLE CONDITION or CICS HANDLE AID commands, the LABEL specified for the CICS HANDLE command must be in the same PROCEDURE DIVISION as the CICS command that causes branching to the CICS HANDLE label. You cannot use the CICS HANDLE commands with the LABEL option to handle conditions, aids, or abends that were caused by another program invoked with the COBOL CALL statement. Attempts to perform cross-program branching by using the CICS HANDLE command with the LABEL option result in a transaction abend.

If a condition, aid, or abend occurs in a nested program, the LABEL for the condition, aid, or abend must be in the same nested program; otherwise unpredictable results will occur.

“Example: handling errors by using CICS HANDLE”

RELATED REFERENCES

CBLPSHPOP run-time option (*Enterprise COBOL Compiler and Run-Time Migration Guide*)

IBM Enterprise COBOL Version 3 Release 1 Performance Tuning

(www.ibm.com/software/awdtools/cobol/zos/pdf/cobpf310.pdf)

Example: handling errors by using CICS HANDLE

The following sample code illustrates the use of CICS HANDLE in COBOL programs. Program A has a CICS HANDLE CONDITION command and program B has no CICS HANDLE commands. Program A calls program B; program A also calls nested program A1.

The following shows how a condition is handled in three scenarios.

- (1) CBLPSHPOP(ON): If the CICS READ command in program B causes a condition, the condition is not handled by program A (the HANDLE specifications are suspended because the run time performs a CICS PUSH HANDLE). The condition turns into a transaction abend.
- (2) CBLPSHPOP(OFF): If the CICS READ command in program B causes a condition, the condition is not handled by program A (the run time diagnoses the attempt to perform cross-program branching by using a CICS HANDLE command with the LABEL option). The condition turns into a transaction abend.
- (3) If the CICS READ command in nested program A1 causes a condition, the flow of control goes to label ERR-1, and unpredictable results occur.

```
*****
* Program A                                     *
*****
ID DIVISION.
PROGRAM-ID. A.
. . .
PROCEDURE DIVISION.
    EXEC CICS HANDLE CONDITION
        ERROR(ERR-1)
        END-EXEC.
    CALL 'B' USING DFHEIBLK DFHCOMMAREA.
    CALL 'A1'.
. . .
THE-END.
    EXEC CICS RETURN END-EXEC.
ERR-1.
. . .
* Nested program A1.
ID DIVISION.
PROGRAM-ID. A1.
PROCEDURE DIVISION.
    EXEC CICS READ                                (3)
        FILE('LEDGER')
        INTO(RECORD)
        RIDFLD(ACCTNO)
        END-EXEC.
END PROGRAM A1.
END PROGRAM A.
*
*****
* Program B                                     *
*****
ID DIVISION.
```



```

PROGRAM-ID. B.
. . .
PROCEDURE DIVISION.
    EXEC CICS READ
        FILE('MASTER')
        INTO(RECORD)
        RIDFLD(ACCTNO)
        END-EXEC.
. . .
END PROGRAM B.

```

(1) (2)

Chapter 21. Programming for a DB2 environment

In general, the coding for your COBOL program will be the same if you want it to access a DB2 database. However, to retrieve, update, insert, and delete DB2 data and use other DB2 services, you must use SQL statements.

To communicate with DB2, do the following:

- Code any SQL statements you need, delimiting them with EXEC SQL and END-EXEC statements.
- Use the DB2 precompiler or compile with the SQL compiler option if you are using DB2 for OS/390 Version 7 or later.

RELATED CONCEPTS

"DB2 coprocessor" on page 375

RELATED TASKS

"Coding SQL statements"

"Compiling with the SQL option" on page 373

Coding SQL statements in a COBOL application (*IBM DB2 Application Programming and SQL Guide*)

RELATED REFERENCES

IBM DB2 SQL Reference

Coding SQL statements

Delimit SQL statements with EXEC SQL and END-EXEC statements. You also need to do these special steps:

- Declare an SQL communication area (SQLCA) in the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION of the outermost program. (LOCAL-STORAGE is recommended for recursive programs and programs compiled using the THREAD compiler option.)
- Declare all host variables that you use in SQL statements in the WORKING-STORAGE SECTION, LOCAL-STORAGE SECTION, or LINKAGE SECTION. However, you do not need to identify them with EXEC SQL BEGIN DECLARE SECTION and EXEC SQL END DECLARE SECTION.
- All programs compiled using the SQL compiler option must have a WORKING-STORAGE SECTION or a LOCAL-STORAGE SECTION. Recursive programs or programs compiled using the THREAD compiler option must have a LOCAL-STORAGE SECTION.
- SQL statements are not allowed in object-oriented classes or methods.

Using SQL INCLUDE with the DB2 coprocessor

An SQL INCLUDE statement is treated identically to a native COBOL COPY statement when you use the SQL compiler option. Therefore, the following two lines are treated the same way:

```
EXEC SQL INCLUDE name END-EXEC.  
COPY name.
```

The *name* in an SQL INCLUDE statement follows the same rules as those for COPY *text-name* and is processed identically to a COPY *text-name* statement that does not have a REPLACING clause.

The library search order for SQL INCLUDE statements is the same SYSLIB concatenation as the compiler uses to resolve COBOL COPY statements that do not specify a library-name.

Using character data

You can code any of the following USAGE clauses to describe host variables for character data that you use in EXEC SQL statements:

- USAGE DISPLAY for single-byte or UTF-8 data
- USAGE DISPLAY-1 for DBCS data
- USAGE NATIONAL for Unicode data

When you use the stand-alone DB2 preprocessor, you must specify the code page (CCSID) in EXEC SQL DECLARE statements for host variables declared with USAGE NATIONAL. You must specify the code page for host variables declared with USAGE DISPLAY or DISPLAY-1 only if the CCSID in effect for the COBOL CODEPAGE compiler option and the CCSIDs used by DB2 for character and graphic data do not match.

For example:

```
CBL CODEPAGE(1140) NSYMBOL(NATIONAL)
. . .
WORKING-STORAGE SECTION.
    EXEC SQL INCLUDE SQLCA END-EXEC.
    EXEC SQL BEGIN DECLARE SECTION END-EXEC.
01  ID PIC S9(4) USAGE COMP.
01  C1140.
    49 C1140-LEN PIC S9(4) USAGE COMP.
    49 C1140-TEXT PIC X(50).
    EXEC SQL DECLARE :C1140 VARIABLE CCSID 1140 END-EXEC.
01  G1200.
    49 G1200-LEN PIC S9(4) USAGE COMP.
    49 G1200-TEXT PIC N(50) USAGE NATIONAL.
    EXEC SQL DECLARE :G1200 VARIABLE CCSID 1200 END-EXEC.
    EXEC SQL END DECLARE SECTION END-EXEC.
. . .
EXEC SQL FETCH C1 INTO :ID, :C1140, :G1200 END-EXEC.
```

When you use the integrated DB2 coprocessor, the statements EXEC SQL DECLARE :C1140 VARIABLE CCSID 1140 END-EXEC and EXEC SQL DECLARE :G1200 VARIABLE CCSID 1200 END-EXEC coded above are not necessary because the code-page information is handled implicitly.

If you specify EXEC SQL DECLARE *variable-name* VARIABLE CCSID *nnnn* END-EXEC, that specification overrides the implied CCSID. For example, the following code would cause DB2 to treat C1208-TEXT as encoded in UTF-8 (CCSID 1208) rather than encoded in the CCSID in effect for the COBOL CODEPAGE compiler option:

```
01  C1208.
    49 C1208-LEN PIC S9(4) USAGE COMP.
    49 C1208-TEXT PIC X(50).
    EXEC SQL DECLARE :C1208 VARIABLE CCSID 1208 END-EXEC.
```

The NSYMBOL compiler option has no effect on a character literal inside an EXEC SQL statement. Character literals in an EXEC SQL statement follow the SQL rules for character constants.

Using binary items

For binary data items that you specify in an EXEC SQL statement, use either of these techniques:

- Declare them as USAGE COMP-5.
- Use the TRUNC(BIN) option if USAGE BINARY, COMP, or COMP-4 is specified. (This might have a larger impact on performance than using USAGE COMP-5 on individual data items.)

If you specify a USAGE BINARY, COMP, or COMP-4 item when option TRUNC(OPT) or TRUNC(STD) or both are in effect, the compiler accepts the item but the data might not be valid because of the decimal truncation rules. You need to ensure that truncation does not affect the validity of the data.

Determining the success of SQL statements

When DB2 finishes executing an SQL statement, DB2 sends a return code in the SQLCA (with one exception) to indicate whether the operation succeeded or failed. Your program should test the return code and take any necessary action.

The exception occurs when a program runs under DSN from one of the alternate entry points of the TSO batch mode module IKJEFT01 (IKJEFT1A or IKJEFT1B). In this case, the return code is passed in register 15.

After execution of SQL statements, the content of the RETURN-CODE special register might not be valid. Therefore, even if your COBOL program terminates normally after successfully using the SQL statements, the job step could end with an undefined return code. To ensure that a meaningful return code is given at termination, set the RETURN-CODE special register before terminating your program.

RELATED CONCEPTS

"Formats for numeric data" on page 40

RELATED REFERENCES

"CODEPAGE" on page 274

Compiling with the SQL option

You use the SQL compiler option on z/OS to enable the DB2 coprocessor and specify the DB2 suboptions. The SQL compiler option works with embedded SQL statements only if the compiler has access to DB2 for OS/390 Version 7 or later.

You can specify the SQL option in any of the compiler option sources: compiler invocation, PROCESS or CBL statements, or installation default. You cannot specify DB2 suboptions when the SQL option is the COBOL installation default, but you can specify default DB2 suboptions by customizing the DB2 product installation defaults.

The DB2 suboption string that you provide on the SQL compiler option is made available to the DB2 coprocessor. Only the DB2 coprocessor views the contents of the string.

When you use the DB2 coprocessor, you must compile with these options:

Table 60. Compiler options required with the DB2 coprocessor

Compiler option	Comment
SQL	If you use also NOLIB, LIB is forced on.
LIB	Must be specified with SQL
SIZE(<i>xxx</i>)	<i>xxx</i> is a size value (not MAX) that leaves enough storage in the user region for the DB2 coprocessor services.

You can use standard JCL procedural statements to compile your program with the DB2 coprocessor. In addition to specifying the above compiler options, specify the following items in your JCL:

- DBRMLIB DD statement with the location for the generated database request module (DBRM).
- STEPLIB override for the COBOL step, adding the data set that contains the DB2 coprocessor services, unless these services are in the LNKLIST. Typically, this data set is DSN710.SDSNLOAD, but your installation might have changed the name.

For example, you might have the following lines in your JCL:

```
//DBRMLIB DD DSN=PAYROLL.MONTHLY.DBRMLIB.DATA(MASTER),DISP=SHR
//STEPLIB DD DSN=DSN710.SDSNLOAD,DISP=SHR
```

Compiling in batch

When you use the SQL option to compile a source file that contains a sequence of COBOL programs (a batch compile sequence), the option must be in effect for the first program of the batch sequence. If the SQL option is specified on CBL or PROCESS cards, the CBL or PROCESS cards must precede the first program in the batch compile sequence.

Separating DB2 suboptions

Because of the concatenation of multiple SQL option specifications, you can separate DB2 suboptions (which might not fit into single CBL statement) into multiple CBL statements.

The DB2 suboptions that you include in the suboption string are cumulative. The compiler concatenates these suboptions from multiple sources in the order that they are specified. For example, suppose that your source file has the following code:

```
| //STEP1 EXEC IGYWC, . . .
| // PARM.COBOL='SQL("string1")'
| //COBOL.SYSIN DD *
|     CBL SQL("string2")
|     CBL SQL("string3")
|     IDENTIFICATION DIVISION.
|     PROGRAM-ID. DRIVER1.
```

During compilation, the compiler passes the following suboption string to the DB2 coprocessor:

```
| "string1 string2 string3"
```

The concatenated strings are delimited with single spaces. When the compiler finds multiple instances of the same DB2 suboption, the last specification of the suboption in the concatenated string will be in effect. The compiler limits the length of the concatenated DB2 suboption string to 4 KB.

RELATED CONCEPTS
“DB2 coprocessor”

RELATED REFERENCES
“SQL” on page 303
IBM DB2 Command Reference

DB2 coprocessor

When you use the DB2 coprocessor (called *SQL statement coprocessor* by DB2), the compiler handles your source program containing embedded SQL statements without your having to use a separate precompile step. When the compiler encounters SQL statements at significant points in the source program, it interfaces with the DB2 coprocessor. This coprocessor takes appropriate actions on the SQL statements and indicates to the compiler what native COBOL statements to generate for them.

Although the use of a separate precompile step continues to be supported, use of the coprocessor is recommended. Interactive debugging with Debug Tool is enhanced when you use the coprocessor because you see the SQL statements in the listing (and not the generated COBOL source). However, you must have DB2 for OS/390 Version 7 or later.

Compiling with the DB2 coprocessor generates a DB2 database request module (DBRM) along with the usual COBOL compiler outputs such as object module and listing. The DBRM writes to the data set that you specified on the DBRMLIBB DD statement in the JCL for the COBOL compile step. As input to the DB2 bind process, the DBRM data set contains information about the SQL statements and host variables in the program.

The COBOL compiler listing includes the error diagnostics (such as syntax errors in the SQL statements) that the DB2 coprocessor generates.

Certain restrictions on the use of COBOL language that apply when you use the precompile step do not apply when you use the DB2 coprocessor:

- You can use SQL statements in any nested program. (With the precompiler, SQL statements are restricted to the outermost program.)
- You can use SQL statements in copybooks.
- REPLACE statements work on SQL statements.

RELATED TASKS
“Compiling with the SQL option” on page 373

Chapter 22. Developing COBOL programs for IMS

Although much of the coding of a COBOL program will be the same when running under IMS, be aware of the following recommendations and restrictions.

In COBOL, IMS message processing programs (MPPs) do not use non-IMS input or output statements such as READ, WRITE, REWRITE, OPEN, and CLOSE.

With Enterprise COBOL, you can invoke IMS facilities using the following interfaces:

- CBLTDLI call
- Language Environment callable service CEETDLI

You code calls to CEETDLI the same way as calls to CBLTDLI. CEETDLI behaves essentially the same way as CBLTDLI.

You can also run object-oriented COBOL programs in an IMS Java dependent region. You can mix the object-oriented COBOL and Java languages in a single application.

RELATED TASKS

“Compiling and linking COBOL programs for running under IMS”

“Using object-oriented COBOL and Java under IMS” on page 378

“Calling a COBOL method from an IMS Java application” on page 378

“Building a mixed COBOL and Java application that starts with COBOL” on page 379

“Writing mixed-language applications” on page 380

Compiling and linking COBOL programs for running under IMS

For best performance in the IMS environment, use the RENT compiler option. It causes COBOL to generate reentrant code. You can then run your application programs in either *preloaded* mode (the programs are always resident in storage) or *nonpreload* mode, without having to recompile with different options.

IMS allows COBOL programs to be preloaded. This preloading can boost performance because subsequent requests for the program can be handled faster when the program is already in storage (rather than being fetched from a library each time it is needed).

You must use the RENT compiler option to compile a program that is to be run preloaded or as both preloaded and nonpreloaded. When you preload a load module that contains COBOL programs, all of the COBOL programs in that load module must be compiled with the RENT option.

For IMS programs, IBM recommends the RENT compiler option.

You can place programs compiled with the RENT option in the z/OS link pack area. There they can be shared among the IMS dependent regions.

To run above the 16-MB line, your application program must be compiled with either RENT or NORENT RMODE(ANY).

The data for IMS application programs can reside above the 16-MB line, and you can use DATA(31) RENT, or RMODE(ANY) NORENT for programs that use IMS services.

The recommended link-edit attributes for proper execution of COBOL programs under IMS are as follows:

- Link as RENT load modules that contain only COBOL programs compiled with the RENT compiler option.
- To link load modules that contain a mixture of COBOL RENT programs and other programs, use the link-edit attributes recommended for the other programs.

RELATED CONCEPTS

“Storage and its addressability” on page 34

RELATED TASKS

Coordinated condition handling under IMS (*Language Environment Programming Guide*)

RELATED REFERENCES

“DATA” on page 277

“RENT” on page 299

IMS considerations (*Enterprise COBOL Compiler and Run-Time Migration Guide*)

Using object-oriented COBOL and Java under IMS

You can mix object-oriented COBOL and Java in an application that runs in an IMS Java dependent region. For example, you can:

- Call a COBOL method from an IMS Java application. You can build the messaging portion of your application in Java and call COBOL methods to access IMS databases.
- Build a mixed COBOL and Java application that starts with the main method of a COBOL class and that invokes Java routines.

You must run these applications in either a Java message processing (JMP) dependent region or a Java batch processing (JBP) dependent region. A program that reads from the message queue (regardless of the language) must run in a JMP dependent region.

RELATED TASKS

“Defining a factory section” on page 514

Chapter 30, “Writing object-oriented programs,” on page 485

Chapter 31, “Communicating with Java methods,” on page 527

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

IMS Java User’s Guide

Calling a COBOL method from an IMS Java application

You can use the object-oriented language support in Enterprise COBOL to write COBOL methods that an IMS Java program can call. When you define a COBOL class and compile it with the Enterprise COBOL compiler, the compiler generates:

- A Java class definition with native methods
- The object code that implements the native methods

You can then create an instance and invoke the methods of this class from an IMS Java program that runs in an IMS Java dependent region, just as you would use any other class.

For example, you can define a COBOL class that uses the appropriate DL/I calls to access an IMS database. To make the implementation of this class available to an IMS Java program, do the following steps:

1. Compile the COBOL class with the Enterprise COBOL compiler to generate a Java source file (.java) that contains the class definition and an object module (.o) that contains the implementation of the native methods.
2. Compile the generated Java source file with the Java compiler to create a class file (.class).
3. Link the object code into a dynamic link library (DLL) in the HFS (.so). (See the related tasks for details.) The HFS directory that contains the COBOL DLLs must be listed in the LIBPATH, as specified in the IMS.PROCLIB member that is indicated by the ENVIRON= parameter of the IMS region procedure.
4. Update the sharable application class path in the master JVM options member (ibm.jvm.sharable.application.class.path in the IMS.PROCLIB member that is specified by the JVMOPMAS= parameter of the IMS region procedure) to enable the JVM to access the Java class file.

When you write the initial routine of a mixed-language application in Java, you must implement a class that is derived from the IMS Java IMSApplication class.

A Java program cannot call procedural COBOL programs directly. To reuse existing COBOL IMS code, you can use one of the following techniques:

- Restructure the COBOL code as a method in a COBOL class.
- Write a COBOL class definition and method that serves as a wrapper for the existing procedural code. The wrapper code can use COBOL CALL statements to access procedural COBOL programs.

RELATED TASKS

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

“Structuring OO applications” on page 524

“Wrapping procedure-oriented COBOL programs” on page 523

IMS Java User's Guide

Building a mixed COBOL and Java application that starts with COBOL

You can also build a mixed COBOL and Java IMS application that starts with COBOL code.

An application that runs in an IMS Java dependent region must start with the main method of a class. A COBOL class definition with a main factory method meets this requirement; therefore, you can use it as the first routine of a mixed COBOL and Java IMS application. (See the related tasks for details about how you can structure OO applications.) Enterprise COBOL generates a Java class with a main method that the IMS Java dependent region can find, instantiate, and invoke in the same way that the region does for the main method of an IMS Java IMSApplication subclass. Although you can code the entire application in COBOL, you would probably build this type of application to call a Java routine. When COBOL run-time support runs within the JVM of an IMS Java dependent region, it automatically finds and uses this JVM to invoke methods on Java classes.

When the main factory method of a COBOL class is the initial routine of a mixed-language application in an IMS Java dependent region, the program is subject to the same requirements as a Java program that runs in the dependent region. That is, the program must explicitly commit resources before it reads

subsequent messages from the message queue or exits the application. (A COBOL DL/I GU call does not commit resources when it is issued in an IMS Java dependent region, as it does when issued in a message processing region (MPR).)

However, the COBOL application is not derived from the IMSApplication class, and it should not use the IMS Java classes for processing messages or synchronizing transactions. Instead, it should use DL/I calls in COBOL for processing messages (GU and GN) and synchronizing transactions (CHKP). A CHKP call in an IMS Java dependent region does not result in the automatic retrieval of a message from the message queue, unlike a CHKP call in a non-IMS Java region.

RELATED TASKS

“Structuring OO applications” on page 524

IMS Java User’s Guide

New IBM Technology featuring Persistent Reusable Java Virtual Machines

Writing mixed-language applications

This section covers some things to consider when you write mixed-language applications.

Using the COBOL STOP RUN statement

If you use the COBOL STOP RUN statement in the COBOL portion of your application, it will terminate all COBOL and Java routines (including the JVM), and return control immediately to IMS. The program and the transaction are left in a stopped state.

Processing messages and synchronizing transactions

IMS message processing applications must do all message processing and transaction synchronization logic in one language, either COBOL or Java, rather than distributing this logic between application components written in the two languages. COBOL components use CALL statements to DL/I services for processing messages (GU and GN) and synchronizing transactions (CHKP). Java components use IMS Java classes to do these functions. You can use object instances of classes derived from IMSFieldMessage to communicate entire IMS messages between the COBOL and Java components of the application.

Accessing databases

Limitation: EXEC SQL statements for DB2 database access are not currently supported in COBOL routines that run in IMS Java dependent regions.

You can use either Java, COBOL, or a mixture of the two languages for accessing IMS databases.

Recommendation: Do not access the same database program communication block (PCB) from both Java and COBOL. The Java and COBOL parts of the application share the same database position. Changes in database position from calls in one part of the application will affect the database position in another part of the application. (This problem occurs whether the affected parts of an application are written in the same language or in different languages.)

Suppose that a Java component of a mixed application builds an SQL SELECT clause and uses Java Database Connectivity (JDBC) to query and retrieve results from an IMS database. The IMS Java class library constructs the appropriate request to IMS to establish the correct position in the database. If you then invoke a COBOL method that builds a segment search argument (SSA) and issues a GU (Get Unique) request to IMS against the same database PCB, the request has probably altered the

position in the database for that PCB. If so, subsequent JDBC requests to retrieve more records by using the initial SQL SELECT clause will be incorrect because the database position has changed. If you must access the same PCB from multiple languages, after an interlanguage call, reestablish the database position before you access more records in the database.

Using the application interface block

The IMS Java dependent region does not provide PCB addresses to its application. Therefore, COBOL applications that run in an IMS Java dependent region are required to use the application interface block (AIB) interface, which requires that all PCBs in a program specification block (PSB) definition have a name.

To use the AIB interface, specify the PCB requested for the call by placing the PCB name (which must be defined as part of the PSBGEN) in the resource name field of the AIB. You do not specify the PCB address directly, and your application does not need to know the relative PCB position in the PCB list. At the completion of the call, the AIB returns the PCB address that corresponds to the PCB name that the application passed.

For example:

```

Local-storage section.
    copy AIB.
    . . .
Linkage section.
01 IOPCB.
    05 logtterm      pic x(08).
    05               pic x(02).
    05 tpstat        pic x(02).
    05 iodate        pic x(04).
    05 iotime        pic x(04).
    05               pic x(02).
    05 seqnum        pic x(02).
    05 mod           pic x(08).
Procedure division.
    Move spaces to input-area
    Move spaces to AIB
    Move "DFSAIB" to AIBRID
    Move length of AIB to AIBRLen
    Move "IOPCB" to AIBRSNM1
    Move length of input-area to AIBOALEN
    Call "CEETDLI" using GU, AIB, input-area
    Set address of IOPCB to AIBRESA1
    If tpstat = spaces
* . . process input message

```

RELATED TASKS

IMS Java User's Guide

IMS Application Programming: Transaction Manager

Chapter 23. Running COBOL programs under UNIX

To run COBOL programs in the UNIX environment, you must compile them with the Enterprise COBOL or the COBOL for OS/390 & VM compiler. They must be reentrant: use the compiler and linker option RENT. If you are going to run them from the HFS, use the linker option AMODE 31. Any AMODE 24 program that you call from within a UNIX application must reside in an MVS PDS or PDSE.

The following restrictions apply to running under UNIX:

- SORT and MERGE statements are not supported.
- You cannot use the old COBOL interfaces for preinitialization (run-time option RTEREUS and functions IGZERRE and ILBOSTP0) to establish a reusable environment.
- You cannot run a COBOL program compiled with the N0THREAD option in more than one thread. If you start a COBOL application in a second thread, you get a software condition from the COBOL run time. You can run N0THREAD COBOL programs in the initial process thread (IPT) or in one non-IPT that you create from a C or PL/I routine.

You can run a COBOL program in more than one thread when you compile all the COBOL programs in the application with the THREAD option.

You can use Debug Tool to debug Unix System Services programs in remote debug mode, for example, by using the Debug Perspective of WebSphere Studio Enterprise Developer, or in full-screen mode (MFI) using a VTAM terminal.

RELATED TASKS

Chapter 15, "Compiling under UNIX," on page 249

"Running OO applications under UNIX" on page 259

"Running in UNIX environments"

"Setting and accessing environment variables" on page 384

"Calling UNIX/POSIX APIs" on page 386

"Accessing main program parameters" on page 388

Language Environment Programming Guide

RELATED REFERENCES

"RENT" on page 299

Running in UNIX environments

You can run UNIX COBOL programs in any of the UNIX execution environments:

- From a UNIX shell, either:
 - The OMVS shell (OMVS), or
 - The ISPF shell (ISHELL)

Enter the program name at the shell prompt. The program must be in the current directory or in your search path.

You can specify run-time options only by setting the environment variable _CEE_RUNOPTS before starting the program.

You can run MVS programs that reside in a cataloged MVS data set from a shell by using the tso utility. For example:

```
tso "call 'my.loadlib(myprog)'"
```

The ISPF shell can direct stdout and stderr only to an HFS file, not to your terminal.

- From outside a shell, either:
 - TSO/E, or
 - Batch

To call a UNIX COBOL program that resides in an HFS file from the TSO/E ready prompt, use the BPXBATCH utility or a spawn() syscall in a REXX exec.

To call a UNIX COBOL program that resides in an HFS file with the JCL EXEC statement, use the BPXBATCH utility.

RELATED TASKS

“Running OO applications under UNIX” on page 259

“Setting and accessing environment variables”

“Calling UNIX/POSIX APIs” on page 386

“Accessing main program parameters” on page 388

“Defining and allocating QSAM files” on page 134

“Defining and allocating line-sequential files” on page 177

“Allocating VSAM files” on page 169

“Displaying values on a screen or in a file (DISPLAY)” on page 30

Running POSIX-enabled programs using a UNIX shell (*Language Environment Programming Guide*)

Running POSIX-enabled programs outside the UNIX shells (*Language Environment Programming Guide*)

RELATED REFERENCES

“TEST” on page 306

The BPXBATCH utility (*UNIX System Services User's Guide*)

Language Environment Programming Reference

Setting and accessing environment variables

You can set environment variables for UNIX COBOL programs in either of these ways:

- From the shell with commands export and set
- From the program

Although setting and resetting environment variables from the shell before you begin to run a program is probably a typical procedure, you can set, reset, and access environment variables from the program while it is running.

If you are running a program with BPXBATCH, you can set environment variables by using an STDENV DD statement.

Setting environment variables that affect execution

To set environment variables from a shell, use the export or set command. For example, to set the environment variable MYFILE:

```
export MYFILE=/usr/mystuff/notes.txt
```

Call POSIX functions setenv() and putenv() to set environment variables from the program.

Environment variables of interest for COBOL programs

_CEE_ENVFILE

Specifies a file from which to read environment variables.

_CEE_RUNOPTS

Run-time options.

CLASSPATH

Directory paths of Java .class files required for an OO application.

COBJVMINITOPTIONS

Java virtual machine (JVM) options used when COBOL initializes a JVM.

_IGZ_SYSOUT

stdout or stderr to direct DISPLAY output. These are the only allowable values.

LIBPATH

Directory paths of dynamic link libraries.

PATH Directory paths of executable programs.

STEPLIB

Location of programs not in the LNKLIST.

Resetting environment variables

You can reset an environment variable from the shell or from your program. To reset an environment variable as if it had not been set, use the UNIX shell command `unset`. To reset an environment variable from a COBOL program, call the `setenv()` function.

Accessing environment variables

To see the values of all environment variables, you can use the `export` command with no parameters.

To access the value of an environment variable from a COBOL program, call the `getenv()` function.

“Example: accessing environment variables”

RELATED TASKS

“Running in UNIX environments” on page 383

“Calling UNIX/POSIX APIs” on page 386

“Accessing main program parameters” on page 388

“Running OO applications under UNIX” on page 259

“Displaying values on a screen or in a file (DISPLAY)” on page 30

RELATED REFERENCES

_CEE_ENVFILE (C/C++ Programming Guide)

Language Environment Programming Reference

MVS JCL Reference

Example: accessing environment variables

The following example shows how you can access and set environment variables from a COBOL program by calling the standard POSIX functions `getenv()` and `putenv()`.

Because `getenv()` and `putenv()` are C functions, you must pass arguments BY VALUE. Pass character strings as BY VALUE pointers that point to null-terminated strings. Compile programs that call these functions with the `NODYNAM` and `PGMNAME(LONGMIXED)` options.

```
CBL pgmname(longmixed),nodynam
Identification division.
Program-id. "envdemo".
Data division.
Working-storage section.
01 P pointer.
01 PATH pic x(5) value Z"PATH".
01 var-ptr pointer.
01 var-len pic 9(4) binary.
01 putenv-arg pic x(14) value Z"MYVAR=ABCDEFGH".
01 rc pic 9(9) binary.
Linkage section.
01 var pic x(5000).
Procedure division.
* Retrieve and display the PATH environment variable
  Set P to address of PATH
  Call "getenv" using by value P returning var-ptr
  If var-ptr = null then
    Display "PATH not set"
  Else
    Set address of var to var-ptr
    Move 0 to var-len
    Inspect var tallying var-len
      for characters before initial X"00"
    Display "PATH = " var(1:var-len)
  End-if
* Set environment variable MYVAR to ABCDEFGH
  Set P to address of putenv-arg
  Call "putenv" using by value P returning rc
  If rc not = 0 then
    Display "putenv failed"
    Stop run
  End-if
Goback.
```

Calling UNIX/POSIX APIs

You can call standard UNIX/POSIX functions from UNIX programs and from traditional MVS COBOL programs by using the `CALL literal` statement. These functions are part of Language Environment.

Because these are C functions, you must pass arguments BY VALUE. Pass character strings as BY VALUE pointers that point to null-terminated strings. You must use the compiler options `NODYNAM` and `PGMNAME(LONGMIXED)` when you compile programs that call these functions.

fork(), exec(), and spawn()

You can call the `fork()`, `exec()`, and `spawn()` functions from a COBOL program, or from a non-COBOL program in the same process as COBOL programs. However, be aware of these restrictions:

- From a forked process you cannot access any COBOL sequential, indexed, or relative files that were open when you issued the `fork`. You get a file status code 92 when you attempt such access (`CLOSE`, `READ`, `WRITE`, `REWRITE`, `DELETE`, or `START`). You can access line-sequential files that were open at the time of a `fork`.
- You cannot use the `fork()` function in a process in which any of the following conditions are true:

- A COBOL SORT or MERGE is running.
- A declarative is running.
- The process has more than one Language Environment enclave (COBOL run unit).
- The process has used any of the COBOL reusable environment interfaces.
- The process has ever run an OS/VS COBOL or VS COBOL II program.
- With one exception, MVS DD allocations are not inherited from a parent process to a child process. The exception is the local spawn, which creates a child process in the same address space as the parent process. You request a local spawn by setting the environment variable `_BPX_ SHAREAS=YES` before you invoke the `spawn()` function.

The `exec()` and `spawn()` functions start a new Language Environment enclave in the new UNIX process. Therefore the target program of the `exec()` or `spawn()` is a main program, and all COBOL programs in the process start in initial state with all files closed.

Samples

Sample code for calling some of the POSIX routines is provided with the product. The sample source code is in the SIGYSAMP data set.

Table 61. Samples with POSIX function calls

Purpose	Sample	Functions used
Shows how to use some of the file and directory routines	IGYTFL1	getcwd() mkdir() rmdir() access()
Shows how to use the <code>iconv</code> routines to convert data	IGYTCNV	iconv_open() iconv() iconv_close()
Shows the use of the <code>exec()</code> routine to run a new program along with other process-related routines	IGYTEXC IGYTEXC1	fork() getpid() getppid() execl() perror() wait()
Shows how to get the <code>errno</code> value	IGYTERNO IGYTGETE	perror() fopen()
Shows the use of the interprocess communication message routines	IGYTMSQ IGYTMSQ2	ftok() msgget() msgsnd() perror() fopen() fclose() msgrcv() msgctl() perror()

RELATED TASKS

“Running in UNIX environments” on page 383

“Setting and accessing environment variables” on page 384

“Accessing main program parameters” on page 388

Language Environment Programming Guide

Accessing main program parameters

When you run a COBOL program from the UNIX shell command line, or with an `exec()` or `spawn()` function, the parameter list consists of three parameters passed by reference:

argument count

A binary fullword integer that contains the number of elements in each of the arrays that are passed in the second and third parameters.

argument length list

An array of pointers. The n th entry in the array is the address of a fullword binary integer that contains the length of the n th entry in the argument list.

argument list

An array of pointers. The n th entry in the array is the address of the n th character string passed as an argument in the `spawn()` or `exec()` function or in the command invocation. Each character string is null-terminated.

This array is never empty. The first argument is the character string that represents the name of the file associated with the process being started.

You can access these parameters with standard COBOL coding.

"Example: accessing main program parameters"

RELATED TASKS

"Running in UNIX environments" on page 383

"Setting and accessing environment variables" on page 384

"Calling UNIX/POSIX APIs" on page 386

Example: accessing main program parameters

The following example shows the three parameters that are passed by reference.

```

Identification division.
Program-id. "EXECED".
*****
* This sample program displays arguments received via exec() *
* function of UNIX System Services *
*****
Data division.
Working-storage section.
01 curr-arg-count pic 9(9) binary value zero.
Linkage section.
01 arg-count pic 9(9) binary. (1)
01 arg-length-list. (2)
    05 arg-length-addr pointer occurs 1 to 9999
        depending on curr-arg-count.
01 arg-list. (3)
    05 arg-addr pointer occurs 1 to 9999
        depending on curr-arg-count.
01 arg-length pic 9(9) binary.
01 arg pic X(65536).
Procedure division using arg-count arg-length-list arg-list.
*****
* Display number of arguments received *
*****

```

```

        Display "Number of arguments received: " arg-count
*****
* Display each argument passed to this program *
*****
        Perform arg-count times
            Add 1 to curr-arg-count
* *****
* * Set address of arg-length to address of current *
* * argument length and display *
* *****
            Set Address of arg-length
              to arg-length-addr(curr-arg-count)
            Display
              "Length of Arg " curr-arg-count " = " arg-length
* *****
* * Set address of arg to address of current argument *
* * and display *
* *****
            Set Address of arg to arg-addr(curr-arg-count)
            Display "Arg " curr-arg-count " = " arg (1:arg-length)
        End-Perform
        Display "Display of arguments complete."
        Goback.

```

- (1) This count contains the number of elements in the arrays that are passed in the second and third parameters.
- (2) This array includes a pointer to the length of the n th entry in the argument list.
- (3) This array includes a pointer to the n th character string passed as an argument on the `spawn()` or `exec()` function or the command invocation.

Part 4. Structuring complex applications

Chapter 24. Using subprograms	393
Main programs, subprograms, and calls	394
Ending and reentering main programs or subprograms	394
Transferring control to another program	396
Making static calls.	397
Making dynamic calls	397
Canceling a subprogram.	398
When to use a dynamic call	398
AMODE switching	399
Performance considerations of static and dynamic calls	401
Making both static and dynamic calls	401
Examples: static and dynamic CALL statements	402
Calling nested COBOL programs.	403
Nested programs	404
Example: structure of nested programs	405
Scope of names.	406
Making recursive calls	407
Calling to and from object-oriented programs	407
Using procedure and function pointers.	407
Deciding which type of pointer to use	408
Calling a C function pointer	408
Calling to alternate entry points	409
Making programs reentrant	409
 Chapter 25. Sharing data	411
Passing data.	411
Describing arguments in the calling program	413
Describing parameters in the called program	413
Testing for OMITTED arguments.	414
Coding the LINKAGE SECTION	414
Coding the PROCEDURE DIVISION for passing arguments	415
Grouping data to be passed	415
Handling null-terminated strings.	415
Using pointers to process a chained list	416
Example: using pointers to process a chained list	417
Passing return code information	419
Understanding the RETURN-CODE special register	419
Using PROCEDURE DIVISION RETURNING	420
Specifying CALL . . . RETURNING	420
Sharing data by using the EXTERNAL clause.	420
Sharing files between programs (external files)	421
Example: using external files	421
 Chapter 26. Creating a DLL or a DLL application	425
Dynamic link libraries (DLLs)	425
Compiling programs to create DLLs.	426
Linking DLLs	427
Example: sample JCL for a procedural DLL application	428
Prelinking certain DLLs	429
Using CALL identifier with DLLs	429
Search order for DLLs in HFS	430
Using DLL linkage and dynamic calls together	430
Using procedure or function pointers with DLLs	431
Calling DLLs from non-DLLs	432
Example: calling DLLs from non-DLLs	432
Using COBOL DLLs with C/C++ programs	434
Using DLLs in OO COBOL applications	434
 Chapter 27. Preparing COBOL programs for multithreading	437
Multithreading	437
Choosing THREAD to support multithreading	439
Transferring control with multithreading	439
Using cancel with threaded programs	439
Ending a program.	439
Preinitializing the COBOL environment	440
Processing files with multithreading.	440
File definition storage	440
Recommended usage for file access	441
Example: usage patterns of file input and output with multithreading.	441
Handling COBOL limitations with multithreading	442

Chapter 24. Using subprograms

Many applications consist of several separately compiled programs linked together. A *run unit* (the COBOL term synonymous with *enclave* in Language Environment) includes one or more object programs and can include object programs written in other Language Environment member languages.

Language Environment provides interlanguage support that allows your Enterprise COBOL programs to call and be called by programs that meet the requirements of Language Environment.

Name prefix alert: Do not use program names that start with prefixes used by IBM products. If you try to use programs whose names start with any of the following, your CALL statements might resolve to IBM library or compiler routines rather than to your intended program:

AFB	AFH	CBC	CEE	EDC
IBM	IFY	IGY	IGZ	ILB

Multithreading: You can combine your multithreaded COBOL programs with C programs and Language Environment-enabled assembler programs in the same run unit when those programs are also appropriately coded for multithreaded execution.

PL/I tasking: To include COBOL programs in applications that contain multiple PL/I tasks, follow these guidelines:

- Compile all COBOL programs that you run on multiple PL/I tasks with the THREAD option. If you compile any COBOL program with the NOTHREAD option, all of the COBOL programs must run in one PL/I task.
- You can call COBOL programs compiled with the THREAD option from one or more PL/I tasks. However, calls from PL/I programs to COBOL programs cannot include the TASK or EVENT option. The PL/I tasking call must first call a PL/I program or function that in turn calls the COBOL program. This indirection is required because you cannot specify the COBOL program directly as the target of a PL/I CALL statement that includes the TASK or EVENT option.
- Be aware that issuing a STOP RUN statement from a COBOL program or a STOP statement from a PL/I program terminates the entire Language Environment enclave, including all the tasks of execution.
- Do not code explicit POSIX threading (calls to pthread_create()) in any run unit that includes PL/I tasking.

RELATED CONCEPTS

“Main programs, subprograms, and calls” on page 394

RELATED TASKS

“Ending and reentering main programs or subprograms” on page 394

“Transferring control to another program” on page 396

“Making recursive calls” on page 407

“Calling to and from object-oriented programs” on page 407

“Using procedure and function pointers” on page 407

“Making programs reentrant” on page 409
Language Environment Writing ILC Applications

RELATED REFERENCES

Register conventions (*Language Environment Programming Guide*)

Main programs, subprograms, and calls

If a COBOL program is the first program in the run unit, that COBOL program is the *main program*. Otherwise, it and all other COBOL programs in the run unit are *subprograms*. No specific source-code statements or options identify a COBOL program as a main program or subprogram.

Whether a COBOL program is a main program or subprogram can be significant for either of two reasons:

- Effect of program termination statements
- State of the program when it is reentered after returning

In the PROCEDURE DIVISION, a program can call another program (generally called a *subprogram*), and this called program can itself call other programs. The program that calls another program is referred to as the *calling program*, and the program it calls is referred to as the *called program*. When the processing of the called program is completed, the called program can either transfer control back to the calling program or end the run unit.

The called COBOL program starts running at the top of the PROCEDURE DIVISION.

RELATED TASKS

“Ending and reentering main programs or subprograms”

“Making recursive calls” on page 407

“Transferring control to another program” on page 396

RELATED REFERENCES

Language Environment Programming Guide

Ending and reentering main programs or subprograms

You can use any of three termination statements in a program, but they have different effects, as shown in the table below:

Table 62. Effects of termination statements

Termination statement	Main program	Subprogram
EXIT PROGRAM	No action taken.	Return to calling program without ending the run unit. An implicit EXIT PROGRAM statement is generated if the called program has no next executable statement. In a threaded environment, the thread is not terminated unless the program is the first (oldest) one in the thread.

Table 62. Effects of termination statements (continued)

Termination statement	Main program	Subprogram
STOP RUN	<p>Return to calling program.¹ (Might be the operating system, and application will end.)</p> <p>STOP RUN terminates the run unit, and deletes all dynamically called programs in the run unit and all programs link-edited with them. (It does not delete the main program.)</p> <p>In a threaded environment the entire Language Environment enclave is terminated, including all threads running within the enclave.</p>	<p>Return directly to the program that called the main program.¹ (Might be the operating system, and application will end.)</p> <p>STOP RUN terminates the run unit, and deletes all dynamically called programs in the run unit and all programs link-edited with them. (It does not delete the main program.)</p> <p>In a threaded environment, the entire Language Environment enclave is terminated, including all threads running within the enclave.</p>
GOBACK	<p>Return to calling program.¹ (Might be the operating system, and application will end.)</p> <p>GOBACK terminates the run unit, and deletes all dynamically called programs in the run unit and all programs link-edited with them. (It does not delete the main program.)</p> <p>In a threaded environment, the thread is terminated.²</p>	<p>Return to calling program.</p> <p>In a threaded environment, if the program is the first program in a thread, the thread is terminated.²</p>
<p>1. If the main program is called by a program written in another language that does not follow Language Environment linkage conventions, return is to this calling program.</p> <p>2. If the thread is the initial thread of execution in an enclave, the enclave is terminated.</p>		

A subprogram is usually left in its *last-used state* when it terminates with EXIT PROGRAM or GOBACK. The next time the subprogram is called in the run unit, its internal values will be as they were left, except that return values for PERFORM statements will be reset to their initial values. (In contrast, a main program is initialized each time it is called.)

There are some cases where programs will be in their initial state:

- A subprogram that is dynamically called and then canceled will be in the initial state the next time it is called.
- A program with the INITIAL attribute will be in the initial state each time it is called.
- Data items defined in the LOCAL-STORAGE SECTION will be reset to the initial state specified by their VALUE clauses each time the program is called.

RELATED CONCEPTS

“Comparison of WORKING-STORAGE and LOCAL-STORAGE” on page 15
Thread termination (*Language Environment Programming Guide*)

RELATED TASKS

“Calling nested COBOL programs” on page 403

“Making recursive calls” on page 407

Transferring control to another program

You can use several different methods to transfer control to another program:

- Static calls
- Dynamic calls
- Calls to nested programs
- Calls to dynamic link libraries (DLLs)

In addition to making calls between Enterprise COBOL programs, you can also make static and dynamic calls between Enterprise COBOL and programs compiled with older compilers in all environments including CICS.

When you want to use OS/VS COBOL with Enterprise COBOL, there are differences in support between non-CICS and CICS:

In a non-CICS environment

You can make static and dynamic calls between Enterprise COBOL and other COBOL programs.

Exception: You cannot call VS COBOL II or OS/VS COBOL programs in the UNIX environment.

In a CICS environment

You cannot call OS/VS COBOL programs in the CICS environment. You must use EXEC CICS LINK to transfer control between OS/VS COBOL programs and other COBOL programs.

Calls to nested programs allow you to create applications using structured programming techniques. You can use nested programs in place of PERFORM procedures to prevent unintentional modification of data items. Call nested programs using either the CALL *literal* or CALL *identifier* statement.

Calls to dynamic link libraries (DLLs) are an alternative to COBOL dynamic CALL, and are well suited to object-oriented COBOL applications, UNIX programs, and applications that interoperate with C/C++.

Under z/OS, linking two load modules together results logically in a single program with a primary entry point and an alternate entry point, each with its own name. Each name by which a subprogram is to be dynamically called must be known to the system. You must specify each such name in linkage-editor or binder control statements as either a NAME or an ALIAS of the load module that contains the subprogram.

RELATED CONCEPTS

“Nested programs” on page 404

RELATED TASKS

“Making static calls” on page 397

“Making dynamic calls” on page 397

“Making both static and dynamic calls” on page 401

“Calling nested COBOL programs” on page 403

Making static calls

When you use the *CALL literal* statement in a program that is compiled using the NODYNAM and NODLL compiler options, a static call occurs. With these options, all calls of the *CALL literal* format are handled as static calls.

In the static *CALL* statement, the COBOL program and all called programs are part of the same load module. When control is transferred, the called program already resides in storage, and a branch to it takes place. Subsequent executions of the *CALL* statement make the called program available in its last-used state, unless the called program has the INITIAL attribute. In that case, the called program and each program directly or indirectly contained within it are placed into its initial state every time the called program is called within a run unit.

If you specify alternate entry points, a static *CALL* statement can use any alternate entry point to enter the called subprogram.

“Examples: static and dynamic *CALL* statements” on page 402

RELATED CONCEPTS

“Performance considerations of static and dynamic calls” on page 401

RELATED TASKS

“Calling to and from object-oriented programs” on page 407

“Making dynamic calls”

“Making both static and dynamic calls” on page 401

RELATED REFERENCES

“DYNAM” on page 282

“DLL” on page 281

CALL statement (*Enterprise COBOL Language Reference*)

Making dynamic calls

When you use the *CALL literal* statement in a program that is compiled using the DYNAM and the NODLL compiler options, or when you use the *CALL identifier* statement in a program that is compiled using the NODLL compiler option, a dynamic call occurs. The program name in the PROGRAM-ID paragraph or ENTRY statement must be identical to the corresponding load module name or load module alias of the load module that contains it.

In this form of the *CALL* statement, the called COBOL subprogram is not link-edited with the main program, but is instead link-edited into a separate load module, and is loaded at run time only when it is required (that is, when called).

Each subprogram that you call with a dynamic *CALL* statement can be part of a different load module that is a member of either the system link library or a private library that you supply. In either case it must be in an MVS load library; it cannot reside in the hierarchical file system. When a dynamic *CALL* statement calls a subprogram that is not resident in storage, the subprogram is loaded from secondary storage into the region or partition containing the main program and a branch to the subprogram is performed.

The first dynamic call to a subprogram within a run unit obtains a fresh copy of the subprogram. Subsequent calls to the same subprogram (by either the original caller or any other subprogram within the same run unit) result in a branch to the

same copy of the subprogram in its last-used state, provided the subprogram does not possess the INITIAL attribute. Therefore, the reinitialization of either of the following items is your responsibility:

- GO TO statements that have been altered
- Data items

If you call the same COBOL program under different run units, a separate copy of working storage is allocated for each run unit.

Restriction: Dynamic calls are not permitted to:

- COBOL DLL programs
- COBOL programs compiled with the PGMNAME(LONGMIXED) option, unless the program name is less than or equal to eight characters in length and is all uppercase
- COBOL programs compiled with the PGMNAME(LONGUPPER) option, unless the program name is less than or equal to eight characters in length
- More than one entry point in the same COBOL program (unless an intervening CANCEL statement has been executed)

Canceling a subprogram

When you issue a CANCEL statement for a subprogram, the storage occupied by the subprogram is freed, and a subsequent call to the subprogram functions as though it were the first call. You can cancel a subprogram from a program other than the original caller.

If the called subprogram has more than one entry point, ensure an intervening CANCEL statement is issued before you specify different entry points in the dynamic CALL statement.

After a CANCEL statement is processed for a dynamically called contained program, the program will be in the first-used state. However, the program is not loaded with the initial call, and storage is not freed after the program is canceled.

When to use a dynamic call

Use a dynamic CALL statement in any of the following circumstances:

- The load module that you want to dynamically call is in an MVS load library rather than in the hierarchical file system.
- You are concerned about ease of maintenance. Applications do not have to be link-edited again when dynamically called subprograms are changed.
- The subprograms called are used infrequently or are very large.

If the subprograms are called on only a few conditions, dynamic calls can bring in the subprogram only when needed.

If the subprograms are very large or there are many of them, using static calls might require too much main storage. Less total storage might be required to call and cancel one, then call and cancel another, than to statically call both.

- You want to call subprograms in their unused state, and you cannot use the INITIAL attribute.

When you cannot use the INITIAL attribute to ensure that a subprogram is placed in its unused state each time it is called, you can set the unused state by using a combination of dynamic CALL and CANCEL statements. When you cancel the subprogram that was first called by a COBOL program, the next call will cause the subprogram to be reinitialized to its unused state.

Using the CANCEL statement to explicitly cancel a subprogram that was dynamically loaded and branched to by a non-COBOL program does not result in any action being taken to release the subprogram's storage or to delete the subprogram.

- You have an OS/VS COBOL or other AMODE 24 program in the same run unit with Enterprise COBOL programs that you want to run in 31-bit addressing mode. COBOL dynamic call processing includes AMODE switching for AMODE 24 programs calling AMODE 31 programs, and vice versa. To have this implicit AMODE switching done, you must use the Language Environment run-time option ALL31(OFF). AMODE switching is not performed when ALL31(ON) is set.

When AMODE switching is performed, control is passed from the caller to a Language Environment library routine. After the switching is performed, control passes to the called program; the save area for the library routine will be positioned between the save area for the caller program and the save area for the called program.

- You do not know the program name to be called until run time. Here, use the format CALL *identifier*, where the *identifier* is a data item that will contain the name of the called program at run time. In terms of practical application, you might use CALL *identifier* when the program to be called is variable, depending on conditional processing in your program. CALL *identifier* is always dynamic, even if you use the NODYNAM compiler option.

"Examples: static and dynamic CALL statements" on page 402

RELATED CONCEPTS

"Performance considerations of static and dynamic calls" on page 401

"AMODE switching"

RELATED TASKS

"Making both static and dynamic calls" on page 401

RELATED REFERENCES

"DYNAM" on page 282

CALL statement (*Enterprise COBOL Language Reference*)

ENTRY statement (*Enterprise COBOL Language Reference*)

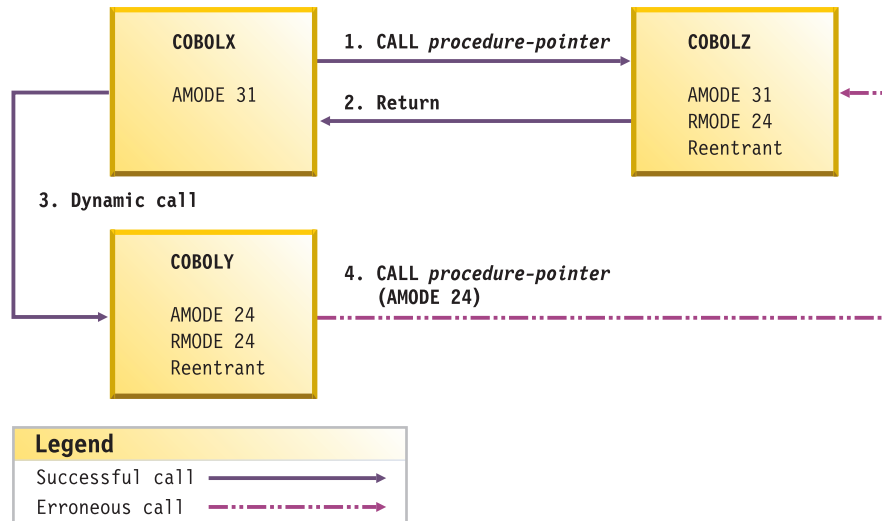
Language Environment Programming Reference

AMODE switching

When you have an application that has COBOL subprograms, some of the COBOL subprograms can be AMODE 31 and some can be AMODE 24. If your application consists of only COBOL programs, and you are using only static and dynamic calls, each COBOL subprogram will always be entered in the proper AMODE. For example, if you are using a COBOL dynamic call from an AMODE 31 COBOL program to an AMODE 24 COBOL program, the AMODE is automatically switched.

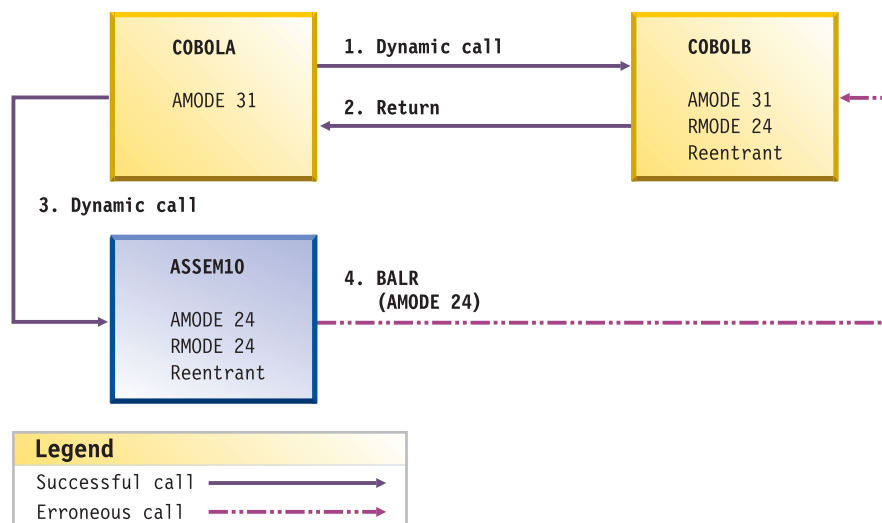
However, if you are using procedure pointers, function pointers, or other languages that call COBOL subprograms, you must ensure that when a COBOL program is called more than once in an enclave, it is entered in the same AMODE each time that it is called. The AMODE is not automatically switched in this case.

The following scenario shows that AMODE problems can arise when procedure pointers are used to call COBOL subprograms. This scenario is not supported because the COBOL program COBOLY is not entered in the same AMODE each time that it is called.



1. COBOLX is AMODE 31. It uses the SET statement to set a procedure pointer to COBOLZ. COBOLZ is a reentrant load module and is AMODE 31 and RMODE 24. COBOLX calls COBOLZ using the procedure pointer. COBOLZ is entered in AMODE 31.
2. COBOLZ returns to COBOLX.
3. COBOLX dynamically calls COBOLY, passing the procedure pointer for COBOLZ. COBOLY is a reentrant load module, and is AMODE 24 and RMODE 24. COBOLY is entered in AMODE 24.
4. COBOLY calls COBOLZ using the procedure pointer. This call causes COBOLZ to be entered in AMODE 24, which is not the same AMODE in which COBOLZ was entered when it was called the first time.

The following scenario uses a mix of COBOL and assembler language. This scenario is not supported because the COBOL program COBOLB is not entered in the same AMODE each time that it is called.



1. COBOLA is AMODE 31. COBOLA dynamically calls COBOLB. COBOLB is a reentrant load module and is AMODE 31 and RMODE 24. COBOLB is entered in AMODE 31.
2. COBOLB returns to COBOLA.

3. COBOLA dynamically calls ASSEM10, which is in assembler language. ASSEM10 is a reentrant load module, and is AMODE 24 and RMODE 24. ASSEM10 is entered in AMODE 24.
4. ASSEM10 loads COBOLB. ASSEM10 does a BALR instruction to COBOLB. COBOLB is entered in AMODE 24, which is not the same AMODE in which COBOLB was entered when it was called the first time.

RELATED CONCEPTS

“Storage and its addressability” on page 34

RELATED TASKS

“Making dynamic calls” on page 397

RELATED REFERENCES

ALL31 (*Language Environment Programming Reference*)

Performance considerations of static and dynamic calls

Because a statically called program is link-edited into the same load module as the calling program, a static call is faster than a dynamic call. A static call is the preferred method if your application does not require the services of the dynamic call.

Statically called programs cannot be deleted (using CANCEL), so static calls might take more main storage. If storage is a concern, think about using dynamic calls. Storage usage of calls depends on whether:

- The subprogram is called only a few times. Regardless of whether it is called, a statically called program is loaded into storage; a dynamically called program is loaded only when it is called.
- You subsequently delete the dynamically called subprogram with a CANCEL statement.

You cannot delete a statically called program, but you can delete a dynamically called program. Using a dynamic call and then a CANCEL statement to delete the dynamically called program after it is no longer needed in the application (and not after each call to it) might require less storage than using a static call.

RELATED TASKS

“Making static calls” on page 397

“Making dynamic calls” on page 397

Making both static and dynamic calls

You can specify both static and dynamic CALL statements in the same program if you compile the program with the NODYNAM compiler option. In this case, with the CALL *literal* statement the called subprogram will be link-edited with the main program into one load module. The CALL *identifier* statement results in the dynamic invocation of a separate load module.

When a dynamic CALL statement and a static CALL statement to the same subprogram are issued within one program, a second copy of the subprogram is loaded into storage. Because this arrangement does not guarantee that the subprogram will be left in its last-used state, results can be unpredictable.

RELATED REFERENCES

“DYNAM” on page 282

Examples: static and dynamic CALL statements

This example has three parts:

- Code that uses a static call to call a subprogram
- Code that uses a dynamic call to call the same subprogram
- The subprogram that is called by the two types of calls

The following example shows how you would code static calls:

```
PROCESS NODYNAM NODLL
IDENTIFICATION DIVISION.
DATA DIVISION.
WORKING-STORAGE SECTION.
01 RECORD-2                PIC X.                (6)
01 RECORD-1.                (2)
    05 PAY                  PICTURE S9(5)V99.
    05 HOURLY-RATE          PICTURE S9V99.
    05 HOURS                PICTURE S99V9.
. . .
PROCEDURE DIVISION.
    CALL "SUBPROG" USING RECORD-1.                (1)
    CALL "PAYMASTR" USING RECORD-1 RECORD-2.      (5)
    STOP RUN.
```

The following example shows how you would code dynamic calls:

```
DATA DIVISION.
WORKING-STORAGE SECTION.
77 PGM-NAME                PICTURE X(8).
01 RECORD-2                PIC x.                (6)
01 RECORD-1.                (2)
    05 PAY                  PICTURE S9(5)V99.
    05 HOURLY-RATE          PICTURE S9V99.
    05 HOURS                PICTURE S99V9.
. . .
PROCEDURE DIVISION.
. . .
    MOVE "SUBPROG" TO PGM-NAME.
    CALL PGM-NAME USING RECORD-1.                (1)
    CANCEL PGM-NAME.
    MOVE "PAYMASTR" TO PGM-NAME.                (4)
    CALL PGM-NAME USING RECORD-1 RECORD-2.      (5)
    STOP RUN.
```

The following example shows a called subprogram that is called by each of the two preceding calling programs:

```
IDENTIFICATION DIVISION.
PROGRAM-ID. SUBPROG.
DATA DIVISION.
LINKAGE SECTION.
01 PAYREC.                (2)
    10 PAY                PICTURE S9(5)V99.
    10 HOURLY-RATE        PICTURE S9V99.
    10 HOURS              PICTURE S99V9.
77 PAY-CODE              PICTURE 9.                (6)
PROCEDURE DIVISION USING PAYREC.                (1)
. . .
    EXIT PROGRAM.                (3)
    ENTRY "PAYMASTR" USING PAYREC PAY-CODE.      (5)
. . .
    GOBACK.                (7)
```

- (1) Processing begins in the calling program. When the first CALL statement is executed, control is transferred to the first statement of the PROCEDURE DIVISION in SUBPROG, which is the called program.

In each of the CALL statements, the operand of the first USING option is identified as RECORD-1.

- (2) When SUBPROG receives control, the values within RECORD-1 are made available to SUBPROG; however, in SUBPROG they are referred to as PAYREC.

The PICTURE character-strings within PAYREC and PAY-CODE contain the same number of characters as RECORD-1 and RECORD-2, although the descriptions are not identical.

- (3) When processing within SUBPROG reaches the EXIT PROGRAM statement, control is returned to the calling program. Processing continues in that program until the second CALL statement is issued.
- (4) In the example of a dynamically called program, because the second CALL statement refers to another entry point within SUBPROG, a CANCEL statement is issued before the second CALL statement.
- (5) With the second CALL statement in the calling program, control is again transferred to SUBPROG, but this time processing begins at the statement following the ENTRY statement in SUBPROG.
- (6) The values within RECORD-1 are again made available to PAYREC. In addition, the value in RECORD-2 is now made available to SUBPROG through the corresponding USING operand PAY-CODE.

When control is transferred the second time from the statically linked program, SUBPROG is made available in its last-used state (that is, if any values in SUBPROG storage were changed during the first execution, those changed values are still in effect). When control is transferred from the dynamically linked program, however, SUBPROG is made available in its initial state, because of the CANCEL statement that has been executed.

- (7) When processing reaches the GOBACK statement, control is returned to the calling program at the statement immediately following the second CALL statement.

In any given execution of the called program and either of the two calling programs, if the values within RECORD-1 are changed between the time of the first CALL and the second, the values passed at the time of the second CALL statement will be the changed, not the original, values. If you want to use the original values, you must save them.

Calling nested COBOL programs

By calling nested programs, you can create applications using structured programming techniques. You can also call nested programs in place of PERFORM procedures to prevent unintentional modification of data items.

Use either the CALL *literal* or CALL *identifier* statement to make calls to nested programs.

You can call a contained program only from its directly containing program, unless you identify the contained program as COMMON in its PROGRAM-ID clause. In that case, you can call the *common program* from any program that is contained (directly or indirectly) in the same program as the common program. Only contained programs can be identified as COMMON. Recursive calls are not allowed.

Follow these guidelines when using nested program structures:

- Code in the IDENTIFICATION DIVISION in each program. All other divisions are optional.
- Make the name of a contained program unique. You can use any valid COBOL word or an alphanumeric literal for the name.
- In the outermost program, set any CONFIGURATION SECTION options that might be required. Contained programs cannot have a CONFIGURATION SECTION.
- Include each contained program in the containing program immediately before its END PROGRAM marker.
- Use an END PROGRAM marker to terminate contained and containing programs.

You cannot use the THREAD option when compiling programs that contain nested programs.

RELATED CONCEPTS

"Nested programs"

RELATED REFERENCES

"Scope of names" on page 406

CALL statement (*Enterprise COBOL Language Reference*)

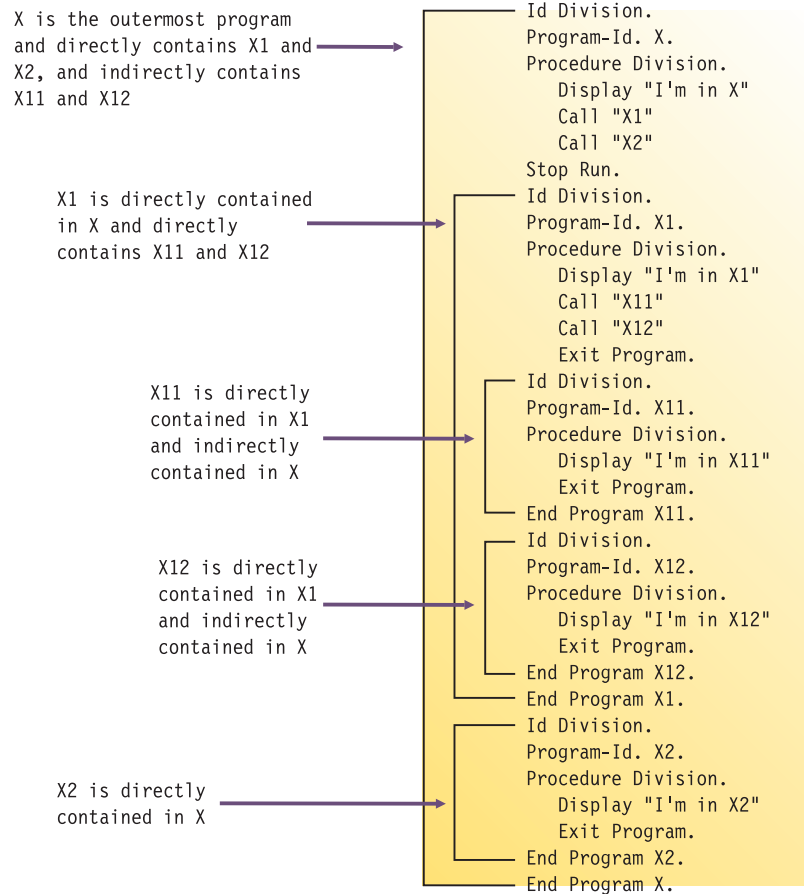
Nested programs

A COBOL program can *nest*, or contain, other COBOL programs. The nested programs can themselves contain other programs. A nested program can be directly or indirectly contained in a program.

There are four main advantages to nesting called programs:

- Nested programs give you a method to create modular functions for your application and maintain structured programming techniques. They can be used analogously to PERFORM procedures, but with more structured control flow and with the ability to protect local data items.
- Nested programs allow for debugging a program before including it in the application.
- Nested programs allow you to compile your application with a single invocation of the compiler.
- Calls to nested programs have the best performance of all the forms of COBOL CALL statements.

The following example describes a nested program structure with directly and indirectly contained programs:



“Example: structure of nested programs”

RELATED TASKS

“Calling nested COBOL programs” on page 403

RELATED REFERENCES

“Scope of names” on page 406

Example: structure of nested programs

The following example shows a nested structure with some contained programs identified as COMMON.

```

Program-Id. A.
Program-Id. A1.
Program-Id. A11.
Program-Id. A111.
End Program A111.
End Program A11.
Program-Id. A12 is Common.
End Program A12.
End Program A1.
Program-Id. A2 is Common.
End Program A2.
Program-Id. A3 is Common.
End Program A3.
End Program A.
  
```

The following table describes the calling hierarchy for the structure that is shown in the example above. Programs A12, A2, and A3 are identified as COMMON, and the calls associated with them differ.

This program	Can call these programs	And can be called by these programs
A	A1, A2, A3	None
A1	A11, A12, A2, A3	A
A11	A111, A12, A2, A3	A1
A111	A12, A2, A3	A11
A12	A2, A3	A1, A11, A111
A2	A3	A, A1, A11, A111, A12, A3
A3	A2	A, A1, A11, A111, A12, A2

Note that:

- A2 cannot call A1 because A1 is not common and is not contained in A2.
- A1 can call A2 because A2 is common.

Scope of names

Names in nested structures are divided into two classes: local and global. The class determines whether a name is known beyond the scope of the program that declares it. A specific search sequence locates the declaration of a name after it is referenced in a program.

Local names: Names (except the program-name) are local unless declared to be otherwise. Local names are visible or accessible only within the program in which they were declared. They are not visible or accessible to contained and containing programs.

Global names: A name that is global (indicated using the GLOBAL clause) is visible and accessible to the program in which it is declared and to all the programs that are directly and indirectly contained in that program. Therefore, the contained programs can share common data and files from the containing program simply by referencing the name of the item.

Any item that is subordinate to a global item (including condition-names and indexes) is automatically global.

You can declare the same name with the GLOBAL clause more than one time, providing that each declaration occurs in a different program. Be aware that you can mask, or hide, a name in a nested structure by having the same name occur in different programs of the same containing structure. However, this masking could cause problems during a search for a name declaration.

Searching for name declarations: When a name is referenced in a program, a search is made to locate the declaration for that name. The search begins in the program that contains the reference and continues outward to containing programs until a match is found. The search follows this process:

1. Declarations in the program are searched first.
2. If no match is found, only global declarations are searched in successive outer containing programs.

3. The search ends when the first matching name is found; otherwise, an error exists if no match is found.

The search is for a global name, not for a particular type of object associated with the name such as a data item or file connector. The search stops when any match is found, regardless of the type of object. If the object declared is of a different type than that expected, an error condition exists.

Making recursive calls

A called program can directly or indirectly execute its caller. For example, program X calls program Y, program Y calls program Z, and program Z then calls program X. This type of call is *recursive*.

To make a recursive call, you must code the RECURSIVE clause on the PROGRAM-ID paragraph of the recursively called program. If you try to recursively call a COBOL program that does not have the RECURSIVE clause coded on its PROGRAM-ID paragraph, a condition is signaled. If the condition remains unhandled, the run unit will end.

RELATED TASKS

“Identifying a program as recursive” on page 6

RELATED REFERENCES

RECURSIVE attribute (*Enterprise COBOL Language Reference*)
“THREAD” on page 309

Calling to and from object-oriented programs

When you create applications that contain object-oriented programs, the object-oriented COBOL programs are COBOL DLL programs and can be in one or more dynamic link libraries (DLLs). (Each class definition must be in a separate DLL, however.) Calls to or from COBOL DLL programs must either use DLL linkage or be static calls. COBOL dynamic calls to or from COBOL DLL programs are not supported.

If you must call a COBOL DLL program from a COBOL non-DLL program, other means that ensure that the DLL linkage mechanism is followed are available.

Using procedure and function pointers

Procedure pointers are data items defined with the USAGE IS PROCEDURE-POINTER clause. Function pointers are data items defined with the USAGE IS FUNCTION-POINTER clause. In this discussion, “pointer” refers to either a procedure-pointer data item or a function-pointer data item. You can set either of these data items to contain entry addresses of (or pointers to) these entry points:

- Another COBOL program that is not nested. For example, to have a user-written error-handling routine take control when an exception condition occurs, you must first pass the entry address of the routine to CEEHDLR, a condition management Language Environment callable service, to have it registered.
- A program written in another language. For example, to receive the entry address of a C function, call the function with the CALL RETURNING format of the CALL statement. It will return a pointer that you can either use as a function pointer or convert to a procedure pointer by using a form of the SET statement.

- An alternate entry point in another COBOL program (as defined in an ENTRY statement).

You can set procedure-pointer and function-pointer data items only by using format 6 of the SET statement. The SET statement sets the pointer to refer either to an entry point in the same load module as your program, to a separate load module, or to an entry point exported from a DLL, depending on the DYNAM|NODYNAM and DLL|NODLL compiler options. Therefore, consider these factors when using these pointer data items:

- If you compile your program with the NODYNAM and NODLL options and set your pointer item to a literal value (to an actual name of an entry point), the value must refer to an entry point in the same load module as your program. Otherwise the reference cannot be resolved.
- If you compile your program with the NODLL option and either set your pointer item to an identifier that will contain the name of the entry point at run time or set your pointer item to a literal and compile with the DYNAM option, then your pointer item, whether a literal or variable, must point to an entry point in a separate load module. The entry point can be either the primary entry point or an alternate entry point named in an ALIAS linkage-editor or binder statement.
- If you compile with the NODYNAM and DLL options and set your pointer item to a literal value (the actual name of an entry point), the value must refer to an entry point in the same load module as your program. or to an entry point name that is exported from a DLL module. In the latter case you must include the DLL side file for the target DLL module in the link edit of your program load module.
- If you compile with the NODYNAM and DLL options and set your pointer item to an identifier (a data item that contains the entry point name at run time), the identifier value must refer to the entry point name that is exported from a DLL module. In this case the DLL module name must match the name of the exported entry point.

If you set your pointer item to an entry address in a dynamically called load module, and your program subsequently cancels that dynamically called module, then your pointer item becomes undefined. Reference to it thereafter is not reliable.

Deciding which type of pointer to use

Use procedure pointers to call other COBOL programs and to call Language Environment callable services. They are more efficient than function pointers for COBOL-to-COBOL calls and are required for calls to Language Environment condition handling services.

Use function pointers to communicate with C/C++ programs or with services provided by the Java Native Interface.

Calling a C function pointer

Many callable services written in C return function pointers. You can call such a C function pointer from your COBOL program by using COBOL function pointers as illustrated here:

```
IDENTIFICATION DIVISION.
PROGRAM-ID. DEMO.
ENVIRONMENT DIVISION.
DATA DIVISION.
*****
WORKING-STORAGE SECTION.
01 FP USAGE FUNCTION-POINTER.
```



```

*****
PROCEDURE DIVISION.
    CALL "c-function" RETURNING FP.
    CALL FP.
    . . .

```

Calling to alternate entry points

You can specify another entry point where the program will begin running by using the ENTRY label in the called program. However, this is not recommended in a structured program.

Static calls to alternate entry points work without restriction.

Dynamic calls to alternate entry points require:

- NAME or ALIAS linkage-editor or binder control statements.
- The NAME compiler option.
- An intervening CANCEL for dynamic calls to the same module at differing entry points. CANCEL causes the program to be invoked in initial state when it is called at a new entry point.

“Examples: static and dynamic CALL statements” on page 402

RELATED TASKS

“Using procedure or function pointers with DLLs” on page 431

“Accessing JNI services” on page 527

RELATED REFERENCES

“DLL” on page 281

“DYNAM” on page 282

“NAME” on page 291

CANCEL statement (*Enterprise COBOL Language Reference*)

Procedure pointer (*Enterprise COBOL Language Reference*)

Function pointer (*Enterprise COBOL Language Reference*)

ENTRY statement (*Enterprise COBOL Language Reference*)

Making programs reentrant

If more than one user will run an application program at the same time (for example, users in different address spaces accessing the same program that resides in the link pack area), you must make the program *reentrant* by using the RENT option when you compile it. You do not need to worry about multiple copies of variables. The compiler creates the necessary reentrancy controls in your object module.

The following Enterprise COBOL programs must be reentrant:

- Programs to be used with CICS
- Programs to be preloaded with IMS
- Programs to be used as DB2 stored procedures
- Programs to be run in the UNIX environment
- Programs that are enabled for DLL support
- Programs that use object-oriented syntax

For reentrant programs, use the DATA compiler option and the HEAP and ALL31 run-time options to control whether dynamic data areas, such as WORKING-STORAGE, are obtained from storage below or above the 16-MB line.

RELATED CONCEPTS

“Storage and its addressability” on page 34

RELATED TASKS

“Compiling programs to create DLLs” on page 426

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

RELATED REFERENCES

“RENT” on page 299

“DATA” on page 277

ALL31 run-time option (*Language Environment Programming Reference*)

HEAP run-time option (*Language Environment Programming Reference*)

Chapter 25. Sharing data

When a run unit consists of several separately compiled programs that call each other, the programs must be able to communicate with each other. They also usually need to have access to common data.

This material describes how you can write programs that can share data with other programs. For the purposes of this discussion, a *subprogram* is any program called by another program.

RELATED TASKS

“Passing data”

“Coding the LINKAGE SECTION” on page 414

“Coding the PROCEDURE DIVISION for passing arguments” on page 415

“Passing return code information” on page 419

“Specifying CALL . . . RETURNING” on page 420

“Sharing data by using the EXTERNAL clause” on page 420

“Sharing files between programs (external files)” on page 421

Passing data

You can choose among three ways of passing data between programs:

BY REFERENCE

The subprogram refers to and processes the data items in storage of the calling program rather than working on a copy of the data.

BY CONTENT

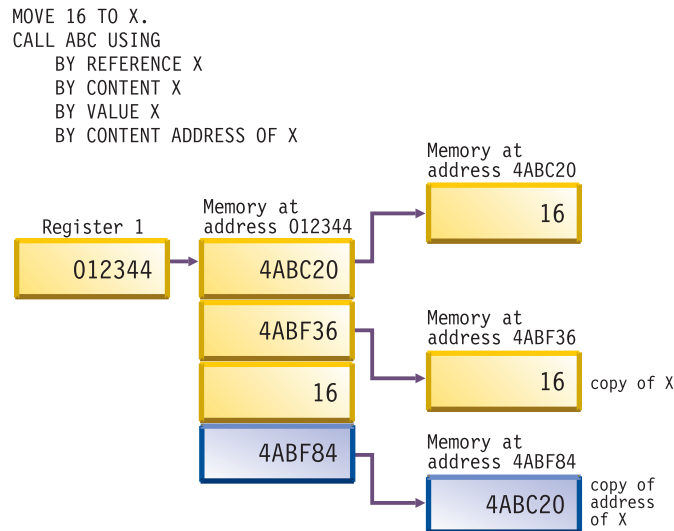
The calling program passes only the contents of the *literal* or *identifier*. With a CALL . . . BY CONTENT, the called program cannot change the value of the *literal* or *identifier* in the calling program, even if it modifies the data item in which it received the *literal* or *identifier*.

BY VALUE

The calling program or method passes the value of the *literal* or *identifier*, not a reference to the sending data item.

The called program or invoked method can change the parameter in the called program or invoked method. However, because the subprogram or method has access only to a temporary copy of the sending data item, these changes do not affect the argument in the calling program.

The following figure shows the differences in values passed BY REFERENCE, BY CONTENT, and BY VALUE:



Determine which of these data-passing methods to use based on what you want your program to do with the data.

Table 63. Methods for passing data in the CALL statement

Code	Purpose	Comments
CALL . . . BY REFERENCE <i>identifier</i>	To have the definition of the argument of the CALL statement in the calling program and the definition of the parameter in the called program share the same memory	Any changes made by the subprogram to the parameter affect the argument in the calling program.
CALL . . . BY REFERENCE <i>file-name</i>	To pass a Data Control Block (DCB) to assembler programs	The file-name must reference a QSAM sequential file. ¹
CALL . . . BY CONTENT ADDRESS OF <i>identifier</i>	To pass the address of <i>identifier</i> to a called program	Any changes to the copy of the address will not affect the address of <i>identifier</i> , but changes to <i>identifier</i> using the copy of the address will cause changes to <i>identifier</i> .
CALL . . . BY CONTENT <i>identifier</i>	To pass a copy of the identifier to the subprogram.	Changes to the parameter by the subprogram will not affect the caller's identifier.
CALL . . . BY CONTENT <i>literal</i>	To pass a copy of a literal value to a called program	
CALL . . . BY CONTENT LENGTH OF <i>identifier</i>	To pass a copy of the length of a data item	The calling program passes the length of the <i>identifier</i> from its LENGTH special register.
A combination of BY REFERENCE and BY CONTENT such as: CALL 'ERRPROC' USING BY REFERENCE A BY CONTENT LENGTH OF A.	To pass both a data item and a copy of its length to a subprogram	
CALL . . . BY VALUE <i>identifier</i>	To pass data to a program, such as a C/C++ program, that uses BY VALUE parameter linkage conventions.	A copy of the identifier is passed directly in the parameter list.
CALL . . . BY VALUE <i>literal</i>	To pass data to a program, such as a C/C++ program, that uses BY VALUE parameter linkage conventions.	A copy of the literal is passed directly in the parameter list.

Table 63. Methods for passing data in the CALL statement (continued)

Code	Purpose	Comments
CALL . . . BY VALUE ADDRESS OF <i>identifier</i>	To pass the address of <i>identifier</i> to a called program. This is the recommended way to pass data to a C/C++ program that expects a pointer to the data.	Any changes to the copy of the address will not affect the address of <i>identifier</i> , but changes to <i>identifier</i> using the copy of the address will cause changes to <i>identifier</i> .
CALL . . . RETURNING	To call a C/C++ function with a function return value	
1. File-names as CALL operands are allowed as an IBM extension to COBOL. Any use of the extension generally depends on the specific internal implementation of the compiler. Control block field settings might change in future releases. Any changes made to the control block are the user's responsibility and not supported by IBM.		

Describing arguments in the calling program

In the calling program, describe arguments in the DATA DIVISION in the same manner as other data items in the DATA DIVISION. Describe these data items in the LINKAGE SECTION of all the programs that it calls directly or indirectly.

Storage for arguments is allocated only in the highest outermost program. For example, program A calls program B, which calls program C. Data items are allocated in program A and are described in the LINKAGE SECTION of programs B and C, making the one set of data available to all three programs.

If you reference data in a file, the file must be open when the data is referenced.

Code the USING phrase of the CALL statement to pass the arguments.

Do not pass parameters allocated in storage above the 16-MB line to AMODE 24 subprograms. Use the DATA(24) option if the RENT option is in effect, or the RMODE(24) option if the NORENT option is in effect.

Describing parameters in the called program

You must know what is being passed from the calling program and describe it in the LINKAGE SECTION of the called program.

Code the USING phrase after the PROCEDURE DIVISION header to receive the parameters.

When arguments are passed to the subprogram BY REFERENCE, it is invalid for the subprogram to specify any relationship between its parameters and any fields other than those that are passed that are defined in the main program. The subprogram must not:

- Define a parameter to be larger in bytes than the corresponding argument.
- Use subscript references to refer to elements beyond the limits of tables that are passed as arguments by the calling program.
- Use reference modification to access data beyond the length of defined parameters.
- Manipulate the address of a parameter in order to access other data items that are defined in the calling program.

If any of these rules are violated, unexpected results might occur when the calling program is compiled with the OPTIMIZE compiler option.

Testing for OMITTED arguments

You can specify that one or more BY REFERENCE arguments are not to be passed to a called program by coding the OMITTED keyword in place of those arguments in the CALL statement. For example, to omit the second argument when calling program sub1, code this statement:

```
Call 'sub1' Using PARM1, OMITTED, PARM3
```

The arguments in the USING phrase of the CALL statement must match the parameters of the called program in number and position.

In a called program, you can test whether an argument was passed as OMITTED by comparing the address of the corresponding parameter to NULL. For example:

```
Program-ID. sub1.
```

```
...
```

```
Procedure Division Using RPARM1, RPARM2, RPARM3.
```

```
    If Address Of RPARM2 = Null Then
```

```
        Display 'No 2nd argument was passed this time'
```

```
    Else
```

```
        Perform Process-Parm-2
```

```
    End-If
```

RELATED CONCEPTS

“Storage and its addressability” on page 34

RELATED TASKS

“Specifying CALL . . . RETURNING” on page 420

“Sharing data by using the EXTERNAL clause” on page 420

“Sharing files between programs (external files)” on page 421

RELATED REFERENCES

CALL statement (*Enterprise COBOL Language Reference*)

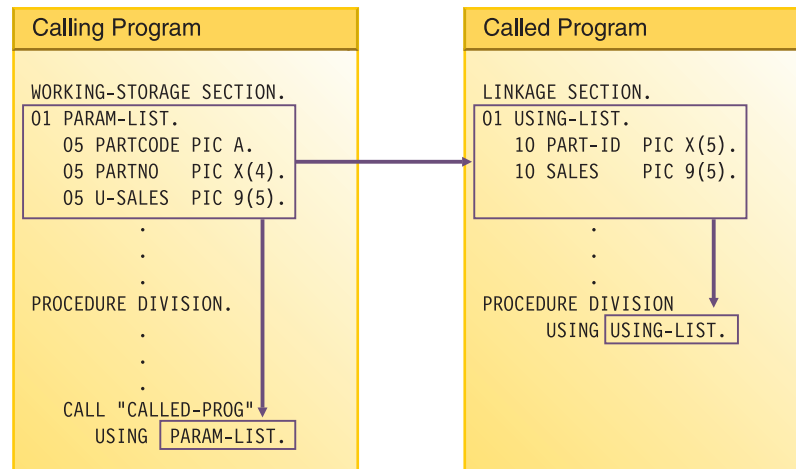
INVOKE statement (*Enterprise COBOL Language Reference*)

Coding the LINKAGE SECTION

Code the same number of data-names in the *identifier* list of the calling program as the number of data-names in the *identifier* list of the called program. Synchronize them by position, because the compiler passes the first *identifier* of the calling program to the first *identifier* of the called program, and so on.

You will introduce errors if the number of data-names in the *identifier* list of a called program is greater than the number of data-names in the *identifier* list of the calling program. The compiler does not try to match arguments and parameters.

The following figure shows a data item being passed from one program to another.



In the calling program, the code for parts (PARTCODE) and the part number (PARTNO) are referred to separately. In the called program, by contrast, the code for parts and the part number are combined into one data item (PART-ID). A reference in the called program to PART-ID is the only valid reference to these items.

Coding the PROCEDURE DIVISION for passing arguments

If you pass an argument BY VALUE, use the USING BY VALUE clause on the PROCEDURE DIVISION header of the subprogram:

```
PROCEDURE DIVISION USING BY VALUE
```

If you pass an argument BY REFERENCE or BY CONTENT, you do not need to indicate how the argument was passed on the PROCEDURE DIVISION.

You can code the header in either of the following ways:

```
PROCEDURE DIVISION USING
PROCEDURE DIVISION USING BY REFERENCE
```

RELATED REFERENCES

The procedure division header (*Enterprise COBOL Language Reference*)

Grouping data to be passed

Consider grouping all the data items you want to pass between programs and putting them under one level-01 item. If you do this, you can pass a single level-01 record between programs.

To make the possibility of mismatched records even smaller, put the level-01 record into a copy library and copy it in both programs. That is, copy it in the WORKING-STORAGE SECTION of the calling program and in the LINKAGE SECTION of the called program.

RELATED TASKS

“Coding the LINKAGE SECTION” on page 414

Handling null-terminated strings

COBOL supports null-terminated strings when you use null-terminated literals, the hexadecimal literal X'00', and string-handling verbs.

You can manipulate null-terminated strings (passed from a C program, for example) by using string-handling mechanisms such as those shown for the following code:

```
01 L      pic X(20) value z'ab'.
01 M      pic X(20) value z'cd'.
01 N      pic X(20).
01 N-Length pic 99    value zero.
01 Y      pic X(13) value 'Hello, World!'.
```

To determine the length of a null-terminated string and then display the value of the string:

```
Inspect N tallying N-length for characters before initial X'00'
Display 'N: ' N(1:N-length) ' Length: ' N-length
```

To move a null-terminated string to an alphanumeric string, and strip null:

```
Unstring N delimited by X'00'
           into X
```

To create a null-terminated string:

```
String Y delimited by size
          X'00' delimited by size
          into N.
```

To concatenate two null-terminated strings:

```
String L delimited by x'00'
          M delimited by x'00'
          X'00' delimited by size
          into N.
```

RELATED TASKS

“Manipulating null-terminated strings” on page 91

RELATED REFERENCES

Null-terminated alphanumeric literals (*Enterprise COBOL Language Reference*)

Using pointers to process a chained list

When you want to pass and receive addresses of record areas, you can manipulate pointer data items, which are a special type of data item to hold data addresses. Pointer data items are data items that either are defined with the `USAGE IS POINTER` clause or are `ADDRESS` special registers. A typical application for using pointer data items is in processing a chained list (a series of records where each record points to the next).

When you pass addresses between programs in a chained list, you can use `NULL` to assign the value of an address that is not valid (nonnumeric 0) to pointer items. You can assign the value `NULL` to a pointer data item in two ways:

- Use a `VALUE IS NULL` clause in its data definition.
- Use `NULL` as the sending field in a `SET` statement.

In the case of a chained list in which the pointer data item in the last record contains a null value, the code to check for the end of the list is as follows:

```
IF PTR-NEXT-REC = NULL
  . . .
  (logic for end of chain)
```


If the program has not reached the end of the list, the program can process the record and move on to the next record.

The data passed from a calling program might contain header information that you want to ignore. Because pointer data items are not numeric, you cannot directly perform arithmetic on them. However, to bypass header information, you can use the SET statement to increment the passed address.

“Example: using pointers to process a chained list”

RELATED TASKS

“Coding the LINKAGE SECTION” on page 414

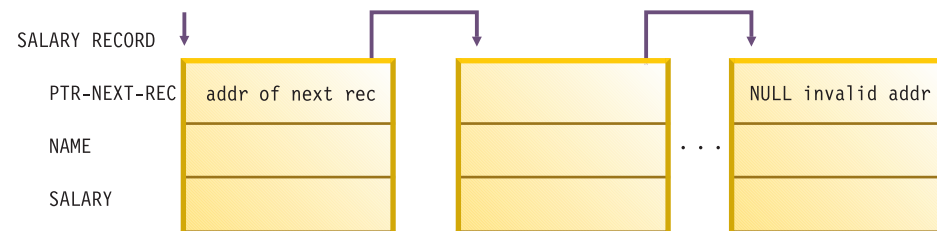
“Coding the PROCEDURE DIVISION for passing arguments” on page 415

RELATED REFERENCES

SET statement (*Enterprise COBOL Language Reference*)

Example: using pointers to process a chained list

For this example, picture a chained list of data that consists of individual salary records. The following figure shows one way to visualize how these records are linked in storage:



The first item in each record points to the next record, except for the last record. The first item in the last record contains a null value instead of an address, to indicate that it is the last record.

The high-level logic of an application that processes these records might look as follows:

```
OBTAIN ADDRESS OF FIRST RECORD IN CHAINED LIST FROM ROUTINE
CHECK FOR END OF THE CHAINED LIST
DO UNTIL END OF THE CHAINED LIST
  PROCESS RECORD
  GO ON TO THE NEXT RECORD
END
```

The following code contains an outline of the calling program, LISTS, used in this example of processing a chained list.

```
IDENTIFICATION DIVISION.
PROGRAM-ID. LISTS.
ENVIRONMENT DIVISION.
DATA DIVISION.
*****
WORKING-STORAGE SECTION.
77 PTR-FIRST          POINTER  VALUE IS NULL.          (1)
77 DEPT-TOTAL         PIC 9(4) VALUE IS 0.
*****
LINKAGE SECTION.
01 SALARY-REC.
   02 PTR-NEXT-REC     POINTER.                          (2)
```

```

02 NAME          PIC X(20).
02 DEPT          PIC 9(4).
02 SALARY        PIC 9(6).
01 DEPT-X        PIC 9(4).
*****
PROCEDURE DIVISION USING DEPT-X.
*****
* FOR EVERYONE IN THE DEPARTMENT RECEIVED AS DEPT-X,
* GO THROUGH ALL THE RECORDS IN THE CHAINED LIST BASED ON THE
* ADDRESS OBTAINED FROM THE PROGRAM CHAIN-ANCH
* AND CUMULATE THE SALARIES.
* IN EACH RECORD, PTR-NEXT-REC IS A POINTER TO THE NEXT RECORD
* IN THE LIST; IN THE LAST RECORD, PTR-NEXT-REC IS NULL.
* DISPLAY THE TOTAL.
*****
CALL "CHAIN-ANCH" USING PTR-FIRST          (3)
SET ADDRESS OF SALARY-REC TO PTR-FIRST      (4)
*****
PERFORM WITH TEST BEFORE UNTIL ADDRESS OF SALARY-REC = NULL (5)

    IF DEPT = DEPT-X
        THEN ADD SALARY TO DEPT-TOTAL
        ELSE CONTINUE
    END-IF
    SET ADDRESS OF SALARY-REC TO PTR-NEXT-REC (6)

END-PERFORM
*****
DISPLAY DEPT-TOTAL
GOBACK.

```

- (1) PTR-FIRST is defined as a pointer data item with an initial value of NULL. On a successful return from the call to CHAIN-ANCH, PTR-FIRST contains the address of the first record in the chained list. If something goes wrong with the call, however, and PTR-FIRST never receives the value of the address of the first record in the chain, a null value remains in PTR-FIRST and, according to the logic of the program, the records will not be processed.
- (2) The LINKAGE SECTION of the calling program contains the description of the records in the chained list. It also contains the description of the department code that is passed, using the USING clause of the CALL statement.
- (3) To obtain the address of the first SALARY-REC record area, the LISTS program calls the program CHAIN-ANCH:
- (4) The SET statement bases the record description SALARY-REC on the address contained in PTR-FIRST.
- (5) The chained list in this example is set up so that the last record contains an address that is not valid. This check for the end of the chained list is accomplished with a do-while structure where the value NULL is assigned to the pointer data item in the last record.
- (6) The address of the record in the LINKAGE-SECTION is set equal to the address of the next record by means of the pointer data item sent as the first field in SALARY-REC. The record-processing routine repeats, processing the next record in the chained list.

To increment addresses received from another program, you could set up the LINKAGE SECTION and PROCEDURE DIVISION like this:

```

LINKAGE SECTION.
01 RECORD-A.
    02 HEADER          PIC X(12).
    02 REAL-SALARY-REC PIC X(30).
. . .
01 SALARY-REC.
    02 PTR-NEXT-REC    POINTER.
    02 NAME            PIC X(20).
    02 DEPT            PIC 9(4).
    02 SALARY          PIC 9(6).
. . .
PROCEDURE DIVISION USING DEPT-X.
. . .
    SET ADDRESS OF SALARY-REC TO ADDRESS OF REAL-SALARY-REC

```

The address of SALARY-REC is now based on the address of REAL-SALARY-REC, or RECORD-A + 12.

RELATED TASKS

“Using pointers to process a chained list” on page 416

Passing return code information

Use the RETURN-CODE special register to pass and receive return codes between programs. Methods do not return information in the RETURN-CODE special register, but they can check the register after a call to a program.

You can also use the RETURNING phrase on the PROCEDURE DIVISION header in your method to return information to an invoking program or method. If you use PROCEDURE DIVISION . . . RETURNING with CALL . . . RETURNING, the RETURN-CODE register will not be set.

Understanding the RETURN-CODE special register

When a COBOL program returns to its caller, the contents of the RETURN-CODE special register are stored into register 15. When control is returned to a COBOL program or method from a call, the contents of register 15 are stored into the RETURN-CODE special register of the calling program or method. When control is returned from a COBOL program to the operating system, the special register contents are returned as a user return code.

You might need to think about this handling of the RETURN-CODE when control is returned to a COBOL program from a non-COBOL program. If the non-COBOL program does not use register 15 to pass back the return code, then the RETURN-CODE special register of the COBOL program might be updated with a value that is not valid. Unless you set this special register to a meaningful value before your Enterprise COBOL program returns to the operating system, a return code that is not valid will be passed back to the system.

For equivalent function between COBOL and C programs, have your COBOL program call the C program with the RETURNING option. If the C program (function) correctly declares a function value, the RETURNING value of the calling COBOL program will be set.

You cannot set the RETURN-CODE special register by using the INVOKE statement.

Using PROCEDURE DIVISION RETURNING . . .

Use the RETURNING phrase on the PROCEDURE DIVISION header of your program to return information to the calling program:

```
PROCEDURE DIVISION RETURNING dataname2
```

When the called program successfully returns to its caller, the value in *dataname2* is stored into the identifier that you specified in the RETURNING phrase of the CALL statement:

```
CALL . . . RETURNING dataname2
```

CEEPIPI: The results of specifying PROCEDURE DIVISION RETURNING on programs that are called with the Language Environment preinitialization service (CEEPIPI) are undefined.

Specifying CALL . . . RETURNING

You can specify the RETURNING phrase of the CALL statement for calls to functions in C/C++ or to subroutines in COBOL.

It has the following format:

```
CALL . . . RETURNING dataname2
```

The return value of the called program is stored into *dataname2*.

You must define *dataname2* in the DATA DIVISION of the calling COBOL program. The data type of the return value that is declared in the target function must be identical to the data type of *dataname2*.

Sharing data by using the EXTERNAL clause

Use the EXTERNAL clause to allow separately compiled programs and methods (including programs in a batch sequence) to share data items.

Code EXTERNAL on the 01-level data description in the WORKING-STORAGE SECTION of your program or method. The following rules apply:

- Items that are subordinate to an EXTERNAL group item are themselves EXTERNAL.
- You cannot use the name for the data item as the name for another EXTERNAL item in the same program.
- You cannot code the VALUE clause for any group item, or subordinate item, that is EXTERNAL.

In the run unit, any COBOL program or method that has the same data description for the item as the program containing the item can access and process the data item. For example, suppose program A has the following data description:

```
01 EXT-ITEM1    EXTERNAL    PIC 99.
```

Program B could access that data item by having the identical data description in its WORKING-STORAGE SECTION.

Remember, any program that has access to an EXTERNAL data item can change its value. Do not use this clause for data items that you need to protect.

Sharing files between programs (external files)

Use the EXTERNAL clause for files to allow separately compiled programs or methods in the run unit to access common files. It is recommended that you follow these guidelines:

- Use the same data-name in the FILE STATUS clause of all the programs that check the file status code.
- For all programs that check the same file status field, code the EXTERNAL clause on the level-01 data definition for the file status field in each program.

Using external files has these benefits:

- Your main program can reference the record area of the file, although the main program does not contain any input or output statements.
- Each subprogram can control a single input or output function, such as OPEN or READ.
- Each program has access to the file.

“Example: using external files”

RELATED REFERENCES

EXTERNAL clause (*Enterprise COBOL Language Reference*)

Example: using external files

The table below describes the main program and subprograms used in the example that follows.

Name	Function
ef1	The main program, which calls all the subprograms and then verifies the contents of a record area
ef1openo	Opens the external file for output and checks the file status code
ef1write	Writes a record to the external file and checks the file status code
ef1openi	Opens the external file for input and checks the file status code
ef1read	Reads a record from the external file and checks the file status code
ef1close	Closes the external file and checks the file status code

Additionally, COPY statements ensure that each subprogram contains an identical description of the file.

Each program in the example declares a data item with the EXTERNAL clause in its WORKING-STORAGE SECTION. This item is used for checking file status codes and is also placed using the COPY statement.

Each program uses three copybooks:

- The first is named efselect and is placed in the FILE-CONTROL paragraph.

```
Select ef1
Assign To ef1
File Status Is efs1
Organization Is Sequential.
```

- The second is named effile and is placed in the FILE SECTION.

```

Fd ef1 Is External
      Record Contains 80 Characters
      Recording Mode F.
01 ef-record-1.
  02 ef-item-1      Pic X(80).

```

- The third is named efwrkstg and is placed in the WORKING-STORAGE SECTION.

```

01 efs1          Pic 99 External.

```

Input-output using external files

```

Identification Division.
Program-Id.
  ef1.

*
* This is the main program that controls the external file
* processing.
*
Environment Division.
Input-Output Section.
File-Control.
  Copy efselect.
Data Division.
File Section.
  Copy effile.
Working-Storage Section.
  Copy efwrkstg.
Procedure Division.
  Call "eflopeno"
  Call "eflwrite"
  Call "eflclose"
  Call "eflopeni"
  Call "eflread"
  If ef-record-1 = "First record" Then
    Display "First record correct"
  Else
    Display "First record incorrect"
    Display "Expected: " "First record"
    Display "Found   : " ef-record-1
  End-If
  Call "eflclose"
  Goback.
End Program ef1.
Identification Division.
Program-Id.
  eflopeno.

*
* This program opens the external file for output.
*
Environment Division.
Input-Output Section.
File-Control.
  Copy efselect.
Data Division.
File Section.
  Copy effile.
Working-Storage Section.
  Copy efwrkstg.
Procedure Division.
  Open Output ef1
  If efs1 Not = 0
    Display "file status " efs1 " on open output"
    Stop Run
  End-If
  Goback.
End Program eflopeno.
Identification Division.

```

```

Program-Id.
    eflwrite.
*
* This program writes a record to the external file.
*
Environment Division.
Input-Output Section.
File-Control.
    Copy efselect.
Data Division.
File Section.
    Copy effile.
Working-Storage Section.
    Copy efwrkstg.
Procedure Division.
    Move "First record" to ef-record-1
    Write ef-record-1
    If efs1 Not = 0
        Display "file status " efs1 " on write"
    Stop Run
End-If
Goback.
End Program eflwrite.
Identification Division.
Program-Id.
    eflopeni.
*
* This program opens the external file for input.
*
Environment Division.
Input-Output Section.
File-Control.
    Copy efselect.
Data Division.
File Section.
    Copy effile.
Working-Storage Section.
    Copy efwrkstg.
Procedure Division.
    Open Input ef1
    If efs1 Not = 0
        Display "file status " efs1 " on open input"
    Stop Run
End-If
Goback.
End Program eflopeni.
Identification Division.
Program-Id.
    eflread.
*
* This program reads a record from the external file.
*
Environment Division.
Input-Output Section.
File-Control.
    Copy efselect.
Data Division.
File Section.
    Copy effile.
Working-Storage Section.
    Copy efwrkstg.
Procedure Division.
    Read ef1
    If efs1 Not = 0
        Display "file status " efs1 " on read"
    Stop Run
End-If

```

```

        Goback.
End Program eflread.
Identification Division.
Program-Id.
    eflclose.
*
* This program closes the external file.
*
Environment Division.
Input-Output Section.
File-Control.
    Copy efselect.
Data Division.
File Section.
    Copy effile.
Working-Storage Section.
    Copy efwrkstg.
Procedure Division.
    Close efl
    If efs1 Not = 0
        Display "file status " efs1 " on close"
        Stop Run
    End-If
    Goback.
End Program eflclose.

```

Chapter 26. Creating a DLL or a DLL application

Creating a dynamic link library (DLL) or a DLL application is similar to creating a regular COBOL application. It involves writing, compiling, and linking your source code.

Special considerations when writing a DLL or a DLL application include:

- Determining how the parts of the load module or the application relate to each other or to other DLLs
- Deciding what linking or calling mechanisms to use

Depending on whether you want a DLL load module or a load module that references a separate DLL, you need to use slightly different compiler and linkage-editor or binder options.

RELATED CONCEPTS

"Dynamic link libraries (DLLs)"

RELATED TASKS

"Using CALL identifier with DLLs" on page 429

"Using DLL linkage and dynamic calls together" on page 430

"Using COBOL DLLs with C/C++ programs" on page 434

"Using DLLs in OO COBOL applications" on page 434

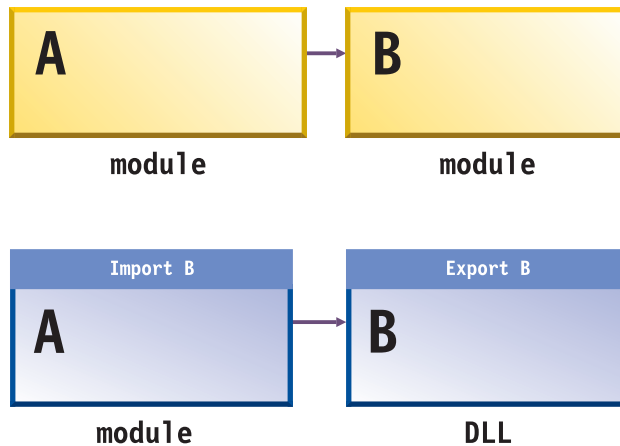
"Compiling programs to create DLLs" on page 426

"Linking DLLs" on page 427

"Using procedure and function pointers" on page 407

Dynamic link libraries (DLLs)

A DLL is a load module or a program object that can be accessed from other separate load modules. A DLL differs from a traditional load module in that it *exports* definitions of programs, functions, or variables to DLLs, DLL applications, or non-DLLs. Therefore, you do not need to link the target routines into the same load module as the referencing routine. When an application references a separate DLL for the first time, the system automatically loads the DLL into memory. In other words, calling a program in a DLL is similar to calling a load module with a dynamic CALL.



A DLL application is an application that references imported definitions of programs, functions, or variables.

Although some functions of z/OS DLLs overlap the functions provided by COBOL dynamic CALL statements, DLLs have several advantages over regular z/OS load modules and dynamic calls:

- DLLs are common across COBOL and C/C++, thus providing better interoperation for applications that use multiple programming languages. Reentrant COBOL and C/C++ DLLs can also interoperate smoothly.
- You can make calls to programs in separate DLL modules that have long program names. (Dynamic call resolution truncates program names to eight characters.) Using the COBOL option `PGMNAME(LONGUPPER)` or `PGMNAME(LONGMIXED)` and the COBOL DLL support, you can make calls between load modules with names of up to 160 characters.

DLLs are supported by IBM Language Environment, based on function provided by the z/OS DFSMS program management binder. DLL support is available for applications running under z/OS in batch or in TSO, CICS, UNIX, or IMS environments.

RELATED REFERENCES

“PGMNAME” on page 297

Binder support for DLLs (*z/OS DFSMS: Program Management*)

Compiling programs to create DLLs

When you compile a COBOL program with the DLL option, it becomes enabled for DLL support. Applications that use DLL support must be reentrant. Therefore, you must compile them with the `RENT` compiler option and link them with the `RENT` binder option.

In an application with DLL support, use the following compiler options depending on where the programs or classes are:

Table 64. Compiler options for DLL applications

Programs or classes in:	Compile with:
Root load module	DLL, RENT, NOEXPORTALL
DLL load modules used by other load modules	DLL, RENT, EXPORTALL

If a DLL load module includes some programs that are used only from within the DLL module, you can hide these routines inside the DLL by compiling them with NOEXPORTALL.

“Example: sample JCL for a procedural DLL application” on page 428

RELATED TASKS

“Linking DLLs”

“Prelinking certain DLLs” on page 429

Chapter 26, “Creating a DLL or a DLL application,” on page 425

RELATED REFERENCES

“DLL” on page 281

“EXPORTALL” on page 283

“RENT” on page 299

Linking DLLs

You can link your DLL-enabled object modules into separate DLL load modules, or you can link them together statically. You can decide whether to package the application as one module or as several DLL modules at link time.

Use of the DLL support in the DFSMS binder is recommended for linking DLL applications. The DFSMS binder can directly receive the output of the COBOL compilers, thus eliminating the prelink step. However, you must use the Language Environment prelinker before standard linkage editing if your DLL must reside in a PDS load library.

A binder-based DLL must reside in a PDSE or in an HFS file rather than in a PDS.

When linking a DLL application by using the DFSMS binder, use the following binder options:

Table 65. Binder options for DLL applications

Type of code	Link using binder parameters:
DLL applications	DYNAM(DLL), RENT, COMPAT(PM3) or COMPAT(CURRENT)
Applications that use mixed-case exported program names	CASE(MIXED)
Class definitions or INVOKE statements	

You must specify a SYSDEFSD DD statement to indicate the data set where the binder should create a DLL definition side file. This side file contains IMPORT control statements for each symbol exported by a DLL. The binder SYSLIN input (the binding code that references the DLL code) must include the DLL definition side files for the DLLs that are to be referenced from the module being linked.

If there are programs in the module that you do not want to make available with DLL linkage, you can edit the definition side file to remove these programs.

“Example: sample JCL for a procedural DLL application” on page 428

RELATED TASKS

Chapter 26, “Creating a DLL or a DLL application,” on page 425

“Compiling programs to create DLLs” on page 426

“Prelinking certain DLLs” on page 429

RELATED REFERENCES

Binder support for DLLs (*z/OS DFSMS: Program Management*)

Example: sample JCL for a procedural DLL application

The following sample shows how to create an application that consists of a main program calling a DLL subprogram. The first step creates the DLL load module containing the subprogram DemoDLLSubprogram. The second step creates the main load module containing the program MainProgram. The third step runs the application.

```
//DILLSAMP JOB ,
// TIME=(1),MSGLEVEL=(1,1),MSGCLASS=H,CLASS=A,
// NOTIFY=&SYSUID,USER=&SYSUID
// SET LEPFX='SYS1'
/*-----
/* Compile COBOL subprogram, bind to form a DLL.
/*-----
//STEP1 EXEC IGYWCL,REGION=80M,GOPGM=DEMODLL,
// PARM.COBOLE='RENT,PGMN(LM),DLL,EXPORTALL',
// PARM.LKED='RENT,LIST,XREF,LET,MAP,DYNAM(DLL),CASE(MIXED)'
//COBOL.SYSIN DD *
    Identification division.
    Program-id. "DemoDLLSubprogram".
    Procedure division.
        Display "Hello from DemoDLLSubprogram!".
    End program "DemoDLLSubprogram".
/*
//LKED.SYSDEFSD DD DSN=&&SIDEDECK,UNIT=SYSDA,DISP=(NEW,PASS),
// SPACE=(TRK,(1,1))
//LKED.SYSLMOD DD DSN=&&GOSET(&GOPGM),DSNTYPE=LIBRARY,DISP=(MOD,PASS)
//LKED.SYSIN DD DUMMY
/*-----
/* Compile and bind COBOL main program
/*-----
//STEP2 EXEC IGYWCL,REGION=80M,GOPGM=MAINPGM,
// PARM.COBOLE='RENT,PGMNAME(LM),DLL',
// PARM.LKED='RENT,LIST,XREF,LET,MAP,DYNAM(DLL),CASE(MIXED)'
//COBOL.SYSIN DD *
    Identification division.
    Program-id. "MainProgram".
    Procedure division.
        Call "DemoDLLSubprogram"
        Stop Run.
    End program "MainProgram".
/*
//LKED.SYSIN DD DSN=&&SIDEDECK,DISP=(OLD,DELETE)
/*-----
/* Execute the main program, calling the subprogram DLL.
/*-----
//STEP3 EXEC PGM=MAINPGM,REGION=80M
//STEPLIB DD DSN=&&GOSET,DISP=(OLD,DELETE)
// DD DSN=&LEPFX..SCEERUN,DISP=SHR
//SYSOUT DD SYSOUT=*
//CEEDUMP DD SYSOUT=*
```

Prelinking certain DLLs

You need to use the Language Environment prelinker before standard linkage editing if the DLL must reside in a PDS load library rather than in a PDSE or an HFS file.

After compiling your source DLL, prelink the object modules to form a single object module:

1. Specify a SYSDEFSD DD statement for the prelink step to indicate the data set where the prelinker should create a DLL definition side file for the DLL. This side file contains `IMPORT` prelinker control statements for each symbol exported by the DLL. The prelinker uses this side file to prelink other modules that reference the new DLL.
2. Specify the `DLLNAME(xxx)` prelinker option to indicate the DLL load module name for the prelinker to use in constructing the `IMPORT` control statements in the side file. Alternatively, the prelinker can obtain the DLL load module name from the `NAME` prelinker control statement or from the PDS member name in the `SYSMOD` DD statement for the prelink step.
3. If this DLL references any other DLLs, include the definition side files for these DLLs together with the object decks that are input to this prelink step. These side files instruct the prelinker to resolve the symbolic references in the current module to the symbols exported from the other DLLs.

Use the linkage editor or binder as usual to create the DLL load module from the object module produced by the prelinker. Specify the `RENT` option of the linkage editor or binder.

RELATED TASKS

“Compiling programs to create DLLs” on page 426

“Linking DLLs” on page 427

Using CALL identifier with DLLs

In a COBOL program that has been compiled with the DLL option, you can use `CALL identifier` statements as well as `CALL literal` statements to make calls to DLLs. However, there are a few additional considerations for the `CALL identifier` case.

For the contents of the *identifier* or for the *literal* in the `CALL` statement, use the name of either of the following programs:

- A nested program in the same compilation unit as is eligible to be called from the program containing the `CALL identifier` statement.
- A program in a separately bound DLL module. The target program name must be exported from the DLL, and the DLL module name must match the exported name of the target program.

In the nonnested case, the run-time environment interprets the program name in the *identifier* according to the setting of the `PGMNAME` compiler option of the program containing the `CALL` statement, and interprets the program name that is exported from the target DLL according to the setting of the `PGMNAME` option used when the target program was compiled.

The search for the target DLL in the hierarchical file system (HFS) is case sensitive. If the target DLL is a PDS or PDSE member, then the DLL member name must be eight characters or less. For the purpose of the search for the DLL as a PDS or PDSE member, the run time automatically converts the name to uppercase.

If the run-time environment cannot resolve the CALL statement in either of these cases, control is transferred to the ON EXCEPTION or ON OVERFLOW phrase of the CALL statement. If the CALL statement does not specify one of these phrases in this situation, Language Environment raises a severity-3 condition.

RELATED TASKS

“Using DLL linkage and dynamic calls together”
“Compiling programs to create DLLs” on page 426
“Linking DLLs” on page 427

RELATED REFERENCES

“DLL” on page 281
“PGMNAME” on page 297
CALL statement (*Enterprise COBOL Language Reference*)
“Search order for DLLs in HFS”

Search order for DLLs in HFS

When you use the hierarchical file system (HFS), the search order for resolving a DLL reference in a CALL statement depends on the setting of the Language Environment POSIX run-time option.

If the POSIX run-time option is set to ON, the search order is as follows:

1. The run-time environment looks for the DLL in the HFS. If the LIBPATH environment variable is set, the run time searches each directory listed. Otherwise, it searches just the current directory. The search for the DLL in the HFS is case sensitive.
2. If the run-time environment does not find the DLL in the HFS, it tries to load the DLL from the MVS load library search order of the caller. In this case, the DLL name must be eight characters or less. The run time automatically converts the DLL name to uppercase for this search.

If the POSIX run-time option is set to OFF, the search order is reversed:

1. The run-time environment tries to load the DLL from the search order for the load library of the caller.
2. If the run-time environment cannot load the DLL from this load library, it tries to load the DLL from the HFS.

RELATED TASKS

“Using CALL identifier with DLLs” on page 429

RELATED REFERENCES

POSIX (*Language Environment Programming Reference*)

Using DLL linkage and dynamic calls together

For applications (that is, Language Environment enclaves) that are structured as multiple, separately bound modules, you should use exclusively one form of linkage between modules: either dynamic call linkage or DLL linkage. *DLL linkage* refers to a call in a program that is compiled with the DLL and NODYNAM options where the call resolves to an exported name in a separate module. DLL linkage can also refer to an invocation of a method that is defined in a separate module.

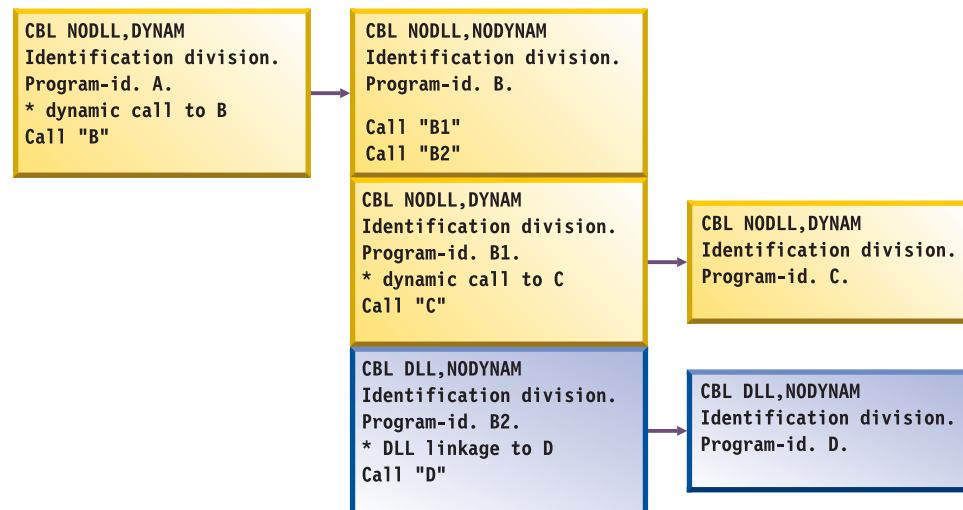
However, some applications require more flexibility. In these cases, you can use both DLL linkage and COBOL dynamic call linkage within a Language Environment enclave if the programs are compiled as follows:

Program A	Program B	Compile both with:
Contains dynamic call	Target of dynamic call	NODLL
Uses DLL linkage	Contains target program or method	DLL

Important: This support is available only in Language Environment V2R9 and later.

If a program contains a CALL statement for a separately compiled program and you compile one program with the DLL compiler option and the other program with NODLL, then the call is supported only if you bind the two programs together in the same module.

The following diagram shows several separately bound modules that mix dynamic calls and DLL linkage:



You cannot cancel programs that are called using DLL linkage.

All components of a DLL application must have the same AMODE. The automatic AMODE switching normally provided by COBOL dynamic calls is not available for DLL linkages.

Using procedure or function pointers with DLLs

In run units that contain a mix of DLLs and non-DLLs, use procedure and function pointers with care. When you use the SET *procedure-pointer-1* TO ENTRY *entry-name* or SET *function-pointer-1* TO ENTRY *entry-name* statement in a program that is compiled with the NODLL option, you must not pass the pointer to a program that is compiled with the DLL option. However, when you use this statement in a program that is compiled with the DLL option, you can pass the pointer to a program that is in a separately bound DLL module.

If you compile with the NODYNAM and DLL options and *entry-name* is an identifier, the identifier value must refer to the entry point name that is exported from a DLL

module. The DLL module name must match the name of the exported entry point. The following are further considerations in this case:

- The program name that is contained in the identifier is interpreted according to the setting of the PGMNAME (COMPAT|LONGUPPER|LONGMIXED) compiler option of the program containing the CALL statement.
- The program name that is exported from the target DLL is interpreted according to the setting of the PGMNAME option used when compiling the target program.
- The search for the target DLL in the HFS is case sensitive.
- If the target DLL is a PDS or PDSE member, then the DLL member name must be eight characters or less. For the purpose of the search for the DLL as a PDS or PDSE member, the name is automatically converted to uppercase.

Calling DLLs from non-DLLs

It is possible to call a DLL from a COBOL program that is compiled with the NODLL option, but there are restrictions. You can use the following methods to ensure that the DLL linkage is followed:

- Put the COBOL DLL programs that you want to call from the COBOL non-DLL programs in the load module that contains the main program. Use static calls from the COBOL non-DLL programs to call the COBOL DLL programs.

The COBOL DLL programs in the load module that contains the main program can call COBOL DLL programs in other DLLs.

- Put the COBOL DLL programs in DLLs and call them from COBOL non-DLL programs with CALL *function-pointer*, where *function-pointer* is set to a function descriptor of the program to be called. You can obtain the address of the function descriptor for the program in the DLL by calling a C routine that uses dlload and dllqueryfn.

“Example: calling DLLs from non-DLLs”

RELATED CONCEPTS

“Dynamic link libraries (DLLs)” on page 425

RELATED TASKS

“Using CALL identifier with DLLs” on page 429

“Using procedure and function pointers” on page 407

“Compiling programs to create DLLs” on page 426

“Linking DLLs” on page 427

RELATED REFERENCES

“DLL” on page 281

“EXPORTALL” on page 283

Example: calling DLLs from non-DLLs

The following sample code shows how a COBOL program that is not in a DLL (COBOL1) can call a COBOL program that is in a DLL (program ooc05R in DLL OOC05R):

```
CBL NODYNAM
  IDENTIFICATION DIVISION.
  PROGRAM-ID. 'COBOL1'.
  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  INPUT-OUTPUT SECTION.
  FILE-CONTROL.
  DATA DIVISION.
```



```

FILE SECTION.
WORKING-STORAGE SECTION.
01 DLL-INFO.
    03 DLL-LOADMOD-NAME PIC X(12).
    03 DLL-PROGRAM-NAME PIC X(160).
    03 DLL-PROGRAM-HANDLE FUNCTION-POINTER.
77 DLL-RC                PIC S9(9) BINARY.
77 DLL-STATUS            PIC X(1) VALUE 'N'.
88 DLL-LOADED            VALUE 'Y'.
88 DLL-NOT-LOADED       VALUE 'N'.

PROCEDURE DIVISION.

    IF DLL-NOT-LOADED
    THEN
*       Move the names in. They must be null terminated.
        MOVE Z'OOC05R' TO DLL-LOADMOD-NAME
        MOVE Z'ooc05r' TO DLL-PROGRAM-NAME

*       Call the C routine to load the DLL and to get the
*       function descriptor address.
        CALL 'A1CCDLGT' USING BY REFERENCE DLL-INFO
                                BY REFERENCE DLL-RC

        IF DLL-RC = 0
        THEN
            SET DLL-LOADED TO TRUE
        ELSE
            DISPLAY 'A1CCDLGT failed with rc = '
                DLL-RC
            MOVE 16 TO RETURN-CODE
            STOP RUN
        END-IF
    END-IF

*       Use the function pointer on the call statement to call the
*       program in the DLL.
*       Call the program in the DLL.
        CALL DLL-PROGRAM-HANDLE

GOBACK.

```

```

#include <stdio.h>
#include <dll.h>
#pragma linkage (A1CCDLGT,COBOL)

typedef struct dll_lm {
    char    dll_loadmod_name[(12)];
    char    dll_func_name[(160)];
    void    (*fptr) (void); /* function pointer */
} dll_lm;

void A1CCDLGT (dll_lm *dll, int *rc)
{
    dllhandle *handle;
    void (*fptr1)(void);
    *rc = 0;
    /* Load the DLL */
    handle = dllload(dll->dll_loadmod_name);
    if (handle == NULL) {
        perror("A1CCDLGT failed on call to load DLL./n");
        *rc = 1;
        return;
    }

    /* Get the address of the function */
    fptr1 = (void (*)(void))

```

```

        dllqueryfn(handle,dll->dll_func_name);
    if (fptrl == NULL) {
        perror("A1CCDLGT failed on retrieving function./n");
        *rc = 2;
        return;
    }
    /* Return the function pointer */
    dll->fptrl = fptrl;
    return;
}

```

Using COBOL DLLs with C/C++ programs

COBOL support for DLLs interoperates with the DLL support in the z/OS C/C++ products, except for COBOL EXTERNAL data. COBOL data items that are declared with the EXTERNAL attribute are independent of DLL support. These data items are accessible by name from any COBOL program in the run unit that declares them, regardless of whether the programs are in DLLs.

In particular, COBOL applications can call functions that are exported from C/C++ DLLs. Similarly, C/C++ applications can call COBOL programs that are exported from COBOL DLLs.

The COBOL options DLL, RENT, and EXPORTALL work much the same way as the DLL, RENT, and EXPORTALL options in C/C++. However, the C/C++ compiler produces DLL-enabled code by default. The DLL option applies only to C.

You can pass a C/C++ DLL function pointer to COBOL and use it within COBOL, receiving the C/C++ function pointer as a COBOL function-pointer data item.

The following example shows a COBOL call to a C function that returns a function pointer to a service, followed by a COBOL call to the service.

```

Identification Division.
Program-id. Demo.
Data Division.
Working-Storage section.
01  fp usage function-pointer.
Procedure Division.
    Call "c-function" returning fp.
    Call fp.

```

RELATED TASKS

“Compiling programs to create DLLs” on page 426

“Linking DLLs” on page 427

RELATED REFERENCES

“DLL” on page 281

“EXPORTALL” on page 283

“RENT” on page 299

EXTERNAL (*Enterprise COBOL Language Reference*)

Using DLLs in OO COBOL applications

You must compile each COBOL class definition using the DLL, THREAD, RENT, and DBCS compiler options, and link-edit it into a separate DLL module using the RENT binder option.

RELATED TASKS

Chapter 16, "Compiling, linking, and running OO applications," on page 257

"Compiling programs to create DLLs" on page 426

"Linking DLLs" on page 427

RELATED REFERENCES

"DLL" on page 281

"THREAD" on page 309

"RENT" on page 299

"DBCS" on page 279

Chapter 27. Preparing COBOL programs for multithreading

You can run your COBOL programs in multiple threads within a process under batch, TSO, IMS, or UNIX. There is no explicit COBOL language to use for multithreaded execution; rather, you compile with the THREAD compiler option.

COBOL does not directly support managing program threads. However, you can run COBOL programs that you compile with the THREAD compiler option in multithreaded application servers, in applications that use a C/C++ driver program to create the threads, in programs that interoperate with Java and use Java threads, and in applications that use PL/I tasking. In other words, other programs can call COBOL programs in such a way that the COBOL programs run in multiple threads within a process or as multiple program invocation instances within a thread. Your threaded application must run within a single Language Environment enclave.

Choosing LOCAL-STORAGE or WORKING-STORAGE: Because you must code your multithreaded programs as recursive, the persistence of data is that of any recursive program:

- Data items in the LOCAL-STORAGE SECTION are automatically allocated for each instance of a program invocation. When a program runs in multiple threads simultaneously, each invocation has a separate copy of LOCAL-STORAGE data.
- Data items in the WORKING-STORAGE SECTION are allocated once for each program and are thus available in their last-used state to all invocations of the program.

For the data that you want to isolate to an individual program invocation instance, define the data in the LOCAL-STORAGE SECTION. In general, this choice is appropriate for working data in threaded programs. If you declare data in WORKING-STORAGE and your program changes the contents of the data, you must take one of the following actions:

- Structure your application so that you do not access data in WORKING-STORAGE simultaneously from multiple threads.
- If you do access data simultaneously from separate threads, write appropriate serialization code.

RELATED CONCEPTS

"Multithreading"

RELATED TASKS

"Choosing THREAD to support multithreading" on page 439

"Transferring control with multithreading" on page 439

"Processing files with multithreading" on page 440

"Handling COBOL limitations with multithreading" on page 442

RELATED REFERENCES

"THREAD" on page 309

PROGRAM-ID paragraph (*Enterprise COBOL Language Reference*)

Multithreading

To use COBOL support for multithreading, you need to understand how processes, threads, run units, and program invocation instances relate to each other.

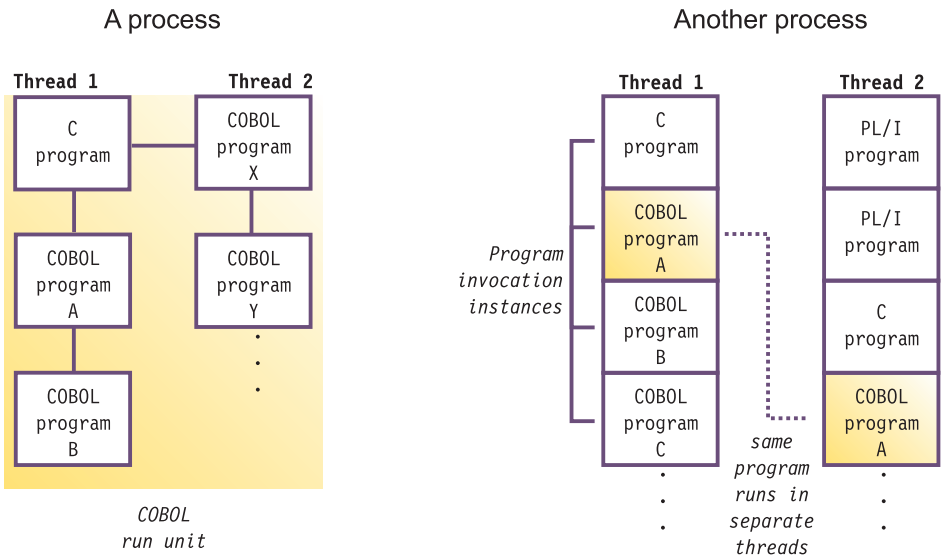
The operating system and multithreaded applications can handle execution flow within a *process*, which is the course of events when all or part of a program runs. Programs that run within a process can share resources. Processes can be manipulated. For example, they can have a high or low priority in terms of the amount of time that the system devotes to running the process.

Within a process, an application can initiate one or more *threads*, each of which is a stream of computer instructions that controls that thread. A multithreaded process begins with one stream of instructions (one thread) and can later create other instruction streams to perform tasks. These multiple threads can run concurrently. Within a thread, control is transferred between executing programs.

In a multithreaded environment, a COBOL *run unit* is the portion of the process that includes threads with actively executing COBOL programs. The COBOL run unit continues until no COBOL program is active in the execution stack for any of the threads. For example, a called COBOL program contains a GOTO statement and returns control to a C program. Within the run unit, COBOL programs can call non-COBOL programs, and vice versa.

Within a thread, control is transferred between separate COBOL and non-COBOL programs. For example, a COBOL program can call another COBOL program or a C program. Each separately called program is a *program invocation instance*. Program invocation instances of a particular program can exist in multiple threads within a given process.

The following illustration shows these relationships between processes, threads, run units, and program invocation instances.



RELATED CONCEPTS

Program Management Model (*Language Environment Programming Guide*)

Threads (*Language Environment Programming Guide*)

RELATED TASKS

"Choosing THREAD to support multithreading" on page 439

"Transferring control with multithreading" on page 439

"Processing files with multithreading" on page 440

"Handling COBOL limitations with multithreading" on page 442

Choosing THREAD to support multithreading

Select the THREAD compiler option for multithreading support. Choose THREAD if your program will be called in more than one thread in a single process by an application. Compiling with THREAD prepares the COBOL program for threading support. However, compiling with THREAD might reduce the performance of your program because of the serialization logic that is automatically generated.

In order to run COBOL programs in more than one thread, you must compile all of the COBOL programs in the run unit with the THREAD option. You must also compile them with the RENT option and link them with the RENT option of the binder or linkage editor.

Language restrictions: When you use the THREAD option, you cannot use certain language elements, as documented in the discussion of the THREAD option.

Recursion: Before you compile a program with the THREAD compiler option, you must specify the RECURSIVE phrase in the PROGRAM-ID paragraph. If you do not, you will get an error.

RELATED TASKS
"Sharing data in recursive or multithreaded programs" on page 17

RELATED REFERENCES
"THREAD" on page 309

Transferring control with multithreading

When you write COBOL programs for a multithreaded environment, choose appropriate program linkage and ending statements.

Using cancel with threaded programs

As in single-threaded environments, a called program is in its initial state when it is first called within a run unit and when it is first called after a CANCEL to the called program. Ensure that the program that you name on a CANCEL statement is not active on any thread. If you try to cancel an active program, a severity-3 Language Environment condition occurs.

Ending a program

Use GOBACK to return to the caller of the program. When you use GOBACK from the first program in a thread, the thread is terminated. If that thread is the initial thread in an enclave, the entire enclave is terminated.

Use EXIT PROGRAM as you would GOBACK, except from a main program where it has no effect.

Use STOP RUN to terminate the entire Language Environment enclave and to return control to the caller of the main program (which might be the operating system). All threads that are executing within the enclave are terminated.

Preinitializing the COBOL environment

If your threaded application requires preinitialization, use the Language Environment services (CEEPIPI interface). You cannot use the COBOL-specific interfaces for preinitialization (run-time option RTEREUS and functions IGZERRE and ILBOSTP0) to establish a reusable environment from any program compiled with the THREAD option.

RELATED CONCEPTS

Enclave termination (*Language Environment Programming Guide*)

RELATED TASKS

“Ending and reentering main programs or subprograms” on page 394

Processing files with multithreading

In your threaded applications, you can code COBOL statements for input and output in QSAM, VSAM, and line-sequential files. Each file definition (FD) has an implicit serialization lock. This lock is used with automatic serialization logic during the input or output operation that is associated with the execution of the following statements:

- OPEN
- CLOSE
- READ
- WRITE
- REWRITE
- START
- DELETE

Automatic serialization also occurs for the implicit MOVE that is associated with the following statements:

```
WRITE recordname FROM identifier  
READ file-name INTO identifier
```

Automatic serialization is not applied to any statements specified within the following conditional phrases:

- AT END
- NOT AT END
- INVALID KEY
- NOT INVALID KEY
- AT END-OF-PAGE
- NOT AT END-OF-PAGE

File definition storage

On all program invocations, the storage that is associated with a file definition (such as FD records and the record area that is associated with the SAME RECORD AREA clause) is allocated and available in its last-used state. All threads of execution share this storage. You can depend on automatic serialization for this storage during the execution of the OPEN, CLOSE, READ, WRITE, REWRITE, START, and DELETE statements, but not between uses of these statements.

Recommended usage for file access

The following file organizations are recommended for use in your threaded programs:

- Sequential organization
- Line-sequential organization
- Relative organization with sequential access
- Indexed organization with sequential access

To take full advantage of automatic serialization and to avoid explicitly writing your own serialization logic, use one of the recommended file organizations and use the following usage patterns when you access files in threaded programs:

Recommended usage pattern for input

```
OPEN INPUT fn
. . .
READ fn INTO local-storage item
. . .
* Process the record from the local-storage item
. . .
CLOSE fn
```

Recommended usage pattern for output

```
OPEN OUTPUT fn
. . .
* Construct output record in local-storage item
. . .
WRITE rec FROM local-storage item
. . .
CLOSE fn
```

With other usage patterns, you must take one of the following actions:

- Verify the safety of your application logic. Ensure that two instances of the program are never simultaneously active on different threads.
- Code explicit serialization logic by using calls to POSIX services.

To avoid serialization problems when you access a file from multiple threads, define the data items that are associated with the file (such as file-status data items and key arguments) in the LOCAL-STORAGE SECTION.

“Example: usage patterns of file input and output with multithreading”

RELATED TASKS

“Closing QSAM files” on page 132

“Closing VSAM files” on page 163

“Coding ERROR declaratives” on page 207

“Calling UNIX/POSIX APIs” on page 386

Example: usage patterns of file input and output with multithreading

The following examples show the need for explicit serialization logic when you deviate from the recommended usage pattern for file input and output in your multithreaded applications. These examples also show the unexpected behavior that might result if you fail to handle serialization properly.

In each example, two instances of one program that contains the sample operations are running within one run unit on two different threads.

Example 1

```
READ F1
. . .
REWRITE R1
```

The second thread might execute the READ statement after the READ statement is executed on the first thread but before the REWRITE statement is executed on the first thread. The REWRITE statement might not update the record that you intended. To ensure the results that you want, write explicit serialization logic.

Example 2

```
READ F1
. . .
* Process the data in the FD record description entry for F1
. . .
```

The second thread might execute the READ statement while the first thread is still processing a record in the FD record description entry. The second READ statement would overlay the record that the first thread is still processing. To avoid this problem, use the recommended technique of READ F1 INTO *local-storage-item*.

Other cases: You must give similar consideration to other usage patterns that involve a sequence of related input and output operations, such as START followed by READ NEXT, or READ followed by DELETE. Take appropriate steps to ensure the correct processing of file input and output.

Handling COBOL limitations with multithreading

Some COBOL applications depend on subsystems or other applications. In a multithreaded environment, these dependencies and others result in some limitations on COBOL programs.

In general, you must synchronize access to resources that are visible to the application within a run unit. Exceptions to this requirement are DISPLAY and ACCEPT, which you can use from multiple threads and supported COBOL file I/O statements with the recommended usage pattern; all synchronization is provided by the run-time environment.

CICS: You cannot run multithreaded applications in the CICS environment. You can run in the CICS environment a COBOL program that has been compiled with the THREAD option and that is part of an application that has no multiple threads or PL/I tasks.

Recursive: Because you must code the programs in a multithreaded application as recursive, you must adhere to all the restrictions and programming considerations that apply to recursive programs, such as not coding nested programs.

Reentrancy: You must compile your multithreading programs with the RENT compiler option and link them with the RENT option of the binder or linkage editor.

POSIX and PL/I: If you use POSIX threads in your multithreaded application, you must specify the Language Environment run-time option POSIX(ON). If the

application uses PL/I tasking, you must specify `POSIX(0FF)`. You cannot mix POSIX threads and PL/I tasks in the same application.

AMODE: You must run your multithreaded applications with `AMODE 31`. You can run a COBOL program that has been compiled with the `THREAD` option with `AMODE 24` as part of an application that does not have multiple threads or PL/I tasks.

Asynchronous signals: In a threaded application your COBOL program might be interrupted by an asynchronous signal or interrupt. If your program contains logic that cannot tolerate such an interrupt, you must disable the interrupts for the duration of that logic. Call a C/C++ function to set the signal mask appropriately.

Older COBOL programs: To run your COBOL programs on multiple threads of a multithreaded application, you must compile them with Enterprise COBOL and use the `THREAD` option. If you run programs that have been compiled with older compilers, you must follow these restrictions:

- Run applications that contain OS/VS COBOL programs only on the initial thread (IPT).
- Run applications that contain programs compiled by other older compilers only on one thread, although it can be a thread other than the initial thread.

IGZBRDGE, IGZETUN, and IGZEOPT: Do not use `IGZBRDGE`, the macro for converting static calls to dynamic calls, with programs that have been compiled with the `THREAD` option; this macro is not supported. Do not use the modules `IGZETUN` (for storage tuning) or `IGZEOPT` (for run-time options) for applications where the main program has been compiled with the `THREAD` option; these CSECTs are ignored.

UPSI switches: All programs and all threads in an application share a single copy of UPSI switches. If you modify switches in a threaded application, you must code appropriate serialization logic.

RELATED TASKS

“Making recursive calls” on page 407

“Processing files with multithreading” on page 440

Part 5. Using XML and COBOL together

Chapter 28. Processing XML input	447
XML parser in COBOL	447
Accessing XML documents	449
Parsing XML documents	449
Processing XML events	450
Writing procedures to process XML	456
Understanding the content of XML-CODE	457
Using XML-TEXT and XML-NTEXT	458
Transforming XML text to COBOL data items	459
Restriction on processing procedures	459
Ending processing procedures	459
Example: parsing XML	460
Understanding the encoding of XML documents	462
Coded character sets for XML documents	463
Code-page-sensitive characters in XML markup	464
Specifying the code page	464
Handling errors in parsing XML documents	465
Unhandled exceptions	467
Handling exceptions	468
Terminating XML parsing	468
Code-page conflict exception	469
Chapter 29. Producing XML output	471
Generating XML output	471
Example: generating XML	473
Program XGFX	473
Program Pretty	475
Output from program XGFX	475
Enhancing XML output	476
Example: enhancing XML output	477
Controlling the encoding of generated XML output	480
Handling errors in generating XML output	480

Chapter 28. Processing XML input

You can process XML input in your COBOL program by using the XML PARSE statement. The XML PARSE statement is the COBOL language interface to the high-speed XML parser, which is part of the COBOL run time. Processing XML input involves control being passed to and received from the XML parser. You start this exchange of control with the XML PARSE statement, which specifies a processing procedure that receives control from the XML parser to handle the parser events. You use special registers in your processing procedure to exchange information with the parser.

Use these COBOL facilities to process XML input:

- XML PARSE statement to begin XML parsing and to identify the document and your processing procedure
- Processing procedure to control the parsing: receive and process the XML events and associated document fragments, and optionally handle exceptions
- Special registers to receive and pass information:
 - XML-CODE to determine the status of XML parsing
 - XML-EVENT to receive the name of each XML event
 - XML-TEXT to receive XML document fragments from an alphanumeric document
 - XML-NTEXT to receive XML document fragments from a national document

RELATED CONCEPTS

“XML parser in COBOL”

RELATED TASKS

“Accessing XML documents” on page 449

“Parsing XML documents” on page 449

“Processing XML events” on page 450

“Handling errors in parsing XML documents” on page 465

“Understanding the encoding of XML documents” on page 462

RELATED REFERENCES

Appendix D, “XML reference material,” on page 625

XML specification (www.w3c.org/XML/)

XML parser in COBOL

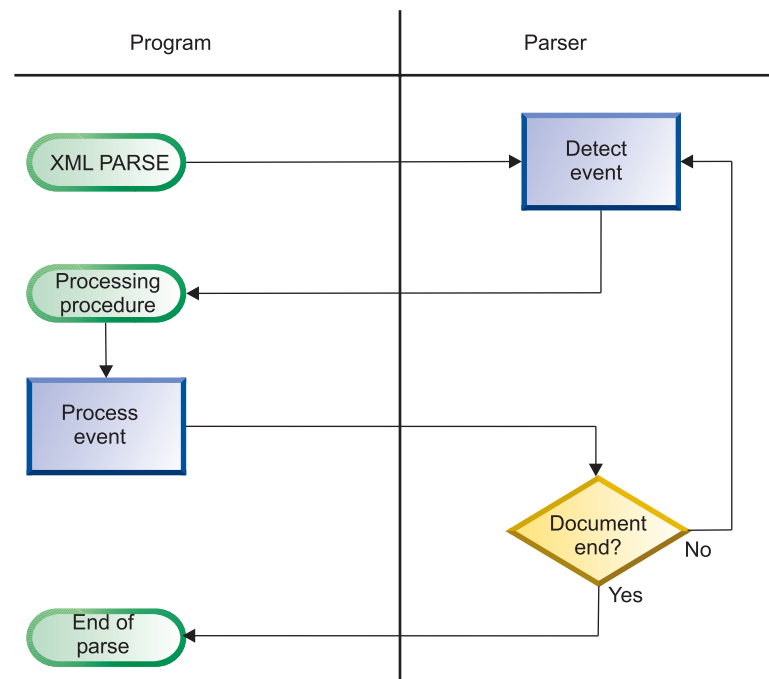
Enterprise COBOL provides an event-based interface that enables you to parse XML documents and transform them to COBOL data structures. The XML parser finds fragments (associated with XML events) within the document, and your processing procedure acts on these fragments. You code your procedure to handle each XML event. Throughout this operation, control passes back and forth between the parser and your procedure.

You start this exchange with the parser by using the XML PARSE statement, in which you designate your processing procedure. Execution of this XML PARSE statement begins the parsing and establishes your processing procedure with the parser. Each execution of your procedure causes the XML parser to continue analyzing the XML document and report the next event, passing back to your procedure the fragment

that it finds, such as the start of a new element. You can also specify in the XML PARSE statement two imperative statements to which you want control to be passed at the end of the parsing; one when a normal end occurs and one when an exception condition exists.

This figure gives a high-level overview of the basic exchange of control between the parser and your program:

XML parsing flow overview



Normally, parsing continues until the entire XML document has been parsed.

When the XML parser parses XML documents, it checks them for most aspects of well formedness as defined in the XML specification. A document is well formed if it adheres to the XML syntax and follows some additional rules such as proper use of end tags and uniqueness of attribute names.

RELATED TASKS

"Accessing XML documents" on page 449

"Parsing XML documents" on page 449

"Writing procedures to process XML" on page 456

"Handling errors in parsing XML documents" on page 465

"Understanding the encoding of XML documents" on page 462

RELATED REFERENCES

XML specification (www.w3c.org/XML/)

"XML conformance" on page 631

Accessing XML documents

Before you can parse an XML document with an XML PARSE statement, you must make the document available to your program. The most likely method of acquiring the document is by retrieval from a WebSphere MQ message, a CICS transient queue or communication area, or an IMS message processing queue.

If the XML document that you want to parse is held in a file, use ordinary COBOL facilities to place the document into a data item in your program:

- A FILE-CONTROL entry to define the file to your program
- The OPEN statement to open the file
- The READ statement to read all the records from the file into an alphanumeric or national data item that is defined in the WORKING-STORAGE SECTION or LOCAL-STORAGE SECTION of your program
- Optionally the STRING statement to string all of the separate records together into one continuous stream, to remove extraneous blanks, and to handle variable-length records

RELATED TASKS

“Coding COBOL programs to run under CICS” on page 359

Chapter 22, “Developing COBOL programs for IMS,” on page 377

Parsing XML documents

To parse XML documents, use the XML PARSE statement, as in the following example:

```
XML PARSE XMLDOCUMENT
    PROCESSING PROCEDURE XMLEVENT-HANDLER
    ON EXCEPTION
        DISPLAY 'XML document error ' XML-CODE
        STOP RUN
    NOT ON EXCEPTION
        DISPLAY 'XML document was successfully parsed.'
```

END-XML

In the XML PARSE statement you first identify the data item (XMLDOCUMENT in the example) that contains the XML document character stream. In the DATA DIVISION, you can declare the identifier as a national data item or as an alphanumeric data item. If it is a national data item, its content must be encoded in Unicode UTF-16BE, CCSID 1200. If it is alphanumeric, its content must be encoded with one of the supported single-byte character sets. (See the related reference below about coded characters sets for further details.)

If the identifier is alphanumeric and the XML document does not contain an encoding declaration, the document is parsed with the code page that is specified by the CODEPAGE compiler option in effect.

XML declaration: If the document that you are parsing contains an XML declaration, the declaration must begin in the first byte of the document. If the string `<?xml` starts after the first byte of the document, the parser generates an exception code. The attribute names that are coded in the XML declaration must all be in lowercase characters.

Next you specify the name of the procedure (XMLEVENT-HANDLER in the example) that is to handle the XML events from the document.

In addition, you can specify either or both of the following phrases to receive control after parsing finishes:

- ON EXCEPTION, to receive control when an unhandled exception occurs during parsing
- NOT ON EXCEPTION, to receive control otherwise

You can end the XML PARSE statement with the explicit scope terminator END-XML. Use END-XML to nest an XML PARSE statement that uses the ON EXCEPTION or NOT ON EXCEPTION phrase in a conditional statement (for example, in another XML PARSE statement or in an XML GENERATE statement).

The parser passes control to the processing procedure for each XML event. Control returns to the parser when the end of the processing procedure is reached. This exchange of control between the XML parser and the processing procedure continues until one of the following events occurs:

- The entire XML document has been parsed, as indicated by the END-OF-DOCUMENT event.
- The parser detects an error in the document and signals an EXCEPTION event, and the processing procedure does not reset the special register XML-CODE to zero before returning to the parser.
- You terminate the parsing process deliberately by setting the special register XML-CODE to -1 before returning to the parser.

RELATED TASKS

“Understanding the encoding of XML documents” on page 462

RELATED REFERENCES

“Coded character sets for XML documents” on page 463

XML PARSE statement (*Enterprise COBOL Language Reference*)

Processing XML events

Use the XML-EVENT special register to determine which event the parser passes to your processing procedure. XML-EVENT contains an event name such as 'START-OF-ELEMENT'. The parser passes the content for the event in special register XML-TEXT or XML-NTEXT, depending on the type of the XML identifier specified in the XML PARSE statement.

The events are shown below in the order in which they would occur for the following sample XML document. The text shown under the “Sample XML text” headings comes from this sample, with exact text delimited by angle brackets (<<>>).

The term “XML text” in the following descriptions means in general the content either of XML-TEXT or XML-NTEXT. (The sample XML document below does not contain any text that requires XML-NTEXT, however, and thus uses only XML-TEXT.)

Note that this example begins with an XML declaration. If an XML declaration occurs in a document that you are parsing, the declaration must begin in the first byte of the document; otherwise, the parser generates an exception code. The attribute names that are coded in the XML declaration must all be in lowercase characters.

```
<?xml version="1.0" encoding="ibm-1140" standalone="yes" ?>
<!--This document is just an example-->
<sandwich>
  <bread type="baker&apos;s best" />
```

```

<?spread please use real mayonnaise ?>
<meat>Ham &amp; turkey</meat>
<filling>Cheese, lettuce, tomato, etc.</filling>
<![CDATA[We should add a <relish> element in future!]]>
</sandwich>junk

```

START-OF-DOCUMENT

Description

Occurs once, at the beginning of the parsing of the document. XML text is the entire document, including any line-control characters such as LF (Line Feed) or NL (New Line).

Sample XML text

The text for this sample is 336 characters in length.

VERSION-INFORMATION

Description

Occurs within the optional XML declaration for the version information. XML text contains the version value. An *XML declaration* is XML text that specifies the version of XML that is used and the encoding of the document.

Sample XML text

```
<<1.0>>
```

ENCODING-DECLARATION

Description

Occurs within the XML declaration for the optional encoding declaration. XML text contains the encoding value.

Sample XML text

```
<<ibm-1140>>
```

STANDALONE-DECLARATION

Description

Occurs within the XML declaration for the optional standalone declaration. XML text contains the standalone value.

Sample XML text

```
<<yes>>
```

DOCUMENT-TYPE-DECLARATION

Description

Occurs when the parser finds a document type declaration. Document type declarations begin with the character sequence '`<!DOCTYPE`' and end with a right angle bracket ('`>`') character; some fairly complicated grammar rules describe the content in between. (See the *XML specification* for details. Also see the related reference below about code-page-sensitive characters for information about coding the exclamation point (!).) For this event, XML text contains the entire declaration, including the opening and closing character sequences. This is the only event for which XML text includes the delimiters.

Sample XML text

The sample does not have a document type declaration.

COMMENT

Description

Occurs for any comments in the XML document. XML text contains the data between the opening and closing comment delimiters, '<!--' and '-->', respectively. (See the related reference below about code-page-sensitive characters for information about coding the exclamation point (!).)

Sample XML text

```
<<This document is just an example>>
```

START-OF-ELEMENT

Description

Occurs once for each element start tag or empty element tag. XML text is set to the element name.

Sample XML text

In the order that they occur as START-OF-ELEMENT events:

1. <<sandwich>>
2. <<bread>>
3. <<meat>>
4. <<filling>>

ATTRIBUTE-NAME

Description

Occurs for each attribute in an element start tag or empty element tag, after a valid name is recognized. XML text contains the attribute name.

Sample XML text

```
<<type>>
```

ATTRIBUTE-CHARACTERS

Description

Occurs for each fragment of an attribute value. XML text contains the fragment. An attribute value normally consists only of a single string, even if it is split across lines. The attribute value might consist of multiple events, however.

Sample XML text

In the order in which they occur as ATTRIBUTE-CHARACTERS events:

1. <<baker>>
2. <<s best>>

Notice that the value of the type attribute in the sample consists of three fragments: the string 'baker', the single character "'", and the string 's best'. The single-character fragment "'" is passed separately as an ATTRIBUTE-CHARACTER event.

ATTRIBUTE-CHARACTER

Description

Occurs in attribute values for the predefined entity references 'ɪmp;#x27;', 'ɪpos;#x27;', '&gt;#x27;', '&lt;#x27;', and '&quot;#x27;'. See the *XML specification* for details of predefined entities.

Sample XML text

```
<<'>>
```

ATTRIBUTE-NATIONAL-CHARACTER

Description

Occurs in attribute values for numeric character references (Unicode code points or "scalar values") of the form '&#dd..;#x27;' or '&#hh..;#x27;', where *d* and *h* represent decimal and hexadecimal digits, respectively. If the scalar value of the national character is greater than 65,535 (NX'FFFF'), XML-NTEXT contains two encoding units (a *surrogate pair*) and has a length of 4 bytes. This pair of encoding units represents a single character. Do not create characters that are not valid by splitting this pair. (See the related reference below about code-page-sensitive characters for information about coding the number sign (#).)

Sample XML text

The sample does not contain a numeric character reference.

END-OF-ELEMENT

Description

Occurs once for each element end tag or empty element tag when the parser recognizes the closing angle bracket of the tag. XML text contains the element name.

Sample XML text

In the order that they occur as END-OF-ELEMENT events:

1. <<bread>>
2. <<meat>>
3. <<filling>>
4. <<sandwich>>

PROCESSING-INSTRUCTION-TARGET

Description

Occurs when the parser recognizes the name that follows the opening character sequence, '<#x26?#x27;', of a processing instruction (PI). PIs allow XML documents to contain special instructions for applications.

Sample XML text
<<spread>>

PROCESSING-INSTRUCTION-DATA

Description

Occurs for the data that follows the PI target, up to but not including the PI closing character sequence, '?>'. XML text contains the PI data, which includes trailing, but not leading, white-space characters.

Sample XML text
<<please use real mayonnaise >>

CONTENT-CHARACTERS

Description

This event represents the principal part of an XML document: the character data between element start and end tags. XML text contains this data, which usually consists only of a single string even if it is split across lines. If the content of an element includes any references or other elements, the complete content might consist of several events. The parser also uses the CONTENT-CHARACTERS event to pass the text of CDATA sections to your program.

Sample XML text

In the order that they occur as CONTENT-CHARACTERS events:

1. <<Ham >>
2. << turkey>>
3. <<Cheese, lettuce, tomato, etc.>>
4. <<We should add a <relish> element in future!>>

Notice that the content of the meat element in the sample consists of the string 'Ham ', the character '&', and the string ' turkey'. The single-character fragment '&' is passed separately as a CONTENT-CHARACTER event. Also notice the trailing and leading spaces, respectively, in these two string fragments.

CONTENT-CHARACTER

Description

Occurs in element content for the predefined entity references '&';', ''';', '>';', '<';', and '"';'. See the *XML specification* for details about predefined entities.

Sample XML text
<<&>>

CONTENT-NATIONAL-CHARACTER

Description

Occurs in element content for numeric character references (Unicode code points or "scalar values") of the form '&#dd..;';' or

'&#hh..;', where *d* and *h* represent decimal and hexadecimal digits, respectively. If the scalar value of the national character is greater than 65,535 (NX'FFFF'), XML-NTEXT contains two encoding units (a surrogate pair) and has a length of 4 bytes. This pair of encoding units represents a single character. Do not create characters that are not valid by splitting this pair. (See the related reference below about code-page-sensitive characters for information about coding the number sign (#).)

Sample XML text

The sample does not contain a numeric character reference.

START-OF-CDATA-SECTION

Description

Occurs at the start of a CDATA section. CDATA sections begin with the string '<![CDATA[' and end with the string ']>'. Such sections are used to "escape" blocks of text that contain characters that would otherwise be recognized as XML markup. XML text always contains the opening character sequence '<![CDATA['. The parser passes the content of a CDATA section between these delimiters as a single CONTENT-CHARACTERS event. (See the related reference below about code-page-sensitive characters for information about coding the exclamation point (!) and left square bracket ([].)

Sample XML text

```
<<<![CDATA[>>
```

END-OF-CDATA-SECTION

Description

Occurs when the parser recognizes the end of a CDATA section. (See the related reference below about code-page-sensitive characters for information about coding the right square bracket (]).)

Sample XML text

```
<<[]>>>
```

UNKNOWN-REFERENCE-IN-ATTRIBUTE

Description

Occurs within attribute values for entity references other than the five predefined entity references, as shown for ATTRIBUTE-CHARACTER above.

Sample XML text

The sample does not have any unknown entity references.

UNKNOWN-REFERENCE-IN-CONTENT

Description

Occurs within element content for entity references other than the predefined entity references, as shown for CONTENT-CHARACTER above.

Sample XML text

The sample does not have any unknown entity references.

END-OF-DOCUMENT

Description

Occurs when document parsing has completed.

Sample XML text

XML text is empty for the END-OF-DOCUMENT event.

EXCEPTION

Description

Occurs when an error in processing the XML document is detected. For encoding conflict exceptions, which are signaled before parsing begins, XML-TEXT (for XML documents in an alphanumeric data item) or XML-NTEXT (for XML documents in a national data item) either is zero length or contains only the encoding declaration value from the document.

Sample XML text

The part of the document that was parsed up to and including the point where the exception (the superfluous 'junk' after the </sandwich> tag) was detected.

RELATED REFERENCES

"Code-page-sensitive characters in XML markup" on page 464

XML-EVENT (*Enterprise COBOL Language Reference*)

4.6 Predefined entities (*XML specification* at www.w3.org/TR/REC-xml#sec-predefined-ent)

2.8 Prolog and document type declaration (*XML specification* at www.w3.org/TR/REC-xml#sec-prolog-dtd)

Writing procedures to process XML

In your processing procedure, code the statements to handle XML events.

For each event that the parser encounters, it passes information to your processing procedure in several special registers, as shown in the following table. Use these registers to populate your data structures and to control your processing.

Table 66. Special registers used by the XML parser

Special register	Content	Implicit definition and usage
XML-EVENT ¹	The name of the XML event	PICTURE X(30) USAGE DISPLAY VALUE SPACE
XML-CODE ²	An exception code or zero for each XML event	PICTURE S9(9) USAGE BINARY VALUE ZERO
XML-TEXT ¹	Text (corresponding to the event that the parser encountered) from the XML document if you specify an alphanumeric data item for the XML PARSE identifier	Variable-length elementary alphanumeric data item; 16-MB size limit

Table 66. Special registers used by the XML parser (continued)

Special register	Content	Implicit definition and usage
XML-NTEXT ¹	Text (corresponding to the event that the parser encountered) from the XML document if you specify a national data item for the XML PARSE identifier	Variable-length elementary national data item; 16-MB size limit
<ol style="list-style-type: none"> 1. You cannot use this special register as a receiving data item. 2. The XML GENERATE statement also uses XML-CODE. Therefore, if you code an XML GENERATE statement in the processing procedure, save the value of XML-CODE before the XML GENERATE statement and restore the saved value after the XML GENERATE statement. 		




When used in nested programs, these special registers are implicitly defined as GLOBAL in the outermost program.

Understanding the content of XML-CODE

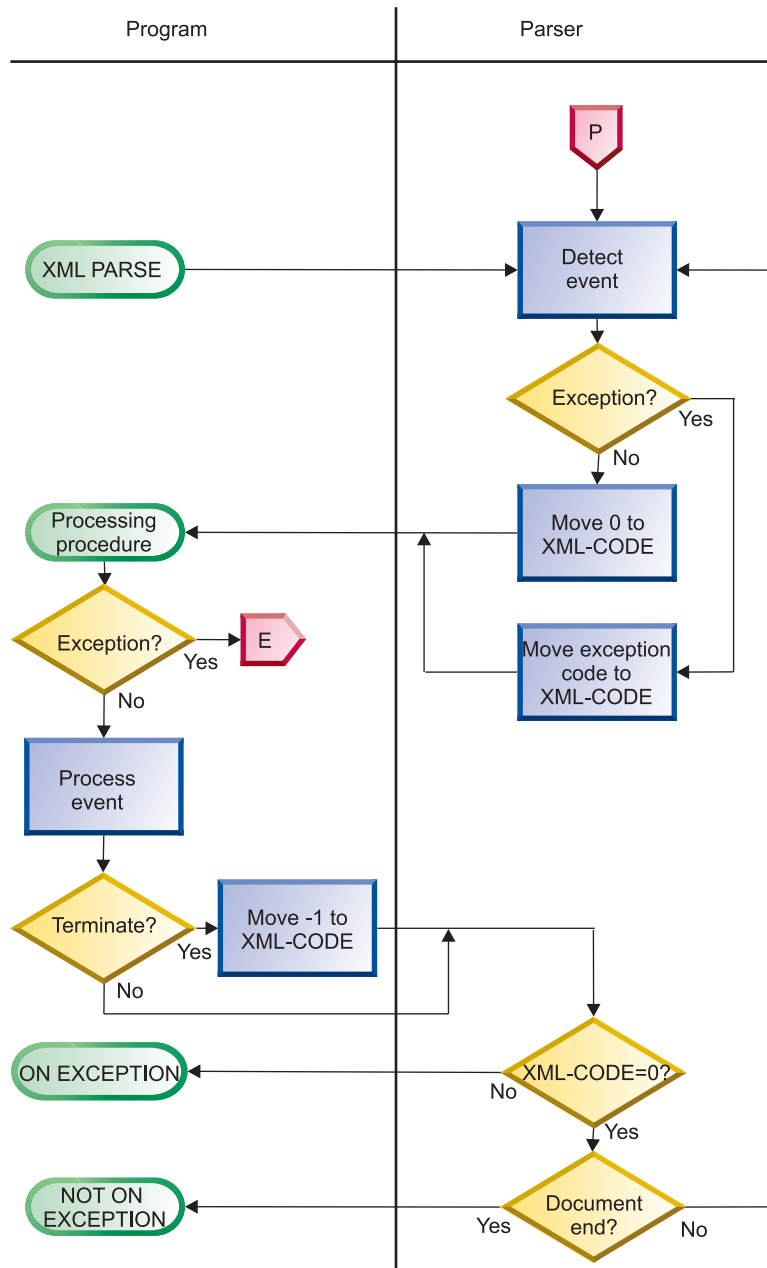
When the parser returns control to your XML PARSE statement, special register XML-CODE contains the most recent value set by the parser or by your processing procedure.

For each event except the EXCEPTION event, the value of XML-CODE is zero. If you set XML-CODE to -1 before you return control to the XML parser for an event other than EXCEPTION, processing stops with a user-initiated exception (as indicated by the returned XML-CODE value of -1). The result of changing XML-CODE to any other nonzero value before returning from any event is undefined.

For the EXCEPTION event, special register XML-CODE contains the exception code.

The following figure shows the flow of control between the parser and your processing procedure and shows how XML-CODE is used to pass information between them. The off-page connectors (for example, ) connect the multiple charts in this information. In particular,  in the following figure connects to the chart Control flow for XML exceptions (page 466), and  connects from XML CCSID exception flow control (page 469).

Control flow between XML parser and program, showing XML-CODE usage



Using XML-TEXT and XML-NTEXT

The special registers XML-TEXT and XML-NTEXT are mutually exclusive. The type of the XML PARSE identifier determines which of these two special registers is set, except for the ATTRIBUTE-NATIONAL-CHARACTER and CONTENT-NATIONAL-CHARACTER events. For these two events, XML-NTEXT is set regardless of the data item that you specify as the XML PARSE identifier.

When the parser sets XML-TEXT, XML-NTEXT is undefined (length 0). When the parser sets XML-NTEXT, XML-TEXT is undefined (length 0).

To determine how many national characters XML-NTEXT contains, use the LENGTH function. LENGTH OF XML-NTEXT contains the number of bytes, rather than characters, used by XML-NTEXT.

Transforming XML text to COBOL data items

Because XML data is neither fixed length nor fixed format, you need to use special techniques when you move XML data to COBOL data items.

For alphanumeric items, decide whether the XML data should go at the left (default) end of your COBOL item or at the right end. If it should go at the right end, specify the JUSTIFIED RIGHT clause in the declaration of the COBOL item.

Give special consideration to numeric XML values, particularly “decorated” monetary values such as ‘\$1,234.00’ or ‘\$1234’. These two strings mean the same thing in XML but would have completely different declarations as COBOL sending fields. Use one of these techniques when you move XML data to COBOL data items:

- If the format is reasonably regular, code a MOVE to an alphanumeric item that is redefined appropriately as a numeric-edited item. Then do the final move to a numeric (operational) item by moving from, and thus de-editing, the numeric-edited item. (A regular format would have the same number of digits after the decimal point, a comma separator for values greater than 999, and so on.)
- For simplicity and vastly increased flexibility, use the following functions for alphanumeric XML data:
 - NUMVAL to extract and decode simple numeric values from XML data that represents plain numbers
 - NUMVAL-C to extract and decode numeric values from XML data that represents monetary quantities

Note, however, that use of these functions is at the expense of performance.

Restriction on processing procedures

A processing procedure must not directly execute an XML PARSE statement. However, if a processing procedure passes control to a method or outermost program by using an INVOKE or CALL statement, the target method or program can execute the same or a different XML PARSE statement. You can also execute the same XML statement or different XML statements simultaneously from a program that is executing on multiple threads.

Ending processing procedures

The compiler inserts a return mechanism after the last statement in each processing procedure. You can code a STOP RUN statement in a processing procedure to end the run unit. However, an EXIT PROGRAM statement (when a CALL statement is active) or a GOBACK statement does not return control to the parser. Using either such statement in a processing procedure results in a severe error.

“Example: parsing XML” on page 460

RELATED TASKS

“Using national data (Unicode) in COBOL” on page 106

RELATED REFERENCES

“XML PARSE exceptions that allow continuation” on page 625

“XML PARSE exceptions that do not allow continuation” on page 628

XML-CODE (*Enterprise COBOL Language Reference*)

XML-EVENT (*Enterprise COBOL Language Reference*)

XML-NTEXT (*Enterprise COBOL Language Reference*)

XML-TEXT (*Enterprise COBOL Language Reference*)

Example: parsing XML

This example shows the basic organization of an XML PARSE statement and of a processing procedure. The XML document is shown in the source so that you can follow the flow of the parsing. The output of the program is also shown below. Compare the document to the output of the program to follow the interaction of the parser and the processing procedure, and to match events to document fragments.

```
Process flag(i,i)
Identification division.
    Program-id. xmlsaml.

Data division.
    Working-storage section.
*****
* XML document, encoded as initial values of data items.      *
*****
1 xml-document.
2 pic x(39) value '<?xml version="1.0" encoding="ibm-1140"'.
2 pic x(19) value ' standalone="yes"?>'.
2 pic x(39) value '<!--This document is just an example-->'.
2 pic x(10) value '<sandwich>'.
2 pic x(35) value ' <bread type="baker&apos;s best"/>'.
2 pic x(41) value ' <?spread please use real mayonnaise ?>'.
2 pic x(31) value ' <meat>Ham & turkey</meat>'.
2 pic x(40) value ' <filling>Cheese, lettuce, tomato, etc.'.
2 pic x(10) value '</filling>'.
2 pic x(35) value ' <![CDATA[We should add a <relish>'.
2 pic x(22) value ' element in future!]]>'.
2 pic x(31) value ' <listprice>$4.99 </listprice>'.
2 pic x(27) value ' <discount>0.10</discount>'.
2 pic x(11) value '</sandwich>'.
1 xml-document-length computational pic 999.

*****
* Sample data definitions for processing numeric XML content.  *
*****
1 current-element pic x(30).
1 xfr-ed pic x(9) justified.
1 xfr-ed-1 redefines xfr-ed pic 999999.99.
1 list-price computational pic 9v99 value 0.
1 discount computational pic 9v99 value 0.
1 display-price pic $$9.99.

Procedure division.
    mainline section.

        XML PARSE xml-document PROCESSING PROCEDURE xml-handler
        ON EXCEPTION
            display 'XML document error ' XML-CODE
        NOT ON EXCEPTION
            display 'XML document successfully parsed'
        END-XML

*****
* Process the transformed content and calculate promo price.  *
*****
display ' '
display '-----+++++++ Using information from XML '
    '+++++++-----'
display ' '
move list-price to display-price
display ' Sandwich list price: ' display-price
compute display-price = list-price * (1 - discount)
display ' Promotional price: ' display-price
display ' Get one today!'
```

```

goback.

xml-handler section.
  evaluate XML-EVENT
* ==> Order XML events most frequent first
  when 'START-OF-ELEMENT'
    display 'Start element tag: <' XML-TEXT '>'
    move XML-TEXT to current-element
  when 'CONTENT-CHARACTERS'
    display 'Content characters: <' XML-TEXT '>'
* ==> Transform XML content to operational COBOL data item...
  evaluate current-element
    when 'listprice'
* ==> Using function NUMVAL-C...
    compute list-price = function numval-c(XML-TEXT)
    when 'discount'
* ==> Using de-editing of a numeric edited item...
    move XML-TEXT to xfr-ed
    move xfr-ed-1 to discount
  end-evaluate
  when 'END-OF-ELEMENT'
    display 'End element tag: <' XML-TEXT '>'
    move spaces to current-element
  when 'START-OF-DOCUMENT'
    compute xml-document-length = function length(XML-TEXT)
    display 'Start of document: length=' xml-document-length
      ' characters.'
  when 'END-OF-DOCUMENT'
    display 'End of document.'
  when 'VERSION-INFORMATION'
    display 'Version: <' XML-TEXT '>'
  when 'ENCODING-DECLARATION'
    display 'Encoding: <' XML-TEXT '>'
  when 'STANDALONE-DECLARATION'
    display 'Standalone: <' XML-TEXT '>'
  when 'ATTRIBUTE-NAME'
    display 'Attribute name: <' XML-TEXT '>'
  when 'ATTRIBUTE-CHARACTERS'
    display 'Attribute value characters: <' XML-TEXT '>'
  when 'ATTRIBUTE-CHARACTER'
    display 'Attribute value character: <' XML-TEXT '>'
  when 'START-OF-CDATA-SECTION'
    display 'Start of CData: <' XML-TEXT '>'
  when 'END-OF-CDATA-SECTION'
    display 'End of CData: <' XML-TEXT '>'
  when 'CONTENT-CHARACTER'
    display 'Content character: <' XML-TEXT '>'
  when 'PROCESSING-INSTRUCTION-TARGET'
    display 'PI target: <' XML-TEXT '>'
  when 'PROCESSING-INSTRUCTION-DATA'
    display 'PI data: <' XML-TEXT '>'
  when 'COMMENT'
    display 'Comment: <' XML-TEXT '>'
  when 'EXCEPTION'
    compute xml-document-length = function length (XML-TEXT)
    display 'Exception ' XML-CODE ' at offset '
      xml-document-length '.'
  when other
    display 'Unexpected XML event: ' XML-EVENT '.'
  end-evaluate
.
End program xmlsaml.

```

Output from parse example: From the following output you can see which parsing events came from which fragments of the document:

```

Start of document: length=390 characters.
Version: <1.0>
Encoding: <ibm-1140>
Standalone: <yes>
Comment: <This document is just an example>
Start element tag: <sandwich>
Content characters: < >
Start element tag: <bread>
Attribute name: <type>
Attribute value characters: <baker>
Attribute value character: <'>
Attribute value characters: <s best>
End element tag: <bread>
Content characters: < >
PI target: <spread>
PI data: <please use real mayonnaise >
Content characters: < >
Start element tag: <meat>
Content characters: <Ham >
Content character: <&>
Content characters: < turkey>
End element tag: <meat>
Content characters: < >
Start element tag: <filling>
Content characters: <Cheese, lettuce, tomato, etc.>
End element tag: <filling>
Content characters: < >
Start of CDATA: <<![CDATA[>
Content characters: <We should add a <relish> element in future!>
End of CDATA: <]]>>
Content characters: < >
Start element tag: <listprice>
Content characters: <$4.99 >
End element tag: <listprice>
Content characters: < >
Start element tag: <discount>
Content characters: <0.10>
End element tag: <discount>
End element tag: <sandwich>
End of document.
XML document successfully parsed

-----+***** Using information from XML *****+-----

Sandwich list price: $4.99
Promotional price: $4.49
Get one today!

```

Understanding the encoding of XML documents

- | The parser decides how to process your document by using the following sources
- | of information about the document encoding:
- |
 - The *basic document encoding*
 - The *type of the data item* that contains the document
 - Any *document encoding declaration*
 - The *external code page*, if applicable
 - The set of *supported code pages*
- |
- | These sources of encoding information must be consistent with one another. The
- | parser signals an XML exception event if it finds a conflict.

The *basic document encoding* is one of the following encoding categories that the parser determines by examining the first few bytes of the XML document:

- ASCII
- EBCDIC
- Unicode UTF-16, either big-endian or little-endian
- Other unsupported encoding
- No recognizable encoding

The *type of the data item* that contains the document is also relevant. The parser supports the following combinations:

- National data items whose contents are encoded using Unicode UTF-16
- Alphanumeric data items whose contents are encoded using one of the supported single-byte character sets

The discovery that the encoding is Unicode UTF-16 also provides the code-page information, 1200 UTF-16BE (big-endian), since Unicode is effectively a single large code page. Thus, if the parser finds a UTF-16 document in a national data item, it ignores external code-page information.

But if the basic document encoding is ASCII or EBCDIC, the parser needs specific code-page information to be able to parse the XML document correctly. This additional code-page information is acquired from the document encoding declaration or from the external code page.

The *document encoding declaration* is an optional part of the XML declaration at the beginning of the document. (See the related task about specifying the code page for details.)

The *external code page* is the value in effect for the CODEPAGE compiler option.

Finally, the encoding must be one of the *supported code pages*. (See the related reference below about coded character sets for XML documents for details.)

RELATED TASKS

“Specifying the code page” on page 464

RELATED REFERENCES

“Coded character sets for XML documents”

“XML PARSE exceptions that allow continuation” on page 625

“XML PARSE exceptions that do not allow continuation” on page 628

Coded character sets for XML documents

Documents in national data items must be encoded with Unicode UTF-16, CCSID 1200.

Documents in alphanumeric data items must be encoded with one of the single-byte EBCDIC code pages shown in the table below.

Table 67. Supported EBCDIC code pages

CCSID	Description
1047	Latin 1 / Open Systems
1140, 37	USA, Canada, . . . Euro Country Extended Code Page (ECECP), Country Extended Code Page (CECP)

Table 67. Supported EBCDIC code pages (continued)

CCSID	Description
1141, 273	Austria, Germany ECECP, CECP
1142, 277	Denmark, Norway ECECP, CECP
1143, 278	Finland, Sweden ECECP, CECP
1144, 280	Italy ECECP, CECP
1145, 284	Spain, Latin America (Spanish) ECECP, CECP
1146, 285	UK ECECP, CECP
1147, 297	France ECECP, CECP
1148, 500	International ECECP, CECP
1149, 871	Iceland ECECP, CECP

To parse XML documents that are encoded in other code pages, first convert the documents to national characters by using the NATIONAL-OF function. You can convert the individual pieces of document text that are passed to the processing procedure in special register XML-NTEXT back to the original code page by using the DISPLAY-OF function.

RELATED TASKS

“Converting national data” on page 107

“Specifying the code page”

Code-page-sensitive characters in XML markup

Several special characters that are used in XML markup have different hexadecimal representations in various EBCDIC code pages. The following table shows the special characters and their hexadecimal values for the supported code page CCSIDs:

Table 68. Hexadecimal values of special characters for code page CCSIDs

Character	1047	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149
[	X'AD'	X'BA'	X'63'	X'9E'	X'B5'	X'90'	X'4A'	X'B1'	X'90'	X'4A'	X'AE'
]	X'BD'	X'BB'	X'FC'	X'9F'	X'9F'	X'51'	X'5A'	X'BB'	X'B5'	X'5A'	X'9E'
!	X'5A'	X'5A'	X'4F'	X'4F'	X'4F'	X'4F'	X'BB'	X'5A'	X'4F'	X'4F'	X'4F'
|	X'4F'	X'4F'	X'BB'	X'BB'	X'BB'	X'BB'	X'4F'	X'4F'	X'BB'	X'BB'	X'BB'
#	X'7B'	X'7B'	X'7B'	X'4A'	X'63'	X'B1'	X'69'	X'7B'	X'B1'	X'7B'	X'7B'

Specifying the code page

The preferred way to specify the code page for parsing an XML document is to omit the encoding declaration from the document and to rely on external code-page information. Doing so makes it possible to transmit an XML document between heterogeneous systems without requiring that you update the encoding declaration to reflect any translation imposed by the transmission process.

Unicode XML documents do not require additional code-page information because Unicode effectively consists of a single large code page. The code page used for parsing EBCDIC XML documents that do not have an encoding declaration is the value in effect for the CODEPAGE compiler option.

You can also specify the encoding information for an XML document in the XML declaration with which most XML documents begin. (Note that the XML parser generates an exception if it encounters an XML declaration that does not begin in the first byte of an XML document.) This is an example of an XML declaration that includes an encoding declaration:

```
<?xml version="1.0" encoding="ibm-1140" ?>
```

Specify the encoding declaration in either of the following ways:

- Specify the CCSID number (with or without any number of leading zeros) optionally prefixed by any of the following strings (in any mixture of uppercase and lowercase):
 - IBM-
 - IBM_
 - CCSID-
 - CCSID_
- Use one of the following supported aliases (in any mixture of uppercase and lowercase):

Table 69. Aliases for XML encoding declarations

Code page	Supported aliases
037	EBCDIC-CP-US, EBCDIC-CP-CA, EBCDIC-CP-WT, EBCDIC-CP-NL
500	EBCDIC-CP-BE, EBCDIC-CP-CH
1200	UTF-16

RELATED TASKS

“Understanding the encoding of XML documents” on page 462

Handling errors in parsing XML documents

Use these facilities to handle errors in an XML document:

- The processing procedure
- The ON EXCEPTION phrase of the XML PARSE statement
- Special register XML-CODE

When the XML parser detects an error in an XML document, it generates an XML exception event. The parser realizes this exception event by passing control to your processing procedure with the following information in special registers:





- XML-EVENT contains 'EXCEPTION'.
- XML-CODE contains a numeric exception code.
- XML-TEXT (for XML documents in an alphanumeric data item) or XML-NTEXT (for XML documents in a national data item) contains the document text up to and including the point where the exception was detected.

You might be able to handle the exception in your processing procedure and continue parsing if the numeric exception code is within one of the following ranges:

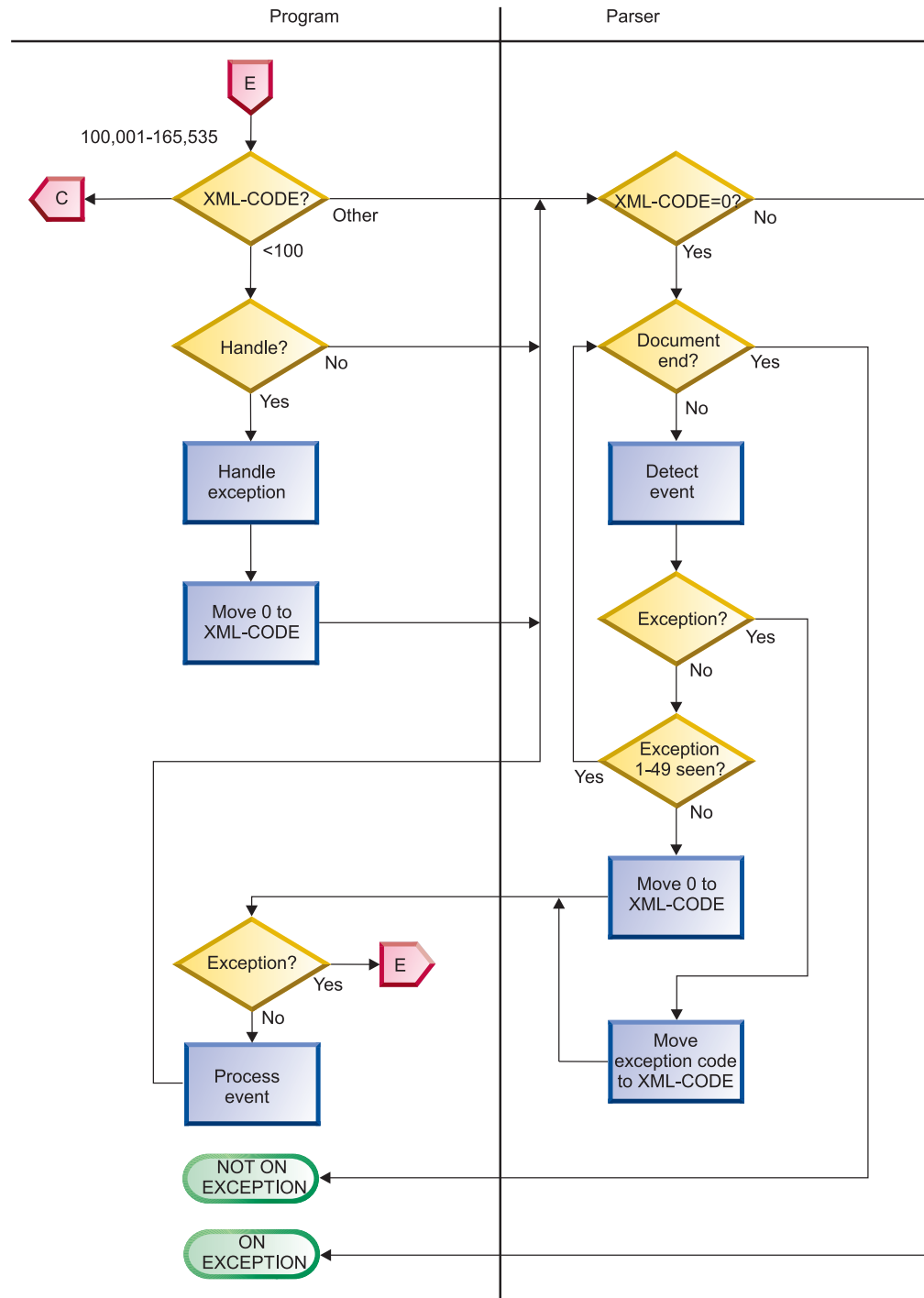
- 1-99
- 100,001-165,535

If the exception code has any other nonzero value, parsing cannot continue. The exceptions for encoding conflicts (50-99 and 300-399) are signaled before the parsing of the document begins. For these exceptions, XML-TEXT (or XML-NTEXT) either is zero length or contains only the encoding declaration value from the document.

Exceptions in the range 1-49 are fatal errors according to the XML specification. Therefore the parser does not continue normal parsing even if you handle the exception. However, the parser does continue scanning for further errors until it reaches the end of the document or encounters an error that does not allow continuation. For these exceptions, the parser does not signal any further normal events except for the END-OF-DOCUMENT event.

Use the following figure to understand the flow of control between the parser and your processing procedure. The figure illustrates how you can handle certain exceptions and can use XML-CODE to identify the exceptions. The off-page connectors (for example, ) connect the multiple charts in this information. In particular,  connects to the chart XML CCSID exception flow control (page 469). Within this figure,  and  serve both as off-page and on-page connectors.

Control flow for XML exceptions



Unhandled exceptions

If you do not want to handle an exception, return control to the parser without changing the value of XML-CODE. The parser transfers control to the statement that you specify in the ON EXCEPTION phrase. If you do not code an ON EXCEPTION phrase, control is transferred to the end of the XML PARSE statement.

Handling exceptions

To handle an exception event in your processing procedure, do these steps:

1. Use the contents of XML-CODE to guide your actions.
2. Set XML-CODE to zero to indicate that you handled the exception.
3. Return control to the parser. The exception condition then no longer exists.

If no unhandled exceptions occur before the end of parsing, control is passed to the statement that you specify in the NOT ON EXCEPTION phrase (normal end of parsing). If you do not code a NOT ON EXCEPTION phrase, control is passed to the end of the XML PARSE statement. The special register XML-CODE contains zero.

You can handle exceptions as explained above only if the exception code passed in XML-CODE is within one of the following ranges, which indicate that an encoding conflict was detected:

- 50-99
- 100,001-165,535

You can do limited handling of exceptions for which the exception code passed in XML-CODE is within the range 1-49. After an exception in this range occurs, the parser does not signal any further normal events, except for the END-OF-DOCUMENT event, even if you set XML-CODE to zero before returning. If you set XML-CODE to zero, the parser continues parsing the document and signals any exceptions that it finds. (Doing so can be useful as a way of discovering multiple errors in the document.) At the end of parsing after an exception in this range, control is passed to the statement that you specify in the ON EXCEPTION phrase, if any, otherwise to the end of the XML PARSE statement. The special register XML-CODE contains the code for the most recent exception that the parser detected.

For all other exceptions, the parser signals no further events, and passes control to the statement that you specify in the ON EXCEPTION phrase. In this case, XML-CODE contains the original exception number even if you set XML-CODE to zero in the processing procedure before returning control to the parser.

If you return control to the parser with XML-CODE set to a nonzero value that is different from the original exception code, the results are undefined.

Terminating XML parsing

You can terminate parsing deliberately by setting XML-CODE to -1 in your processing procedure before returning to the parser from any normal XML event (that is, not an EXCEPTION event). You can use this technique when you have seen enough of the document or have detected some irregularity in the document that precludes further meaningful processing.

In this case, the parser does not signal any further events although an exception condition exists. Therefore control returns to the ON EXCEPTION phrase, if specified. In the imperative statement of the ON EXCEPTION phrase, you can test whether XML-CODE is -1, which would indicate that you terminated parsing deliberately. If you do not specify an ON EXCEPTION phrase, control returns to the end of the XML PARSE statement.

You can also terminate parsing after any XML exception event by returning to the parser without changing XML-CODE. The result is similar to the result of deliberate termination, except that the parser returns to the XML PARSE statement with XML-CODE containing the exception number.




Code-page conflict exception

A special case applies to exception events in which the document data item is alphanumeric and the exception code in XML-CODE is in the range 100,001 through 165,535. These exception codes indicate that the code page of the document (as specified by its encoding declaration) conflicts with the external code-page information.

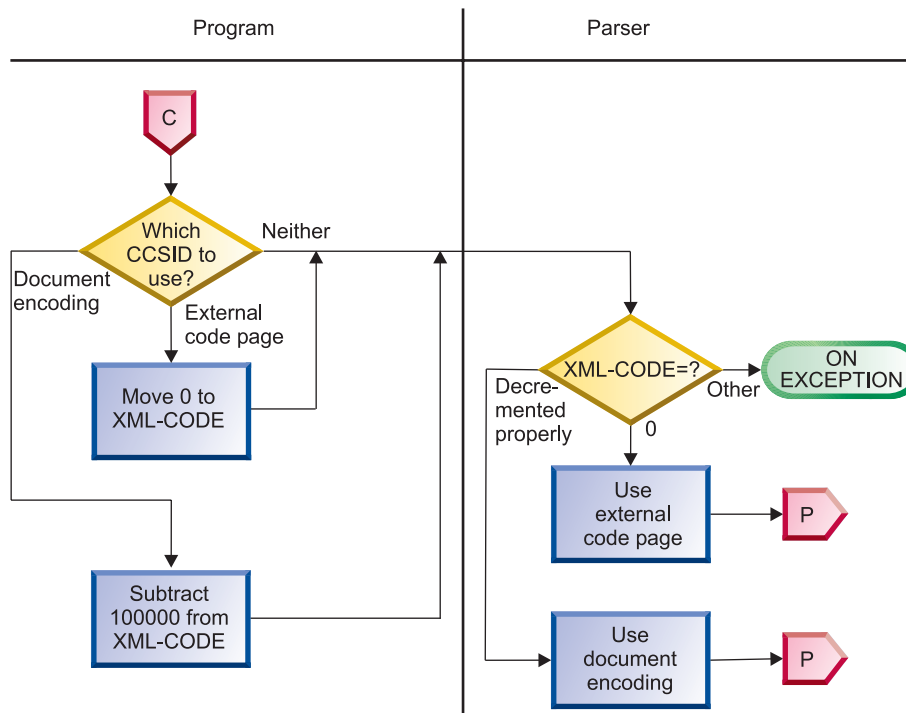
In this case, you can choose to parse with the code page of the document by subtracting 100,000 from the value in XML-CODE. For instance, if XML-CODE contains 101,140, the code page of the document is 1140. Alternatively, you can choose to parse with the external code page by setting XML-CODE to zero before returning to the parser.

The parser takes one of three actions after returning from a processing procedure for a code-page conflict exception event:

- If you set XML-CODE to zero, the parser uses the external code page: the CODEPAGE compiler option value.
- If you set XML-CODE to the code page of the document (that is, the original XML-CODE value minus 100,000), the parser uses the code page of the document. This is the only case where the parser continues when XML-CODE has a nonzero value upon returning from a processing procedure.
- Otherwise, the parser stops processing the document and returns control to the XML PARSE statement with an exception condition. XML-CODE contains the exception code that was originally passed to the exception event.

The following figure illustrates these actions. The off-page connectors (for example, ) connect the multiple charts in this information. In particular,  in the following figure connects to Control flow between XML parser and program, showing XML-CODE usage (page 457), and  connects from Control flow for XML exceptions (page 466).

XML CCSID exception flow control



In this figure, *CCSID* (coded character set identifier) is a value from 1 to 65,536 that denotes the code page.

RELATED TASKS

“Understanding the encoding of XML documents” on page 462

RELATED REFERENCES

“XML PARSE exceptions that allow continuation” on page 625

“XML PARSE exceptions that do not allow continuation” on page 628

XML-CODE (*Enterprise COBOL Language Reference*)

Chapter 29. Producing XML output

You can produce XML output in a COBOL program by using the XML GENERATE statement. In the XML GENERATE statement, you can also identify a field to receive a count of the number of characters of XML output generated, and a statement to receive control if an exception occurs.

To produce XML output, use:

- The XML GENERATE statement to identify the source and target data items, count field, and ON EXCEPTION statement
- Special register XML-CODE to determine the status of XML generation

After you transform COBOL data items to XML, you can use the resulting XML output in various ways, such as deploying it in a Web service, passing it as a message to WebSphere MQ, or transmitting it for subsequent conversion to a CICS communication area.

RELATED TASKS

“Generating XML output”

“Enhancing XML output” on page 476

“Controlling the encoding of generated XML output” on page 480

“Handling errors in generating XML output” on page 480

Generating XML output

To transform COBOL data to XML, use the XML GENERATE statement as in the following example:

```
XML GENERATE XML-OUTPUT FROM SOURCE-REC
COUNT IN XML-CHAR-COUNT
ON EXCEPTION
  DISPLAY 'XML generation error ' XML-CODE
  STOP RUN
NOT ON EXCEPTION
  DISPLAY 'XML document was successfully generated.'
END-XML
```

In the XML GENERATE statement, you first identify the data item (XML-OUTPUT in the example) that is to receive the XML output. Define the data item to be large enough to contain the generated XML output, typically five to eight times the size of the COBOL source data depending on the length of its data-name or data-names.

In the DATA DIVISION, you can declare the identifier as an alphanumeric data item or as a national data item. You must declare it as USAGE NATIONAL if the CODEPAGE compiler option specifies a DBCS code page or the XML output will contain any data from the COBOL source record that has any of the following characteristics:

- Is described implicitly or explicitly with the USAGE NATIONAL phrase or the USAGE DISPLAY-1 phrase
- Has a DBCS name (that is, is a data item whose name contains DBCS characters)
- Is an alphanumeric data item that contains DBCS characters

Next you identify the group or elementary data item (SOURCE-REC in the example) that is to be transformed to XML format. Do not specify the RENAMES clause in the data description of that data item.

Some COBOL data items are not transformed to XML, but are ignored. Subordinate data items of a group data item that you transform to XML are ignored if they:

- Specify the REDEFINES clause, or are subordinate to such a redefining item
- Specify the RENAMES clause

These items are also ignored when you generate XML:

- Elementary FILLER (or unnamed) data items
- Slack bytes inserted for SYNCHRONIZED data items

There must be at least one elementary data item that is not ignored when you generate XML. For the data items that are not ignored, ensure that the identifier that you are transforming to XML satisfies these conditions when you declare it in the DATA DIVISION:

- Each elementary data item is either an index data item or belongs to one of these classes:
 - Alphabetic
 - Alphanumeric
 - Numeric
 - National

That is, no elementary data item is described with the USAGE POINTER, USAGE FUNCTION-POINTER, USAGE PROCEDURE-POINTER, or USAGE OBJECT REFERENCE phrase.

- Each data-name other than FILLER is unique within the immediately containing group, if any.
- Any DBCS data-names, when converted to Unicode, are legal as names in the XML specification, version 1.0.
- The data item or items do not specify the DATE FORMAT clause, or the DATEPROC compiler option is not in effect.

An XML declaration is not generated. No white space (for example, new lines or indentation) is inserted to make the generated XML more readable.

Optionally, you can code the COUNT IN phrase to obtain the number of XML character positions that are filled during generation of the XML output. Declare the count field as an integer data item that does not have the symbol P in its PICTURE string. You can use the count field and reference modification to obtain only that portion of the receiving data item that contains the generated XML output. For example, XML-OUTPUT(1:XML-CHAR-COUNT) references the first XML-CHAR-COUNT character positions of XML-OUTPUT.

In addition, you can specify either or both of the following phrases to receive control after generation of the XML document:

- ON EXCEPTION, to receive control if an error occurs during XML generation
- NOT ON EXCEPTION, to receive control if no error occurs

You can end the XML GENERATE statement with the explicit scope terminator END-XML. Code END-XML to nest an XML GENERATE statement that has the ON EXCEPTION or NOT ON EXCEPTION phrase in a conditional statement.

XML generation continues until either the COBOL source record has been transformed to XML or an error occurs. If an error occurs, the results are as follows:

- Special register XML-CODE contains a nonzero exception code.
- Control is passed to the ON EXCEPTION phrase, if specified, otherwise to the end of the XML GENERATE statement.

If no error occurs during XML generation, special register XML-CODE contains zero, and control is passed to the NOT ON EXCEPTION phrase if specified or to the end of the XML GENERATE statement otherwise.

“Example: generating XML”

RELATED TASKS

“Controlling the encoding of generated XML output” on page 480

“Handling errors in generating XML output” on page 480

RELATED REFERENCES

XML GENERATE statement (*Enterprise COBOL Language Reference*)

Operation of XML GENERATE (*Enterprise COBOL Language Reference*)

XML specification (www.w3c.org/XML/)

Example: generating XML

The following example simulates the building of a purchase order in a group data item, and generates an XML version of that purchase order.

Program XGFX uses XML GENERATE to produce XML output in elementary data item xmlP0 from the source record, group data item purchaseOrder. Elementary data items in the source record are converted to character format as necessary, and the characters are inserted in XML elements whose names are derived from the data-names in the source record.

XGFX calls program Pretty, which uses the XML PARSE statement with processing procedure p to format the XML output with new lines and indentation so that the XML content can more easily be verified.

Program XGFX

```
Identification division.
  Program-id. XGFX.
Data division.
  Working-storage section.
    01 numItems pic 99 global.
    01 purchaseOrder global.
      05 orderDate pic x(10).
      05 shipTo.
        10 country pic xx value 'US'.
        10 name pic x(30).
        10 street pic x(30).
        10 city pic x(30).
        10 state pic xx.
        10 zip pic x(10).
      05 billTo.
        10 country pic xx value 'US'.
        10 name pic x(30).
        10 street pic x(30).
        10 city pic x(30).
        10 state pic xx.
        10 zip pic x(10).
      05 orderComment pic x(80).
```

```

05 items occurs 0 to 20 times depending on numItems.
10 item.
15 partNum pic x(6).
15 productName pic x(50).
15 quantity pic 99.
15 USPrice pic 999v99.
15 shipDate pic x(10).
15 itemComment pic x(40).
01 numChars comp pic 999.
01 xmlPO pic x(999).
Procedure division.
m.
Move 20 to numItems
Move spaces to purchaseOrder

Move '1999-10-20' to orderDate

Move 'US' to country of shipTo
Move 'Alice Smith' to name of shipTo
Move '123 Maple Street' to street of shipTo
Move 'Mill Valley' to city of shipTo
Move 'CA' to state of shipTo
Move '90952' to zip of shipTo

Move 'US' to country of billTo
Move 'Robert Smith' to name of billTo
Move '8 Oak Avenue' to street of billTo
Move 'Old Town' to city of billTo
Move 'PA' to state of billTo
Move '95819' to zip of billTo
Move 'Hurry, my lawn is going wild!' to orderComment

Move 0 to numItems
Call 'addFirstItem'
Call 'addSecondItem'
Move space to xmlPO
Xml generate xmlPO from purchaseOrder count in numChars
Call 'pretty' using xmlPO value numChars
Goback
.

Identification division.
Program-id. 'addFirstItem'.
Procedure division.
Add 1 to numItems
Move '872-AA' to partNum(numItems)
Move 'Lawnmower' to productName(numItems)
Move 1 to quantity(numItems)
Move 148.95 to USPrice(numItems)
Move 'Confirm this is electric' to itemComment(numItems)
Goback.
End program 'addFirstItem'.

Identification division.
Program-id. 'addSecondItem'.
Procedure division.
Add 1 to numItems
Move '926-AA' to partNum(numItems)
Move 'Baby Monitor' to productName(numItems)
Move 1 to quantity(numItems)
Move 39.98 to USPrice(numItems)
Move '1999-05-21' to shipDate(numItems)
Goback.
End program 'addSecondItem'.

End program XGFX.

```

Program Pretty

```
Identification division.
  Program-id. Pretty.
Data division.
  Working-storage section.
    01 prettyPrint.
      05 pose pic 999.
      05 posd pic 999.
      05 depth pic 99.
      05 element pic x(30).
      05 indent pic x(20).
      05 buffer pic x(100).
  Linkage section.
    1 doc.
      2 pic x occurs 16384 times depending on len.
    1 len comp-5 pic 9(9).
  Procedure division using doc value len.
    m.
      Move space to prettyPrint
      Move 0 to depth posd
      Move 1 to pose
      Xml parse doc processing procedure p
      Goback.
    p.
      Evaluate xml-event
      When 'START-OF-ELEMENT'
        If element not = space
          If depth > 1
            Display indent(1:2 * depth - 2) buffer(1:pose - 1)
          Else
            Display buffer(1:pose - 1)
          End-if
        End-if
      Move xml-text to element
      Add 1 to depth
      Move 1 to pose
      String '<' xml-text '>' delimited by size into buffer
        with pointer pose
      Move pose to posd
      When 'CONTENT-CHARACTERS'
        String xml-text delimited by size into buffer
          with pointer posd
      When 'CONTENT-CHARACTER'
        String xml-text delimited by size into buffer
          with pointer posd
      When 'END-OF-ELEMENT'
        Move space to element
        String '</' xml-text '>' delimited by size into buffer
          with pointer posd
        If depth > 1
          Display indent(1:2 * depth - 2) buffer(1:posd - 1)
        Else
          Display buffer(1:posd - 1)
        End-if
        Subtract 1 from depth
        Move 1 to posd
      When other
        Continue
      End-evaluate
    .
  End program Pretty.
```

Output from program XGFX

```
<purchaseOrder>
  <orderDate>1999-10-20</orderDate>
  <shipTo>
```

```

|         <country>US</country>
|         <name>Alice Smith</name>
|         <street>123 Maple Street</street>
|         <city>Mill Valley</city>
|         <state>CA</state>
|         <zip>90952</zip>
|     </shipTo>
|     <billTo>
|         <country>US</country>
|         <name>Robert Smith</name>
|         <street>8 Oak Avenue</street>
|         <city>Old Town</city>
|         <state>PA</state>
|         <zip>95819</zip>
|     </billTo>
|     <orderComment>Hurry, my lawn is going wild!</orderComment>
|     <items>
|         <item>
|             <partNum>872-AA</partNum>
|             <productName>Lawnmower</productName>
|             <quantity>1</quantity>
|             <USPrice>148.95</USPrice>
|             <shipDate> </shipDate>
|             <itemComment>Confirm this is electric</itemComment>
|         </item>
|     </items>
|     <items>
|         <item>
|             <partNum>926-AA</partNum>
|             <productName>Baby Monitor</productName>
|             <quantity>1</quantity>
|             <USPrice>39.98</USPrice>
|             <shipDate>1999-05-21</shipDate>
|             <itemComment> </itemComment>
|         </item>
|     </items>
| </purchaseOrder>

```

RELATED TASKS

Chapter 28, “Processing XML input,” on page 447

RELATED REFERENCES

Operation of XML GENERATE (*Enterprise COBOL Language Reference*)

Enhancing XML output

It might happen that the information that you want to express in XML format already exists in a group item in the DATA DIVISION, but you are unable to use that group item directly to generate an XML document because of one or more of the following factors:

- In addition to the required data, the group item has data items that contain working data values that are irrelevant to the XML output document.
- The names of the required data items are unsuitable for external presentation, and are possibly meaningful only to programmers.
- The definition of the data is not of the required data type. Perhaps only the redefinitions (which are ignored by the XML GENERATE statement) have the appropriate format.
- The required data items are nested too deeply within irrelevant subordinate group data items. The XML output should be “flattened,” rather than hierarchical as it would be by default.

- The required data items are broken up into too many components, and should be output as the content of the containing group.
- The group item contains the required information, but in the wrong order.

There are various ways that you can deal with such situations. One possible technique is to define a new data item that has the appropriate characteristics, and move the required data to the appropriate fields of this new data item. However, this approach is somewhat laborious and requires careful maintenance to keep the original and new data items synchronized.

An alternative approach that has some advantages is to provide a redefinition of the original group data item, and to generate the XML output from that redefinition. To do so, start from the original set of data descriptions, and make these changes:

- Exclude elementary data items from the generated XML either by renaming them to FILLER or by deleting their names.
- Provide more meaningful and appropriate names for the selected elementary items and for the group items that contain them.
- Remove unneeded intermediate group items to flatten the hierarchy.
- Specify different data types to obtain the desired trimming behavior.
- Choose a different order for the output by using a sequence of XML GENERATE statements.

The safest way to accomplish these changes is to use another copy of the original declarations accompanied by one or more REPLACE compiler-directing statements.

“Example: enhancing XML output”

RELATED REFERENCES

Operation of XML GENERATE (*Enterprise COBOL Language Reference*)

Example: enhancing XML output

Consider the following example data structure:

```

01 CDR-LIFE-BASE-VALUES-BOX.
   15 CDR-LIFE-BASE-VAL-DATE    PIC X(08).
   15 CDR-LIFE-BASE-VALUE-LINE OCCURS 2 TIMES.
      20 CDR-LIFE-BASE-DESC.
         25 CDR-LIFE-BASE-DESC1 PIC X(15).
         25 FILLER                PIC X(01).
         25 CDR-LIFE-BASE-LIT    PIC X(08).
         25 CDR-LIFE-BASE-DTE    PIC X(08).
      20 CDR-LIFE-BASE-PRICE.
         25 CDR-LIFE-BP-SPACE    PIC X(02).
         25 CDR-LIFE-BP-DASH     PIC X(02).
         25 CDR-LIFE-BP-SPACE1   PIC X(02).
      20 CDR-LIFE-BASE-PRICE-ED REDEFINES
         CDR-LIFE-BASE-PRICE PIC $$$.$$$.
      20 CDR-LIFE-BASE-QTY.
         25 CDR-LIFE-QTY-SPACE    PIC X(08).
         25 CDR-LIFE-QTY-DASH     PIC X(02).
         25 CDR-LIFE-QTY-SPACE1   PIC X(02).
         25 FILLER                PIC X(02).
      20 CDR-LIFE-BASE-QTY-ED REDEFINES
         CDR-LIFE-BASE-QTY PIC ZZ,ZZZ,ZZZ.ZZZ.
      20 CDR-LIFE-BASE-VALUE    PIC X(15).
      20 CDR-LIFE-BASE-VALUE-ED REDEFINES
         CDR-LIFE-BASE-VALUE

```

```

PIC $(4),$$,$$9.99.
15 CDR-LIFE-BASE-TOT-VALUE-LINE.
20 CDR-LIFE-BASE-TOT-VALUE PIC X(15).

```

When this data structure is populated with some sample values, and XML is generated directly from it and then formatted using program Pretty (shown in “Example: generating XML” on page 473), the result is as follows:

```

<CDR-LIFE-BASE-VALUES-BOX>
<CDR-LIFE-BASE-VAL-DATE>01/02/03</CDR-LIFE-BASE-VAL-DATE>
<CDR-LIFE-BASE-VALUE-LINE>
  <CDR-LIFE-BASE-DESC>
    <CDR-LIFE-BASE-DESC1>First</CDR-LIFE-BASE-DESC1>
    <CDR-LIFE-BASE-LIT> </CDR-LIFE-BASE-LIT>
    <CDR-LIFE-BASE-DTE>01/01/01</CDR-LIFE-BASE-DTE>
  </CDR-LIFE-BASE-DESC>
  <CDR-LIFE-BASE-PRICE>
    <CDR-LIFE-BP-SPACE>$2</CDR-LIFE-BP-SPACE>
    <CDR-LIFE-BP-DASH>3.</CDR-LIFE-BP-DASH>
    <CDR-LIFE-BP-SPACE1>00</CDR-LIFE-BP-SPACE1>
  </CDR-LIFE-BASE-PRICE>
  <CDR-LIFE-BASE-QTY>
    <CDR-LIFE-QTY-SPACE>1</CDR-LIFE-QTY-SPACE>
    <CDR-LIFE-QTY-DASH>23</CDR-LIFE-QTY-DASH>
    <CDR-LIFE-QTY-SPACE1>.0</CDR-LIFE-QTY-SPACE1>
  </CDR-LIFE-BASE-QTY>
  <CDR-LIFE-BASE-VALUE> $765.00</CDR-LIFE-BASE-VALUE>
</CDR-LIFE-BASE-VALUE-LINE>
<CDR-LIFE-BASE-VALUE-LINE>
  <CDR-LIFE-BASE-DESC>
    <CDR-LIFE-BASE-DESC1>Second</CDR-LIFE-BASE-DESC1>
    <CDR-LIFE-BASE-LIT> </CDR-LIFE-BASE-LIT>
    <CDR-LIFE-BASE-DTE>02/02/02</CDR-LIFE-BASE-DTE>
  </CDR-LIFE-BASE-DESC>
  <CDR-LIFE-BASE-PRICE>
    <CDR-LIFE-BP-SPACE>$3</CDR-LIFE-BP-SPACE>
    <CDR-LIFE-BP-DASH>4.</CDR-LIFE-BP-DASH>
    <CDR-LIFE-BP-SPACE1>00</CDR-LIFE-BP-SPACE1>
  </CDR-LIFE-BASE-PRICE>
  <CDR-LIFE-BASE-QTY>
    <CDR-LIFE-QTY-SPACE>2</CDR-LIFE-QTY-SPACE>
    <CDR-LIFE-QTY-DASH>34</CDR-LIFE-QTY-DASH>
    <CDR-LIFE-QTY-SPACE1>.0</CDR-LIFE-QTY-SPACE1>
  </CDR-LIFE-BASE-QTY>
  <CDR-LIFE-BASE-VALUE> $654.00</CDR-LIFE-BASE-VALUE>
</CDR-LIFE-BASE-VALUE-LINE>
<CDR-LIFE-BASE-TOT-VALUE-LINE>
  <CDR-LIFE-BASE-TOT-VALUE>Very high!</CDR-LIFE-BASE-TOT-VALUE>
</CDR-LIFE-BASE-TOT-VALUE-LINE>
</CDR-LIFE-BASE-VALUES-BOX>

```

This generated XML suffers from several problems:

- The element names are long and not very meaningful.
- There is unwanted data, for example, CDR-LIFE-BASE-LIT and CDR-LIFE-BASE-DTE.
- Required data has an unnecessary parent. For example, CDR-LIFE-BASE-DESC1 has parent CDR-LIFE-BASE-DESC.
- Other required fields are split into too many subcomponents. For example, CDR-LIFE-BASE-PRICE has three subcomponents for one amount.

These and other characteristics of the XML output can be remedied by redefining the storage as follows:

```

1 BaseValues redefines CDR-LIFE-BASE-VALUES-BOX.
2 BaseValueDate pic x(8).
2 BaseValueLine occurs 2 times.
3 Description pic x(15).
3 pic x(9).
3 BaseDate pic x(8).
3 BasePrice pic x(6) justified.
3 BaseQuantity pic x(14) justified.
3 BaseValue pic x(15) justified.
2 TotalValue pic x(15).

```

The result of generating and formatting XML from the set of definitions of the data values shown above is more usable:

```

<BaseValues>
  <BaseValueDate>01/02/03</BaseValueDate>
  <BaseValueLine>
    <Description>First</Description>
    <BaseDate>01/01/01</BaseDate>
    <BasePrice>$23.00</BasePrice>
    <BaseQuantity>123.000</BaseQuantity>
    <BaseValue>$765.00</BaseValue>
  </BaseValueLine>
  <BaseValueLine>
    <Description>Second</Description>
    <BaseDate>02/02/02</BaseDate>
    <BasePrice>$34.00</BasePrice>
    <BaseQuantity>234.000</BaseQuantity>
    <BaseValue>$654.00</BaseValue>
  </BaseValueLine>
  <TotalValue>Very high!</TotalValue>
</BaseValues>

```

You can redefine the original data definition directly, as shown above. However, it is generally safer to use the original definition, but to modify it suitably using the text-manipulation capabilities of the compiler. An example is shown in the REPLACE compiler-directing statement below. This REPLACE statement might appear complicated, but it has the advantage of being self-maintaining if the original data definitions are modified.

```

replace ==CDR-LIFE-BASE-VALUES-BOX== by
  ==BaseValues redefines CDR-LIFE-BASE-VALUES-BOX==
  ==CDR-LIFE-BASE-VAL-DATE== by ==BaseValueDate==
  ==CDR-LIFE-BASE-VALUE-LINE== by ==BaseValueLine==
  ==20 CDR-LIFE-BASE-DESC== by ====
  ==CDR-LIFE-BASE-DESC1== by ==Description==
  ==CDR-LIFE-BASE-LIT== by ====
  ==CDR-LIFE-BASE-DTE== by ==BaseDate==
  ==20 CDR-LIFE-BASE-PRICE== by ====
  ==25 CDR-LIFE-BP-SPACE PIC X(02).== by ====
  ==25 CDR-LIFE-BP-DASH PIC X(02).== by ====
  ==25 CDR-LIFE-BP-SPACE1 PIC X(02).== by ====
  ==CDR-LIFE-BASE-PRICE-ED== by ==BasePrice==
  ==REDEFINES CDR-LIFE-BASE-PRICE PIC $$$.$$.== by
  ==pic x(6) justified.==
  ==20 CDR-LIFE-BASE-QTY.
    25 CDR-LIFE-QTY-SPACE PIC X(08).
    25 CDR-LIFE-QTY-DASH PIC X(02).
    25 CDR-LIFE-QTY-SPACE1 PIC X(02).
    25 FILLER PIC X(02).== by ====
  ==CDR-LIFE-BASE-QTY-ED== by ==BaseQuantity==
  ==REDEFINES CDR-LIFE-BASE-QTY PIC ZZ,ZZZ,ZZZ.ZZZ.== by
  ==pic x(14) justified.==
  ==CDR-LIFE-BASE-VALUE-ED== by ==BaseValue==
  ==20 CDR-LIFE-BASE-VALUE PIC X(15).== by ====
  ==REDEFINES CDR-LIFE-BASE-VALUE PIC $(4),$$$,$$9.99.==

```

```
|      by ==pic x(15) justified.==  
|      ==CDR-LIFE-BASE-TOT-VALUE-LINE. 20== by ====  
|      ==CDR-LIFE-BASE-TOT-VALUE== by ==TotalValue==.
```

| The result of this REPLACE statement followed by a second instance of the original
| set of definitions is similar to the suggested redefinition of group item BaseValues
| shown above. This REPLACE statement illustrates a variety of techniques for
| eliminating unwanted definitions and for modifying the definitions that should be
| retained. Use whichever technique is appropriate for your situation.

RELATED REFERENCES
Operation of XML GENERATE (*Enterprise COBOL Language Reference*)
REPLACE statement (*Enterprise COBOL Language Reference*)

Controlling the encoding of generated XML output

| When you generate XML output by using the XML GENERATE statement, you can
| control the encoding of the output by the class of the data item that receives the
| XML output. The following table shows the possible output formats.

Table 70. Encoding of generated XML output

If you define the receiving XML identifier as:	The generated XML output is encoded in:
Alphanumeric	The code page specified by the CODEPAGE compiler option in effect when the source was compiled
National	UTF-16 big-endian (UTF-16BE, CCSID 1200) ¹
1. A byte order mark is not generated.	

| For details about how data items are converted to XML and how the XML element
| names are formed from the COBOL data-names, see the related reference below
| about the operation of the XML GENERATE statement.

RELATED REFERENCES
"CODEPAGE" on page 274
Operation of XML GENERATE (*Enterprise COBOL Language Reference*)

Handling errors in generating XML output

| When an error is detected during generation of XML output, an exception
| condition exists. You can write code to check the special register XML-CODE, which
| contains a numeric exception code that indicates the error type.

| To handle errors, use either or both of the following phrases of the XML GENERATE
| statement:

- | • ON EXCEPTION
- | • COUNT IN

| If you code the ON EXCEPTION phrase in the XML GENERATE statement, control is
| transferred to the imperative statement that you specify. You might code an
| imperative statement, for example, to display the XML-CODE value. If you do not
| code an ON EXCEPTION phrase, control is transferred to the end of the XML GENERATE
| statement.

| When an error occurs, one problem might be that the data item that receives the
| XML output is not large enough. In that case, the XML output is not complete, and
| special register XML-CODE contains error code 400.

| You can examine the generated XML output by doing these steps:

- | 1. Code the COUNT IN phrase in the XML GENERATE statement.

| The count field that you specify holds a count of the XML character positions
| that are filled during XML generation. If you define the XML output as a
| national data item, the count is in national character positions (UTF-16
| character encoding units); otherwise the count is in bytes.

- | 2. Use the count field with reference modification to refer to the substring of the
| receiving data item that contains the generated XML output.

| For example, if XML-OUTPUT is the data item that receives the XML output, and
| XML-CHAR-COUNT is the count field, then XML-OUTPUT(1:XML-CHAR-COUNT)
| references the XML output.

| Use the contents of XML-CODE to determine what corrective action to take. For a list
| of the exceptions that can occur during XML generation, see the related reference
| below.

RELATED TASKS

"Referring to substrings of data items" on page 93

RELATED REFERENCES

"XML GENERATE exceptions" on page 633

Part 6. Developing object-oriented programs

Chapter 30. Writing object-oriented programs	485	WORKING-STORAGE SECTION for defining	
Example: accounts	486	factory data	515
Subclasses	487	Defining a factory method	516
Defining a class	488	Hiding a factory or static method	517
CLASS-ID paragraph for defining a class	490	Invoking factory or static methods	517
REPOSITORY paragraph for defining a class	490	Example: defining a factory (with methods)	518
Example: external class-names and Java		Account class	518
packages	491	CheckingAccount class (subclass of Account)	520
WORKING-STORAGE SECTION for defining		Check class	522
class instance data	492	TestAccounts client program	522
Example: defining a class	493	Output produced by the TestAccounts client	
Defining a class instance method	493	program	523
METHOD-ID paragraph for defining a class		Wrapping procedure-oriented COBOL programs	523
instance method	494	Structuring OO applications	524
INPUT-OUTPUT SECTION for defining a class		Examples: COBOL applications that you can run	
instance method	495	using the java command	524
DATA DIVISION for defining a class instance		Displaying a message:	524
method	495	Echoing the input strings:	525
PROCEDURE DIVISION for defining a class			
instance method	496	Chapter 31. Communicating with Java methods	527
USING phrase for obtaining passed		Accessing JNI services	527
arguments	497	Handling Java exceptions	528
RETURNING phrase for returning a value	497	Throwing an exception from your COBOL	
Overriding an instance method	497	program	529
Overloading an instance method	498	Catching a Java exception	529
Coding attribute (get and set) methods	499	Example: handling Java exceptions	529
Example: coding a get method	499	Managing local and global references	530
Example: defining a method	500	Deleting, saving, and freeing local references	530
Account class	500	JNI services	531
Check class	501	Java access controls	531
Defining a client	502	Sharing data with Java	531
REPOSITORY paragraph for defining a client	503	Coding interoperable data types in COBOL and	
DATA DIVISION for defining a client	504	Java	532
Choosing LOCAL-STORAGE or		Declaring arrays and strings for Java	532
WORKING-STORAGE	504	Manipulating Java arrays	534
Comparing and setting object references	505	Example: processing a Java int array	535
Invoking methods (INVOKE)	506	Manipulating Java strings	536
USING phrase for passing arguments	507	Services for Unicode	536
RETURNING phrase for obtaining a returned		Services for EBCDIC	537
value	507	Services for UTF-8	538
Invoking overridden superclass methods	507	Example: J2EE client written in COBOL	539
Creating and initializing instances of classes	508	COBOL client (ConverterClient.cbl)	539
Instantiating Java classes	508	Java client (ConverterClient.java)	541
Instantiating COBOL classes	509		
Freeing instances of classes	509		
Example: defining a client	510		
Defining a subclass	510		
CLASS-ID paragraph for defining a subclass	511		
REPOSITORY paragraph for defining a subclass	512		
WORKING-STORAGE SECTION for defining			
subclass instance data	512		
Defining a subclass instance method	513		
Example: defining a subclass (with methods)	513		
CheckingAccount class (subclass of Account)	513		
Defining a factory section	514		

Chapter 30. Writing object-oriented programs

When you write an object-oriented (OO) program, you have to determine what classes you need and the methods and data that the classes need to do their work.

OO programs are based on *objects* (entities that encapsulate state and behavior) and their classes, methods, and data. A *class* is a template that defines the state and the capabilities of an object. Usually a program creates and works with multiple *object instances* (or simply, *instances*) of a class, that is, multiple objects that are members of that class. The state of each instance is stored in data known as *instance data*, and the capabilities of each instance are called *instance methods*. A class can define data that is shared by all instances of the class, known as *factory* or *static* data, and methods that are supported independently of any object instance, known as *factory* or *static* methods.

Using Enterprise COBOL, you can:

- Define classes, with methods and data implemented in COBOL.
- Create instances of Java and COBOL classes.
- Invoke methods on Java and COBOL objects.
- Write classes that inherit from Java classes or other COBOL classes.
- Define and invoke overloaded methods.

In Enterprise COBOL programs, you can call the services provided by the Java Native Interface (JNI) to obtain Java-oriented capabilities in addition to the basic OO capabilities available directly in the COBOL language.

In Enterprise COBOL classes, you can code CALL statements to interface with procedural COBOL programs. Thus COBOL class definition syntax can be especially useful for writing *wrapper* classes for procedural COBOL logic, enabling existing COBOL code to be accessed from Java.

Java code can create instances of COBOL classes, invoke methods of these classes, and can extend COBOL classes.

It is recommended that you develop and run OO COBOL programs and Java programs in the z/OS UNIX System Services environment.

Restrictions:

- COBOL class definitions and methods cannot contain EXEC SQL statements and cannot be compiled using the SQL compiler option.
- COBOL class definitions and methods cannot contain EXEC CICS statements, cannot be run in a CICS environment, and cannot be compiled using the CICS compiler option.

“Example: accounts” on page 486

RELATED TASKS

“Defining a class” on page 488

“Defining a class instance method” on page 493

“Defining a client” on page 502

“Defining a subclass” on page 510

“Defining a factory section” on page 514
Chapter 16, “Compiling, linking, and running OO applications,” on page 257
Upgrading IBM COBOL programs (*Enterprise COBOL Compiler and Run-Time Migration Guide*)

RELATED REFERENCES

The Java Language Specification

Example: accounts

Consider the example of a bank in which customers can open accounts and make deposits to and withdrawals from their accounts. You could represent an account by a general-purpose class, called `Account`. Because there are many customers, multiple instances of the `Account` class could exist simultaneously.

Once you determine the classes that you need, your next step is to determine the methods that the classes need to do their work. An `Account` class for example must provide the following services:

- Open the account.
- Get the current balance.
- Deposit to the account.
- Withdraw from the account.
- Report account status.

The following methods for an `Account` class meet the above needs:

init Open an account and assign it an account number.

getBalance

Return the current balance of the account.

credit Deposit a given sum to the account.

debit Withdraw a given sum from the account.

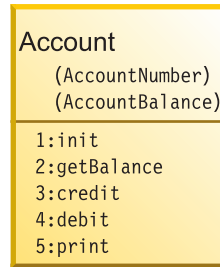
print Display account number and account balance.

As you design an `Account` class and its methods, you discover the need for the class to keep some instance data. Typically, an `Account` object would need the following instance data:

- Account number
- Account balance
- Customer information: name, address, home phone, work phone, social security number, and so forth

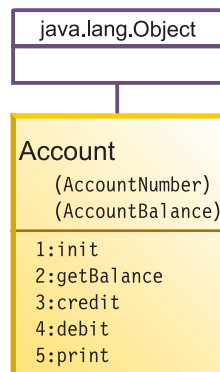
To keep the example simple, however, it is assumed that the account number and account balance are the only instance data that the `Account` class needs.

Diagrams are helpful when you design classes and methods. The following diagram depicts a first attempt at a design of the `Account` class:



The words in parentheses in the diagrams are the names of the instance data, and the words following a number and colon are the names of the instance methods.

The structure below shows how the classes relate to each other, and is known as the *inheritance hierarchy*. The Account class inherits directly from the class `java.lang.Object`.



Subclasses

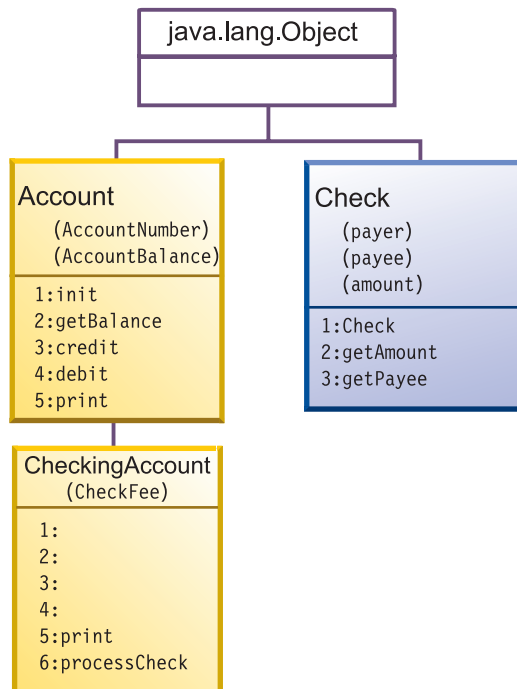
In the account example, Account is a general-purpose class. However, a bank could have many different types of accounts: checking accounts, savings accounts, mortgage loans, and so forth, all of which have all the general characteristics of accounts but could have additional characteristics not shared by all types of accounts.

For example, a CheckingAccount class could have, in addition to the account number and account balance that all accounts have, a check fee that applies to each check written on the account. A CheckingAccount class also needs a method to process checks (that is, to read the amount, debit the payer, credit the payee, and so forth). So it makes sense to define CheckingAccount as a subclass of Account, and to define in the subclass the additional instance data and instance methods that the subclass needs.

As you design the CheckingAccount class, you discover the need for a class that models checks. An instance of class Check would need, at a minimum, instance data for payer, payee, and the check amount.

Many additional classes (and database and transaction-processing logic) would need to be designed in a real-world OO account system, but have been omitted from this discussion to keep the example simple.

The updated inheritance diagram is shown below.



A number and colon with no method-name following them indicate that the method with that number is inherited from the superclass.

Multiple inheritance: You cannot use *multiple inheritance* in your OO COBOL applications. All classes that you define must have exactly one parent, and `java.lang.Object` must be at the root of every inheritance hierarchy. The class structure of any object-oriented system defined in an OO COBOL application is thus a tree.

“Example: defining a method” on page 500

RELATED TASKS

“Defining a class”

“Defining a class instance method” on page 493

“Defining a subclass” on page 510

Defining a class

A COBOL class definition consists of an IDENTIFICATION DIVISION and ENVIRONMENT DIVISION, followed by an optional factory definition and optional object definition, followed by an END CLASS marker:

Table 71. Structure of class definitions

Section	Purpose	Syntax
IDENTIFICATION DIVISION (required)	Name the class. Provide inheritance information for it.	“CLASS-ID paragraph for defining a class” on page 490 (required) AUTHOR paragraph (optional) INSTALLATION paragraph (optional) DATE-WRITTEN paragraph (optional) DATE-COMPILED paragraph (optional)

Table 71. Structure of class definitions (continued)

Section	Purpose	Syntax
ENVIRONMENT DIVISION (required)	Describe the computing environment. Relate class-names used within the class definition to the corresponding external class-names known outside the compilation unit.	CONFIGURATION SECTION (required) “REPOSITORY paragraph for defining a class” on page 490 (required) SOURCE-COMPUTER paragraph (optional) OBJECT-COMPUTER paragraph (optional) SPECIAL-NAMES paragraph (optional)
Factory definition (optional)	Define data to be shared by all instances of the class, and methods supported independently of any object instance.	IDENTIFICATION DIVISION. FACTORY. DATA DIVISION. WORKING-STORAGE SECTION. * (Factory data here) PROCEDURE DIVISION. * (Factory methods here) END FACTORY.
Object definition (optional)	Define instance data and instance methods.	IDENTIFICATION DIVISION. OBJECT. DATA DIVISION. WORKING-STORAGE SECTION. * (Instance data here) PROCEDURE DIVISION. * (Instance methods here) END OBJECT.

If you specify the SOURCE-COMPUTER, OBJECT-COMPUTER, or SPECIAL-NAMES paragraphs in a class CONFIGURATION SECTION, they apply to the entire class definition including all methods that the class introduces.

A class CONFIGURATION SECTION can consist of the same entries as a program CONFIGURATION SECTION, except that a class CONFIGURATION SECTION cannot contain an INPUT-OUTPUT SECTION. You define an INPUT-OUTPUT SECTION only in the individual methods that require it rather than defining it at the class level.

As shown above, you define instance data and methods in the DATA DIVISION and PROCEDURE DIVISION, respectively, within the OBJECT paragraph of the class definition. In classes that require data and methods that are to be associated with the class itself rather than with individual object instances, define a separate DATA DIVISION and PROCEDURE DIVISION within the FACTORY paragraph of the class definition.

Each COBOL class definition must be in a separate source file.

“Example: defining a class” on page 493

RELATED TASKS

“WORKING-STORAGE SECTION for defining class instance data” on page 492

“Defining a class instance method” on page 493

“Defining a subclass” on page 510

“Defining a factory section” on page 514

“Describing the computing environment” on page 7

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

RELATED REFERENCES

COBOL class definition structure (*Enterprise COBOL Language Reference*)

CLASS-ID paragraph for defining a class

Use the CLASS-ID paragraph in the IDENTIFICATION DIVISION to name a class and provide inheritance information for it. For example:

```
Identification Division.           Required  
Class-id. Account inherits Base. Required
```

Use the CLASS-ID paragraph to identify these classes:

- The class that you are defining (Account in the example above).
- The immediate superclass from which the class that you are defining inherits its characteristics. The superclass can be implemented in Java or COBOL.

In the example above, `inherits Base` indicates that the Account class inherits methods and data from the class known within the class definition as Base. It is recommended that you use the name Base in your OO COBOL programs to refer to `java.lang.Object`.

A class-name must use single-byte characters and must conform to the normal rules of formation for a COBOL user-defined word.

Use the REPOSITORY paragraph in the CONFIGURATION SECTION of the ENVIRONMENT DIVISION to associate the superclass name (Base in the example above) with the name of the superclass as it is known externally (`java.lang.Object` for Base). You can optionally also specify the name of the class that you are defining (Account in the example above) in the REPOSITORY paragraph and associate it with its corresponding external class-name.

You must derive all classes directly or indirectly from the `java.lang.Object` class.

RELATED TASKS

"REPOSITORY paragraph for defining a class"

RELATED REFERENCES

CLASS-ID paragraph (*Enterprise COBOL Language Reference*)

User-defined words (*Enterprise COBOL Language Reference*)

REPOSITORY paragraph for defining a class

Use the REPOSITORY paragraph to declare to the compiler that the specified words are class-names when you use them within a class definition, and to optionally relate the class-names to the corresponding external class-names (the class-names as they are known outside the compilation unit). External class-names are case sensitive and must conform to Java rules of formation. For example, in the Account class definition you might code this:

```
Environment Division.           Required  
Configuration Section.         Required  
Repository.                    Required  
    Class Base is "java.lang.Object" Required  
    Class Account is "Account".      Optional
```

The REPOSITORY paragraph entries indicate that the external class-names of the classes referred to as Base and Account within the class definition are `java.lang.Object` and Account, respectively.

In the REPOSITORY paragraph, you must code an entry for each class-name that you explicitly reference in the class definition. For example:

- Base
- A superclass from which the class that you are defining inherits
- The classes that you reference in methods within the class definition

In a REPOSITORY paragraph entry, you must specify the external class-name if the name contains non-COBOL characters.

You must specify the external class-name for any referenced class that is part of a Java *package*. For such a class, specify the external class-name as the fully qualified name of the package, followed by period (.), followed by the simple name of the Java class. For example, the Object class is part of the java.lang package, so specify its external name as java.lang.Object as shown above.

An external class-name that you specify in the REPOSITORY paragraph must be an alphanumeric literal that conforms to the rules of formation for a fully qualified Java class-name.

If you do not include the external class-name in a REPOSITORY paragraph entry, the external class-name is formed from the class-name in the following manner:

- The class-name is converted to uppercase.
- Each hyphen is changed to zero.
- The first character, if a digit, is changed:
 - 1-9 are changed to A-I.
 - 0 is changed to J.

In the example above, class Account is known externally as Account (in mixed case) because the external name is spelled using mixed case.

You can optionally include in the REPOSITORY paragraph an entry for the class that you are defining (Account in this example). You must include an entry for the class that you are defining if the external class-name contains non-COBOL characters, or to specify a fully package-qualified class-name if the class is to be part of a Java package.

“Example: external class-names and Java packages”

RELATED TASKS

“Declaring arrays and strings for Java” on page 532

RELATED REFERENCES

REPOSITORY paragraph (*Enterprise COBOL Language Reference*)

Identifiers (*The Java Language Specification*)

Packages (*The Java Language Specification*)

Example: external class-names and Java packages

The following example shows how external class-names are determined from entries in a REPOSITORY paragraph:

Environment division.

Configuration section.

Repository.

Class Employee is "com.acme.Employee"

Class JavaException is "java.lang.Exception"

Class Orders.

The local class-names (the class-names as used within the class definition), the Java packages that contain the classes, and the associated external class-names are as shown in the table below:

Local class-name	Java package	External class-name
Employee	com.acme	com.acme.Employee
JavaException	java.lang	java.lang.Exception
Orders	(unnamed)	ORDERS

The external class-name (the name following the class-name and optional IS in the REPOSITORY paragraph entry) is composed of the fully qualified name of the package (if any) followed by a period, followed by the simple name of the class.

RELATED TASKS

“REPOSITORY paragraph for defining a class” on page 490

RELATED REFERENCES

REPOSITORY paragraph (*Enterprise COBOL Language Reference*)

WORKING-STORAGE SECTION for defining class instance data

Use the WORKING-STORAGE SECTION in the DATA DIVISION of the OBJECT paragraph to describe the *instance data* that a COBOL class needs, that is, the data to be allocated for each instance of the class. The OBJECT keyword, which you must immediately precede with an IDENTIFICATION DIVISION declaration, indicates the beginning of the definitions of the instance data and instance methods for the class. For example, the definition of the instance data for the Account class might look like this:

```
Identification division.
Object.
  Data division.
    Working-storage section.
      01 AccountNumber pic 9(6).
      01 AccountBalance pic S9(9) value zero.
      . . .
End Object.
```

The instance data is allocated when an object instance is created, and exists until garbage collection of the instance by the Java run time.

You can initialize simple instance data by using VALUE clauses as shown above. You can initialize more complex instance data by coding customized methods to create and initialize instances of classes.

COBOL instance data is equivalent to Java private nonstatic member data. No other class or subclass (nor factory method in the same class, if any) can reference COBOL instance data directly. Instance data is global to all instance methods that the OBJECT paragraph defines. If you want to make instance data accessible from outside the OBJECT paragraph, define attribute (get or set) instance methods for doing so.

The syntax of the WORKING-STORAGE SECTION for instance data declaration is generally the same as in a program, with these exceptions:

- You cannot use the EXTERNAL attribute.

- You can use the GLOBAL attribute, but it has no effect.

RELATED TASKS

“Creating and initializing instances of classes” on page 508

“Freeing instances of classes” on page 509

“Defining a factory method” on page 516

“Coding attribute (get and set) methods” on page 499

Example: defining a class

This example shows a first attempt at the definition of the Account class, excluding method definitions.

```

cbl dll,thread,pgmname(longmixed)
Identification Division.
Class-id. Account inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base    is "java.lang.Object"
    Class Account is "Account".
*
Identification division.
Object.
Data division.
Working-storage section.
01 AccountNumber pic 9(6).
01 AccountBalance pic S9(9) value zero.
*
Procedure Division.
*
*   (Instance method definitions here)
*
End Object.
*
End class Account.

```

RELATED TASKS

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

“Defining a client” on page 502

Defining a class instance method

Define COBOL *instance methods* in the PROCEDURE DIVISION of the OBJECT paragraph of a class definition. An instance method defines an operation that is supported for each object instance of a class.

A COBOL instance method definition consists of four divisions (like a COBOL program), followed by an END METHOD marker:

Table 72. Structure of instance method definitions

Division	Purpose	Syntax
IDENTIFICATION (required)	Name a method.	“METHOD-ID paragraph for defining a class instance method” on page 494 (required) AUTHOR paragraph (optional) INSTALLATION paragraph (optional) DATE-WRITTEN paragraph (optional) DATE-COMPILED paragraph (optional)

Table 72. Structure of instance method definitions (continued)

Division	Purpose	Syntax
ENVIRONMENT (optional)	Relate the file-names used in a method to the corresponding file-names known to the operating system.	"INPUT-OUTPUT SECTION for defining a class instance method" on page 495 (optional)
DATA (optional)	Define external files. Allocate a copy of the data.	"DATA DIVISION for defining a class instance method" on page 495 (optional)
PROCEDURE (optional)	Code the executable statements to complete the service provided by the method.	"PROCEDURE DIVISION for defining a class instance method" on page 496 (optional)

Definition: The *signature* of a method consists of the name of the method and the number and type of its formal parameters. (You define the formal parameters of a COBOL method in the USING phrase of the method's PROCEDURE DIVISION header.)

Within a class definition, you do not need to make each method-name unique, but you do need to give each method a unique signature. (You *overload* methods by giving them the same name but a different signature.)

COBOL instance methods are equivalent to Java public nonstatic methods.

"Example: defining a method" on page 500

RELATED TASKS

"PROCEDURE DIVISION for defining a class instance method" on page 496

"Overloading an instance method" on page 498

"Overriding an instance method" on page 497

"Invoking methods (INVOKE)" on page 506

"Defining a subclass instance method" on page 513

"Defining a factory method" on page 516

METHOD-ID paragraph for defining a class instance method

Use the METHOD-ID paragraph to name an instance method. Immediately precede the METHOD-ID paragraph with an IDENTIFICATION DIVISION declaration to indicate the beginning of the method definition. For example, the definition of the credit method in the Account class begins like this:

```
Identification Division.
Method-id. "credit".
```

Code the method-name as an alphanumeric or national literal. The method-name is processed in a case-sensitive manner and must conform to the rules of formation for a Java method-name.

Other Java or COBOL methods or programs (that is, clients) use the method-name to invoke a method.

In the example above, credit is the method-name.

RELATED TASKS

“Invoking methods (INVOKE)” on page 506

“Using national data (Unicode) in COBOL” on page 106

RELATED REFERENCES

Meaning of method names (*The Java Language Specification*)

Identifiers (*The Java Language Specification*)

METHOD-ID paragraph (*Enterprise COBOL Language Reference*)

INPUT-OUTPUT SECTION for defining a class instance method

The ENVIRONMENT DIVISION of an instance method can have only one section, the INPUT-OUTPUT SECTION. For example, if the Account class defined a method that read information from a file, the Account class might have an INPUT-OUTPUT SECTION that looks like this:

```
Environment Division.  
Input-Output Section.  
File-Control.  
    Select account-file Assign AcctFile.
```

The INPUT-OUTPUT SECTION relates the file-names used in a method definition to the corresponding file-names as they are known to the operating system. The syntax for the INPUT-OUTPUT SECTION of a method is the same as the syntax for the INPUT-OUTPUT SECTION of a program.

RELATED TASKS

“Describing the computing environment” on page 7

RELATED REFERENCES

INPUT-OUTPUT section (*Enterprise COBOL Language Reference*)

DATA DIVISION for defining a class instance method

The DATA DIVISION of an instance method consists of any of the following four sections:

FILE SECTION

The same as a program FILE SECTION, except that a method FILE SECTION can define EXTERNAL files only.

LOCAL-STORAGE SECTION

A separate copy of the LOCAL-STORAGE data is allocated for each invocation of the method, and is freed on return from the method.

If you specify the VALUE clause on a data item, the item is initialized to that value on each invocation of the method.

The method LOCAL-STORAGE SECTION is similar to a program LOCAL-STORAGE SECTION.

WORKING-STORAGE SECTION

A single copy of the WORKING-STORAGE data is allocated. The data persists in its last-used state until the run unit ends. The same copy of the data is used whenever the method is invoked, regardless of the invoking object or thread.

If you specify the VALUE clause on a data item, the item is initialized to that value on the first invocation of the method. You can specify the EXTERNAL clause for the data items.

The method WORKING-STORAGE SECTION is similar to a program WORKING-STORAGE SECTION.

LINKAGE SECTION

The same as a program LINKAGE SECTION.

If you define a data item with the same name in both the DATA DIVISION of an instance method and the DATA DIVISION of the OBJECT paragraph, a reference in the method to that data-name refers only to the method data item. The method DATA DIVISION takes precedence.

RELATED TASKS

“Describing the data” on page 12

“Sharing data by using the EXTERNAL clause” on page 420

RELATED REFERENCES

Data Division overview (*Enterprise COBOL Language Reference*)

PROCEDURE DIVISION for defining a class instance method

Code the executable statements to implement the service that an instance method provides in the PROCEDURE DIVISION of the instance method.

You can code most COBOL statements in the PROCEDURE DIVISION of a method that you can code in the PROCEDURE DIVISION of a program. You cannot, however, code the following statements in a method:

- ENTRY
- EXIT PROGRAM
- The following obsolete elements of COBOL 85:
 - ALTER
 - GOTO without a specified procedure-name
 - SEGMENT-LIMIT
 - USE FOR DEBUGGING

Additionally, because you must compile all COBOL class definitions with the THREAD compiler option, you cannot use SORT or MERGE statements in a COBOL method.

You can code the EXIT METHOD or GOBACK statement in an instance method to return control to the invoking client. Both statements have the same effect. If you specify the RETURNING phrase upon invocation of the method, the EXIT METHOD or GOBACK statement returns the value of the data item to the invoking client.

An implicit EXIT METHOD is generated as the last statement in the PROCEDURE DIVISION of each method.

You can specify STOP RUN in a method; doing so terminates the entire run unit including all threads executing within it.

You must terminate a method definition with an END METHOD marker. For example, the following statement marks the end of the credit method:

End method "credit".

USING phrase for obtaining passed arguments

Specify the formal parameters to a method, if any, in the USING phrase of the method's PROCEDURE DIVISION header. You must specify that the arguments are passed BY VALUE. Define each parameter as a level-01 or level-77 item in the method's LINKAGE SECTION. The data type of each parameter must be one of the types that are interoperable with Java.

RETURNING phrase for returning a value

Specify the data item to be returned as the method result, if any, in the RETURNING phrase of the method's PROCEDURE DIVISION header. Define the data item as a level-01 or level-77 item in the method's LINKAGE SECTION. The data type of the return value must be one of the types that are interoperable with Java.

RELATED TASKS

"Coding interoperable data types in COBOL and Java" on page 532

"Overriding an instance method"

"Overloading an instance method" on page 498

"Comparing and setting object references" on page 505

"Invoking methods (INVOKE)" on page 506

Chapter 16, "Compiling, linking, and running OO applications," on page 257

RELATED REFERENCES

"THREAD" on page 309

The procedure division header (*Enterprise COBOL Language Reference*)

Overriding an instance method

An instance method defined in a subclass is said to *override* an inherited instance method that would otherwise be accessible in the subclass if the two methods have the same signature.

To override a superclass instance method `m1` in a COBOL subclass, define an instance method `m1` in the subclass that has the same name and whose PROCEDURE DIVISION USING phrase (if any) has the same number and type of formal parameters as the superclass method has. (If the superclass method is implemented in Java, you must code formal parameters that are interoperable with the data types of the corresponding Java parameters.) When a client invokes `m1` on an instance of the subclass, the subclass method rather than the superclass method is invoked.

For example, the `Account` class defines a method `debit` whose LINKAGE SECTION and PROCEDURE DIVISION header look like this:

```
Linkage section.  
01 inDebit    pic S9(9) binary.  
Procedure Division using by value inDebit.
```

If you define a `CheckingAccount` subclass and want it to have a `debit` method that overrides the `debit` method defined in the `Account` superclass, define the subclass method with exactly one input parameter also specified as `pic S9(9) binary`. If a client invokes `debit` using an object reference to a `CheckingAccount` instance, the `CheckingAccount` `debit` method (rather than the `debit` method in the `Account` superclass) is invoked.

The presence or absence of a method return value and the data type of the return value used in the PROCEDURE DIVISION RETURNING phrase (if any) must be identical in the subclass instance method and the overridden superclass instance method.

An instance method must not override a factory method in a COBOL superclass nor a static method in a Java superclass.

“Example: defining a method” on page 500

RELATED TASKS

“PROCEDURE DIVISION for defining a class instance method” on page 496

“Coding interoperable data types in COBOL and Java” on page 532

“Invoking methods (INVOKE)” on page 506

“Invoking overridden superclass methods” on page 507

“Defining a subclass” on page 510

“Hiding a factory or static method” on page 517

RELATED REFERENCES

Inheritance, overriding, and hiding (*The Java Language Specification*)

Overloading an instance method

Two methods supported in a class (whether defined in the class or inherited from a superclass) are said to be *overloaded* if they have the same name but different signatures.

You overload methods when you want to enable clients to invoke different versions of a method, for example, to initialize data using different sets of parameters.

To overload a method, define a method whose PROCEDURE DIVISION USING phrase (if any) has a different number or type of formal parameters than an identically named method supported in the same class.

For example, the Account class defines an instance method `init` that has exactly one formal parameter. The LINKAGE SECTION and PROCEDURE DIVISION header of the `init` method look like this:

```
Linkage section.  
01 inAccountNumber pic S9(9) binary.  
Procedure Division using by value inAccountNumber.
```

Clients invoke this method to initialize an Account instance with a given account number (and a default account balance of zero) by passing exactly one argument that matches the data type of `inAccountNumber`.

But the Account class could define, for example, a second instance method `init` that has an additional formal parameter that allows the opening account balance to also be specified. The LINKAGE SECTION and PROCEDURE DIVISION header of this `init` method could look like this:

```
Linkage section.  
01 inAccountNumber pic S9(9) binary.  
01 inBalance       pic S9(9) binary.  
Procedure Division using by value inAccountNumber  
                               inBalance.
```

Clients could invoke either `init` method by passing arguments that match the signature of the desired method.

The presence or absence of a method return value does not have to be consistent in overloaded methods, and the data type of the return value given in the PROCEDURE DIVISION RETURNING phrase (if any) does not have to be identical in overloaded methods.

You can overload factory methods in exactly the same way that you overload instance methods.

The rules for overloaded method definition and resolution of overloaded method invocations are based on the corresponding rules for Java.

RELATED TASKS

“Invoking methods (INVOKE)” on page 506

“Defining a factory method” on page 516

RELATED REFERENCES

Overloading (*The Java Language Specification*)

Coding attribute (get and set) methods

You can provide access to an instance variable *X* from outside the class in which *X* is defined by coding accessor (get) or mutator (set) methods for *X*.

Instance variables in COBOL are *private*. The class that defines instance variables fully encapsulates them, and only the instance methods defined in the same OBJECT paragraph can access them directly. Normally a well-designed object-oriented application does not need to access instance variables from outside the class.

COBOL does not directly support the concept of a *public* instance variable as defined in Java and other object-oriented languages, nor the concept of a class attribute as defined by CORBA. (A CORBA *attribute* is an instance variable that has an automatically generated get method for accessing the value of the variable, and an automatically generated set method for modifying the value of the variable if the variable is not read-only.)

“Example: coding a get method”

RELATED TASKS

“WORKING-STORAGE SECTION for defining class instance data” on page 492

“Processing the data” on page 18

Example: coding a get method

In the Account class you could define an instance method, `getBalance`, to return the value of the instance variable `AccountBalance` to a client. Define `getBalance` and `AccountBalance` in the OBJECT paragraph of the Account class definition:

```
Identification Division.
Class-id. Account inherits Base.
* (ENVIRONMENT DIVISION not shown)
* (FACTORY paragraph not shown)
*
Identification division.
Object.
Data division.
Working-storage section.
01 AccountBalance pic S9(9) value zero.
* (Other instance data not shown)
*
Procedure Division.
*
```

```

    Identification Division.
    Method-id. "getBalance".
    Data division.
    Linkage section.
    01 outBalance pic S9(9) binary.
*
    Procedure Division returning outBalance.
        Move AccountBalance to outBalance.
    End method "getBalance".
*
* (Other instance methods not shown)
End Object.
*
End class Account.

```

Example: defining a method

This example adds to the previous example ("Example: defining a class" on page 493) the instance method definitions of the Account class, and shows the definition of the Java Check class.

Account class

```

cbl dll,thread,pgmname(longmixed)
Identification Division.
Class-id. Account inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base is "java.lang.Object"
    Class Account is "Account".
*
* (FACTORY paragraph not shown)
*
    Identification division.
    Object.
    Data division.
    Working-storage section.
    01 AccountNumber pic 9(6).
    01 AccountBalance pic S9(9) value zero.
*
    Procedure Division.
*
*   init method to initialize the account:
    Identification Division.
    Method-id. "init".
    Data division.
    Linkage section.
    01 inAccountNumber pic S9(9) binary.
    Procedure Division using by value inAccountNumber.
        Move inAccountNumber to AccountNumber.
    End method "init".
*
*   getBalance method to return the account balance:
    Identification Division.
    Method-id. "getBalance".
    Data division.
    Linkage section.
    01 outBalance pic S9(9) binary.
    Procedure Division returning outBalance.
        Move AccountBalance to outBalance.
    End method "getBalance".
*
*   credit method to deposit to the account:
    Identification Division.
    Method-id. "credit".
    Data division.

```

```

Linkage section.
01 inCredit    pic S9(9) binary.
Procedure Division using by value inCredit.
    Add inCredit to AccountBalance.
End method "credit".
*
*    debit method to withdraw from the account:
Identification Division.
Method-id. "debit".
Data division.
Linkage section.
01 inDebit     pic S9(9) binary.
Procedure Division using by value inDebit.
    Subtract inDebit from AccountBalance.
End method "debit".
*
*    print method to display formatted account number and balance:
Identification Division.
Method-id. "print".
Data division.
Local-storage section.
01 PrintableAccountNumber pic ZZZZZ999999.
01 PrintableAccountBalance pic $$$,$$$,$$9CR.
Procedure Division.
    Move AccountNumber to PrintableAccountNumber
    Move AccountBalance to PrintableAccountBalance
    Display " Account: " PrintableAccountNumber
    Display " Balance: " PrintableAccountBalance.
End method "print".
*
End Object.
*
End class Account.

```

Check class

```

/**
 * A Java class for check information
 */
public class Check {
    private CheckingAccount payer;
    private Account         payee;
    private int              amount;

    public Check(CheckingAccount inPayer, Account inPayee, int inAmount) {
        payer=inPayer;
        payee=inPayee;
        amount=inAmount;
    }

    public int getAmount() {
        return amount;
    }

    public Account getPayee() {
        return payee;
    }
}

```

RELATED TASKS

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

Defining a client

A program or method that requests services from one or more methods in a class is called a *client* of that class.

In a COBOL or Java client, you can:

- Create object instances of Java and COBOL classes.
- Invoke instance methods on Java and COBOL objects.
- Invoke COBOL factory methods and Java static methods.

In a COBOL client, you can also call services provided by the Java Native Interface (JNI).

A COBOL client program consists of the usual four divisions:

Table 73. Structure of COBOL clients

Division	Purpose	Syntax
IDENTIFICATION (required)	Name a client.	Code as usual, except that a client program must be: <ul style="list-style-type: none">• Recursive (declared RECURSIVE in the PROGRAM-ID paragraph)• Thread-enabled (compiled with the THREAD option, and conforming to the coding guidelines for threaded applications)
ENVIRONMENT (required)	Describe the computing environment. Relate class-names used in the client to the corresponding external class-names known outside the compilation unit.	CONFIGURATION SECTION (required) “REPOSITORY paragraph for defining a client” on page 503 (required)
DATA (optional)	Describe the data that the client needs.	“DATA DIVISION for defining a client” on page 504 (optional)
PROCEDURE (optional)	Create instances of classes, manipulate object reference data items, and invoke methods.	Code using INVOKE, IF, and SET statements.

A method can request services from another method. Therefore a COBOL method can act as a client and use the statements discussed in this section.

Because you must compile all COBOL programs that contain object-oriented syntax or that interoperate with Java with the THREAD compiler option, you cannot use the following language elements in a COBOL client:

- SORT or MERGE statements
- Nested programs

Any programs that you compile with the THREAD compiler option must be recursive. You must specify the RECURSIVE clause in the PROGRAM-ID paragraph of each OO COBOL client program.

"Example: defining a client" on page 510

RELATED TASKS

Chapter 16, "Compiling, linking, and running OO applications," on page 257

Chapter 27, "Preparing COBOL programs for multithreading," on page 437

Chapter 31, "Communicating with Java methods," on page 527

"Coding interoperable data types in COBOL and Java" on page 532

"Creating and initializing instances of classes" on page 508

"Comparing and setting object references" on page 505

"Invoking methods (INVOKE)" on page 506

"Invoking factory or static methods" on page 517

RELATED REFERENCES

"THREAD" on page 309

REPOSITORY paragraph for defining a client

Use the REPOSITORY paragraph in the CONFIGURATION SECTION of the ENVIRONMENT DIVISION to declare to the compiler that the specified words are class-names when you use them in a COBOL client, and to optionally relate the class-names to the corresponding external class-names (the class-names as they are known outside the compilation unit). External class-names are case sensitive, and must conform to Java rules of formation. For example, in a client program that uses the Account and Check classes you might code this:

```
Environment division.      Required
Configuration section.    Required
    Source-Computer.      IBM-390.
    Object-Computer.      IBM-390.
Repository.               Required
    Class Account is "Account"
    Class Check   is "Check".
```

The REPOSITORY paragraph entries indicate that the external class-names of the classes referred to as Account and Check within the client are Account and Check, respectively.

In the REPOSITORY paragraph, you must code an entry for each class-name that you explicitly reference in the client.

In a REPOSITORY paragraph entry, you must specify the external class-name if the name contains non-COBOL characters.

You must specify the external class-name for any referenced class that is part of a Java package. For such a class, specify the external class-name as the fully qualified name of the package, followed by period (.), followed by the simple name of the Java class.

An external class-name that you specify in the REPOSITORY paragraph must be an alphanumeric literal that conforms to the rules of formation for a fully qualified Java class-name.

If you do not include the external class-name in a REPOSITORY paragraph entry, the external class-name is formed from the class-name in the same manner as it is when an external class-name is not included in a REPOSITORY paragraph entry in a class definition. In the example above, class Account and class Check are known externally as Account and Check (in mixed case), respectively, because the external names are spelled using mixed case.

The SOURCE-COMPUTER, OBJECT-COMPUTER, and SPECIAL-NAMES paragraphs of the CONFIGURATION SECTION are optional.

RELATED TASKS

“REPOSITORY paragraph for defining a class” on page 490

RELATED REFERENCES

REPOSITORY paragraph (*Enterprise COBOL Language Reference*)

Identifiers (*The Java Language Specification*)

Packages (*The Java Language Specification*)

DATA DIVISION for defining a client

You can use any of the sections of the DATA DIVISION to describe the data that the client needs. For example:

Data Division.

Local-storage section.

```
01  anAccount      usage object reference Account.
01  aCheckingAccount usage object reference CheckingAccount.
01  aCheck         usage object reference Check.
01  payee          usage object reference Account.
. . .
```

Because a client references classes, it needs one or more special data items called *object references*, that is, references to instances of the classes. All requests to instance methods require an object reference to an instance of a class in which the method is supported (that is, either defined or available by inheritance). You code object references to refer to instances of Java classes using the same syntax as you use to code object references to refer to instances of COBOL classes. In the example above, the phrase *usage object reference* indicates an object reference data item.

All four object references above are called *typed* object references because a class-name appears after the OBJECT REFERENCE phrase. A typed object reference can refer only to an instance of the class named in the OBJECT REFERENCE phrase or to one of its subclasses. Thus *anAccount* can refer to instances of the *Account* class or one of its subclasses, but cannot refer to instances of any other class. Similarly, *aCheck* can refer only to instances of the *Check* class or any subclasses that it might have.

Another type of object reference, not shown above, does not have a class-name after the OBJECT REFERENCE phrase. Such a reference is called a *universal* object reference, which means that it can refer to instances of any class. Avoid coding universal object references, because they are interoperable with Java in only very limited circumstances (when used in the RETURNING phrase of the INVOKE *class-name* NEW . . . statement).

You must define, in the REPOSITORY paragraph of the CONFIGURATION SECTION, class-names that you use in the OBJECT REFERENCE phrase.

Choosing LOCAL-STORAGE or WORKING-STORAGE

You can in general use the WORKING-STORAGE SECTION to define working data that a client program needs. However, if the program could simultaneously run on multiple threads, you might instead want to define the data in the LOCAL-STORAGE SECTION, as shown above. Each thread has access to a separate copy of LOCAL-STORAGE data but shares access to a single copy of WORKING-STORAGE data. If you define the data in the WORKING-STORAGE SECTION, you need to synchronize access to the data or ensure that no two threads can access it simultaneously.

RELATED TASKS

Chapter 27, “Preparing COBOL programs for multithreading,” on page 437
“Coding interoperable data types in COBOL and Java” on page 532
“Invoking methods (INVOKE)” on page 506
“REPOSITORY paragraph for defining a client” on page 503

RELATED REFERENCES

RETURNING phrase (*Enterprise COBOL Language Reference*)

Comparing and setting object references

You can compare object references by using conditional statements. For example, code either IF statement below to check whether the object reference `anAccount` refers to no object instance:

```
If anAccount = Null . . .  
If anAccount = Nulls . . .
```

You can code a call to the JNI service `IsSameObject` to check whether two object references, `object1` and `object2`, refer to the same object instance or whether each refers to no object instance. To ensure that the arguments and return value are interoperable with Java and to establish addressability to the callable service, code the following data definitions and statements preceding the call to `IsSameObject`:

Local-storage Section.

```
. . .  
01 is-same Pic X.  
   88 is-same-false Value X'00'.  
   88 is-same-true  Value X'01' Through X'FF'.
```

Linkage Section.

Copy JNI.

Procedure Division.

```
Set Address Of JNIEnv To JNIEnvPtr  
Set Address Of JNINativeInterface To JNIEnv  
. . .  
Call IsSameObject Using By Value JNIEnvPtr object1 object2  
Returning is-same  
If is-same-true . . .
```

Within a method you can check whether an object reference refers to the object instance on which the method was invoked by coding a call to `IsSameObject` that compares the object reference and `SELF`.

You can instead invoke the Java `equals` method (inherited from `java.lang.Object`) to determine whether two object references refer to the same object instance.

You can make an object reference refer to no object instance by using the `SET` statement. For example:

```
Set anAccount To Null.
```

You can also make one object reference refer to the same instance as another object reference does by using the `SET` statement. For example:

```
Set anotherAccount To anAccount.
```

This `SET` statement causes `anotherAccount` to refer to the same object instance as `anAccount` does. If the receiver (`anotherAccount`) is a universal object reference, the sender (`anAccount`) can be either a universal or a typed object reference. If the receiver is a typed object reference, the sender must be a typed object reference bound to the same class as the receiver or to one of its subclasses.

Within a method you can make an object reference refer to the object instance on which the method was invoked by setting it to SELF. For example:

Set anAccount To Self.

RELATED TASKS

“Coding interoperable data types in COBOL and Java” on page 532

“Accessing JNI services” on page 527

RELATED REFERENCES

IsSameObject (*The Java Native Interface*)

Invoking methods (INVOKE)

In a Java client, you can create object instances of classes that were implemented in COBOL and invoke methods on those objects. Use standard Java syntax to do so.

In a COBOL client, you can invoke methods defined in Java or COBOL classes by coding the INVOKE statement. For example:

```
Invoke Account "createAccount"
    using by value 123456
    returning anAccount
Invoke anAccount "credit" using by value 500.
```

The first statement uses the class-name Account to invoke a method called createAccount, which must be either a Java static method or a COBOL factory method supported (that is, either defined or inherited) in the Account class. using by value 123456 indicates that 123456 is an input argument to the method, passed by value. 123456 and anAccount must conform to the definition of the formal parameters and return type, respectively, of the (possibly overloaded) createAccount method.

The second INVOKE statement uses the returned object reference anAccount to invoke the instance method credit defined in the Account class. The input argument 500 must conform to the definition of the formal parameters of the (possibly overloaded) credit method.

Code the name of the method to be invoked either as a literal or as an identifier whose value at run time matches the method-name in the signature of the target method. The method-name must be an alphanumeric or national literal or data item, and is interpreted in a case-sensitive manner.

For example, when you code an INVOKE statement using an object reference (as in the second statement above), the statement begins with one of the following two forms:

```
Invoke objRef "literal-name" . . .
Invoke objRef identifier-name . . .
```

When the method-name is an identifier, you must define the object reference (objRef) as USAGE OBJECT REFERENCE with no specified type, that is, as a universal object reference.

If an invoked method is not supported in the class to which the object reference refers, a severity-3 Language Environment condition is raised at run time unless you code the ON EXCEPTION phrase of the INVOKE statement.

You can use the optional scope terminator END-INVOKE with the INVOKE statement.

The INVOKE statement does not set the RETURN-CODE special register.

USING phrase for passing arguments

Specify the arguments to a method, if any, in the USING phrase of the INVOKE statement. Code the data types of the arguments so that they match the signature of the intended target method. If the target method is overloaded, the data types of the arguments are used to select from among the methods that have the same name.

You must specify that the arguments are passed BY VALUE, which means that the arguments are not affected by any change to the corresponding formal parameters in the invoked method. The data type of each argument must be one of the types that are interoperable with Java.

RETURNING phrase for obtaining a returned value

Specify the data item to be returned as the method result, if any, in the RETURNING phrase of the INVOKE statement. Define the returned item in the DATA DIVISION of the client.

The item that you specify in the RETURNING phrase of the INVOKE statement must conform to the type returned by the target method:

- If the target method is implemented in COBOL and the returned item is not an object reference, code the DATA DIVISION definition of the returned item exactly like the definition of the RETURNING item in the target method.
- If the target method is implemented in Java, code the DATA DIVISION definition of the returned item to be interoperable with the returned Java data item.
- If the returned item is an object reference, code the DATA DIVISION definition of the returned item as an object reference typed to the same class as the object reference returned by the target method.

In all cases, the data type of the returned value must be one of the types that are interoperable with Java.

RELATED TASKS

“Overloading an instance method” on page 498

“Coding interoperable data types in COBOL and Java” on page 532

“PROCEDURE DIVISION for defining a class instance method” on page 496

“Invoking overridden superclass methods”

“Invoking factory or static methods” on page 517

“Using national data (Unicode) in COBOL” on page 106

RELATED REFERENCES

INVOKE statement (*Enterprise COBOL Language Reference*)

Invoking overridden superclass methods

Sometimes within a class you need to invoke an overridden superclass method instead of invoking a method with the same signature that is defined in the current class.

For example, suppose that the CheckingAccount class overrides the debit instance method defined in its immediate superclass, Account. You could invoke the Account debit method within a method in the CheckingAccount class by coding this statement:

Invoke Super "debit" Using By Value amount.

You would define amount as PIC S9(9) BINARY to match the signature of the debit methods.

The CheckingAccount class overrides the print method that is defined in the Account class. Because the print method has no formal parameters, a method in the CheckingAccount class could invoke the superclass print method with this statement:

Invoke Super "print".

The keyword SUPER indicates that you want to invoke a superclass method rather than a method in the current class. (SUPER is an implicit reference to the object used in the invocation of the currently executing method.)

“Example: accounts” on page 486

RELATED TASKS

“Overriding an instance method” on page 497

RELATED REFERENCES

INVOKE statement (*Enterprise COBOL Language Reference*)

Creating and initializing instances of classes

Before you can use the instance methods defined in a Java or COBOL class, you must first create an instance of the class. To create a new instance of class *class-name* and to obtain a reference *object-reference* to the created object, code a statement of this form:

```
INVOKE class-name NEW . . . RETURNING object-reference
```

You must define *object-reference* in the DATA DIVISION of the client.

When you code the INVOKE . . . NEW statement within a method, and the use of the returned object reference is not limited to the duration of the method invocation, you must convert the returned object reference to a global reference by calling the JNI service NewGlobalRef:

```
Call NewGlobalRef using by value JNIEnvPtr object-reference  
returning object-reference
```

If you do not call NewGlobalRef, the returned object reference is only a local reference, which means that it is automatically freed after the method returns.

For further information about managing local and global references, see the related task below.

Instantiating Java classes

To instantiate a Java class, you can invoke any parameterized constructor that the class supports by coding the USING phrase in the INVOKE . . . NEW statement immediately before the RETURNING phrase, passing BY VALUE the number and types of arguments that match the signature of the constructor. The data type of each argument must be one of the types that are interoperable with Java. To invoke the default (parameterless) constructor, omit the USING phrase.

For example, to create an instance of the Check class, initialize its instance data, and obtain reference aCheck to the Check instance created, you could code this statement in a COBOL client:

```
Invoke Check New
  using by value aCheckingAccount, payee, 125
  returning aCheck
```

Instantiating COBOL classes

To instantiate a COBOL class, you can specify either a typed or universal object reference in the RETURNING phrase of the INVOKE . . . NEW statement. However, you cannot code the USING phrase: the instance data is initialized as specified in the VALUE clauses in the class definition. Thus the INVOKE . . . NEW statement is useful for instantiating COBOL classes that have only simple instance data.

For example, the following statement creates an instance of the Account class, initializes the instance data as specified in VALUE clauses in the WORKING-STORAGE SECTION of the OBJECT paragraph of the Account class definition, and provides reference outAccount to the new instance:

```
Invoke Account New returning outAccount
```

To make it possible to initialize COBOL instance data that cannot be initialized using VALUE clauses alone, when designing a COBOL class you must define a parameterized creation method in the FACTORY paragraph and a parameterized initialization method in the OBJECT paragraph:

1. In the parameterized factory creation method, do these steps:
 - a. Code INVOKE *class-name* NEW RETURNING *objectRef* to create an instance of *class-name* and to give initial values to the instance data items that have VALUE clauses.
 - b. Invoke the parameterized initialization method on the instance (*objectRef*), passing BY VALUE the arguments that were supplied to the factory method.
2. In the initialization method, code logic to complete the instance data initialization using the values supplied through the formal parameters.

To create an instance of the COBOL class and properly initialize it, the client invokes the parameterized factory method, passing BY VALUE the desired arguments. The object reference returned to the client is a local reference. If the client code is within a method, and the use of the returned object reference is not limited to the duration of that method, the client code must convert the returned object reference to a global reference by calling the JNI service NewGlobalRef.

“Example: defining a factory (with methods)” on page 518

RELATED TASKS

“Accessing JNI services” on page 527

“Managing local and global references” on page 530

“DATA DIVISION for defining a client” on page 504

“Invoking methods (INVOKE)” on page 506

“Defining a factory section” on page 514

“Coding interoperable data types in COBOL and Java” on page 532

RELATED REFERENCES

VALUE clause (*Enterprise COBOL Language Reference*)

INVOKE statement (*Enterprise COBOL Language Reference*)

Freeing instances of classes

You do not need to take any action to free individual object instances of any class. No syntax is available for doing so.

The Java run-time system automatically performs *garbage collection*, that is, it reclaims the memory for objects that are no longer in use.

There could be times, however, when you need to explicitly free local or global references to objects within a native COBOL client in order to permit garbage collection of the referenced objects to occur.

RELATED TASKS

“Managing local and global references” on page 530

Example: defining a client

This example shows a small client program of the Account class (as seen in “Example: defining a method” on page 500). The program does this:

1. Invokes a factory method `createAccount` to create an Account instance with a default balance of zero
2. Invokes the instance method `credit` to deposit \$500 to the new account
3. Invokes the instance method `print` to display the account status

```
cb1 dll,thread,pgmname(1ongmixed)
Identification division.
Program-id. "TestAccounts" recursive.
Environment division.
Configuration section.
Repository.
    Class Account is "Account".
Data Division.
* Working data is declared in LOCAL-STORAGE instead of
* WORKING-STORAGE so that each thread has its own copy:
Local-storage section.
01 anAccount usage object reference Account.
*
Procedure division.
Test-Account-section.
    Display "Test Account class"
* Create account 123456 with 0 balance:
    Invoke Account "createAccount"
        using by value 123456
        returning anAccount
* Deposit 500 to the account:
    Invoke anAccount "credit" using by value 500
    Invoke anAccount "print"
    Display space
*
    Stop Run.
End program "TestAccounts".
```

“Example: defining a factory (with methods)” on page 518

RELATED TASKS

“Defining a factory method” on page 516

“Invoking factory or static methods” on page 517

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

Defining a subclass

You can make a class (called a *subclass*, derived class, or child class) a specialization of another class (called a *superclass*, base class, or parent class). A subclass inherits the methods and instance data of its superclasses, and is related to its superclasses by an *is-a* relationship. For example, if subclass P inherits from

superclass Q, and subclass Q inherits from superclass S, then an instance of P is an instance of Q and also (by transitivity) an instance of S. An instance of P inherits the methods and data of Q and S.

Restriction: You cannot use *multiple inheritance* in your COBOL programs. Each COBOL class that you define must have exactly one immediate superclass that is implemented in Java or COBOL, and each class must be derived directly or indirectly from `java.lang.Object`. The semantics of inheritance are as defined by Java.

Using subclasses has several advantages:

- Reuse of code. Through inheritance, a subclass can reuse methods that already exist in a superclass.
- Specialization. In a subclass you can add new methods to handle cases that the superclass does not handle. You can also add new data items that the superclass does not need.
- Change in action. A subclass can override a method that it inherits from a superclass by defining a method of the same signature as that in the superclass. When you override a method, you might make only a few minor changes or completely change what the method does.

The structure and syntax of a subclass definition are identical to those of a class definition: Define instance data and methods in the DATA DIVISION and PROCEDURE DIVISION, respectively, within the OBJECT paragraph of the subclass definition. In subclasses that require data and methods that are to be associated with the subclass itself rather than with individual object instances, define a separate DATA DIVISION and PROCEDURE DIVISION within the FACTORY paragraph of the subclass definition.

COBOL instance data is private. A subclass can access the instance data of a COBOL superclass only if the superclass defines attribute (get or set) instance methods for doing so.

“Example: accounts” on page 486

“Example: defining a subclass (with methods)” on page 513

RELATED TASKS

“Defining a class” on page 488

“Overriding an instance method” on page 497

“Coding attribute (get and set) methods” on page 499

“Defining a subclass instance method” on page 513

“Defining a factory section” on page 514

RELATED REFERENCES

Inheritance, overriding, and hiding (*The Java Language Specification*)

COBOL class definition structure (*Enterprise COBOL Language Reference*)

CLASS-ID paragraph for defining a subclass

Use the CLASS-ID paragraph to name the subclass and indicate from which immediate Java or COBOL superclass it inherits its characteristics. For example:

```
Identification Division.                                     Required  
Class-id. CheckingAccount inherits Account. Required
```

In the example above, `CheckingAccount` is the subclass being defined. `CheckingAccount` inherits all the methods of the class known within the subclass

definition as Account. CheckingAccount methods can access Account instance data only if the Account class provides attribute (get or set) methods for doing so.

You must specify the name of the immediate superclass in the REPOSITORY paragraph in the CONFIGURATION SECTION of the ENVIRONMENT DIVISION. You can optionally associate the superclass name with the name of the class as it is known externally. You can also specify the name of the subclass that you are defining (here, CheckingAccount) in the REPOSITORY paragraph and associate it with its corresponding external class-name.

RELATED TASKS

“CLASS-ID paragraph for defining a class” on page 490

“Coding attribute (get and set) methods” on page 499

“REPOSITORY paragraph for defining a subclass”

REPOSITORY paragraph for defining a subclass

Use the REPOSITORY paragraph to declare to the compiler that the specified words are class-names when you use them within a subclass definition, and to optionally relate the class-names to the corresponding external class-names (the class-names as they are known outside the compilation unit). For example, in the CheckingAccount subclass definition you might code this:

Environment Division.		Required
Configuration Section.		Required
Repository.		Required
Class CheckingAccount	is "CheckingAccount"	Optional
Class Check	is "Check"	Required
Class Account	is "Account".	Required

The REPOSITORY paragraph entries indicate that the external class-names of the classes referred to as CheckingAccount, Check, and Account within the subclass definition are CheckingAccount, Check, and Account, respectively.

In the REPOSITORY paragraph, you must code an entry for each class-name that you explicitly reference in the subclass definition. For example:

- A user-defined superclass from which the subclass that you are defining inherits
- The classes that you reference in methods within the subclass definition

The rules for coding REPOSITORY paragraph entries in a subclass are identical to those for coding REPOSITORY paragraph entries in a class.

RELATED TASKS

“REPOSITORY paragraph for defining a class” on page 490

RELATED REFERENCES

REPOSITORY paragraph (*Enterprise COBOL Language Reference*)

WORKING-STORAGE SECTION for defining subclass instance data

Use the WORKING-STORAGE SECTION in the DATA DIVISION of the subclass OBJECT paragraph to describe any instance data that the subclass needs in addition to the instance data defined in its superclasses. Use the same syntax that you use to define instance data in a class.

For example, the definition of the instance data for the CheckingAccount subclass of the Account class might look like this:


```

Identification division.
Object.
  Data division.
  Working-storage section.
  01 CheckFee pic S9(9) value 1.
  .
  .
End Object.

```

RELATED TASKS

“WORKING-STORAGE SECTION for defining class instance data” on page 492

Defining a subclass instance method

A subclass inherits the methods of its superclasses. In a subclass definition, you can override any instance method that the subclass inherits by defining an instance method that has the same signature as the inherited method. In a subclass definition you can also define new methods that the subclass needs.

The structure and syntax of a subclass instance method are identical to those of a class instance method. Define subclass instance methods in the PROCEDURE DIVISION of the OBJECT paragraph of the subclass definition.

“Example: defining a subclass (with methods)”

RELATED TASKS

“Defining a class instance method” on page 493

“Overriding an instance method” on page 497

“Overloading an instance method” on page 498

Example: defining a subclass (with methods)

This example shows the instance method definitions for the CheckingAccount subclass of the Account class (as seen in “Example: defining a method” on page 500):

- The processCheck method invokes the Java instance methods getAmount and getPayee of the Check class to get the check data. It invokes the credit and debit instance methods inherited from the Account class to credit the payee and debit the payer of the check.
- The print method overrides the print instance method defined in the Account class. It invokes the overridden print method to display account status, and also displays the check fee. CheckFee is an instance data item defined in the subclass.

CheckingAccount class (subclass of Account)

```

cbl dll,thread,pgmname(longmixed)
Identification Division.
Class-id. CheckingAccount inherits Account.
Environment Division.
Configuration section.
Repository.
  Class CheckingAccount is "CheckingAccount"
  Class Check           is "Check"
  Class Account         is "Account".
*
* (FACTORY paragraph not shown)
*
Identification division.
Object.
  Data division.
  Working-storage section.
  01 CheckFee pic S9(9) value 1.

```

```

Procedure Division.
*
*   processCheck method to get the check amount and payee,
*   add the check fee, and invoke inherited methods debit
*   to debit the payer and credit to credit the payee:
  Identification Division.
  Method-id. "processCheck".
  Data division.
  Local-storage section.
  01 amount pic S9(9) binary.
  01 payee usage object reference Account.
  Linkage section.
  01 aCheck usage object reference Check.
*
  Procedure Division using by value aCheck.
    Invoke aCheck "getAmount" returning amount
    Invoke aCheck "getPayee" returning payee
    Invoke payee "credit" using by value amount
    Add checkFee to amount
    Invoke self "debit" using by value amount.
  End method "processCheck".
*
*   print method override to display account status:
  Identification Division.
  Method-id. "print".
  Data division.
  Local-storage section.
  01 printableFee pic $,$,$,$,$9.
  Procedure Division.
    Invoke super "print"
    Move CheckFee to printableFee
    Display " Check fee: " printableFee.
  End method "print".
*
  End Object.
*
  End class CheckingAccount.

```

RELATED TASKS

Chapter 16, “Compiling, linking, and running OO applications,” on page 257
 “Invoking methods (INVOKE)” on page 506
 “Overriding an instance method” on page 497
 “Invoking overridden superclass methods” on page 507

Defining a factory section

Use the `FACTORY` paragraph in a class definition to define data and methods that are to be associated with the class itself rather than with individual object instances:

- COBOL *factory data* is equivalent to Java private static data. A single copy of the data is instantiated for the class and is shared by all object instances of the class. You most commonly use factory data when you want to gather data from all the instances of a class. For example, you could define a factory data item to keep a running total of the number of instances of the class that are created.
- COBOL *factory methods* are equivalent to Java public static methods. The methods are supported by the class independently of any object instance. You most commonly use factory methods to customize object creation when you cannot use `VALUE` clauses alone to initialize instance data.

By contrast, you use the OBJECT paragraph in a class definition to define data that is created for each object instance of the class, and methods that are supported for each object instance of the class.

A factory definition consists of three divisions, followed by an END FACTORY statement:

Table 74. Structure of factory definitions

Division	Purpose	Syntax
IDENTIFICATION (required)	Identify the start of the factory definition.	IDENTIFICATION DIVISION. FACTORY.
DATA (optional)	Describe data that is allocated once for the class (as opposed to data allocated for each instance of a class).	“WORKING-STORAGE SECTION for defining factory data” (optional)
PROCEDURE (optional)	Define factory methods.	Factory method definitions: “Defining a factory method” on page 516

“Example: defining a factory (with methods)” on page 518

RELATED TASKS

“Defining a class” on page 488

“Creating and initializing instances of classes” on page 508

“Wrapping procedure-oriented COBOL programs” on page 523

“Structuring OO applications” on page 524

WORKING-STORAGE SECTION for defining factory data

Use the WORKING-STORAGE SECTION in the DATA DIVISION of the FACTORY paragraph to describe the *factory data* that a COBOL class needs, that is, statically allocated data to be shared by all object instances of the class. The FACTORY keyword, which you must immediately precede with an IDENTIFICATION DIVISION declaration, indicates the beginning of the definitions of the factory data and factory methods for the class. For example, the definition of the factory data for the Account class might look like this:

```
Identification division.  
Factory.  
Data division.  
Working-storage section.  
01 NumberOfAccounts pic 9(6) value zero.  
....  
End Factory.
```

You can initialize simple factory data by using VALUE clauses as shown above.

COBOL factory data is equivalent to Java private static data. No other class or subclass (nor instance method in the same class, if any) can reference COBOL factory data directly. Factory data is global to all factory methods that the FACTORY paragraph defines. If you want to make factory data accessible from outside the FACTORY paragraph, define factory attribute (get or set) methods for doing so.

RELATED TASKS

“Coding attribute (get and set) methods” on page 499

“Creating and initializing instances of classes” on page 508

Defining a factory method

Define COBOL *factory methods* in the PROCEDURE DIVISION of the FACTORY paragraph of a class definition. A factory method defines an operation that is supported by a class independently of any object instance of the class.

You typically define factory methods for classes whose instances require complex initialization, that is, to values that you cannot assign by using VALUE clauses alone. Within a factory method you can invoke instance methods to initialize the instance data. A factory method cannot directly access instance data.

You can code factory attribute (get and set) methods to make factory data accessible from outside the FACTORY paragraph, for example, to make the data accessible from instance methods in the same class or from a client program. For example, the Account class could define a factory method getNumberOfAccounts to return the current tally of the number of accounts.

You can use factory methods to wrap procedure-oriented COBOL programs so that they are accessible from Java programs. You can code a factory method called main to enable you to run an OO application by using the java command, and to structure your applications in keeping with standard Java practice. See the related tasks for details.

In defining factory methods, you use the same syntax that you use to define instance methods. A COBOL factory method definition consists of four divisions (like a COBOL program), followed by an END METHOD marker:

Table 75. Structure of factory method definitions

Division	Purpose	Syntax
IDENTIFICATION (required)	Same as for a class instance method	Same as for a class instance method (required)
ENVIRONMENT (optional)	Same as for a class instance method	Same as for a class instance method
DATA (optional)	Same as for a class instance method	Same as for a class instance method
PROCEDURE (optional)	Same as for a class instance method	Same as for a class instance method

Within a class definition, you do not need to make each factory method-name unique, but you do need to give each factory method a unique signature. You can overload factory methods in exactly the same way that you overload instance methods. For example, the CheckingAccount subclass provides two versions of the factory method createCheckingAccount: one that initializes the account to have a default balance of zero, and one that allows the opening balance to be passed in. Clients can invoke either createCheckingAccount method by passing arguments that match the signature of the desired method.

If you define a data item with the same name in both the DATA DIVISION of a factory method and the DATA DIVISION of the FACTORY paragraph, a reference in the method to that data-name refers only to the method data item. The method DATA DIVISION takes precedence.

COBOL factory methods are equivalent to Java public static methods.

“Example: defining a factory (with methods)” on page 518

RELATED TASKS

- “Structuring OO applications” on page 524
- “Wrapping procedure-oriented COBOL programs” on page 523
- “Creating and initializing instances of classes” on page 508
- “Defining a class instance method” on page 493
- “Coding attribute (get and set) methods” on page 499
- “Overloading an instance method” on page 498
- “Hiding a factory or static method”
- “Invoking factory or static methods”
- “Using object-oriented COBOL and Java under IMS” on page 378

Hiding a factory or static method

A factory method defined in a subclass is said to *hide* an inherited COBOL or Java method that would otherwise be accessible in the subclass if the two methods have the same signature.

To hide a superclass factory method `f1` in a COBOL subclass, define a factory method `f1` in the subclass that has the same name and whose `PROCEDURE DIVISION USING` phrase (if any) has the same number and type of formal parameters as the superclass method has. (If the superclass method is implemented in Java, you must code formal parameters that are interoperable with the data types of the corresponding Java parameters.) When a client invokes `f1` using the subclass name, the subclass method rather than the superclass method is invoked.

The presence or absence of a method return value and the data type of the return value used in the `PROCEDURE DIVISION RETURNING` phrase (if any) must be identical in the subclass factory method and the hidden superclass method.

A factory method must not hide an instance method in a Java or COBOL superclass.

“Example: defining a factory (with methods)” on page 518

RELATED TASKS

- “Coding interoperable data types in COBOL and Java” on page 532
- “Overriding an instance method” on page 497
- “Invoking methods (INVOKE)” on page 506

RELATED REFERENCES

Inheritance, overriding, and hiding (*The Java Language Specification*)
The procedure division header (*Enterprise COBOL Language Reference*)

Invoking factory or static methods

To invoke a COBOL factory method or Java static method in a COBOL method or client program, code the class-name as the first operand of the `INVOKE` statement.

For example, a client program could invoke one of the overloaded `CheckingAccount` factory methods called `createCheckingAccount` to create a checking account with account number `777777` and an opening balance of \$300 by coding this statement:

```
Invoke CheckingAccount "createCheckingAccount"  
  using by value 777777 300  
  returning aCheckingAccount
```

To invoke a factory method from within the same class in which you define the factory method, you also use the class-name as the first operand in the `INVOKE` statement.

Code the name of the method to be invoked either as a literal or as an identifier whose value at run time is the method-name. The method-name must be an alphanumeric or national literal or data item, and is interpreted in a case-sensitive manner.

If an invoked method is not supported in the class that you name in the `INVOKE` statement, a severity-3 Language Environment condition is raised at run time unless you code the `ON EXCEPTION` phrase in the `INVOKE` statement.

The conformance requirements for passing arguments to a COBOL factory method or Java static method in the `USING` phrase, and receiving a return value in the `RETURNING` phrase, are the same as those for invoking instance methods.

“Example: defining a factory (with methods)”

RELATED TASKS

“Invoking methods (`INVOKE`)” on page 506

“Using national data (Unicode) in COBOL” on page 106

“Coding interoperable data types in COBOL and Java” on page 532

RELATED REFERENCES

`INVOKE` statement (*Enterprise COBOL Language Reference*)

Example: defining a factory (with methods)

This example updates the previous examples (“Example: defining a method” on page 500, “Example: defining a client” on page 510, and “Example: defining a subclass (with methods)” on page 513):

- The `Account` class adds factory data and a parameterized factory method, `createAccount`, which allows an `Account` instance to be created using an account number that is passed in.
- The `CheckingAccount` subclass adds factory data and an overloaded parameterized factory method, `createCheckingAccount`. One implementation of `createCheckingAccount` initializes the account with a default balance of zero, and the other allows the opening balance to be passed in. Clients can invoke either method by passing arguments that match the signature of the desired method.
- The `TestAccounts` client invokes the services provided by the factory methods of the `Account` and `CheckingAccount` classes, and instantiates the Java `Check` class.
- The output from the `TestAccounts` client program is shown.

You can also find the complete source code for this example in the `cobol/demo/oosample` subdirectory in the HFS. Typically the complete path for the source is `/usr/lpp/cobol/demo/oosample`. You can use the `makefile` there to compile and link the code.

Account class

```
cb1 dll,thread,pgmname(longmixed),lib
Identification Division.
Class-id. Account inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base      is "java.lang.Object"
```

```

        Class Account is "Account".
*
Identification division.
Factory.
Data division.
Working-storage section.
01 NumberOfAccounts pic 9(6) value zero.
*
Procedure Division.
*
*   createAccount method to create a new Account
*   instance, then invoke the OBJECT paragraph's init
*   method on the instance to initialize its instance data:
Identification Division.
Method-id. "createAccount".
Data division.
Linkage section.
01 inAccountNumber pic S9(6) binary.
01 outAccount object reference Account.
*   Facilitate access to JNI services:
Copy JNI.
Procedure Division using by value inAccountNumber
    returning outAccount.
*   Establish addressability to JNI environment structure:
Set address of JNIEnv to JNIEnvPtr
Set address of JNINativeInterface to JNIEnv
Invoke Account New returning outAccount
Invoke outAccount "init" using by value inAccountNumber
Add 1 to NumberOfAccounts.
End method "createAccount".
*
End Factory.
*
Identification division.
Object.
Data division.
Working-storage section.
01 AccountNumber pic 9(6).
01 AccountBalance pic S9(9) value zero.
*
Procedure Division.
*
*   init method to initialize the account:
Identification Division.
Method-id. "init".
Data division.
Linkage section.
01 inAccountNumber pic S9(9) binary.
Procedure Division using by value inAccountNumber.
    Move inAccountNumber to AccountNumber.
End method "init".
*
*   getBalance method to return the account balance:
Identification Division.
Method-id. "getBalance".
Data division.
Linkage section.
01 outBalance pic S9(9) binary.
Procedure Division returning outBalance.
    Move AccountBalance to outBalance.
End method "getBalance".
*
*   credit method to deposit to the account:
Identification Division.
Method-id. "credit".
Data division.
Linkage section.

```

```

01 inCredit    pic S9(9) binary.
Procedure Division using by value inCredit.
    Add inCredit to AccountBalance.
End method "credit".
*
*    debit method to withdraw from the account:
Identification Division.
Method-id. "debit".
Data division.
Linkage section.
01 inDebit     pic S9(9) binary.
Procedure Division using by value inDebit.
    Subtract inDebit from AccountBalance.
End method "debit".
*
*    print method to display formatted account number and balance:
Identification Division.
Method-id. "print".
Data division.
Local-storage section.
01 PrintableAccountNumber pic ZZZZZZ999999.
01 PrintableAccountBalance pic $$$,$$$,$$9CR.
Procedure Division.
    Move AccountNumber to PrintableAccountNumber
    Move AccountBalance to PrintableAccountBalance
    Display " Account: " PrintableAccountNumber
    Display " Balance: " PrintableAccountBalance.
End method "print".
*
* End Object.
*
* End class Account.

```

CheckingAccount class (subclass of Account)

```

cbl dll,thread,pgmname(longmixed),lib
Identification Division.
Class-id. CheckingAccount inherits Account.
Environment Division.
Configuration section.
Repository.
    Class CheckingAccount is "CheckingAccount"
    Class Check          is "Check"
    Class Account        is "Account".
*
Identification division.
Factory.
Data division.
Working-storage section.
01 NumberOfCheckingAccounts pic 9(6) value zero.
*
Procedure Division.
*
*    createCheckingAccount overloaded method to create a new
*    CheckingAccount instance with a default balance, invoke
*    inherited instance method init to initialize the account
*    number, and increment factory data tally of checking accounts:
Identification Division.
Method-id. "createCheckingAccount".
Data division.
Linkage section.
01 inAccountNumber pic S9(6) binary.
01 outCheckingAccount object reference CheckingAccount.
*    Facilitate access to JNI services:
    Copy JNI.
Procedure Division using by value inAccountNumber
    returning outCheckingAccount.
*    Establish addressability to JNI environment structure:

```



```

        Set address of JNIEnv to JNIEnvPtr
        Set address of JNIInterface to JNIEnv
        Invoke CheckingAccount New returning outCheckingAccount
        Invoke outCheckingAccount "init"
            using by value inAccountNumber
        Add 1 to NumberOfCheckingAccounts.
    End method "createCheckingAccount".

*
*   createCheckingAccount overloaded method to create a new
*   CheckingAccount instance, invoke inherited instance methods
*   init to initialize the account number and credit to set the
*   balance, and increment factory data tally of checking accounts:
    Identification Division.
    Method-id. "createCheckingAccount".
    Data division.
    Linkage section.
    01 inAccountNumber pic S9(6) binary.
    01 inInitialBalance pic S9(9) binary.
    01 outCheckingAccount object reference CheckingAccount.
    Copy JNI.
    Procedure Division using by value inAccountNumber
                                inInitialBalance
        returning outCheckingAccount.
        Set address of JNIEnv to JNIEnvPtr
        Set address of JNIInterface to JNIEnv
        Invoke CheckingAccount New returning outCheckingAccount
        Invoke outCheckingAccount "init"
            using by value inAccountNumber
        Invoke outCheckingAccount "credit"
            using by value inInitialBalance
        Add 1 to NumberOfCheckingAccounts.
    End method "createCheckingAccount".

*
End Factory.

*
    Identification division.
    Object.
    Data division.
    Working-storage section.
    01 CheckFee pic S9(9) value 1.
    Procedure Division.

*
*   processCheck method to get the check amount and payee,
*   add the check fee, and invoke inherited methods debit
*   to debit the payer and credit to credit the payee:
    Identification Division.
    Method-id. "processCheck".
    Data division.
    Local-storage section.
    01 amount pic S9(9) binary.
    01 payee usage object reference Account.
    Linkage section.
    01 aCheck usage object reference Check.
    Procedure Division using by value aCheck.
        Invoke aCheck "getAmount" returning amount
        Invoke aCheck "getPayee" returning payee
        Invoke payee "credit" using by value amount
        Add checkFee to amount
        Invoke self "debit" using by value amount.
    End method "processCheck".

*
*   print method override to display account status:
    Identification Division.
    Method-id. "print".
    Data division.
    Local-storage section.
    01 printableFee pic $$,$$$,$$$9.

```

```

    Procedure Division.
        Invoke super "print"
        Move CheckFee to printableFee
        Display " Check fee: " printableFee.
    End method "print".
*
End Object.
*
End class CheckingAccount.

```

Check class

```

/**
 * A Java class for check information
 */
public class Check {
    private CheckingAccount payer;
    private Account payee;
    private int amount;

    public Check(CheckingAccount inPayer, Account inPayee, int inAmount) {
        payer=inPayer;
        payee=inPayee;
        amount=inAmount;
    }

    public int getAmount() {
        return amount;
    }

    public Account getPayee() {
        return payee;
    }
}

```

TestAccounts client program

```

cbl dll,thread,pgmname(longmixed)
Identification division.
Program-id. "TestAccounts" recursive.
Environment division.
Configuration section.
Repository.
    Class Account          is "Account"
    Class CheckingAccount is "CheckingAccount"
    Class Check            is "Check".
Data Division.
* Working data is declared in Local-storage
* so that each thread has its own copy:
Local-storage section.
01 anAccount      usage object reference Account.
01 aCheckingAccount usage object reference CheckingAccount.
01 aCheck         usage object reference Check.
01 payee          usage object reference Account.
*
Procedure division.
Test-Account-section.
    Display "Test Account class"
* Create account 123456 with 0 balance:
    Invoke Account "createAccount"
        using by value 123456
        returning anAccount
* Deposit 500 to the account:
    Invoke anAccount "credit" using by value 500
    Invoke anAccount "print"
    Display space
*
    Display "Test CheckingAccount class"

```

```

* Create checking account 777777 with balance of 300:
  Invoke CheckingAccount "createCheckingAccount"
    using by value 777777 300
    returning aCheckingAccount
* Set account 123456 as the payee:
  Set payee to anAccount
* Initialize check for 125 to be paid by account 777777 to payee:
  Invoke Check New
    using by value aCheckingAccount, payee, 125
    returning aCheck
* Debit the payer, and credit the payee:
  Invoke aCheckingAccount "processCheck"
    using by value aCheck
  Invoke aCheckingAccount "print"
  Invoke anAccount "print"
*
  Stop Run.
End program "TestAccounts".

```

Output produced by the TestAccounts client program

```

Test Account class
Account:      123456
Balance:      $500

Test CheckingAccount class
Account:      777777
Balance:      $174
Check fee:    $1
Account:      123456
Balance:      $625

```

RELATED TASKS

“Creating and initializing instances of classes” on page 508
 “Defining a factory method” on page 516
 “Invoking factory or static methods” on page 517
 Chapter 16, “Compiling, linking, and running OO applications,” on page 257

Wrapping procedure-oriented COBOL programs

A *wrapper* is a class that provides an interface between object-oriented code and procedure-oriented code.

Factory methods provide a convenient means for writing wrappers for existing procedural COBOL code to make it accessible from Java programs.

To wrap COBOL code, do these steps:

1. Create a simple COBOL class that contains a FACTORY paragraph.
2. In the FACTORY paragraph, code a factory method that uses a CALL statement to call the procedural program.

A Java program can invoke the factory method by using a static method invocation expression, thus invoking the COBOL procedural program.

RELATED TASKS

“Defining a class” on page 488
 “Defining a factory section” on page 514
 “Defining a factory method” on page 516

Structuring OO applications

You can structure applications that use object-oriented COBOL syntax in one of three ways. An OO application can begin with:

- A COBOL program, which can have any name.

Under UNIX, you can run the application by specifying the name of the linked module (which should match the program name) at the command prompt. You can also bind the program as a module in a PDSE and run it in JCL using the EXEC PGM statement.

- A Java class definition that contains a method called main. Declare main as public, static, and void, with a single parameter of type String[].

You can run the application with the java command, specifying the name of the class that contains main and zero or more strings as command-line arguments.

- A COBOL class definition that contains a factory method called main. Declare main with no RETURNING phrase and a single USING parameter, an object reference to a class that is an array with elements of type java.lang.String. (Thus main is in effect public, static, and void, with a single parameter of type String[].)

You can run the application with the java command, specifying the name of the class that contains main and zero or more strings as command-line arguments.

Structure an OO application this way if you want to:

- Run the application by using the java command.
- Run the application in an environment where applications must start with the main method of a Java class file (such as an IMS Java dependent region).
- Follow standard Java programming practice.

“Examples: COBOL applications that you can run using the java command”

RELATED TASKS

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

“Defining a factory method” on page 516

“Declaring arrays and strings for Java” on page 532

Chapter 22, “Developing COBOL programs for IMS,” on page 377

Examples: COBOL applications that you can run using the java command

The following examples show COBOL class definitions that contain a factory method called main. In each case, main has no RETURNING phrase and has a single USING parameter, an object reference to a class that is an array with elements of type java.lang.String. You can run these applications by using the java command.

Displaying a message:

```
cb1 dll,thread
Identification Division.
Class-id. CBLmain inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base is "java.lang.Object"
    Class stringArray is "java.lang.String"
    Class CBLmain is "CBLmain".
```

```
*
Identification Division.
Factory.
Procedure division.
*
Identification Division.
```

```

Method-id. "main".
Data division.
Linkage section.
01 SA usage object reference stringArray.
Procedure division using by value SA.
    Display " >> COBOL main method entered"
.
End method "main".
End factory.
End class CBLmain.

```

Echoing the input strings:

```

cbl dll,thread,lib,pgmname(longmixed),ssrange
Identification Division.
Class-id. Echo inherits Base.
Environment Division.
Configuration section.
Repository.
    Class Base is "java.lang.Object"
    Class stringArray is "jobjectArray:java.lang.String"
    Class jstring is "java.lang.String"
    Class Echo is "Echo".
*
Identification Division.
Factory.
Procedure division.
*
Identification Division.
Method-id. "main".
Data division.
Local-storage section.
01 SAlen          pic s9(9) binary.
01 I              pic s9(9) binary.
01 SAelement      object reference jstring.
01 SAelementlen   pic s9(9) binary.
01 Sbuffer        pic X(65535).
01 P              pointer.
Linkage section.
01 SA              object reference stringArray.
Copy "JNI.cpy" suppress.
Procedure division using by value SA.
    Set address of JNIEnv to JNIEnvPtr
    Set address of JNINativeInterface to JNIEnv
    Call GetArrayLength using by value JNIEnvPtr SA
        returning SAlen
    Display "Input string array length: " SAlen
    Display "Input strings:"
    Perform varying I from 0 by 1 until I = SAlen
        Call GetObjectArrayElement
            using by value JNIEnvPtr SA I
            returning SAelement
        Call "GetStringPlatformLength"
            using by value JNIEnvPtr
                SAelement
                address of SAelementlen
                0
        Call "GetStringPlatform"
            using by value JNIEnvPtr
                SAelement
                address of Sbuffer
                length of Sbuffer
                0
        Display Sbuffer(1:SAelementlen)
    End-perform

```

```
    End method "main".  
End factory.  
End class Echo.
```

RELATED TASKS

Chapter 16, "Compiling, linking, and running OO applications," on page 257

"Defining a factory method" on page 516

Chapter 31, "Communicating with Java methods," on page 527

Chapter 31. Communicating with Java methods

To achieve interlanguage interoperability with Java, you need to follow certain rules and guidelines for:

- Using services in the Java Native Interface (JNI)
- Coding data types
- Compiling your COBOL programs

You can invoke methods that are written in Java from COBOL programs, and you can invoke methods that are written in COBOL from Java programs. You need to code COBOL object-oriented language for basic Java object capabilities. For additional Java capabilities, you can call JNI services.

Because Java programs might be multithreaded and use asynchronous signals, compile your COBOL programs with the THREAD option.

“Example: J2EE client written in COBOL” on page 539

RELATED TASKS

“Using national data (Unicode) in COBOL” on page 106

“Accessing JNI services”

“Sharing data with Java” on page 531

Chapter 30, “Writing object-oriented programs,” on page 485

Chapter 16, “Compiling, linking, and running OO applications,” on page 257

Chapter 27, “Preparing COBOL programs for multithreading,” on page 437

RELATED REFERENCES

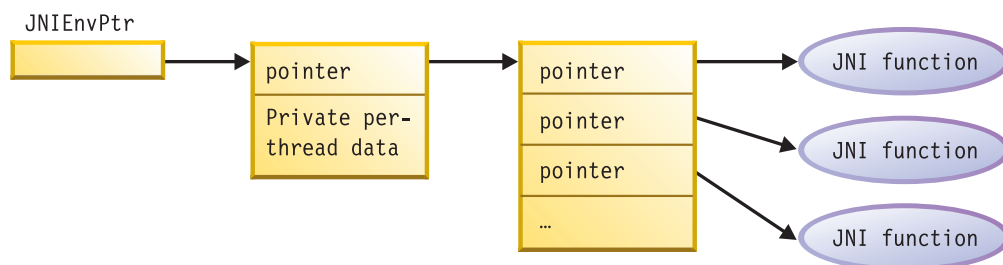
The Java 2 Enterprise Edition Developer's Guide

Accessing JNI services

The Java Native Interface (JNI) provides many callable services that you can use when you develop applications that mix COBOL and Java. To facilitate access to these services, copy JNI.cpy into the LINKAGE SECTION of your COBOL program. This copybook contains:

- COBOL data definitions that correspond to the Java JNI types
- The JNI environment structure JNINativeInterface, which contains function pointers for accessing the callable service functions

You obtain the JNI environment structure by two levels of indirection from the JNI environment pointer, as this illustration shows:



Use the special register `JNIEnvPtr` to reference the JNI environment pointer to obtain the address for the JNI environment structure. `JNIEnvPtr` is implicitly defined with `USAGE POINTER`; do not use it as a receiving data item.

Before you reference the contents of the JNI environment structure, you must code the following statements to establish its addressability:

```
Linkage section.  
COPY JNI  
.  
.  
.  
Procedure division.  
.  
.  
.  
    Set address of JNIEnv to JNIEnvPtr  
    Set address of JNINativeInterface to JNIEnv  
.  
.  
.
```

This code sets the addresses of the following items:

- `JNIEnv` is a pointer data item that `JNI.cpy` provides. `JNIEnvPtr` is the COBOL special register that contains the environment pointer.
- `JNINativeInterface` is the COBOL group structure that `JNI.cpy` contains. This structure maps the JNI environment structure, which contains an array of function pointers for the JNI callable services.

After you code the above statements, you can access the JNI callable services with `CALL` statements that reference the function pointers. You can pass the `JNIEnvPtr` special register as the first argument to the services that require the environment pointer, as shown in this example:

```
01 InputArrayObj usage object reference jlongArray.  
01 ArrayLen pic S9(9) comp-5.  
.  
.  
.  
    Call GetArrayLength using by value JNIEnvPtr InputArrayObj  
    returning ArrayLen
```

Important: Pass all arguments to the JNI callable services by value.

Some JNI callable services require a Java class-object reference as an argument. To obtain a reference to the class object that is associated with a class, use one of the following JNI callable services:

- `GetObjectClass`
- `FindClass`

Restriction: The JNI environment pointer is thread specific, therefore do not pass it from one thread to another.

RELATED TASKS

“Managing local and global references” on page 530

“Handling Java exceptions”

“Coding interoperable data types in COBOL and Java” on page 532

“Defining a client” on page 502

RELATED REFERENCES

Appendix F, “`JNI.cpy`,” on page 649

The Java Native Interface

Handling Java exceptions

Use JNI services to throw and catch Java exceptions.

Throwing an exception from your COBOL program

Use one of the following services to throw a Java exception from a COBOL method:

- Throw
- ThrowNew

You must make the thrown object an instance of a subclass of `java.lang.Throwable`.

The Java virtual machine (JVM) does not recognize and process the thrown exception until the method that contains the call has completed and returned to the JVM.

Catching a Java exception

After you invoke a method that might have thrown a Java exception, you can use the following JNI services to test whether an exception actually occurred, to process the exception, and to clear the exception, if clearing is appropriate:

- ExceptionOccurred
- ExceptionCheck
- ExceptionDescribe
- ExceptionClear

To do error analysis, use the methods supported by the exception object that is returned. This object is an instance of `java.lang.Throwable`.

“Example: handling Java exceptions”

Example: handling Java exceptions

This example shows the use of JNI services for catching an exception from Java and using the `PrintStackTrace` method of `java.lang.Throwable` for error analysis.

Repository.

```
Class JavaException is "java.lang.Exception".
```

```
...
```

```
Local-storage section.
```

```
01 ex usage object reference JavaException.
```

```
Linkage section.
```

```
COPY "JNI.cpy".
```

```
...
```

```
Procedure division.
```

```
Set address of JNIEnv to JNIEnvPtr
```

```
Set address of JNINativeInterface to JNIEnv
```

```
...
```

```
Invoke anObj "someMethod"
```

```
Perform ErrorCheck
```

```
...
```

```
ErrorCheck.
```

```
Call ExceptionOccurred
```

```
using by value JNIEnvPtr
```

```
returning ex
```

```
If ex not = null then
```

```
Call ExceptionClear using by value JNIEnvPtr
```

```
Display "Caught an unexpected exception"
```

```
Invoke ex "printStackTrace"
```

```
Stop run
```

```
End-if
```

Managing local and global references

The Java virtual machine tracks the object references that you use in native methods, such as COBOL methods. This tracking ensures that the objects are not prematurely released during garbage collection. There are two classes of such references:

Local references

Local references are valid only while the method that you invoke runs. They are automatically freed after the native method returns.

Global references

Global references remain valid until you explicitly delete them. You can create global references from local references by using the JNI service `NewGlobalRef`.

The following object references are always local:

- Object references that are received as method parameters
- Object references that are returned as the method RETURNING value from a method invocation
- Object references that are returned by a call to a JNI function
- Object references that you create by using the INVOKE . . . NEW statement

You can pass either a local reference or a global reference as an object reference argument to a JNI service.

You can code methods to return either local or global references as RETURNING values. However, in either case, the reference that is received by the invoking program is a local reference.

You can pass either local or global references as USING arguments in a method invocation. However, in either case, the reference that is received by the invoked method is a local reference.

Local references are valid only in the thread in which you create them. Do not pass them from one thread to another.

Deleting, saving, and freeing local references

You can manually delete local references at any point within a method.

Save local references only in object references that you define in the LOCAL-STORAGE SECTION of a method. If you want to save a local reference with a SET statement to an object instance variable, a factory variable, or a data item in the WORKING-STORAGE SECTION of a method, first convert the local reference to a global reference. Otherwise, you will get an error because these storage areas persist when the method returns, but the local reference is no longer valid.

In most cases you can rely on the automatic freeing of local references that occurs when a method returns. However, in some cases you should explicitly free a local reference within a method by using the JNI service `DeleteLocalRef`. Here are two situations where explicit freeing is appropriate:

- In a method you access a large object, thereby creating a local reference to the object. After extensive computations, the method returns. You should free the large object if you do not need it for the additional computations, because the local reference prevents the object from being released during garbage collection.

- You create a large number of local references in a method but do not use all of them at the same time. Because the Java virtual machine requires space to keep track of each local reference, you should free those that you no longer need to avoid causing the system to run out of memory.

For example, in a COBOL method you loop through a large array of objects, retrieve the elements as local references, and operate on one element at each iteration. You can free the local reference to the array element after each iteration.

JNI services

Use these callable services to manage local references and global references:

Table 76. JNI services for local and global references

Service	Input arguments	Return value	Purpose
NewGlobalRef	<ul style="list-style-type: none"> • The JNI environment pointer • A local or global object reference 	The global reference, or NULL if the system is out of memory	To create a new global reference to the object that the input object reference refers to
DeleteGlobalRef	<ul style="list-style-type: none"> • The JNI environment pointer • A global object reference 	None	To delete a global reference to the object that the input object reference refers to
DeleteLocalRef	<ul style="list-style-type: none"> • The JNI environment pointer • A local object reference 	None	To delete a local reference to the object that the input object reference refers to

Java access controls

The Java access modifiers `protected` and `private` are not enforced when you use the Java Native Interface. Therefore a COBOL program could invoke a `protected` or `private` Java method that would not have been invocable from a Java client. This usage is not recommended.

Sharing data with Java

Some COBOL data types have Java equivalents, but others do not. You can pass the types that have Java equivalents as arguments in the `USING` phrase of an `INVOKE` statement or receive them as the `RETURNING` value on an `INVOKE` statement. Similarly, you can receive these types from a Java method as parameters on the `USING` phrase or return them as the value in the `RETURNING` phrase of the `PROCEDURE DIVISION` header in a COBOL method.

To pass or receive arrays and strings, declare them as object references:

- Declare an array as an object reference that contains an instance of one of the special array classes.
- Declare a string as an object reference that contains an instance of the `jstring` class.

RELATED TASKS

“Coding interoperable data types in COBOL and Java” on page 532

“Declaring arrays and strings for Java” on page 532

“Manipulating Java arrays” on page 534

“Manipulating Java strings” on page 536
 “Invoking methods (INVOKE)” on page 506
 Chapter 25, “Sharing data,” on page 411

Coding interoperable data types in COBOL and Java

Use only the COBOL data types in this table when you communicate with Java:

Table 77. Interoperable data types in COBOL and Java

Primitive Java data type	Corresponding COBOL data type
boolean ¹	PIC X followed by exactly two condition names of the form shown: <i>level-number data-name</i> PIC X. 88 <i>data-name-false</i> value X'00'. 88 <i>data-name-true</i> value X'01' through X'FF'.
byte ¹	Single-byte alphanumeric: PIC X or PIC A
short	USAGE BINARY, COMP, COMP-4, or COMP-5, with PICTURE clause of the form S9(<i>n</i>), where 1<= <i>n</i> <=4
int	USAGE BINARY, COMP, COMP-4, or COMP-5, with PICTURE clause of the form S9(<i>n</i>), where 5<= <i>n</i> <=9
long	USAGE BINARY, COMP, COMP-4, or COMP-5, with PICTURE clause of the form S9(<i>n</i>), where 10<= <i>n</i> <=18
float ²	USAGE COMP-1
double ²	USAGE COMP-2
char	Single-character national: PIC N USAGE NATIONAL
class types (object references)	USAGE OBJECT REFERENCE <i>class-name</i>
1. You must distinguish boolean from byte, because they both correspond to PIC X. PIC X is interpreted as boolean only when you define an argument or a parameter with the two condition names as shown. Otherwise, a PIC X data item is interpreted as the Java byte type. 2. Java floating-point data is represented in IEEE floating point. Enterprise COBOL, however, uses hexadecimal floating-point representation. When you pass floating-point arguments by using an INVOKE statement or you receive floating-point data from a Java method, the arguments and data are automatically converted as needed.	

Declaring arrays and strings for Java

When you communicate with Java, declare arrays and strings with the special array classes and with jstring, respectively, by coding the COBOL data types shown in this table:

Table 78. Interoperable arrays and strings in COBOL and Java

Java data type	Corresponding COBOL data type
boolean[]	object reference jbooleanArray
byte[]	object reference jbyteArray
short[]	object reference jshortArray
int[]	object reference jintArray
long[]	object reference jlongArray
char[]	object reference jcharArray
Object[]	object reference jobjectArray

Table 78. Interoperable arrays and strings in COBOL and Java (continued)

Java data type	Corresponding COBOL data type
String	object reference jstring

When you use these special classes for array and string interoperability with Java, you must code an entry for the classes that you use in the REPOSITORY paragraph, such as in this example:

Configuration section.

Repository.

Class jbooleanArray is "jbooleanArray".

The REPOSITORY paragraph entry for an object array type must specify an external class-name of one of the following forms:

"jobjectArray"

"jobjectArray:external-classname-2"

In the first case, the REPOSITORY entry specifies an array class where the elements of the array are objects of type java.lang.Object.

In the second case, the REPOSITORY entry specifies an array class where the elements of the array are objects of type *external-classname-2*. A colon is required as a separator between the specification of the jobjectArray type and the external class-name of the elements of the array.

The following example shows both cases:

Environment Division.

Configuration Section.

Repository.

Class jobjectArray is "jobjectArray"

Class Employee is "com.acme.Employee"

Class Department is "jobjectArray:com.acme.Employee".

. . .

Linkage section.

01 oa usage object reference jobjectArray.

01 aDepartment usage object reference Department.

. . .

Procedure division using by value aDepartment.

. . .

In this example, oa defines an array of elements that are objects of type java.lang.Object. aDepartment defines an array of elements that are objects of type com.acme.Employee.

"Examples: COBOL applications that you can run using the java command" on page 524

The following Java array types are currently not supported for interoperation with COBOL programs:

Table 79. Noninteroperable array types in COBOL and Java

Java data type	Corresponding COBOL data type
float[]	object reference jfloatArray
double[]	object reference jdoubleArray

Manipulating Java arrays

To represent the array in a COBOL program, code a group data item that contains a single elementary item of the data type that corresponds to the Java type of the array. Specify an OCCURS or OCCURS DEPENDING ON clause that is appropriate for the array.

For example, the following code specifies a structure to receive 500 or fewer integer values from a jlongArray object:

```
01 jlongArray.
  02 X pic S9(9) comp-5 occurs 1 to 500 times depending on N.
```

To operate on objects of the special Java-array classes, call the services that the JNI provides. You can use services to access and set individual elements of an array and for the following purposes, using the services cited:

Table 80. JNI array services

Service	Input arguments	Return value	Purpose
GetArrayLength	<ul style="list-style-type: none"> The JNI environment pointer The array object reference 	The array length as a binary fullword integer	To get the number of elements in a Java array object
NewBooleanArray NewByteArray NewCharArray NewShortArray NewIntArray NewLongArray	<ul style="list-style-type: none"> The JNI environment pointer The number of elements in the array, as a binary fullword integer 	The array object reference, or NULL if the array cannot be constructed	To create a new Java array object
GetBooleanArrayElements GetByteArrayElements GetCharArrayElements GetShortArrayElements GetIntArrayElements GetLongArrayElements	<ul style="list-style-type: none"> The JNI environment pointer The array object reference A pointer to a boolean item. If the pointer is not null, the boolean item is set to true if a copy of the array elements was made. If a copy was made, the corresponding ReleasexxxArrayElements service must be called if changes are to be written back to the array object. 	A pointer to the storage buffer	To extract the array elements from a Java array into a storage buffer. The services return a pointer to the storage buffer, which you can use as the address of a COBOL group data item defined in the LINKAGE SECTION.
ReleaseBooleanArrayElements ReleaseByteArrayElements ReleaseCharArrayElements ReleaseShortArrayElements ReleaseIntArrayElements ReleaseLongArrayElements	<ul style="list-style-type: none"> The JNI environment pointer The array object reference A pointer to the storage buffer The release mode, as a binary fullword integer. See Java JNI documentation for details. Recommendation: Specify 0, to copy back the array content and free the storage buffer. 	None; the storage for the array is released.	To release the storage buffer that contains elements that have been extracted from a Java array and conditionally map the updated array values back into the array object

Table 80. JNI array services (continued)

Service	Input arguments	Return value	Purpose
NewObjectArray	<ul style="list-style-type: none"> The JNI environment pointer The number of elements in the array, as a binary fullword integer An object reference for the array element class An object reference for the initial element value. All array elements are set to this value. 	The array object reference, or NULL if the array cannot be constructed ¹	To create a new Java object array
GetObjectArrayElement	<ul style="list-style-type: none"> The JNI environment pointer The array object reference An array element index, as a binary fullword integer using origin zero 	An object reference ²	To return the element at a given index within an object array
SetObjectArrayElement	<ul style="list-style-type: none"> The JNI environment pointer The array object reference The array element index, as a binary fullword integer using origin zero The object reference for the new value 	None ³	To set an element within an object array
<ol style="list-style-type: none"> NewObjectArray throws an exception if the system runs out of memory. GetObjectArrayElement throws an exception if the index is not valid. SetObjectArrayElement throws an exception if the index is not valid or if the new value is not a subclass of the element class of the array. 			

“Examples: COBOL applications that you can run using the java command” on page 524

“Example: processing a Java int array”

RELATED TASKS

“Coding interoperable data types in COBOL and Java” on page 532

“Declaring arrays and strings for Java” on page 532

“Accessing JNI services” on page 527

Example: processing a Java int array

This example illustrates using the Java-array classes and JNI services to process a Java array in COBOL.

```

cbl lib,thread,dll
Identification division.
Class-id. OOARRAY inherits Base.
Environment division.
Configuration section.
Repository.
    Class Base is "java.lang.Object"
    Class jintArray is "jintArray".
Identification division.
Object.
Procedure division.
    Identification division.
    Method-id. "ProcessArray".

```

```

Data Division.
Local-storage section.
01 intArrayPtr pointer.
01 intArrayLen pic S9(9) comp-5.
Linkage section.
  COPY JNI.
01 inIntArrayObj usage object reference jintArray.
01 intArrayGroup.
  02 X pic S9(9) comp-5
    occurs 1 to 1000 times depending on intArrayLen.
Procedure division using by value inIntArrayObj.
  Set address of JNIEnv to JNIEnvPtr
  Set address of JNINativeInterface to JNIEnv

  Call GetArrayLength
    using by value JNIEnvPtr inIntArrayObj
    returning intArrayLen
  Call GetIntArrayElements
    using by value JNIEnvPtr inIntArrayObj 0
    returning IntArrayPtr
  Set address of intArrayGroup to intArrayPtr

* . . . process the array elements X(I) . . .

  Call ReleaseIntArrayElements
    using by value JNIEnvPtr inIntArrayObj intArrayPtr 0.
  End method "ProcessArray".
End Object.
End class OOARRAY.

```

Manipulating Java strings

Java String data is represented in Unicode. To represent a Java String in a COBOL program, declare it as an object reference of the `jstring` class. Then use JNI services to set or extract COBOL alphanumeric or national (Unicode) data from the object.

Services for Unicode

Use the following standard services to convert between `jstring` object references and COBOL national data items (PIC N(*n*)).

Table 81. Services that convert between jstring references and national data

Service	Input arguments	Return value
NewString ¹	<ul style="list-style-type: none"> The JNI environment pointer A pointer to a Unicode string, such as a COBOL national data item The number of characters in the string; binary fullword 	jstring object reference
GetStringLength	<ul style="list-style-type: none"> The JNI environment pointer A jstring object reference 	The number of Unicode characters in the jstring object reference; binary fullword
GetStringChars ¹	<ul style="list-style-type: none"> The JNI environment pointer A jstring object reference A pointer to a boolean data item, or NULL 	<ul style="list-style-type: none"> A pointer to the array of Unicode characters extracted from the jstring object, or NULL if the operation fails. The pointer is valid until it is released with <code>ReleaseStringChars</code>. When the pointer to the boolean data item is not null, the boolean value is set to true if a copy is made of the string and to false if no copy is made.

Table 81. Services that convert between jstring references and national data (continued)

Service	Input arguments	Return value
ReleaseStringChars	<ul style="list-style-type: none"> The JNI environment pointer A jstring object reference A pointer to the array of Unicode characters that was returned from GetStringChars 	None; the storage for the array is released.
1. This service throws an exception if the system runs out of memory.		

Access these services by using function pointers in the JNI environment structure `JNINativeInterface`.

Services for EBCDIC

Use the following z/OS services, an extension of the JNI, to convert between jstring object references and COBOL alphanumeric data (PIC X(n)).

Table 82. Services that convert between jstring references and alphanumeric data

Service	Input arguments	Return value						
NewStringPlatform	<ul style="list-style-type: none">• The JNI environment pointer• Pointer to the null-terminated EBCDIC character string that you want to convert to a jstring object• Pointer to the jstring object reference in which you want the result• Pointer to the Java encoding name for the string, represented as a null-terminated EBCDIC character string¹	<p>Return code as a binary fullword integer:</p> <table><tr><td>0</td><td>Success.</td></tr><tr><td>-1</td><td>Malformed input or illegal input character.</td></tr><tr><td>-2</td><td>Unsupported encoding; the jstring object reference pointer is set to NULL.</td></tr></table>	0	Success.	-1	Malformed input or illegal input character.	-2	Unsupported encoding; the jstring object reference pointer is set to NULL.
0	Success.							
-1	Malformed input or illegal input character.							
-2	Unsupported encoding; the jstring object reference pointer is set to NULL.							
GetStringPlatformLength	<ul style="list-style-type: none">• The JNI environment pointer• jstring object reference for which you want the length• Pointer to a binary fullword integer for the result• Pointer to the Java encoding name for the string, represented as a null-terminated EBCDIC character string¹	<p>Return code as a binary fullword integer:</p> <table><tr><td>0</td><td>Success.</td></tr><tr><td>-1</td><td>Malformed input or illegal input character.</td></tr><tr><td>-2</td><td>Unsupported encoding; the jstring object reference pointer is set to NULL.</td></tr></table> <p>Returns, in the third argument, the needed length in bytes of the output buffer to hold the converted Java string, including the terminating null byte referenced by the second argument.</p>	0	Success.	-1	Malformed input or illegal input character.	-2	Unsupported encoding; the jstring object reference pointer is set to NULL.
0	Success.							
-1	Malformed input or illegal input character.							
-2	Unsupported encoding; the jstring object reference pointer is set to NULL.							

Table 82. Services that convert between jstring references and alphanumeric data (continued)

Service	Input arguments	Return value
GetStringPlatform	<ul style="list-style-type: none"> The JNI environment pointer jstring object reference that you want to convert to a null-terminated string Pointer to the output buffer in which you want the converted string Length of the output buffer as a binary fullword integer Pointer to the Java encoding name for the string, represented as a null-terminated EBCDIC character string¹ 	Return code as a binary fullword integer: 0 Success. -1 Malformed input or illegal input character. -2 Unsupported encoding; the output string is set to a null string. -3 Conversion buffer is full.
1. If the pointer is NULL, the encoding from the Java file.encoding property is used.		

The EBCDIC services are packaged as a DLL that is part of the IBM Developer Kit for OS/390, Java 2 Technology Edition. Use CALL *literal* statements to call these services. The calls are resolved through the libjvm.x DLL side file, which you must include in the link step of any COBOL program that uses object-oriented language.

For example, the following code creates a Java String object from the EBCDIC string 'MyConverter'. (This code fragment is from the J2EE client program, which is shown in full in "Example: J2EE client written in COBOL" on page 539.)

```

Move z"MyConverter" to stringBuffer
Call "NewStringPlatform"
    using by value JNIEnvPtr
                address of stringBuffer
                address of jstring1
                0
    returning rc

```

If the EBCDIC services are the only JNI services that you call from a COBOL program, you do not need to copy the JNI.cpy copybook nor do you need to establish addressability with the JNI environment pointer.

For details on these services, see jni_convert.h, which is shipped with the IBM Developer Kit for OS/390, Java 2 Technology Edition.

Access these services by using function pointers in the JNI environment structure JNINativeInterface.

Services for UTF-8

The Java Native Interface also provides services for conversion between jstring object references and UTF-8 strings. These services are not recommended for use in COBOL due to the difficulty in handling UTF-8 character strings on the z/OS platform.

RELATED TASKS

"Accessing JNI services" on page 527

"Coding interoperable data types in COBOL and Java" on page 532

"Declaring arrays and strings for Java" on page 532

"Using national data (Unicode) in COBOL" on page 106

Chapter 16, "Compiling, linking, and running OO applications," on page 257

Example: J2EE client written in COBOL

This example shows a COBOL client program that can access enterprise beans running on a J2EE-compliant EJB server. It is equivalent to the J2EE client program given in the Getting Started chapter of *The Java 2 Enterprise Edition Developer's Guide*.

For your convenience in comparing implementations, the equivalent Java version of the sample client from the guide is shown after the COBOL implementation. The enterprise bean is not shown here; it is assumed to be the Java implementation of the simple currency converter enterprise bean that is given in the same guide.

COBOL client (ConverterClient.cbl)

```
Process pgmname(longmixed),lib,dll,thread
*****
* Demo J2EE client written in COBOL.                                     *
*                                                                           *
* Based on the sample J2EE client written in Java, which is             *
* given in the "Getting Started" chapter of "The Java(TM) 2             *
* Enterprise Edition Developer's Guide."                                 *
*                                                                           *
* The client:                                                            *
*   - Locates the home interface of a session enterprise bean          *
*     (a simple currency converter bean)                                *
*   - Creates an enterprise bean instance                               *
*   - Invokes a business method (currency conversion)                   *
*****
Identification division.
Program-id. "ConverterClient" is recursive.
Environment Division.
Configuration section.
Repository.
    Class InitialContext is "javax.naming.InitialContext"
    Class PortableRemoteObject
        is "javax.rmi.PortableRemoteObject"
    Class JavaObject is "java.lang.Object"
    Class JavaClass is "java.lang.Class"
    Class JavaException is "java.lang.Exception"
    Class jstring is "jstring"
    Class Converter is "Converter"
    Class ConverterHome is "ConverterHome".
Data division.
Working-storage section.
01 initialCtx          object reference InitialContext.
01 obj                 object reference JavaObject.
01 classObj            object reference JavaClass.
01 ex                  object reference JavaException.
01 currencyConverter   object reference Converter.
01 home                object reference ConverterHome.
01 homeObject redefines home object reference JavaObject.
01 jstring1            object reference jstring.
01 stringBuffer        pic X(500) usage display.
01 len                 pic s9(9) comp-5.
01 rc                  pic s9(9) comp-5.
01 amount              comp-2.
Linkage section.
    Copy JNI.
Procedure division.
    Set address of JNIenv to JNIEnvPtr
    Set address of JNINativeInterface to JNIenv

*****
* Create JNDI naming context.                                           *
*****
```

```

        Invoke InitialContext New returning initialCtx
        Perform JavaExceptionCheck

*****
* Create a jstring object for the string "MyConverter" for use *
* as argument to the lookup method. *
*****
        Move z"MyConverter" to stringBuffer
        Call "NewStringPlatform"
            using by value JNIEnvPtr
                address of stringBuffer
                address of jstring1
                0
        returning rc
        If rc not = zero then
            Display "Error occurred creating jstring object"
            Stop run
        End-if

*****
* Use the lookup method to obtain a reference to the home *
* object bound to the name "MyConverter". (This is the JNDI *
* name specified when deploying the J2EE application.) *
*****
        Invoke initialCtx "lookup" using by value jstring1
        returning obj
        Perform JavaExceptionCheck

*****
* Narrow the home object to be of type ConverterHome. *
* First obtain class object for the ConverterHome class, by *
* passing the null-terminated ASCII string "ConverterHome" to *
* the FindClass API. Then use this class object as the *
* argument to the static method "narrow". *
*****
        Move z"ConverterHome" to stringBuffer
        Call "__etoa"
            using by value address of stringBuffer
            returning len
        If len = -1 then
            Display "Error occurred on ASCII conversion"
            Stop run
        End-if
        Call FindClass
            using by value JNIEnvPtr
                address of stringBuffer
            returning classObj
        If classObj = null
            Display "Error occurred locating ConverterHome class"
            Stop run
        End-if
        Invoke PortableRemoteObject "narrow"
            using by value obj
                classObj
            returning homeObject
        Perform JavaExceptionCheck

*****
* Create the ConverterEJB instance and obtain local object *
* reference for its remote interface *
*****
        Invoke home "create" returning currencyConverter
        Perform JavaExceptionCheck

*****
* Invoke business methods *
*****

```

```

        Invoke currencyConverter "dollarToYen"
            using by value +100.00E+0
            returning amount
        Perform JavaExceptionCheck

    Display amount

    Invoke currencyConverter "yenToEuro"
        using by value +100.00E+0
        returning amount
    Perform JavaExceptionCheck

    Display amount

*****
* Remove the object and return.                                     *
*****
    Invoke currencyConverter "remove"
    Perform JavaExceptionCheck

    Goback
    .

*****
* Check for thrown Java exceptions                                   *
*****
    JavaExceptionCheck.
        Call ExceptionOccurred using by value JNIEnvPtr
        returning ex
    If ex not = null then
        Call ExceptionClear using by value JNIEnvPtr
        Display "Caught an unexpected exception"
        Invoke ex "PrintStackTrace"
        Stop run
    End-if
    .
End program "ConverterClient".

```

Java client (ConverterClient.java)

```

/*
 *
 * Copyright 2000 Sun Microsystems, Inc. All Rights Reserved.
 *
 * This software is the proprietary information of Sun Microsystems, Inc.
 * Use is subject to license terms.
 *
 */

import javax.naming.Context;
import javax.naming.InitialContext;
import javax.rmi.PortableRemoteObject;

import Converter;
import ConverterHome;

public class ConverterClient {

    public static void main(String[] args) {
        try {
            Context initial = new InitialContext();
            Object objref = initial.lookup("MyConverter");

            ConverterHome home =
                (ConverterHome)PortableRemoteObject.narrow(objref,
                                                            ConverterHome.class);

```

```

        Converter currencyConverter = home.create();

        double amount = currencyConverter.dollarToYen(100.00);
        System.out.println(String.valueOf(amount));
        amount = currencyConverter.yenToEuro(100.00);
        System.out.println(String.valueOf(amount));

        currencyConverter.remove();

    } catch (Exception ex) {
        System.err.println("Caught an unexpected exception!");
        ex.printStackTrace();
    }
}

```

RELATED TASKS

Chapter 16, “Compiling, linking, and running OO applications,” on page 257
WebSphere for z/OS: Assembling J2EE Applications

RELATED REFERENCES

The Java 2 Enterprise Edition Developer's Guide

Part 7. Specialized processing

Chapter 32. Interrupts and checkpoint/restart 545

Setting checkpoints	545
Designing checkpoints	546
Testing for a successful checkpoint	546
DD statements for defining checkpoint data sets	547
Examples: defining checkpoint data sets	547
Messages generated during checkpoint	548
Restarting programs	548
Requesting automatic restart	549
Requesting deferred restart	549
Formats for requesting deferred restart	550
Example: requesting a deferred restart	550
Resubmitting jobs for restart	551
Example: restarting a job at a specific checkpoint step.	551
Example: requesting a step restart	551
Example: resubmitting a job for a step restart	551
Example: resubmitting a job for a checkpoint restart	552

Avoiding problems with packed-decimal fields 574

Moving from expanded to windowed date fields 574

Chapter 33. Processing two-digit-year dates 553

Millennium language extensions (MLE)	554
Principles and objectives of these extensions	554
Resolving date-related logic problems	555
Using a century window	556
Example: century window	557
Using internal bridging	557
Example: internal bridging	558
Moving to full field expansion.	558
Example: converting files to expanded date form	559
Using year-first, year-only, and year-last date fields	560
Compatible dates	561
Example: comparing year-first date fields	562
Using other date formats	562
Example: isolating the year	562
Manipulating literals as dates	563
Assumed century window	564
Treatment of nondates	565
Setting triggers and limits	565
Example: using limits	566
Using sign conditions	567
Sorting and merging by date	567
Example: sorting by date and time	568
Performing arithmetic on date fields.	569
Allowing for overflow from windowed date fields	569
Specifying the order of evaluation	570
Controlling date processing explicitly	571
Using DATEVAL	571
Using UNDATE	571
Example: DATEVAL	572
Example: UNDATE	572
Analyzing and avoiding date-related diagnostic messages	572
Avoiding problems in processing dates	574

Chapter 32. Interrupts and checkpoint/restart

When programs run for an extended period of time, interruptions might halt processing before the end of a job. The checkpoint/restart functions of z/OS allow an interrupted program to be restarted at the beginning of a job step or at a checkpoint that you have set.

Because the checkpoint/restart functions cause a lot of extra processing, use them only when you anticipate interruptions caused by machine malfunctions, input or output errors, or intentional operator intervention.

The checkpoint routine starts from the COBOL load module containing your program. While your program is running, the checkpoint routine creates records at points you have designated using the COBOL RERUN clause. A checkpoint record contains a snapshot of the information in the registers and main storage when the program reached the checkpoint.

The restart routine restarts an interrupted program. You can perform a restart at any time after the program was interrupted: either immediately (automatic restart), or later (deferred restart).

RELATED TASKS

“Setting checkpoints”

“Restarting programs” on page 548

“Resubmitting jobs for restart” on page 551

z/OS DFSMS: Checkpoint/Restart

RELATED REFERENCES

“DD statements for defining checkpoint data sets” on page 547

“Messages generated during checkpoint” on page 548

“Formats for requesting deferred restart” on page 550

Setting checkpoints

To set checkpoints, use job control statements and use the RERUN clause in the ENVIRONMENT DIVISION. Associate each RERUN clause with a particular COBOL file.

The RERUN clause indicates that a checkpoint record is to be written onto a checkpoint data set whenever a specified number of records in the COBOL file has been processed, or when END OF VOLUME is reached. You cannot use the RERUN clause with files that have been defined with the EXTERNAL attribute.

You can write checkpoint records from several COBOL files onto one checkpoint data set, but you must use a separate data set exclusively for checkpoint records. You cannot embed checkpoint records in one of your program data sets.

Restriction: A checkpoint data set must have sequential organization. You cannot write checkpoints on VSAM data sets or on data sets allocated to extended-format QSAM data sets. Also, a checkpoint cannot be taken if any program in the run unit has an extended-format QSAM data set open.

Checkpoint records are written on the checkpoint data set defined by a DD statement. In the DD statement, you also choose the checkpoint method:

Single (store single checkpoints)

Only one checkpoint record exists at any given time. After the first checkpoint record is written, any succeeding checkpoint record overlays the previous one.

This method is acceptable for most programs. You save space on the checkpoint data set, and you can restart your program at the latest checkpoint.

Multiple (store multiple contiguous checkpoints)

Checkpoints are recorded and numbered sequentially. Each checkpoint is saved.

Use this method when you want to restart a program at a checkpoint other than the latest one taken.

You must use the multiple checkpoint method for complete compliance to the COBOL 85 Standard.

Checkpoints during sort operations have the following requirements:

- If checkpoints are to be taken during a sort operation, add a DD statement for SORTCKPT in the job control procedure for execution.
- You can take checkpoint records on ASCII-collated sorts, but the *system-name* indicating the checkpoint data set must not specify an ASCII file.

Designing checkpoints

Design your checkpoints at critical points in your program so that data can be easily reconstructed. Do not change the contents of files between the time of a checkpoint and the time of the restart.

In a program using disk files, design the program so that you can identify previously processed records. For example, consider a disk file containing loan records that are periodically updated for interest due. If a checkpoint is taken, records are updated, and then the program is interrupted, you would want to test that the records updated after the last checkpoint are not updated again when the program is restarted. To do this, set up a date field in each record, and update the field each time the record is processed. Then, after the restart, test the field to determine whether the record was already processed.

For efficient repositioning of a print file, take checkpoints on the file only after printing the last line of a page.

Testing for a successful checkpoint

After each input or output statement that issues a checkpoint, the RETURN-CODE special register is updated with the return code from the checkpoint routine. Therefore, you can test whether the checkpoint was successful and decide whether conditions are right to allow a restart. If the return code is greater than 4, an error has occurred in the checkpoint. Check the return code to prevent a restart that could cause incorrect output.

RELATED TASKS

“Using checkpoint/restart with DFSORT” on page 198

RELATED REFERENCES

“DD statements for defining checkpoint data sets” on page 547

Return codes (z/OS DFSMS: Checkpoint/Restart)

DD statements for defining checkpoint data sets

To define checkpoint data sets, use the following DD statements:

For tape:

```
//ddname DD DSN= data-set-name,  
//          [VOLUME=SER=volser,]UNIT=device-type,  
//          DISP=( {NEW|MOD} ,PASS)
```

For direct-access devices:

```
//ddname DD DSN= data-set-name,  
//          [VOLUME=(PRIVATE,RETAIN,SER=volser),]  
//          UNIT=device-type,SPACE=(subparms),  
//          DISP=( {NEW|MOD} ,PASS,KEEP)
```

ddname

Provides a link to the DD statement. The same as the *ddname* portion of the *assignment-name* used in the COBOL RERUN clause.

data-set-name

Identifies the checkpoint data set to the restart procedure. The name given to the data set used to record checkpoint records.

volser

Identifies the volume by serial number.

device-type

Identifies the device.

subparms

Specifies the amount of track space needed for the data set.

MOD Specifies the multiple contiguous checkpoint method.

NEW Specifies the single checkpoint method.

PASS Prevents deletion of the data set at successful completion of the job step, unless the job step is the last in the job. If it is the last step, the data set is deleted.

KEEP Keeps the data set if the job step abnormally ends.

“Examples: defining checkpoint data sets”

Examples: defining checkpoint data sets

The following examples show the job control language and COBOL coding you can use to define checkpoint data sets.

Writing single checkpoint records, using tape:

```
//CHECKPT DD DSN=CHECK1,VOLUME=SER=ND0003,  
//          UNIT=TAPE,DISP=(NEW,KEEP),LABEL=(,NL)  
          . . .  
          ENVIRONMENT DIVISION.  
          . . .  
          RERUN ON CHECKPT EVERY  
          5000 RECORDS OF ACCT-FILE.
```

Writing single checkpoint records, using disk:

```
//CHEK DD DSN=CHECK2,  
//          VOLUME=(PRIVATE,RETAIN,SER=DB0030),  
//          UNIT=3380,DISP=(NEW,KEEP),SPACE=(CYL,5)  
          . . .  
          ENVIRONMENT DIVISION.
```

```

      . . .
      RERUN ON CHEK EVERY
      20000 RECORDS OF PAYCODE.
      RERUN ON CHEK EVERY
      30000 RECORDS OF IN-FILE.

```

Writing multiple contiguous checkpoint records, using tape:

```

//CHEKPT DD DSN=CHECK3,VOLUME=SER=111111,
//        UNIT=TAPE,DISP=(MOD,PASS),LABEL=(,NL)
      . . .
      ENVIRONMENT DIVISION.
      . . .
      RERUN ON CHEKPT EVERY
      10000 RECORDS OF PAY-FILE.

```

Messages generated during checkpoint

The system checkpoint routine advises the operator of the status of the checkpoints taken by displaying informative messages on the console.

Each time a checkpoint has been successfully completed, a message is displayed associating the jobname (*ddname*, *unit*, *volser*) with a *checkid*.

checkid is the identification name of the checkpoint taken. The control program assigns *checkid* as an eight-character string. The first character is the letter C, followed by a decimal number indicating the checkpoint. For example, the following message indicates the fourth checkpoint taken in the job step:

checkid C0000004

Restarting programs

The system restart routine does the following:

- Retrieves the information recorded in a checkpoint record
- Restores the contents of main storage and all registers
- Restarts the program

You can begin the restart routine in one of two ways:

- Automatically, at the time an interruption stopped the program
- At a later time, as a deferred restart

The RD parameter of the job control language determines the type of restart. You can use the RD parameter on either the JOB or the EXEC statement. If coded on the JOB statement, the parameter overrides any RD parameters on the EXEC statement.

To suppress both restart and writing checkpoints, code RD=NC.

Restriction: If you try to restart at a checkpoint taken by a COBOL program during a SORT or MERGE operation, an error message is issued and the restart is canceled. Only checkpoints taken by DFSORT are valid.

Data sets that have the SYSOUT parameter coded on their DD statements are handled in various ways depending on the type of restart.

If the checkpoint data set is multivolume, include in the VOLUME parameter the sequence number of the volume on which the checkpoint entry was written. If the checkpoint data set is on a 7-track tape with nonstandard labels or no labels, the SYSCHK DD statement must contain DCB=(TRTCH=C,. . .).

Requesting automatic restart

Automatic restart occurs only at the latest checkpoint taken. If no checkpoint was taken before interruption, automatic restart occurs at the beginning of the job step.

Whenever automatic restart is to occur, the system repositions all devices except unit-record devices.

If you want automatic restart, code RD=R or RD=RNC as follows:

- RD=R indicates that restart is to occur at the latest checkpoint. Code the RERUN clause for at least one data set in the program in order to record checkpoints. If no checkpoint is taken before interruption, restart occurs at the beginning of the job step.
- RD=RNC indicates that no checkpoint is to be written, and any restart is to occur at the beginning of the job step. In this case, RERUN clauses are unnecessary; if any are present, they are ignored.

If you omit the RD parameter, the CHKPT macro instruction remains active, and checkpoints can be taken during processing. If an interrupt occurs after the first checkpoint, automatic restart will occur.

To restart automatically, a program must satisfy the following conditions:

- In the program you must request restart by using the RD parameter or by taking a checkpoint.
- An abend that terminated the job must return a code that allows restart.
- The operator must authorize the restart.

“Example: requesting a step restart” on page 551

Requesting deferred restart

Deferred restart can occur at any checkpoint, not necessarily the latest one taken. You can restart your program at a checkpoint other than at the beginning of the job step.

When a deferred restart has been successfully completed, the system displays a message on the console stating that the job has been restarted. Control is then given to your program.

If you want deferred restart, code the RD parameter as RD=NR. This form of the parameter suppresses automatic restart, but allows a checkpoint record to be written provided that a RERUN clause has been coded.

Request a deferred restart by using the RESTART parameter on the JOB card and a SYSCHK DD statement to identify the checkpoint data set. If a SYSCHK DD statement is present in a job and the JOB statement does not contain the RESTART parameter, the SYSCHK DD statement is ignored. If a RESTART parameter without the CHECKID subparameter is included in a job, a SYSCHK DD statement must not appear before the first EXEC statement for the job.

“Example: restarting a job at a specific checkpoint step” on page 551

RELATED TASKS

“Using checkpoint/restart with DFSORT” on page 198

RELATED REFERENCES

“Formats for requesting deferred restart”

Formats for requesting deferred restart

The formats for the RESTART parameter on the JOB statement and the SYSCHK DD statements are as follows:

```
//jobname JOB MSGLEVEL=1,RESTART=(request[,checkid])
//SYSCHK DD DSN=DSNAME=data-set-name,
//          DISP=OLD[,UNIT=device-type,
//          VOLUME=SER=volser]
```

MSGLEVEL=1 (or MSGLEVEL=(1,y))

MSGLEVEL is required.

RESTART=(request[,checkid])

Identifies the particular checkpoint at which restart is to occur.

request

Takes one of the following forms:

* Indicates restart at the beginning of the job.

stepname

Indicates restart at the beginning of a job step.

stepname.procstep

Indicates restart at a procedure step within the job step.

checkid

Identifies the checkpoint where restart is to occur.

SYSCHK

The ddname used to identify a checkpoint data set to the control program. The SYSCHK DD statement must immediately precede the first EXEC statement of the resubmitted job, and must follow any JOBLIB statement.

data-set-name

Identifies the checkpoint data set. It must be the same name that was used when the checkpoint was taken.

device-type and *volser*

Identify the device type and the serial number of the volume containing the checkpoint data set.

“Example: requesting a deferred restart”

Example: requesting a deferred restart

A restart of the GO step of an IGYWCLG procedure, at checkpoint identifier (CHECKID) C00000003, might appear as follows:

```
//jobname JOB MSGLEVEL=1,RESTART=(stepname.GO,C00000003)
//SYSCHK DD DSN=DSNAME=CHKPT,
//          DISP=OLD[,UNIT=3380,VOLUME=SER=111111]
. . .
```

Resubmitting jobs for restart

When you resubmit a job for restart, be careful with any DD statements that might affect the execution of the restarted job step. The restart routine uses information from DD statements in the resubmitted job to reset files for use after restart. Pay attention to the following:

- If you want a data set to be deleted at the end of a job step, give it a conditional disposition of PASS or KEEP (rather than DELETE) when you run it. This disposition allows the data set to be available if an interruption forces a restart.
If you want to restart a job at the beginning of a step, you must first discard any data set created (defined as NEW on a DD statement) in the previous run, or change the DD statement to mark the data set as OLD.
- At restart time, position input data sets on cards as they were at the time of the checkpoint. The system automatically repositions input data sets on tape or disk.

“Example: resubmitting a job for a step restart”

“Example: resubmitting a job for a checkpoint restart” on page 552

Example: restarting a job at a specific checkpoint step

This example shows a sequence of job control statements for restarting a job at a specific step:

```
//PAYROLL JOB MSGLEVEL=1,REGION=80K,  
//          RESTART=(STEP1,CHECKPT4)  
//JOBLIB DD DSN=PRIV.LIB3,DISP=OLD  
//SYSCHK DD DSN=CHKPTLIB,  
//          [UNIT=TAPE,VOL=SER=456789,]  
//          DISP=(OLD,KEEP)  
//STEP1 EXEC PGM=PROG4,TIME=5
```

Example: requesting a step restart

This example shows the use of the RD parameter. Here, the RD parameter requests step restart for any abnormally terminated job step. The DD statement DDCKPNT defines a checkpoint data set. For this step, after a RERUN clause is performed, only automatic checkpoint restart can occur unless a CHKPT cancel is issued.

```
//J1234 JOB 386,SMITH,MSGLEVEL=1,RD=R  
//S1 EXEC PGM=MYPROG  
//INDATA DD DSN=INVENT[,UNIT=TAPE],DISP=OLD,  
//          [VOLUME=SER=91468,]  
//          LABEL=RETPD=14  
//REPORT DD SYSOUT=A  
//WORK DD DSN=T91468,DISP=(,KEEP),  
//          UNIT=SYSDA,SPACE=(3000,(5000,500)),  
//          VOLUME=(PRIVATE,RETAIN,,6)  
//DDCKPNT DD UNIT=TAPE,DISP=(MOD,PASS,CATLG),  
//          DSN=C91468,LABEL=(,NL)
```

Example: resubmitting a job for a step restart

This example shows the changes that you might make to control statements before you resubmit the job for step restart:

- The job name has been changed (from J1234 to J3412) to distinguish the original job from the restarted job.
- The RESTART parameter has been added to the JOB statement, and indicates that restart is to begin with the first job step.
- The WORK DD statement was originally assigned a conditional disposition of KEEP for this data set:

- If the step terminated normally in the previous run of the job, the data set was deleted and no changes need to be made to this statement.
- If the step abnormally terminated, the data set was kept. In that case, define a new data set (S91468 instead of T91468, as shown below), or change the status of the data set to OLD before resubmitting the job.
- A new data set (R91468 instead of C91468) has also been defined as the checkpoint data set.

```
//J3412 JOB 386,SMITH,MSGLEVEL=1,RD=R,RESTART=*
//S1 EXEC PGM=MYPROG
//INDATA DD DSN=INVENT,UNIT=TAPE,DISP=OLD,
// [VOLUME=SER=91468,]LABEL=RETPD=14
//REPORT DD SYSOUT=A
//WORK DD DSN=S91468,
// DISP=(,KEEP),UNIT=SYSDA,
// SPACE=(3000,(5000,500)),
// VOLUME=(PRIVATE,RETAIN,,6)
//DDCHKPNT DD UNIT=TAPE,DISP=(MOD,PASS,CATLG),
// DSN=R91468,LABEL=(,NL)
```

“Example: requesting a step restart” on page 551

Example: resubmitting a job for a checkpoint restart

This example shows the changes that you might make to control statements before you resubmit a job for checkpoint restart:

- The job name has been changed (from J1234 to J3412) to distinguish the original job from the restarted job.
- The RESTART parameter has been added to the JOB statement, and indicates that restart is to begin with the first step at the checkpoint entry named C0000002.
- The DD statement DDCHKPNT was originally assigned a conditional disposition of CATLG for the checkpoint data set:
 - If the step terminated normally in the previous run of the job, the data set was kept. In that case, the SYSCHK DD statement must contain all of the information necessary for retrieving the checkpoint data set.
 - If the job abnormally terminated, the data set was cataloged. In that case, the only parameters required on the SYSCHK DD statement (as shown below) are DSN and DISP.

If a checkpoint is taken in a job that is running when V=R is specified, the job cannot be restarted until adequate nonpageable dynamic storage becomes available.

```
//J3412 JOB 386,SMITH,MSGLEVEL=1,RD=R,
// RESTART=(*,C0000002)
//SYSCHK DD DSN=C91468,DISP=OLD
//S1 EXEC PGM=MYPROG
//INDATA DD DSN=INVENT,UNIT=TAPE,DISP=OLD,
// VOLUME=SER=91468,LABEL=RETPD=14
//REPORT DD SYSOUT=A
//WORK DD DSN=T91468,DISP=(,KEEP),
// UNIT=SYSDA,SPACE=(3000,(5000,500)),
// VOLUME=(PRIVATE,RETAIN,,6)
//DDCHKPNT DD UNIT=TAPE,DISP=(MOD,KEEP,CATLG),
// DSN=C91468,LABEL=(,NL)
```

Chapter 33. Processing two-digit-year dates

With the millennium language extensions, you can make simple changes in your COBOL programs to define date fields. The compiler recognizes and acts on these dates by using a century window to ensure consistency. Use the following steps to implement automatic date recognition in a COBOL program:

1. Add the DATE FORMAT clause to the data description entries of the data items in the program that contain dates. You must identify all dates with DATE FORMAT clauses, even those that are not used in comparisons.
2. To expand dates, use MOVE or COMPUTE statements to copy the contents of windowed date fields to expanded date fields.
3. If necessary, use the DATEVAL and UNDATE intrinsic functions to convert between date fields and nondates.
4. Use the YEARWINDOW compiler option to set the century window as either a fixed window or a sliding window.
5. Compile the program with the DATEPROC(FLAG) compiler option, and review the diagnostic messages to see if date processing has produced any unexpected side effects.
6. When the compilation has only information-level diagnostic messages, you can recompile the program with the DATEPROC(NOFLAG) compiler option to produce a clean listing.

You can use certain programming techniques to take advantage of date processing and control the effects of using date fields such as when comparing dates, sorting and merging by date, and performing arithmetic operations involving dates. The millennium language extensions support year-first, year-only, and year-last date fields for the most common operations on date fields: comparisons, moving and storing, and incrementing and decrementing.

RELATED CONCEPTS

"Millennium language extensions (MLE)" on page 554

RELATED TASKS

"Resolving date-related logic problems" on page 555

"Using year-first, year-only, and year-last date fields" on page 560

"Manipulating literals as dates" on page 563

"Setting triggers and limits" on page 565

"Sorting and merging by date" on page 567

"Performing arithmetic on date fields" on page 569

"Controlling date processing explicitly" on page 571

"Analyzing and avoiding date-related diagnostic messages" on page 572

"Avoiding problems in processing dates" on page 574

RELATED REFERENCES

DATE FORMAT clause (*Enterprise COBOL Language Reference*)

"DATEPROC" on page 278

"YEARWINDOW" on page 315

Millennium language extensions (MLE)

The term *millennium language extensions* refers to the features of Enterprise COBOL that the DATEPROC compiler option activates to help with logic problems involving twenty-first century dates.

When enabled, the extensions include:

- The DATE FORMAT clause. Add this clause to items in the DATA DIVISION to identify date fields and to specify the location of the year component within the date.
- The reinterpretation of the function return value as a date field, for the following intrinsic functions:

```
DATE-OF-INTEGERS  
DATE-TO-YYYYMMDD  
DAY-OF-INTEGERS  
DAY-TO-YYYYDDD  
YEAR-TO-YYYY
```

- The reinterpretation as a date field of the conceptual data items DATE, DATE YYYYMMDD, DAY, and DAY YYYYDDD in the following forms of the ACCEPT statement:

```
ACCEPT identifier FROM DATE  
ACCEPT identifier FROM DATE YYYYMMDD  
ACCEPT identifier FROM DAY  
ACCEPT identifier FROM DAY YYYYDDD
```

- The intrinsic functions UNDATE and DATEVAL, used for selective reinterpretation of date fields and nondates.
- The intrinsic function YEARWINDOW, which retrieves the starting year of the century window set by the YEARWINDOW compiler option.

The DATEPROC compiler option enables special date-oriented processing of identified date fields. The YEARWINDOW compiler option specifies the 100-year window (the century window) to use for interpreting two-digit windowed years.

RELATED CONCEPTS

"Principles and objectives of these extensions"

RELATED REFERENCES

"DATEPROC" on page 278

"YEARWINDOW" on page 315

Principles and objectives of these extensions

To gain the most benefit from the millennium language extensions, you need to understand the reasons for their introduction into the COBOL language.

The millennium language extensions focus on a few key principles:

- Programs to be recompiled with date semantics are fully tested and valuable assets of the enterprise. Their only relevant limitation is that two-digit years in the programs are restricted to the range 1900-1999.
- No special processing is done for the nonyear part of dates. That is why the nonyear part of the supported date formats is denoted by Xs. To do otherwise might change the meaning of existing programs. The only date-sensitive semantics that are provided involve automatically expanding (and contracting) the two-digit year part of dates with respect to the century window for the program.

- Dates with four-digit year parts are generally of interest only when used in combination with windowed dates. Otherwise there is little difference between four-digit year dates and nondates.

Based on these principles, the millennium language extensions are designed to meet several objectives. You should evaluate the objectives that you need to meet in order to resolve your date-processing problems, and compare them with the objectives of the millennium language extensions, to determine how your application can benefit from them. You should not consider using the extensions in new applications or in enhancements to existing applications, unless the applications are using old data that cannot be expanded until later.

The objectives of the millennium language extensions are as follows:

- Extend the useful life of your application programs as they are currently specified.
- Keep source changes to a minimum, preferably limited to augmenting the declarations of date fields in the DATA DIVISION. To implement the century window solution, you should not need to change the program logic in the PROCEDURE DIVISION.
- Preserve the existing semantics of the programs when adding date fields. For example, when a date is expressed as a literal, as in the following statement, the literal is considered to be compatible (windowed or expanded) with the date field to which it is compared:

```
If Expiry-Date Greater Than 980101 . . .
```

Because the existing program assumes that two-digit-year dates expressed as literals are in the range 1900-1999, the extensions do not change this assumption.

- The windowing feature is not intended for long-term use. It can extend the useful life of applications as a start toward a long-term solution that can be implemented later.
- The expanded date field feature is intended for long-term use, as an aid for expanding date fields in files and databases.

The extensions do not provide fully specified or complete date-oriented data types, with semantics that recognize, for example, the month and day parts of Gregorian dates. They do, however, provide special semantics for the year part of dates.

Resolving date-related logic problems

You can adopt any of three approaches to assist with date-processing problems:

Century window

You define a century window and specify the fields that contain windowed dates. The compiler then interprets the two-digit years in these data fields according to the century window.

Internal bridging

If your files and databases have not yet been converted to four-digit-year dates, but you prefer to use four-digit expanded-year logic in your programs, you can use an internal bridging technique to process the dates as four-digit-year dates.

Full field expansion

This solution involves explicitly expanding two-digit-year date fields to contain full four-digit years in your files and databases and then using these fields in expanded form in your programs. This is the only method that assures reliable date processing for all applications.

You can use the millennium language extensions with each approach to achieve a solution, but each has advantages and disadvantages, as shown below.

Table 83. Advantages and disadvantages of Year 2000 solutions

Aspect	Century window	Internal bridging	Full field expansion
Implementation	Fast and easy but might not suit all applications	Some risk of corrupting data	Must ensure that changes to databases, copybooks, and programs are synchronized
Testing	Less testing is required because no changes to program logic	Testing is easy because changes to program logic are straightforward	
Duration of fix	Programs can function beyond 2000, but not a long-term solution	Programs can function beyond 2000, but not a permanent solution	Permanent solution
Performance	Might degrade performance	Good performance	Best performance
Maintenance			Maintenance is easier.

“Example: century window” on page 557

“Example: internal bridging” on page 558

“Example: converting files to expanded date form” on page 559

RELATED TASKS

“Using a century window”

“Using internal bridging” on page 557

“Moving to full field expansion” on page 558

Using a century window

A century window is a 100-year interval, such as 1950-2049, within which any two-digit year is unique. For windowed date fields, you specify the century window start date by using the YEARWINDOW compiler option. When the DATEPROC option is in effect, the compiler applies this window to two-digit date fields in the program. For example, with a century window of 1930-2029, COBOL interprets two-digit years as follows:

- Year values from 00 through 29 are interpreted as years 2000-2029.
- Year values from 30 through 99 are interpreted as years 1930-1999.

To implement this century window, you use the DATE FORMAT clause to identify the date fields in your program and use the YEARWINDOW compiler option to define the century window as either a fixed window or a sliding window:

- For a fixed window, specify a four-digit year between 1900 and 1999 as the YEARWINDOW option value. For example, YEARWINDOW(1950) defines a fixed window of 1950-2049.
- For a sliding window, specify a negative integer from -1 through -99 as the YEARWINDOW option value. For example, YEARWINDOW(-50) defines a sliding window that starts 50 years before the year in which the program is running. So if the program is running in 2003, the century window is 1953-2052, and in 2004 it automatically becomes 1954-2053, and so on.

The compiler then automatically applies the century window to operations on the date fields that you have identified. You do not need any extra program logic to implement the windowing.

“Example: century window”

Example: century window

The following example shows (in bold) how to modify a program to use the automatic date windowing capability. The program checks whether a video tape was returned on time:

```
CBL LIB,QUOTE,NOOPT,DATEPROC(FLAG),YEARWINDOW(-60)
. . .
01 Loan-Record.
   05 Member-Number   Pic X(8).
   05 Tape-ID         Pic X(8).
   05 Date-Due-Back   Pic X(6) Date Format yyxxxx.
   05 Date-Returned   Pic X(6) Date Format yyxxxx.
. . .
   If Date-Returned > Date-Due-Back Then
       Perform Fine-Member.
```

In this example, there are no changes to the PROCEDURE DIVISION. The addition of the DATE FORMAT clause on the two date fields means that the compiler recognizes them as windowed date fields, and therefore applies the century window when processing the IF statement. For example, if Date-Due-Back contains 000102 (January 2, 2000) and Date-Returned contains 991231 (December 31, 1999), Date-Returned is less than (earlier than) Date-Due-Back, so the program does not perform the Fine-Member paragraph.

Using internal bridging

For internal bridging, you can structure your program as follows:

1. Read the input files with two-digit-year dates.
2. Declare these two-digit dates as windowed date fields and move them to expanded date fields, so that the compiler automatically expands them to four-digit-year dates.
3. In the main body of the program, use the four-digit-year dates for all date processing.
4. Window the dates back to two-digit years.
5. Write the two-digit-year dates to the output files.

This process provides a convenient migration path to a full expanded-date solution, and can have performance advantages over using windowed dates.

When you use this technique, your changes to the program logic are minimal. You simply add statements to expand and contract the dates, and change the statements that refer to dates to use the four-digit-year date fields in WORKING-STORAGE instead of the two-digit-year fields in the records.

Because you are converting the dates back to two-digit years for output, you should allow for the possibility that the year is outside the century window. For example, if a date field contains the year 2020, but the century window is 1920-2019, then the date is outside the window, and simply moving it to a two-digit-year field will be incorrect. To protect against this problem, you can use a COMPUTE statement to store the date, with the ON SIZE ERROR phrase to detect whether or not the date is within the century window.

“Example: internal bridging”

RELATED TASKS

“Using a century window” on page 556

“Performing arithmetic on date fields” on page 569

“Moving to full field expansion”

Example: internal bridging

The following example shows (in bold) how a program can be changed to implement internal bridging:

```
CBL  DATEPROC(FLAG),YEARWINDOW(-60)

. . .
File Section.
FD  Customer-File.
01  Cust-Record.
    05  Cust-Number      Pic 9(9) Binary.

    . . .
    05  Cust-Date        Pic 9(6) Date Format yyxxxx.
Working-Storage Section.
77  Exp-Cust-Date        Pic 9(8) Date Format yyyyxxxx.

. . .
Procedure Division.
    Open I-O Customer-File.
    Read Customer-File.
    Move Cust-Date to Exp-Cust-Date.
    . . .

=====
* Use expanded date in the rest of the program logic *
=====

. . .
Compute Cust-Date = Exp-Cust-Date
On Size Error Display "Exp-Cust-Date outside
century window"

End-Compute
Rewrite Cust-Record.
```

Moving to full field expansion

Using the millennium language extensions, you can move gradually toward a solution that fully expands the date field:

1. Apply the century window solution, and use this solution until you have the resources to implement a more permanent solution.
2. Apply the internal bridging solution. This way you can use expanded dates in your programs while your files continue to hold dates in two-digit-year form. You can progress more easily to a full-field-expansion solution, because there will be no further changes to the logic in the main body of the programs.
3. Change the file layouts and database definitions to use four-digit-year dates.
4. Change your COBOL copybooks to reflect these four-digit-year date fields.
5. Run a utility program (or special-purpose COBOL program) to copy files from the old format to the new format.
6. Recompile your programs and do regression testing and date testing.

After you have completed the first two steps, you can repeat the remaining steps any number of times. You do not need to change every date field in every file at the same time. Using this method, you can select files for progressive conversion based on criteria such as business needs or interfaces with other applications.

When you use this method, you need to write special-purpose programs to convert your files to expanded-date form.

“Example: converting files to expanded date form”

Example: converting files to expanded date form

The following example shows a simple program that copies from one file to another while expanding the date fields. The record length of the output file is larger than that of the input file because the dates are expanded.

```
CBL  LIB,QUOTE,NOOPT,DATEPROC(FLAG),YEARWINDOW(-80)
*****
** CONVERT - Read a file, convert the date    **
**          fields to expanded form, write    **
**          the expanded records to a new     **
**          file.                             **
*****
IDENTIFICATION DIVISION.
PROGRAM-ID.  CONVERT.

ENVIRONMENT DIVISION.

INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT INPUT-FILE
        ASSIGN TO INFIL
        FILE STATUS IS INPUT-FILE-STATUS.

    SELECT OUTPUT-FILE
        ASSIGN TO OUTFILE
        FILE STATUS IS OUTPUT-FILE-STATUS.

DATA DIVISION.
FILE SECTION.
FD  INPUT-FILE
    RECORDING MODE IS F.
01  INPUT-RECORD.
    03  CUST-NAME.
        05  FIRST-NAME  PIC X(10).
        05  LAST-NAME   PIC X(15).
    03  ACCOUNT-NUM     PIC 9(8).
    03  DUE-DATE        PIC X(6) DATE FORMAT YYXXXX.      (1)
    03  REMINDER-DATE   PIC X(6) DATE FORMAT YYXXXX.
    03  DUE-AMOUNT      PIC S9(5)V99 COMP-3.

FD  OUTPUT-FILE
    RECORDING MODE IS F.
01  OUTPUT-RECORD.
    03  CUST-NAME.
        05  FIRST-NAME  PIC X(10).
        05  LAST-NAME   PIC X(15).
    03  ACCOUNT-NUM     PIC 9(8).
    03  DUE-DATE        PIC X(8) DATE FORMAT YYYYXXXX.    (2)
    03  REMINDER-DATE   PIC X(8) DATE FORMAT YYYYXXXX.
    03  DUE-AMOUNT      PIC S9(5)V99 COMP-3.

WORKING-STORAGE SECTION.

01  INPUT-FILE-STATUS  PIC 99.
01  OUTPUT-FILE-STATUS PIC 99.

PROCEDURE DIVISION.

    OPEN INPUT INPUT-FILE.
    OPEN OUTPUT OUTPUT-FILE.

READ-RECORD.
    READ INPUT-FILE
        AT END GO TO CLOSE-FILES.
    MOVE CORRESPONDING INPUT-RECORD TO OUTPUT-RECORD.      (3)
```



```

WRITE OUTPUT-RECORD.

GO TO READ-RECORD.

CLOSE-FILES.
CLOSE INPUT-FILE.
CLOSE OUTPUT-FILE.

EXIT PROGRAM.

END PROGRAM CONVERT.

```

Notes

- (1) The fields DUE-DATE and REMINDER-DATE in the input record are both Gregorian dates with two-digit-year components. They are defined with a DATE FORMAT clause in this program so that the compiler will recognize them as windowed date fields.
- (2) The output record contains the same two fields in expanded date format. They are defined with a DATE FORMAT clause so that the compiler will treat them as four-digit-year date fields.
- (3) The MOVE CORRESPONDING statement moves each item in INPUT-RECORD individually to its matching item in OUTPUT-RECORD. When the two windowed date fields are moved to the corresponding expanded date fields, the compiler will expand the year values using the current century window.

Using year-first, year-only, and year-last date fields

A *year-first* date field is a date field whose DATE FORMAT specification consists of YY or YYYY, followed by one or more Xs. The date format of a *year-only* date field has just the YY or YYYY. When you compare two date fields of either of these types, the two dates must be compatible; that is, they must have the same number of nonyear characters. The number of digits for the year component need not be the same.

A *year-last* date field is a date field whose DATE FORMAT clause specifies one or more Xs preceding the YY or YYYY. Such date formats are commonly used to display dates, but are less useful computationally, because the year, which is the most significant part of the date, is in the least significant position of the date representation.

If your version of DFSORT (or equivalent) has the appropriate capabilities, year-last dates are supported as windowed keys in SORT or MERGE statements. Apart from sort and merge operations, functional support for year-last date fields is limited to equal or unequal comparisons and certain kinds of assignment. The operands must be either dates with identical (year-last) date formats, or a date and a nondate. The compiler does not provide automatic windowing for operations on year-last dates. When an unsupported usage (such as arithmetic on year-last dates) occurs, the compiler provides an error-level message.

If you need more general date-processing capability for year-last dates, you should isolate and operate on the year part of the date.

“Example: comparing year-first date fields” on page 562

RELATED CONCEPTS

“Compatible dates”

RELATED TASKS

“Sorting and merging by date” on page 567

“Using other date formats” on page 562

Compatible dates

The meaning of the term *compatible dates* depends on the COBOL division in which the usage occurs, as follows:

- The DATA DIVISION usage deals with the declaration of date fields, and the rules governing COBOL language elements such as subordinate data items and the REDEFINES clause. In the following example, Review-Date and Review-Year are compatible because Review-Year can be declared as a subordinate data item to Review-Date:

```
01 Review-Record.  
   03 Review-Date          Date Format yyxxxx.  
       05 Review-Year Pic XX Date Format yy.  
       05 Review-M-D Pic XXXX.
```

- The PROCEDURE DIVISION usage deals with how date fields can be used together in operations such as comparisons, moves, and arithmetic expressions. For year-first and year-only date fields, to be considered compatible, date fields must have the same number of nonyear characters. For example, a field with DATE FORMAT YYXXXX is compatible with another field that has the same date format, and with a YYYYXXXX field, but not with a YYXXX field.

Year-last date fields must have identical DATE FORMAT clauses. In particular, operations between windowed date fields and expanded year-last date fields are not allowed. For example, you can move a date field with a date format of XXXXY to another XXXXY date field, but not to a date field with a format of XXXYYYY.

You can perform operations on date fields, or on a combination of date fields and nondates, provided that the date fields in the operation are compatible. For example, assume the following definitions:

```
01 Date-Gregorian-Win Pic 9(6) Packed-Decimal Date Format yyxxxx.  
01 Date-Julian-Win    Pic 9(5) Packed-Decimal Date Format yyxxx.  
01 Date-Gregorian-Exp Pic 9(8) Packed-Decimal Date Format yyyyxxxx.
```

The following statement is inconsistent because the number of nonyear digits is different between the two fields:

```
If Date-Gregorian-Win Less than Date-Julian-Win . . .
```

The following statement is accepted because the number of nonyear digits is the same for both fields:

```
If Date-Gregorian-Win Less than Date-Gregorian-Exp . . .
```

In this case the century window is applied to the windowed date field (Date-Gregorian-Win) to ensure that the comparison is meaningful.

When a nondate is used in conjunction with a date field, the nondate either is assumed to be compatible with the date field or is treated as a simple numeric value.

Example: comparing year-first date fields

In this example, a windowed date field is compared with an expanded date field, so the century window is applied to Date-Due-Back:

```
77  Todays-Date          Pic X(8) Date Format yyyyxxxx.
01  Loan-Record.
    05  Date-Due-Back    Pic X(6) Date Format yyxxxx.
. . .
    If Date-Due-Back > Todays-Date Then . . .
```

Todays-Date must have a DATE FORMAT clause in this case to define it as an expanded date field. If it did not, it would be treated as a nondate field, and would therefore be considered to have the same number of year digits as Date-Due-Back. The compiler would apply the assumed century window of 1900-1999, which would create an inconsistent comparison.

Using other date formats

To be eligible for automatic windowing, a date field should contain a two-digit year as the first or only part of the field. The remainder of the field, if present, must be between one and four characters, but its content is not important. For example, it can contain a three-digit Julian day, or a two-character identifier of some event specific to the enterprise.

If there are date fields in your application that do not fit these criteria, you might have to make some code changes to define just the year part of the date as a date field with the DATE FORMAT clause. Some examples of these types of date formats are:

- A seven-character field consisting of a two-digit year, three characters containing an abbreviation of the month and two digits for the day of the month. This format is not supported because date fields can have only one through four nonyear characters.
- A Gregorian date of the form DDMMYY. Automatic windowing is not provided because the year component is not the first part of the date. Year-last dates such as these are fully supported as windowed keys in SORT or MERGE statements, and are also supported in a limited number of other COBOL operations.

If you need to use date windowing in cases like these, you will need to add some code to isolate the year portion of the date.

“Example: isolating the year”

Example: isolating the year

In the following example, the two date fields contain dates of the form DDMMYY:

```
03  Last-Review-Date Pic 9(6).
03  Next-Review-Date Pic 9(6).
. . .
Add 1 to Last-Review-Date Giving Next-Review-Date.
```

In this example, if Last-Review-Date contains 230197 (January 23, 1997), then Next-Review-Date will contain 230198 (January 23, 1998) after the ADD statement is executed. This is a simple method for setting the next date for an annual review. However, if Last-Review-Date contains 230199, then adding 1 gives 230200, which is not the desired result.

Because the year is not the first part of these date fields, the DATE FORMAT clause cannot be applied without some code to isolate the year component. In the next

example, the year component of both date fields has been isolated so that COBOL can apply the century window and maintain consistent results:

```
03 Last-Review-Date Date Format xxxxyy.  
   05 Last-R-DDMM Pic 9(4).  
   05 Last-R-YY Pic 99 Date Format yy.  
03 Next-Review-Date Date Format xxxxyy.  
   05 Next-R-DDMM Pic 9(4).  
   05 Next-R-YY Pic 99 Date Format yy.  
. . .  
Move Last-R-DDMM to Next-R-DDMM.  
Add 1 to Last-R-YY Giving Next-R-YY.
```

Manipulating literals as dates

If a windowed date field has an 88-level condition-name associated with it, the literal in the VALUE clause is windowed against the century window for the compile unit rather than against the assumed century window of 1900-1999.

For example, suppose you have these data definitions:

```
05 Date-Due Pic 9(6) Date Format yyxxxx.  
88 Date-Target Value 051220.
```

If the century window is 1950-2049 and the contents of Date-Due is 051220 (representing December 20, 2005), then the first condition below evaluates to true, but the second condition evaluates to false:

```
If Date-Target  
If Date-Due = 051220
```

The literal 051220 is treated as a nondate, and therefore it is windowed against the assumed century window of 1900-1999 to represent December 20, 1905. But where the same literal is specified in the VALUE clause of an 88-level condition-name, the literal becomes part of the data item to which it is attached. Because this data item is a windowed date field, the century window is applied whenever it is referenced.

You can also use the DATEVAL intrinsic function in a comparison expression to convert a literal to a date field, and the output from the intrinsic function will then be treated as either a windowed date field or an expanded date field to ensure a consistent comparison. For example, using the above definitions, both of these conditions evaluate to true:

```
If Date-Due = Function DATEVAL (051220 "YYYYXX")  
If Date-Due = Function DATEVAL (20051220 "YYYYXXXX")
```

With a level-88 condition-name, you can specify the THRU option on the VALUE clause, but you must specify a fixed century window on the YEARWINDOW compiler option rather than a sliding window. For example:

```
05 Year-Field Pic 99 Date Format yy.  
88 In-Range Value 98 Thru 06.
```

With this form, the windowed value of the second item must be greater than the windowed value of the first item. However, the compiler can verify this difference only if the YEARWINDOW compiler option specifies a fixed century window (for example, YEARWINDOW(1940) rather than YEARWINDOW(-60).

The windowed order requirement does not apply to year-last date fields. If you specify a condition-name VALUE clause with the THROUGH phrase for a year-last date field, the two literals must follow normal COBOL rules. That is, the first literal must be less than the second literal.

RELATED CONCEPTS

"Assumed century window"

"Treatment of nondates" on page 565

RELATED TASKS

"Controlling date processing explicitly" on page 571

Assumed century window

When a program uses windowed date fields, the compiler applies the century window for the compilation unit (that is, the century window defined by the YEARWINDOW compiler option). When a windowed date field is used in conjunction with a nondate, and the context demands that the nondate also be treated as a windowed date, the compiler uses an assumed century window to resolve the nondate field.

The assumed century window is 1900-1999, which typically is not the same as the century window for the compilation unit.

In many cases, particularly for literal nondates, this assumed century window is the correct choice. In the following construct, the literal should retain its original meaning of January 1, 1972, and not change to 2072 if the century window is, for example, 1975-2074:

```
01 Manufacturing-Record.  
   03 Makers-Date Pic X(6) Date Format yyxxxx.  
   . . .  
   If Makers-Date Greater than "720101" . . .
```

Even if the assumption is correct, it is better to make the year explicit and eliminate the warning-level diagnostic message (which results from applying the assumed century window) by using the DATEVAL intrinsic function:

```
If Makers-Date Greater than  
   Function Dateval("19720101" "YYYYXXXX") . . .
```

In some cases, the assumption might not be correct. For the following example, assume that Project-Controls is in a copy member that is used by other applications that have not yet been upgraded for year 2000 processing, and therefore Date-Target cannot have a DATE FORMAT clause:

```
01 Project-Controls.  
   03 Date-Target      Pic 9(6).  
   . . .  
01 Progress-Record.  
   03 Date-Complete    Pic 9(6) Date Format yyxxxx.  
   . . .  
   If Date-Complete Less than Date-Target . . .
```

In the example above, the following three conditions need to be true to make Date-Complete earlier than (less than) Date-Target:

- The century window is 1910-2009.
- Date-Complete is 991202 (Gregorian date: December 2, 1999).
- Date-Target is 000115 (Gregorian date: January 15, 2000).

However, because Date-Target does not have a DATE FORMAT clause, it is a nondate. Therefore, the century window applied to it is the assumed century window of 1900-1999, and it is processed as January 15, 1900. So Date-Complete will be greater than Date-Target, which is not the desired result.

In this case, you should use the DATEVAL intrinsic function to convert Date-Target to a date field for this comparison. For example:

```
If Date-Complete Less than
    Function Dateval (Date-Target "YYXXXX") . . .
```

RELATED TASKS

“Controlling date processing explicitly” on page 571

Treatment of nondates

The simplest kind of nondate is a literal value. The following items are also nondates:

- A data item whose data description does not include a DATE FORMAT clause.
- The results (intermediate or final) of some arithmetic expressions. For example, the difference of two date fields is a nondate, whereas the sum of a date field and a nondate is a date field.
- The output from the UNDATE intrinsic function.

When you use a nondate in conjunction with a date field, the compiler interprets the nondate either as a date whose format is compatible with the date field or as a simple numeric value. This interpretation depends on the context in which the date field and nondate are used, as follows:

- **Comparison**

When a date field is compared with a nondate, the nondate is considered to be compatible with the date field in the number of year and nonyear characters. In the following example, the nondate literal 971231 is compared with a windowed date field:

```
01 Date-1                Pic 9(6) Date Format yyxxxx.
. . .
    If Date-1 Greater than 971231 . . .
```

The nondate literal 971231 is treated as if it had the same DATE FORMAT as Date-1, but with a base year of 1900.

- **Arithmetic operations**

In all supported arithmetic operations, nondate fields are treated as simple numeric values. In the following example, the numeric value 10000 is added to the Gregorian date in Date-2, effectively adding one year to the date:

```
01 Date-2                Pic 9(6) Date Format yyxxxx.
. . .
    Add 10000 to Date-2.
```

- **MOVE statement**

Moving a date field to a nondate is not supported. However, you can use the UNDATE intrinsic function to do this.

When you move a nondate to a date field, the sending field is assumed to be compatible with the receiving field in the number of year and nonyear characters. For example, when you move a nondate to a windowed date field, the nondate field is assumed to contain a compatible date with a two-digit year.

Setting triggers and limits

Triggers and limits are special values that never match valid dates because either the value is nonnumeric or the nonyear part of the value cannot occur in an actual date. Triggers and limits are recognized in date fields and also in nondates used in combination with date fields.

Type of field	Special value
Alphanumeric windowed date or year fields	HIGH-VALUE, LOW-VALUE, and SPACE
Alphanumeric and numeric windowed date fields with at least one X in the DATE FORMAT clause (that is, date fields other than just a year)	All nines or all zeros

The difference between a trigger and a limit is not in the particular value, but in the way it is used. You can use any of the special values as either a trigger or a limit.

When used as triggers, special values can indicate a specific condition such as “date not initialized” or “account past due.” When used as limits, special values are intended to act as dates earlier or later than any valid date. LOW-VALUE, SPACE and zeros are lower limits; HIGH-VALUE and nines are upper limits.

You activate trigger and limit support by specifying the TRIG suboption of the DATEPROC compiler option. If the DATEPROC(TRIG) compiler option is in effect, automatic expansion of windowed date fields (before their use as operands in comparisons, arithmetic, and so on) is sensitive to these special values.

The DATEPROC(TRIG) option results in slower performing code when comparing windowed dates. The DATEPROC(NOTRIG) option is a performance option that assumes valid date values in all windowed date fields.

When an actual or assumed windowed date field contains a trigger, the compiler expands the trigger as if the trigger value were propagated to the century part of the expanded date result, rather than inferring 19 or 20 as the century value as in normal windowing. In this way, your application can test for special values or use them as upper or lower date limits. Specifying DATEPROC(TRIG) also enables SORT and MERGE statement support of the DFSORT special indicators, which correspond to triggers and limits.

“Example: using limits”

RELATED TASKS

“Using sign conditions” on page 567

Example: using limits

Suppose that your application checks subscriptions for expiration, but you want some subscriptions to last indefinitely. You can use the expiration date field to hold either normal expiration dates or a high limit for the “everlasting” subscription. For example, consider the following code fragment:

```
Process DateProc(Flag,Trig). . .
. . .
01 SubscriptionRecord.
. . .
03 ExpirationDate PIC 9(6) Date Format yyxxxx.
. . .
77 TodaysDate Pic 9(6) Date Format yyxxxx.
. . .
If TodaysDate >= ExpirationDate
Perform SubscriptionExpired
```

Suppose that you have the following values:

- Today's date is January 4, 2000, represented in `TodaysDate` as 000104.
- One subscription record has a normal expiration date of December 31, 1999, represented as 991232.
- The special subscription expiration date is coded as 999999.

Because both dates are windowed, the first subscription is tested as if 20000104 were compared with 19991231, and so the test succeeds. However, when the compiler detects the special value, it uses trigger expansion instead of windowing. Therefore, the test proceeds as if 20000104 were compared with 99999999, and it fails and will always fail.

Using sign conditions

Some applications use special values such as zeros in date fields to act as a trigger, that is, to signify that some special processing is required. For example, in an `Orders` file, a value of zero in `Order-Date` might signify that the record is a customer totals record rather than an order record. The program compares the date to zero, as follows:

```
01 Order-Record.
   05 Order-Date      Pic S9(5) Comp-3 Date Format yxxxx.
. . .
   If Order-Date Equal Zero Then . . .
```

However, if you are compiling with the `NOTRIG` suboption of the `DATEPROC` compiler option, this comparison is not valid because the literal value `Zero` is a nondate, and is therefore windowed against the assumed century window to give a value of 1900000.

Alternatively, or if compiling on the Windows or AIX workstation, you can use a sign condition instead of a literal comparison as follows:

```
If Order-Date Is Zero Then . . .
```

With a sign condition, `Order-Date` is treated as a nondate, and the century window is not considered.

This approach applies only if the operand in the sign condition is a simple identifier rather than an arithmetic expression. If an expression is specified, the expression is evaluated first, with the century window being applied where appropriate. The sign condition is then compared with the results of the expression.

You could use the `UNDATE` intrinsic function instead or the `TRIG` suboption of the `DATEPROC` compiler option to achieve the same result.

RELATED CONCEPTS

"Treatment of nondates" on page 565

RELATED TASKS

"Setting triggers and limits" on page 565

"Controlling date processing explicitly" on page 571

Sorting and merging by date

DFSORT is the IBM licensed program for sorting and merging. Wherever DFSORT is mentioned here, you can use any equivalent product.

If your sort product supports the Y2PAST option and the windowed year identifiers (Y2B, Y2C, Y2D, Y2S, and Y2Z), you can perform sort and merge operations using windowed date fields as sort keys. Virtually all date fields that can be specified with a DATE FORMAT clause are supported, including binary year fields and year-last date fields. The fields will be sorted in windowed year sequence, according to the century window that you specify in the YEARWINDOW compiler option.

If your sort product also supports the date field identifiers Y2T, Y2U, Y2W, Y2X, and Y2Y, you can use the TRIG suboption of the DATEPROC compiler option. (Support for these date field identifiers was added to DFSORT through APAR PQ19684.)

The special indicators that DFSORT recognizes match exactly those supported by COBOL: LOW-VALUE, HIGH-VALUE, and SPACE for alphanumeric date or year fields, and all zeros and all nines for numeric and alphanumeric date fields with at least one nonyear digit.

“Example: sorting by date and time”

RELATED TASKS

OPTION control statement (Y2PAST) (*DFSORT Application Programming Guide*)

RELATED REFERENCES

“DATEPROC” on page 278

“YEARWINDOW” on page 315

Example: sorting by date and time

The following example shows a transaction file, with the transaction records sorted by date and time within account number. The field Trans-Date is a windowed Julian date field.

```
SD Transaction-File
   Record Contains 29 Characters
   Data Record is Transaction-Record

01 Transaction-Record.
   05 Trans-Account PIC 9(8).
   05 Trans-Type    PIC X.
   05 Trans-Date    PIC 9(5) Date Format yyxxx.
   05 Trans-Time    PIC 9(6).
   05 Trans-Amount PIC 9(7)V99.
. . .
Sort Transaction-File
   On Ascending Key Trans-Account
                   Trans-Date
                   Trans-Time
   Using Input-File
   Giving Sorted-File.
```

COBOL passes the relevant information to DFSORT for it to perform the sort. In addition to the information COBOL always passes to DFSORT, COBOL also passes the following information:

- Century window as the Y2PAST sort option
- Windowed year field and date format of Trans-Date.

DFSORT uses this information to perform the sort.

Performing arithmetic on date fields

You can perform arithmetic operations on numeric date fields in the same manner as any numeric data item, and, where appropriate, the century window will be used in the calculation. However, there are some restrictions on where date fields can be used in arithmetic expressions and arithmetic statements.

Arithmetic operations that include date fields are restricted to:

- Adding a nondate to a date field
- Subtracting a nondate from a date field
- Subtracting a date field from a compatible date field to give a nondate result

The following arithmetic operations are not allowed:

- Any operation between incompatible date fields
- Adding two date fields
- Subtracting a date field from a nondate
- Unary minus, applied to a date field
- Multiplication, division, or exponentiation of or by a date field
- Arithmetic expressions that specify a year-last date field
- Arithmetic expressions that specify a year-last date field, except as a receiving data item when the sending field is a nondate

Date semantics are provided for the year parts of date fields but not for the nonyear parts. For example, adding 1 to a windowed Gregorian date field that contains the value 980831 gives a result of 980832, not 980901.

Allowing for overflow from windowed date fields

A (nonyear-last) windowed date field that participates in an arithmetic operation is processed as if the value of the year component of the field were first incremented by 1900 or 2000, depending on the century window. For example:

```
01 Review-Record.  
   03 Last-Review-Year Pic 99 Date Format yy.  
   03 Next-Review-Year Pic 99 Date Format yy.  
   . . .  
   Add 10 to Last-Review-Year Giving Next-Review-Year.
```

If the century window is 1910-2009, and the value of Last-Review-Year is 98, then the computation proceeds as if Last-Review-Year is first incremented by 1900 to give 1998. Then the ADD operation is performed, giving a result of 2008. This result is stored in Next-Review-Year as 08.

However, the following statement would give a result of 2018:

```
Add 20 to Last-Review-Year Giving Next-Review-Year.
```

This result falls outside the range of the century window. If the result is stored in Next-Review-Year, it will be incorrect because later references to Next-Review-Year will interpret it as 1918. In this case, the result of the operation depends on whether the ON SIZE ERROR phrase is specified on the ADD statement:

- If SIZE ERROR is specified, the receiving field is not changed, and the SIZE ERROR imperative statement is executed.
- If SIZE ERROR is not specified, the result is stored in the receiving field with the left-hand digits truncated.

This consideration is important when you use internal bridging. When you contract a four-digit-year date field back to two digits to write it to the output file, you need to ensure that the date falls within the century window. Then the two-digit-year date will be represented correctly in the field.

To ensure appropriate calculations, use a COMPUTE statement to do the contraction, with a SIZE ERROR phrase to handle the out-of-window condition. For example:

```
Compute Output-Date-YY = Work-Date-YYYY  
On Size Error Perform CenturyWindowOverflow.
```

SIZE ERROR processing for windowed date receivers recognizes any year value that falls outside the century window. That is, a year value less than the starting year of the century window raises the SIZE ERROR condition, as does a year value greater than the ending year of the century window.

If the DATEPROC (TRIG) compiler option is in effect, trigger values of zeros or nines in the result also cause the SIZE ERROR condition, even though the year part of the result (00 or 99, respectively) falls within the century window.

Specifying the order of evaluation

Because of the restrictions on date fields in arithmetic expressions, you might find that programs that previously compiled successfully now produce diagnostic messages when some of the data items are changed to date fields.

Consider the following example:

```
01 Dates-Record.  
   03 Start-Year-1 Pic 99 Date Format yy.  
   03 End-Year-1 Pic 99 Date Format yy.  
   03 Start-Year-2 Pic 99 Date Format yy.  
   03 End-Year-2 Pic 99 Date Format yy.  
   . . .  
   Compute End-Year-2 = Start-Year-2 + End-Year-1 - Start-Year-1.
```

In this example, the first arithmetic expression evaluated is:

Start-Year-2 + End-Year-1

However, the addition of two date fields is not permitted. To resolve these date fields, you should use parentheses to isolate the parts of the arithmetic expression that are allowed. For example:

```
Compute End-Year-2 = Start-Year-2 + (End-Year-1 - Start-Year-1).
```

In this case, the first arithmetic expression evaluated is:

End-Year-1 - Start-Year-1

The subtraction of one date field from another is permitted and gives a nondate result. This nondate result is then added to the date field End-Year-1, giving a date field result that is stored in End-Year-2.

RELATED TASKS

“Using internal bridging” on page 557

Controlling date processing explicitly

There might be times when you want COBOL data items to be treated as date fields only under certain conditions, or only in specific parts of the program. Or your application might contain two-digit-year date fields that cannot be declared as windowed date fields because of some interaction with another software product. For example, if a date field is used in a context where it is recognized only by its true binary contents without further interpretation, the date in this field cannot be windowed. Such date fields include:

- A key on a VSAM file
- A search field in a database system such as DB2
- A key field in a CICS command

Conversely, there might be times when you want a date field to be treated as a nondate in specific parts of the program.

COBOL provides two intrinsic functions to deal with these conditions:

DATEVAL

Converts a nondate to a date field

UNDATE Converts a date field to a nondate

Using **DATEVAL**

You can use the **DATEVAL** intrinsic function to convert a nondate to a date field, so that COBOL will apply the relevant date processing to the field. The first argument in the function is the nondate to be converted, and the second argument specifies the date format. The second argument is a literal string with a specification similar to that of the date pattern in the **DATE FORMAT** clause.

In most cases, the compiler makes the correct assumption about the interpretation of a nondate, but accompanies this assumption with a warning-level diagnostic message. This message typically happens when a windowed date is compared with a literal:

```
03 When-Made          Pic x(6) Date Format yyxxxx.
. . .
If When-Made = "850701" Perform Warranty-Check.
```

The literal is assumed to be a compatible windowed date but with a century window of 1900-1999, thus representing July 15, 1985. You can use the **DATEVAL** intrinsic function to make the year of the literal date explicit and eliminate the warning message:

```
If When-Made = Function Dateval("19850701" "YYYYXXXX")
    Perform Warranty-Check.
```

“Example: **DATEVAL**” on page 572

Using **UNDATE**

The **UNDATE** intrinsic function converts a date field to a nondate, so that it can be referenced without any date processing.

Attention: Avoid using **UNDATE** except as a last resort, because the compiler will lose the flow of date fields in your program. This problem could result in date comparisons not being windowed properly. Use more **DATE FORMAT** clauses instead of function **UNDATE** for **MOVE** and **COMPUTE**.

“Example: UNDATE”

Example: DATEVAL

Assume that a program contains a field Date-Copied and that this field is referenced many times in the program, but that most of these references move it between records or reformat it for printing. Only one reference relies on it to contain a date, for comparison with another date.

In this case, it is better to leave the field as a nondate, and use the DATEVAL intrinsic function in the comparison statement. For example:

```
03 Date-Distributed Pic 9(6) Date Format yyxxxx.
03 Date-Copied      Pic 9(6).
. . .
If FUNCTION DATEVAL(Date-Copied "YYXXXX") Less than
    Date-Distributed . . .
```

In this example, the DATEVAL intrinsic function converts Date-Copied to a date field so that the comparison will be meaningful.

RELATED REFERENCES

DATEVAL (*Enterprise COBOL Language Reference*)

Example: UNDATE

In the following example, the field Invoice-Date in Invoice-Record is a windowed Julian date. In some records, it contains a value of 00999 to indicate that this is not a true invoice record, but a record containing file control information.

Invoice-Date has been given a DATE FORMAT clause because most of its references in the program are date-specific. However, in the instance where it is checked for the existence of a control record, the value of 00 in the year component will lead to some confusion. A year of 00 in Invoice-Date will represent a year of either 1900 or 2000, depending on the century window. This is compared with a nondate (the literal 00999 in the example), which will always be windowed against the assumed century window and will therefore always represent the year 1900.

To ensure a consistent comparison, you should use the UNDATE intrinsic function to convert Invoice-Date to a nondate. Therefore, if the IF statement is not comparing date fields, it does not need to apply windowing. For example:

```
01 Invoice-Record.
  03 Invoice-Date   Pic x(5) Date Format yyxxx.
. . .
  If FUNCTION UNDATE(Invoice-Date) Equal "00999" . . .
```

RELATED REFERENCES

UNDATE (*Enterprise COBOL Language Reference*)

Analyzing and avoiding date-related diagnostic messages

When the DATEPROC(FLAG) compiler option is in effect, the compiler produces diagnostic messages for every statement that defines or references a date field. As with all compiler-generated messages, each date-related message has one of the following severity levels:

- Information-level, to draw your attention to the definition or use of a date field.
- Warning-level, to indicate that the compiler has had to make an assumption about a date field or nondate because of inadequate information coded in the

program, or to indicate the location of date logic that should be manually checked for correctness. Compilation proceeds, with any assumptions continuing to be applied.

- Error-level, to indicate that the usage of the date field is incorrect. Compilation continues, but run-time results are unpredictable.
- Severe-level, to indicate that the usage of the date field is incorrect. The statement that caused this error is discarded from the compilation.

The easiest way to use the MLE messages is to compile with a FLAG option setting that embeds the messages in the source listing after the line to which the messages refer. You can choose to see all MLE messages or just certain severities.

To see all MLE messages, specify the FLAG(I,I) and DATEPROC(FLAG) compiler options. Initially, you might want to see all of the messages to understand how MLE is processing the date fields in your program. For example, if you want to do a static analysis of the date usage in a program by using the compile listing, use FLAG (I,I).

However, it is recommended that you specify FLAG(W,W) for MLE-specific compiles. You must resolve all severe-level (S-level) error messages, and you should resolve all error-level (E-level) messages as well. For the warning-level (W-level) messages, you need to examine each message and use the following guidelines to either eliminate the message or, for unavoidable messages, ensure that the compiler makes correct assumptions:

- The diagnostic messages might indicate some date data items that should have had a DATE FORMAT clause. Either add DATE FORMAT clauses to these items or use the DATEVAL intrinsic function in references to them.
- Pay particular attention to literals in relation conditions that involve date fields or in arithmetic expressions that include date fields. You can use the DATEVAL function on literals (as well as nondate data items) to specify a DATE FORMAT pattern to be used. As a last resort, you can use the UNDATE function to enable a date field to be used in a context where you do not want date-oriented behavior.
- With the REDEFINES and RENAMES clauses, the compiler might produce a warning-level diagnostic message if a date field and a nondate occupy the same storage location. You should check these cases carefully to confirm that all uses of the aliased data items are correct, and that none of the perceived nondate redefinitions actually is a date or can adversely affect the date logic in the program.

In some cases, a the W-level message might be acceptable, but you might want to change the code to get a compile with a return code of zero.

To avoid warning-level diagnostic messages, follow these guidelines:

- Add DATE FORMAT clauses to any data items that will contain date data, even if they are not used in comparisons.
- Do not specify a date field in a context where a date field does not make sense, such as a FILE STATUS, PASSWORD, ASSIGN USING, LABEL RECORD, or LINAGE item. If you do, you will get a warning-level message and the date field will be treated as a nondate.
- Ensure that implicit or explicit aliases for date fields are compatible, such as in a group item that consists solely of a date field.
- Ensure that if a date field is defined with a VALUE clause, the value is compatible with the date field definition.

- Use the DATEVAL intrinsic function if you want a nondate treated as a date field, such as when moving a nondate to a date field or when comparing a windowed date with a nondate and you want a windowed date comparison. If you do not use DATEVAL, the compiler will make an assumption about the use of the nondate and produce a warning-level diagnostic message. Even if the assumption is correct, you might want to use DATEVAL to eliminate the message.
- Use the UNDATE intrinsic function if you want a date field treated as a nondate, such as moving a date field to a nondate, or comparing a nondate and a windowed date field and you do not want a windowed comparison.

RELATED TASKS

“Controlling date processing explicitly” on page 571

Analyzing date-related diagnostic messages (*COBOL Millennium Language Extensions Guide*)

Avoiding problems in processing dates

When you change a COBOL program to use the millennium language extensions, you might find that some parts of the program need special attention to resolve unforeseen changes in behavior. This section outlines some of the areas that you might need to consider.

Avoiding problems with packed-decimal fields

COMPUTATIONAL-3 fields (packed-decimal format) are often defined as having an odd number of digits, even if the field will not be used to hold a number of that magnitude. The internal representation of packed-decimal numbers always allows for an odd number of digits.

A field that holds a six-digit Gregorian date, for example, can be declared as PIC S9(6) COMP-3, and this declaration will reserve 4 bytes of storage. But the programmer might have declared the field as PIC S9(7), knowing that this would reserve the same 4 bytes, with the high-order digit always containing a zero.

If you add a DATE FORMAT YYXXXX clause to this field, the compiler will give you a diagnostic message because the number of digits in the PICTURE clause does not match the size of the date format specification. In this case, you need to check carefully each use of the field. If the high-order digit is never used, you can simply change the field definition to PIC S9(6). If it is used (for example, if the same field can hold a value other than a date), you need to take some other action, such as:

- Using a REDEFINES clause to define the field as both a date and a nondate (this usage will also produce a warning-level diagnostic message)
- Defining another WORKING-STORAGE field to hold the date, and moving the numeric field to the new field
- Not adding a DATE FORMAT clause to the data item, and using the DATEVAL intrinsic function when referring to it as a date field

Moving from expanded to windowed date fields

When you move an expanded alphanumeric date field to a windowed date field, the move does not follow the normal COBOL conventions for alphanumeric moves. When both the sending and receiving fields are date fields, the move is right justified, not left justified as normal. For an expanded-to-windowed (contracting) move, the leading two digits of the year are truncated.

Depending on the contents of the sending field, the results of such a move might be incorrect. For example:

```
77 Year-Of-Birth-Exp    Pic x(4) Date Format yyyy.  
77 Year-Of-Birth-Win    Pic xx   Date Format yy.  
.  
.  
.  
    Move Year-Of-Birth-Exp to Year-Of-Birth-Win.
```

If Year-Of-Birth-Exp contains '1925', Year-Of-Birth-Win will contain '25'. However, if the century window is 1930-2029, subsequent references to Year-Of-Birth-Win will treat it as 2025, which is incorrect.

Part 8. Improving performance and productivity

Chapter 34. Tuning your program	579
Using an optimal programming style	579
Using structured programming	580
Factoring expressions.	580
Using symbolic constants	580
Grouping constant computations	580
Grouping duplicate computations	581
Choosing efficient data types	581
Computational data items	581
Consistent data types.	582
Arithmetic expressions	582
Exponentiations	582
Handling tables efficiently	583
Optimization of table references	584
Optimization of constant and variable items	585
Optimization of duplicate items	585
Optimization of variable-length items	585
Comparison of direct and relative indexing	585
Optimizing your code	586
Optimization	586
Contained program procedure integration	587
PERFORM procedure integration.	587
Example: PERFORM procedure integration	588
Choosing compiler features to enhance performance.	588
Performance-related compiler options	589
Evaluating performance	592
Running efficiently with CICS, IMS, or VSAM	592
CICS	592
IMS	593
VSAM.	593
 Chapter 35. Simplifying coding.	 595
Eliminating repetitive coding	595
Example: using the COPY statement.	596
Using Language Environment callable services	597
Sample list of Language Environment callable services	598
Calling Language Environment services	599
Example: Language Environment callable services	600

Chapter 34. Tuning your program

When a program is comprehensible, you can assess its performance. A program that has a tangled control flow is difficult to understand and maintain. The tangled control flow also inhibits the optimization of the code. Therefore, before you try to improve the performance directly, you need to assess certain aspects:

1. Examine the underlying algorithms for your program. For top performance, a sound algorithm is essential. For example, a sophisticated algorithm for sorting a million items can be hundreds of thousands times faster than a simple algorithm.
2. Look at the data structures. They should be appropriate for the algorithm. When your program frequently accesses data, reduce the number of steps needed to access the data wherever possible.
3. After you have improved the algorithm and data structures, look at other details of the COBOL source code that affect performance.

You can write programs that result in better generated code sequences and use system services better. These five areas affect program performance:

- Coding techniques. These include using a programming style that helps the optimizer, choosing efficient data types, and handling tables efficiently.
- Optimization. You can optimize your code by using the OPTIMIZE compiler option.
- Compiler options and USE FOR DEBUGGING ON ALL PROCEDURES. Certain compiler options and language affect the efficiency of your program.
- Run-time environment. Carefully consider your choice of run-time options and other run-time considerations that control how your compiled program runs.
- Running under CICS, IMS, or using VSAM. Various tips can help make these programs run efficiently.

RELATED CONCEPTS

"Optimization" on page 586

IBM Enterprise COBOL Version 3 Release 1 Performance Tuning

(www.ibm.com/software/awdtools/cobol/zos/pdf/cobpf310.pdf)

RELATED TASKS

"Using an optimal programming style"

"Choosing efficient data types" on page 581

"Handling tables efficiently" on page 583

"Optimizing your code" on page 586

"Choosing compiler features to enhance performance" on page 588

Specifying run-time options (*Language Environment Programming Guide*)

"Running efficiently with CICS, IMS, or VSAM" on page 592

RELATED REFERENCES

"Performance-related compiler options" on page 589

Storage performance considerations (*Language Environment Programming Guide*)

Using an optimal programming style

The coding style you use can, in certain circumstances, affect how the optimizer handles your code.

Using structured programming

Using structured programming statements (such as EVALUATE and inline PERFORM) makes your program more comprehensible and generates a linear control flow. The optimizer can then operate over larger regions of the program, which gives you more efficient code.

Avoid using the following constructs:

- ALTER statement
- Backward branches (except as needed for loops for which PERFORM is unsuitable)
- PERFORM procedures that involve irregular control flow (such as a PERFORM procedure that prevents control from passing to the end of the procedure and returning to the PERFORM statement)

Use top-down programming constructs. Out-of-line PERFORM statements are a natural means of doing top-down programming. With the optimizer, out-of-line PERFORM statements can often be as efficient as inline PERFORM statements, because the optimizer can simplify or remove the linkage code.

Factoring expressions

Factoring can save a lot of computation. For example, this code:

```
MOVE ZERO TO TOTAL
PERFORM VARYING I FROM 1 BY 1 UNTIL I = 10
  COMPUTE TOTAL = TOTAL + ITEM(I)
END-PERFORM
COMPUTE TOTAL = TOTAL * DISCOUNT
```

is more efficient than this code:

```
MOVE ZERO TO TOTAL
PERFORM VARYING I FROM 1 BY 1 UNTIL I = 10
  COMPUTE TOTAL = TOTAL + ITEM(I) * DISCOUNT
END-PERFORM
```

The optimizer does not do factoring for you.

Using symbolic constants

To have the optimizer recognize a data item as a constant throughout the program, initialize it with a VALUE clause and do not change it anywhere in the program.

If you pass a data item to a subprogram BY REFERENCE, the optimizer considers it to be an external data item and assumes that it is changed at every subprogram call.

If you move a literal to a data item, the optimizer recognizes it as a constant, but only in a limited region of the program after the MOVE statement.

Grouping constant computations

When several items of an expression are constant, ensure that the optimizer is permitted to optimize them. For evaluating expressions, the compiler is bound by the left-to-right evaluation rules of COBOL. Therefore, either move all the constants to the left side of the expression or group them inside parentheses.

For example, given that V1, V2, and V3 are variables and that C1, C2, and C3 are constants, the expressions that contain the constant computations are preferable to those that do not:

More efficient

$V1 * V2 * V3 * (C1 * C2 * C3)$
 $C1 + C2 + C3 + V1 + V2 + V3$

Less efficient

$V1 * V2 * V3 * C1 * C2 * C3$
 $V1 + C1 + V2 + C2 + V3 + C3$

Often, in production programming, there is a tendency to place constant factors on the right-hand side of expressions. However, this placement can result in less efficient code because optimization is lost.

Grouping duplicate computations

When several components of different expressions are duplicates, make sure the compiler is permitted to optimize them. For evaluating arithmetic expressions, the compiler is bound by the left-to-right evaluation rules of COBOL. Therefore, either move all the duplicates to the left side of the expressions or group them inside parentheses.

Given that V1 through V5 are variables, the computation $V2 * V3 * V4$ is a duplicate (known as a common subexpression) between the following two statements:

```
COMPUTE A = V1 * (V2 * V3 * V4)
COMPUTE B = V2 * V3 * V4 * V5
```

In the following example, the common subexpression is $V2 + V3$:

```
COMPUTE C = V1 + (V2 + V3)
COMPUTE D = V2 + V3 + V4
```

No common subexpressions are in these examples:

```
COMPUTE A = V1 * V2 * V3 * V4
COMPUTE B = V2 * V3 * V4 * V5
COMPUTE C = V1 + (V2 + V3)
COMPUTE D = V4 + V2 + V3
```

The optimizer can eliminate duplicate computations; you do not need to introduce artificial temporary computations. The program is often more comprehensible without them.

Choosing efficient data types

Choosing the appropriate data type and PICTURE clause can produce more efficient code, as can avoiding USAGE DISPLAY data items in areas heavily used for computations. Consistent data types can reduce the need for conversions when performing operations on data items. You can also improve program performance by carefully determining when to use fixed-point and floating-point data types.

Computational data items

When you use a data item mainly for arithmetic or as a subscript, code USAGE BINARY on the data description entry for the item. The operations for manipulating binary data are faster than those for manipulating decimal data.

However, if a fixed-point arithmetic statement has intermediate results with a large precision (number of significant digits), the compiler uses decimal arithmetic anyway, after converting the operands to packed-decimal form. For fixed-point arithmetic statements, the compiler normally uses binary arithmetic for simple

computations with binary operands if the precision is eight digits or fewer. Above 18 digits, the compiler always uses decimal arithmetic. With a precision of nine to 18 digits, the compiler uses either form.

To produce the most efficient code for a BINARY data item, ensure that it has:

- A sign (an S in its PICTURE clause)
- Eight or fewer digits

For a data item that is larger than eight digits or is used with DISPLAY data items, use PACKED-DECIMAL. The code generated for PACKED-DECIMAL data items can be as fast as that for BINARY data items in some cases, especially if the statement is complicated or specifies rounding.

To produce the most efficient code for a PACKED-DECIMAL data item, ensure that it has:

- A sign (an S in its PICTURE clause)
- An odd number of digits (9s in the PICTURE clause), so that it occupies an exact number of bytes without a half byte left over
- 15 or fewer digits in the PICTURE specification to avoid using library routines for multiplication and division

Consistent data types

In operations on operands of different types, one of the operands must be converted to the same type as the other. Each conversion requires several instructions. For example, one of the operands might need to be scaled to give it the appropriate number of decimal places.

You largely avoid conversions by using consistent data types, giving both operands the same usage and also appropriate PICTURE specifications. That is, you should give two numbers to be compared, added, or subtracted not only have the same usage but also the same number of decimal places (9s after the V in the PICTURE clause).

Arithmetic expressions

Computation of arithmetic expressions that are evaluated in floating point is most efficient when the operands need little or no conversion. Use operands that are COMP-1 or COMP-2 to produce the most efficient code.

Declare integer items as BINARY or PACKED-DECIMAL with nine or fewer digits to afford quick conversion to floating-point data. Also, conversion from a COMP-1 or COMP-2 item to a fixed-point integer with nine or fewer digits, without SIZE ERROR in effect, is efficient when the value of the COMP-1 or COMP-2 item is less than 1,000,000,000.

Exponentiations

Use floating point for exponentiations for large exponents to achieve faster evaluation and more accurate results. For example, the first statement below is computed more quickly and accurately than the second statement:

```
COMPUTE fixed-point1 = fixed-point2 ** 100000.E+00
```

```
COMPUTE fixed-point1 = fixed-point2 ** 100000
```

A floating-point exponent causes floating-point arithmetic to be used to compute the exponentiation.

RELATED CONCEPTS

“Formats for numeric data” on page 40

Handling tables efficiently

Pay close attention to table-handling operations, particularly when they are a major part of an application. Several techniques can improve the efficiency of these operations and can also influence the optimizer. The return for your efforts can be significant.

The following two guidelines affect your choice of how to refer to table elements:

- Use indexing rather than subscripting.

Although the compiler can eliminate duplicate indexes and subscripts, the original reference to a table element is more efficient with indexes than with subscripts, even if the subscripts are `BINARY`. The value of an index has the element size factored into it, whereas the value of a subscript must be multiplied by the element size when the subscript is used. The index already contains the displacement from the start of the table, and this value does not have to be calculated at run time. However, subscripting might be easier to understand and maintain.

- Use relative indexing.

Relative index references (that is, references in which an unsigned numeric literal is added to or subtracted from the index name) are executed as fast as direct index references and sometimes faster. There is no merit in keeping alternative indexes with the offset factored in.

Whether you use indexes or subscripts, the following guidelines can help you get better performance in terms of how you code them:

- Put constant and duplicate indexes or subscripts on the left.

You can reduce or eliminate run-time computations by making the constant and duplicate indexes or subscripts the leftmost ones. Even when all the indexes or subscripts are variable, try to use your tables so that the rightmost subscript varies most often for references that occur close to each other in the program. This practice also improves the pattern of storage references as well as paging. If all the indexes or subscripts are duplicates, then the entire index or subscript computation is a common subexpression.

- Specify the element length so that it matches that of related tables.

When you index or subscript tables, it is most efficient if all the tables have the same element length. With equal element lengths, the stride for the last dimension of the tables will be equal. The optimizer can then reuse the rightmost index or subscript computed for one table. If both the element lengths and the number of occurrences in each dimension are equal, then the strides for dimensions other than the last are also equal, resulting in greater commonality between their subscript computations. The optimizer can then reuse indexes or subscripts other than the rightmost.

- Avoid errors in references by coding index and subscript checks into your program.

If you need to validate your indexes and subscripts, it might be faster to code your own checks in your COBOL program than to use the `SSRANGE` compiler option.

You can also improve the efficiency of tables in situations covered by the following guidelines:

- Use binary data items for all subscripts.

When you use subscripts to address a table, use a BINARY signed data item with eight or fewer digits. In some cases, using four or fewer digits for the data item might also improve processing time.

- Use binary data items for variable-length table items.

For tables with variable-length items, you can improve the code for OCCURS DEPENDING ON (ODO). To avoid unnecessary conversions each time the variable-length items are referenced, specify BINARY for OCCURS . . . DEPENDING ON objects.

- Use fixed-length data items whenever possible.

Copying variable-length data items into a fixed-length data item before a period of high-frequency use can reduce some of the overhead associated with using variable-length data items.

- Organize tables according to the type of search method used.

If the table is searched sequentially, put the data values most likely to satisfy the search criteria at the beginning of the table. If the table is searched using a binary search algorithm, put the data values in the table sorted alphabetically on the search key field.

RELATED CONCEPTS

“Optimization of table references”

RELATED TASKS

“Referring to an item in a table” on page 61

“Choosing efficient data types” on page 581

RELATED REFERENCES

“SSRANGE” on page 304

Optimization of table references

For the table element reference `ELEMENT(S1 S2 S3)`, where S1, S2, and S3 are subscripts, the compiler evaluates the following expression:

```
comp_s1 * d1 + comp_s2 * d2 + comp_s3 * d3 + base_address
```

Here `comp_s1` is the value of S1 after conversion to binary, `comp-s2` is the value of S2 after conversion to binary, and so on. The strides for each dimension are d1, d2, and d3. The stride of a given dimension is the distance in bytes between table elements whose occurrence numbers in that dimension differ by 1 and whose other occurrence numbers are equal. For example, the stride, d2, of the second dimension in the above example is the distance in bytes between `ELEMENT(S1 1 S3)` and `ELEMENT(S1 2 S3)`.

Index computations are similar to subscript computations, except that no multiplication needs to be done. Index values have the stride factored into them. They involve loading the indexes into registers, and these data transfers can be optimized, much as the individual subscript computation terms are optimized.

Because the compiler evaluates expressions from left to right, the optimizer finds the most opportunities to eliminate computations when the constant or duplicate subscripts are the leftmost.

Optimization of constant and variable items

Assume that C1, C2, . . . are constant data items and that V1, V2, . . . are variable data items. Then, for the table element reference ELEMENT(V1 C1 C2) the compiler can eliminate only the individual terms comp_c1 * d2 and comp_c2 * d3 as constant from the expression:

$$\text{comp_v1} * \text{d1} + \text{comp_c1} * \text{d2} + \text{comp_c2} * \text{d3} + \text{base_address}$$

However, for the table element reference ELEMENT(C1 C2 V1) the compiler can eliminate the entire subexpression comp_c1 * d1 + comp_c2 * d2 as constant from the expression:

$$\text{comp_c1} * \text{d1} + \text{comp_c2} * \text{d2} + \text{comp_v1} * \text{d3} + \text{base_address}$$

In the table element reference ELEMENT(C1 C2 C3), all the subscripts are constant, and so no subscript computation is done at run time. The expression is:

$$\text{comp_c1} * \text{d1} + \text{comp_c2} * \text{d2} + \text{comp_c3} * \text{d3} + \text{base_address}$$

With the optimizer, this reference can be as efficient as a reference to a scalar (nontable) item.

Optimization of duplicate items

In the table element references ELEMENT(V1 V3 V4) and ELEMENT(V2 V3 V4) only the individual terms comp_v3 * d2 and comp_v4 * d3 are common subexpressions in the expressions needed to reference the table elements:

$$\begin{aligned} &\text{comp_v1} * \text{d1} + \text{comp_v3} * \text{d2} + \text{comp_v4} * \text{d3} + \text{base_address} \\ &\text{comp_v2} * \text{d1} + \text{comp_v3} * \text{d2} + \text{comp_v4} * \text{d3} + \text{base_address} \end{aligned}$$

However, for the two table element references ELEMENT(V1 V2 V3) and ELEMENT(V1 V2 V4) the entire subexpression comp_v1 * d1 + comp_v2 * d2 is common between the two expressions needed to reference the table elements:

$$\begin{aligned} &\text{comp_v1} * \text{d1} + \text{comp_v2} * \text{d2} + \text{comp_v3} * \text{d3} + \text{base_address} \\ &\text{comp_v1} * \text{d1} + \text{comp_v2} * \text{d2} + \text{comp_v4} * \text{d3} + \text{base_address} \end{aligned}$$

In the two references ELEMENT(V1 V2 V3) and ELEMENT(V1 V2 V3), the expressions are the same:

$$\begin{aligned} &\text{comp_v1} * \text{d1} + \text{comp_v2} * \text{d2} + \text{comp_v3} * \text{d3} + \text{base_address} \\ &\text{comp_v1} * \text{d1} + \text{comp_v2} * \text{d2} + \text{comp_v3} * \text{d3} + \text{base_address} \end{aligned}$$

With the optimizer, the second (and any subsequent) reference to the same element can be as efficient as a reference to a scalar (nontable) item.

Optimization of variable-length items

A group item that contains a subordinate OCCURS DEPENDING ON data item has a variable length. The program must perform special code every time a variable-length data item is referenced.

Because this code is out-of-line, it might interrupt optimization. Furthermore, the code to manipulate variable-length data items is much less efficient than that for fixed-size data items and can significantly increase processing time. For instance, the code to compare or move a variable-length data item might involve calling a library routine and is much slower than the same code for fixed-length data items.

Comparison of direct and relative indexing

Relative index references are as fast as or faster than direct index references.

The direct indexing in ELEMENT (I5, J3, K2) requires this preprocessing:

```
SET I5 TO I
SET I5 UP BY 5
SET J3 TO J
SET J3 DOWN BY 3
SET K2 TO K
SET K2 UP BY 2
```

This processing makes the direct indexing less efficient than the relative indexing in ELEMENT (I + 5, J - 3, K + 2).

RELATED CONCEPTS
"Optimization"

RELATED TASKS
"Handling tables efficiently" on page 583

Optimizing your code

When your program is ready for final test, specify OPTIMIZE so that the tested code and the production code are identical.

You might also want to use this compiler option during development if a program is used frequently without recompilation. However, the overhead for OPTIMIZE might outweigh its benefits if you recompile frequently, unless you are using the assembler language expansion (LIST compiler option) to fine-tune your program.

For unit-testing your program, you will probably find it easier to debug code that has not been optimized.

To see how the optimizer works on your program, compile it with and without the OPTIMIZE option and compare the generated code. (Use the LIST compiler option to request the assembler language listing of the generated code.)

RELATED CONCEPTS
"Optimization"

RELATED REFERENCES
"LIST" on page 289
"OPTIMIZE" on page 295

Optimization

To improve the efficiency of the generated code, you can use the OPTIMIZE compiler option to cause the COBOL optimizer to do the following:

- Eliminate unnecessary transfers of control and inefficient branches, including those generated by the compiler that are not evident from looking at the source program.
- Simplify the compiled code for both a PERFORM statement and a CALL statement to a contained (nested) program. Where possible, the optimizer places the statements inline, eliminating the need for linkage code. This optimization is known as *procedure integration*. If procedure integration cannot be done, the optimizer uses the simplest linkage possible (perhaps as few as two instructions) to get to and from the called program.
- Eliminate duplicate computations (such as subscript computations and repeated statements) that have no effect on the results of the program.

- Eliminate constant computations by performing them when the program is compiled.
- Eliminate constant conditional expressions.
- Aggregate moves of contiguous items (such as those that often occur with the use of MOVE CORRESPONDING) into a single move. Both the source and target must be contiguous for the moves to be aggregated.
- Delete from the program, and identify with a warning message, code that can never be performed (unreachable code elimination).
- Discard unreferenced data items from the DATA DIVISION, and suppress generation of code to initialize these data items to their VALUE clauses. (The optimizer takes this action only when you use the FULL suboption.)

Contained program procedure integration

In contained program procedure integration, the contained program code replaces a CALL to a contained program. The resulting program runs faster without the overhead of CALL linkage and with more linear control flow.

Program size: If several CALL statements call contained programs and these programs replace each such statement, the containing program can become large. The optimizer limits this increase to no more than 50 percent, after which it no longer integrates the programs. The optimizer then chooses the next best optimization for the CALL statement; the linkage overhead can be as few as two instructions.

Unreachable code: As a result of this integration, one contained program might be repeated several times. As further optimization proceeds on each copy of the program, portions might be found to be unreachable, depending on the context into which the code was copied.

PERFORM procedure integration

PERFORM procedure integration is the process whereby a PERFORM statement is replaced by its performed procedures. The advantage is that the resulting program runs faster without the overhead of PERFORM linkage and with more linear control flow.

Program size: If the performed procedures are invoked by several PERFORM statements and replace each such statement, the program could become large. The optimizer limits this increase to no more than 50 percent, after which it no longer integrates these procedures. If you are concerned about program size, you can prevent procedure integration in specific instances by using a priority number on section names.

If you do not want a PERFORM statement to be replaced by its performed procedures, put the PERFORM statement in one section and put the performed procedures in another section with a different priority number. The optimizer then chooses the next best optimization for the PERFORM statement; the linkage overhead can be as few as two instructions.

Unreachable code: Because of procedure integration, one PERFORM procedure might be repeated several times. As further optimization proceeds on each copy of the procedure, portions might be found to be unreachable, depending on the context into which the code was copied.

“Example: PERFORM procedure integration” on page 588

RELATED CONCEPTS

“Optimization of table references” on page 584

RELATED REFERENCES

“OPTIMIZE” on page 295

Example: PERFORM procedure integration

All the PERFORM statements in the following program will be transformed by procedure integration:

```
1  SECTION 5.  
11. PERFORM 12  
    STOP RUN.  
12. PERFORM 21  
    PERFORM 21.  
2  SECTION 5.  
21. IF A < 5 THEN  
    ADD 1 TO A  
    DISPLAY A  
    END-IF.
```

The program will be compiled as if it had originally been written as follows:

```
1  SECTION 5.  
11.  
12. IF A < 5 THEN  
    ADD 1 TO A  
    DISPLAY A  
    END-IF.  
    IF A < 5 THEN  
        ADD 1 TO A  
        DISPLAY A  
    END-IF.  
    STOP RUN.
```

By contrast, in the following program only the first PERFORM statement, PERFORM 12, will be optimized by procedure integration:

```
1  SECTION.  
11. PERFORM 12  
    STOP RUN.  
12. PERFORM 21  
    PERFORM 21.  
2  SECTION 5.  
21. IF A < 5 THEN  
    ADD 1 TO A  
    DISPLAY A  
    END-IF.
```

RELATED CONCEPTS

“Optimization of table references” on page 584

RELATED TASKS

“Optimizing your code” on page 586

Chapter 34, “Tuning your program,” on page 579

Choosing compiler features to enhance performance

Your choice of performance-related compiler options and your use of the USE FOR DEBUGGING ON ALL PROCEDURES statement can affect how well your program is optimized.

You might have a customized system that requires certain options for optimum performance. Do these steps:

1. To see what your system defaults are, get a short listing for any program and review the listed option settings.
2. Check with your system programmer as to which options are fixed as nonoverridable for your installation.
3. For the options not fixed by installation, select performance-related options for compiling your programs.

Important: Confer with your system programmer on how you should tune your COBOL programs. Doing so will ensure that the options you choose are appropriate for programs being developed at your site.

Another compiler feature to consider besides compiler options is the `USE FOR DEBUGGING ON ALL PROCEDURES` statement. It can greatly affect the compiler optimizer. The `ON ALL PROCEDURES` option generates extra code at each transfer to a procedure name. Although very useful for debugging, it can make the program significantly larger and inhibit optimization substantially.

Although COBOL allows segmentation language, you will not improve storage allocation by using it, because COBOL does not perform overlay.

RELATED CONCEPTS

“Optimization” on page 586

RELATED TASKS

“Optimizing your code” on page 586

“Getting listings” on page 331

RELATED REFERENCES

“Performance-related compiler options”

Performance-related compiler options

In the table below you can see a brief description of the purpose of each option, its performance advantages and disadvantages, and usage notes where applicable.

Table 84. Performance-related compiler options

Compiler option	Purpose	Performance advantages	Performance disadvantages	Usage notes
“AWO” on page 272	To get optimum use of buffer and device space	Can result in performance savings, because this option results in fewer calls to data management services to handle input and output	In general, none	When you use AWO, the <code>APPLY WRITE-ONLY</code> clause is in effect for all files in the program that are physical sequential with V-mode records.
DATA(31) (see “DATA” on page 277)	To have DFSMS allocate QSAM buffers above the 16-MB line (by using the <code>RENT</code> and <code>DATA(31)</code> compiler options)	Because extended-format QSAM data sets can require many buffers, allocating the buffers in unrestricted storage avoids virtual storage constraint problems.	In general, none	On a z/OS system with DFSMS, if your application processes striped extended-format QSAM data sets, use the <code>RENT</code> and <code>DATA(31)</code> compiler options to have the input-output buffers for your QSAM files allocated from storage above the 16-MB line.

Table 84. Performance-related compiler options (continued)

Compiler option	Purpose	Performance advantages	Performance disadvantages	Usage notes
"DYNAM" on page 282	To have subprograms (called through the CALL statement) dynamically loaded at run time	Subprograms are easier to maintain, because the application does not have to be link-edited again if a subprogram is changed.	There is a slight performance penalty because the call must go through a Language Environment routine.	To free virtual storage that is no longer needed, issue the CANCEL statement.
"FASTSRT" on page 284	To specify that the IBM DFSORT product (or equivalent) will handle all of the input and output	Eliminates the overhead of returning to Enterprise COBOL after each record is processed	None	FASTSRT is recommended when direct work files are used for the sort work files. Not all sorts are eligible for this option.
NUMPROC(PFD) (see "NUMPROC" on page 293)	To have invalid sign processing bypassed for numeric operations	Generates significantly more efficient code for numeric comparisons	For most references to COMP-3 and DISPLAY numeric data items, NUMPROC(PFD) inhibits extra code from being generated to "fix up" signs. This extra code might also inhibit some other types of optimizations. The extra code is generated with NUMPROC(MIG) and NUMPROC(NOPFD).	When you use NUMPROC(PFD), the compiler assumes that the data has the correct sign and bypasses the sign "fix up" process. Because not all external data files contain the proper sign for COMP-3 or DISPLAY signed numeric data, NUMPROC(PFD) might not be applicable for all programs. For performance-sensitive applications, NUMPROC(PFD) is recommended.
OPTIMIZE(STD) (see "OPTIMIZE" on page 295)	To optimize generated code for better performance	Generally results in more efficient run-time code	Longer compile time: OPTIMIZE requires more processing time for compiles than NOOPTIMIZE.	NOOPTIMIZE is generally used during program development when frequent compiles are needed; it also allows for easier debugging. For production runs, OPTIMIZE is recommended.
OPTIMIZE(FULL) (see "OPTIMIZE" on page 295)	To optimize generated code for better performance and also optimize the DATA DIVISION	Generally results in more efficient run-time code and less storage usage	Longer compile time: OPTIMIZE requires more processing time for compiles than NOOPTIMIZE.	OPT(FULL) deletes unused data items, which might be undesirable in the case of time stamps or data items that are used only as markers for dump reading.
"RENT" on page 299	To generate a reentrant program	Enables the program to be placed in shared storage (LPA/ELPA) for faster execution	Generates additional code to ensure that the program is reentrant	
RMODE(ANY) (see "RMODE" on page 300)	To let the program be loaded anywhere	RMODE(ANY) with NORENT lets the program and its WORKING-STORAGE be located above the 16-MB line, relieving storage below the line.	In general, none	

Table 84. Performance-related compiler options (continued)

Compiler option	Purpose	Performance advantages	Performance disadvantages	Usage notes
NOSSRANGE (see “SSRANGE” on page 304)	To verify that all table references and reference modification expressions are in proper bounds	SSRANGE generates additional code for verifying table references. Using NOSSRANGE causes that code not to be generated.	None	In general, if you need to verify the table references only a few times instead of at every reference, coding your own checks might be faster than using SSRANGE. You can turn off SSRANGE at run time with the CHECK(OFF) run-time option. For performance-sensitive applications, NOSSRANGE is recommended.
TEST(NONE) or NOTEST (see “TEST” on page 306)	To avoid the additional object code that would be produced to take full advantage of Debug Tool, use TEST(NONE) or NOTEST. Additionally, when using TEST(NONE), you can use the SEPARATE suboption of TEST option to further reduce the size of your object code.	Because the TEST compiler option with any hook-location suboption other than NONE (that is, ALL, STMT, PATH, BLOCK) generates additional code, it can cause significant performance degradation when used in a production environment. The more compiled-in hooks you specify, the more additional code is generated and the greater performance degradation might be.	None	TEST without the hook-location suboption NONE in effect forces the NOOPTIMIZE compiler option into effect. For production runs, using NOTEST or TEST(NONE,SYM) with or without the SEPARATE suboption, is recommended. This results in overlay hooks rather than compiled-in hooks. If during the production run, you want a symbolic dump of the data items in a formatted dump when the program abends, compile with TEST(NONE,SYM) with or without the SEPARATE suboption.
TRUNC(OPT) (see “TRUNC” on page 310)	To avoid having code generated to truncate the receiving fields of arithmetic operations	Does not generate extra code and generally improves performance	Both TRUNC(BIN) and TRUNC(STD) generate extra code whenever a BINARY data item is changed. TRUNC(BIN) is usually the slowest of these options, though its performance was improved in COBOL for OS/390 & VM V2 R2.	TRUNC(STD) conforms to the COBOL 85 Standard, but TRUNC(BIN) and TRUNC(OPT) do not. With TRUNC(OPT), the compiler assumes that the data conforms to the PICTURE and USAGE specifications. TRUNC(OPT) is recommended where possible.

RELATED CONCEPTS

“Optimization” on page 586

“Storage and its addressability” on page 34

RELATED TASKS

“Generating a list of compiler error messages” on page 246

“Evaluating performance” on page 592

“Optimizing buffer and device space” on page 12

“Choosing compiler features to enhance performance” on page 588

“Improving sort performance with FASTSRT” on page 193
 “Using striped extended-format QSAM data sets” on page 139
 “Handling tables efficiently” on page 583

RELATED REFERENCES

“Sign representation and processing” on page 45
 “Allocation of buffers for QSAM files” on page 140

Evaluating performance

Fill in this worksheet to help you evaluate the performance of your program. If you answer yes to each question, you are probably improving the performance.

In thinking about the performance tradeoff, be sure you understand the function of each option as well as the performance advantages and disadvantages. You might prefer function over increased performance in many instances.

Table 85. Performance-tuning worksheet

Compiler option	Consideration	Yes?
AWO	Do you use the AWO option when possible?	
DATA	When you use QSAM striped data sets, do you use the DATA(31) option?	
DYNAM	Do you use NODYNAM? Consider the performance tradeoffs.	
FASTSRT	When you use direct work files for the sort work files, have you selected the FASTSRT option?	
NUMPROC	Do you use NUMPROC(PFD) when possible?	
OPTIMIZE	Do you use OPTIMIZE for production runs? Can you use OPTIMIZE(FULL)?	
RENT	Do you use NORENT? Consider the performance tradeoffs.	
RMODE(ANY)	Do you use RMODE(ANY) with your NORENT programs? Consider the performance tradeoffs with storage usage.	
SSRANGE	Do you use NOSSRANGE for production runs?	
TEST	Do you use NOTEST, TEST(NONE,SYM), or TEST(NONE,SYM,SEPARATE) for production runs?	
TRUNC	Do you use TRUNC(OPT) when possible?	

RELATED TASKS

“Choosing compiler features to enhance performance” on page 588

RELATED REFERENCES

“Performance-related compiler options” on page 589

Running efficiently with CICS, IMS, or VSAM

You can improve performance for online programs running under CICS or IMS, or programs that use VSAM, by following these tips:

CICS

If your application runs under CICS, convert EXEC CICS LINK commands to COBOL CALL statements to improve transaction response time.

IMS

If your application is running under IMS, preloading the application program and the library routines can help to reduce the overhead of load and search. It can also reduce the input-output activity.

For better system performance, use the RENT compiler option and preload the applications and library routines when possible.

You can also use the Language Environment library routine retention (LRR) function to improve performance in IMS/TM regions.

VSAM

When you use VSAM files, increase the number of data buffers for sequential access or index buffers for random access. Also, select a control interval size (CISZ) appropriate for the application. Smaller CISZ results in faster retrieval for the random processing at the expense of inserts, and a larger CISZ is more efficient for sequential processing.

For better performance, access the records sequentially and avoid using multiple alternate indexes when possible. If you do use alternate indexes, access method services builds them more efficiently than the AIXBLD run-time option.

RELATED TASKS

“Coding COBOL programs to run under CICS” on page 359

Chapter 22, “Developing COBOL programs for IMS,” on page 377

“Improving VSAM performance” on page 171

Language Environment Customization

RELATED REFERENCES

Specifying run-time options (*Language Environment Programming Guide*)

Chapter 35. Simplifying coding

This material provides techniques for improving your productivity. By using the COPY statement, COBOL intrinsic functions, and Language Environment callable services, you can avoid repetitive coding and having to code many arithmetic calculations or other complex tasks.

If your program contains frequently used code sequences (such as blocks of common data items, input-output routines, error routines, or even entire COBOL programs), write the code sequences once and put them into a COBOL copy library. Then you can use the COPY statement to retrieve these code sequences from the library and have them included in your program at compile time. This eliminates repetitive coding.

COBOL provides various capabilities for manipulating strings and numbers. These capabilities can help you simplify your coding.

The Language Environment date and time callable services store dates as fullword binary integers and timestamps as long (64-bit) floating-point values. These formats let you do arithmetic calculations on date and time values simply and efficiently. You do not need to write special subroutines that use services outside the language library for your application in order to perform these calculations.

RELATED CONCEPTS

“Numeric intrinsic functions” on page 48

“Math and date Language Environment services” on page 49

RELATED TASKS

“Eliminating repetitive coding”

“Converting data items (intrinsic functions)” on page 97

“Evaluating data items (intrinsic functions)” on page 99

“Using Language Environment callable services” on page 597

Eliminating repetitive coding

Use the COPY statement to include stored source statements in any part of your program. You can code them in any program division and at every code sequence level. You can nest COPY statements to any depth.

To specify more than one copy library, use either multiple system definitions or a combination of multiple definitions and the IN/OF phrase (IN/OF *library-name*):

z/OS batch

Use JCL to concatenate data sets on your SYSLIB DD statement.

Alternatively, define multiple DD statements and use the IN/OF phrase of the COPY statement.

TSO Use the ALLOCATE command to concatenate data sets for SYSLIB.

Alternatively, issue multiple ALLOCATE statements and use the IN/OF phrase of the COPY statement.

UNIX Use the SYSLIB environment variable to define multiple paths to your copybooks. Alternatively, use multiple environment variables and use the IN/OF phrase of the COPY statement.

For example:

```
COPY MEMBER1 OF COPYLIB
```

If you omit this qualifying phrase, the default is SYSLIB.

COPY and debugging line: In order for the text copied to be treated as debug lines, for example, as if there were a D inserted in column 7, put the D on the first line of the COPY statement. A COPY statement itself cannot be a debugging line; if it contains a D and WITH DEBUGGING mode is not specified, the COPY statement is nevertheless processed.

“Example: using the COPY statement”

RELATED REFERENCES

Chapter 18, “Compiler-directing statements,” on page 317

Example: using the COPY statement

Suppose the library entry CFILEA consists of the following FD entries:

```
      BLOCK CONTAINS 20 RECORDS
      RECORD CONTAINS 120 CHARACTERS
      LABEL RECORDS ARE STANDARD
      DATA RECORD IS FILE-OUT.
01  FILE-OUT          PIC X(120).
```

You can retrieve the text-name CFILEA by using the COPY statement in a source program:

```
FD FILEA
      COPY CFILEA.
```

The library entry is copied into your program, and the resulting program listing looks like this:

```
FD FILEA
      COPY CFILEA.
C  BLOCK CONTAINS 20 RECORDS
C  RECORD CONTAINS 120 CHARACTERS
C  LABEL RECORDS ARE STANDARD
C  DATA RECORD IS FILE-OUT.
C  01  FILE-OUT          PIC X(120).
```

In the compiler source listing, the COPY statement prints on a separate line. C precedes copied lines.

Assume that a copybook with the text-name DOWORK is stored by using the following statements:

```
      COMPUTE QTY-ON-HAND = TOTAL-USED-NUMBER-ON-HAND
      MOVE QTY-ON-HAND to PRINT-AREA
```

To retrieve the copybook identified as DOWORK, code:

```
paragraph-name.
      COPY DOWORK.
```

The statements included in the DOWORK procedure will follow *paragraph-name*.

If you use the EXIT compiler option to provide a LIBEXIT module, your results might differ from those shown here.

RELATED TASKS

“Eliminating repetitive coding” on page 595

RELATED REFERENCES

Chapter 18, “Compiler-directing statements,” on page 317

Using Language Environment callable services

Language Environment callable services make many types of programming tasks easier. Called with standard COBOL CALL statements, Language Environment services help you with the following tasks:

- Handling conditions

The Language Environment condition-handling facilities allow COBOL applications to react to unexpected errors. You can use language constructs or run-time options to select the level at which you want to handle each condition. For example, you can decide to handle a particular error in your COBOL program, let Language Environment take care of it, or have the operating system handle it.

In support of Language Environment condition handling, COBOL provides procedure-pointer data items.

- Managing dynamic storage

These services enable you to get, free, and reallocate storage. In addition, you can create your own storage pools.

- Calculating dates and times

With the date and time services, you can get the current local time and date in several formats, and perform date and time conversions. Two callable services, CEEQCEN and CEESCEN, provide a predictable way to handle two-digit years, such as 91 for 1991 or 03 for 2003.

- Making math calculations

Calculations that are easy to perform with mathematical callable services include logarithmic, exponential, trigonometric, square root, and integer functions.

COBOL also supports a set of intrinsic functions that include some of the same mathematical and date functions as those provided by the callable services. The Language Environment callable services and intrinsic functions provide equivalent results, with few exceptions. You should be familiar with these differences before deciding which to use.

- Handling messages

Message-handling services include getting, dispatching, and formatting messages. Messages for non-CICS applications can be directed to files or printers; CICS messages are directed to a CICS transient data queue. Language Environment splits messages to accommodate the record length of the destination, and presents messages in the correct national language such as Japanese or English.

- Supporting national languages

These services make it easy for your applications to support the language desired by application users. You can set the language and country, and obtain default date, time, number, and currency formats. For example, you might want dates to appear as 23 June 03 or as 6,23,03.

- General services such as starting Debug Tool and obtaining a Language Environment formatted dump

Debug Tool provides advanced debugging functions for COBOL applications, including both batch and interactive debugging of COBOL-CICS programs.

Debug Tool enables you to debug a COBOL application from the host or, in conjunction with the Debug Perspective of WebSphere Studio Enterprise Developer, from the Windows workstation.

Depending on the options that you select, the Language Environment formatted dump might contain the names and values of data items, and information about conditions, program tracebacks, control blocks, storage, and files. All Language Environment dumps have a common, well-labeled, and easy-to-read format.

“Example: Language Environment callable services” on page 600

RELATED CONCEPTS

“Sample list of Language Environment callable services”

“Numeric intrinsic functions” on page 48

“Math and date Language Environment services” on page 49

RELATED TASKS

“Calling Language Environment services” on page 599

“Using procedure and function pointers” on page 407

Sample list of Language Environment callable services

The following table gives some examples of the callable services available with Language Environment. Many more services are available than those listed.

Table 86. Language Environment callable services

Function type	Service	Purpose
Condition handling	CEEHDLR	To register a user condition handler
	CEESGL	To raise or signal a condition
	CEEMRCR	To indicate where the program will resume running after the condition handler has completed
Dynamic storage	CEEGTST	To get storage
	CEECZST	To change the size of a previously allocated storage block
	CEEFRST	To free storage
Date and time	CEECBLDY	To convert a string that represents a date into COBOL integer date format, which represents a date as the number of days since 31 December 1600
	CEEQCEN, CEESCEN	To query and set the Language Environment century window, which is valuable when a program uses two digits to express a year
	CEEGMTO	To calculate the difference between the local system time and Greenwich Mean Time
	CEELOCT	To get the current local time in your choice of three formats
Math	CEESIABS	To calculate the absolute value of an integer
	CEESSNWN	To calculate the nearest whole number for a single-precision floating-point number
	CEESSCOS	To calculate the cosine of an angle
Message handling	CEEMOUT	To dispatch a message
	CEEMGET	To retrieve a message

Table 86. Language Environment callable services (continued)

Function type	Service	Purpose
National language support	CEE3LNG	To change or query the current national language
	CEE3CTY	To change or query the current national country
	CEE3MCS	To obtain the default currency symbol for a given country
General	CEE3DMP	To obtain a Language Environment formatted dump
	CEETEST	To start a debugging tool, such as Debug Tool

RELATED REFERENCES

Language Environment Programming Reference

Calling Language Environment services

To invoke a Language Environment service, use a CALL statement with the correct parameters for that particular service:

CALL "CEESSSQT" using argument, feedback-code, result

Define the variables for the CALL statement in the DATA DIVISION with the definitions required by the function you are calling:

```

77 argument      comp-1.
77 feedback-code pic x(12) display.
77 result        comp-1.

```

In this example, Language Environment service CEESSSQT calculates the value of the square root of the variable argument and returns this value in the variable result.

You can choose whether you want to specify the feedback code parameter. If you specify the feedback code, the value returned in feedback-code indicates whether the service completed successfully. If you specify OMITTED instead of the feedback code and the service is not successful, a Language Environment condition is automatically signaled to the Language Environment condition manager. You can handle such a condition by recovery logic implemented in a user-written condition handler, or allow the default Language Environment processing for unhandled conditions to occur. In any case, this avoids the requirement to write logic to check the feedback code explicitly after each call.

When you call a Language Environment callable service and specify OMITTED for the feedback code, the RETURN-CODE special register is set to 0 if the service is successful. It is not altered if the service is unsuccessful. If you do not specify OMITTED for the feedback code, the RETURN-CODE special register is always set to 0 regardless of whether the service completed successfully.

"Example: Language Environment callable services" on page 600

RELATED CONCEPTS

General callable services (*Language Environment Programming Guide*)

RELATED REFERENCES

General callable services (*Language Environment Programming Reference*)

CALL statement (*Enterprise COBOL Language Reference*)

Example: Language Environment callable services

Many callable services offer you entirely new function that would require extensive coding using previous versions of COBOL. This example shows a sample COBOL program that uses Language Environment services CEEDAYS and CEEDATE to format and display a date from the results of a COBOL ACCEPT statement. Using CEEDAYS and CEEDATE reduces the code that would be required without Language Environment.

```
ID DIVISION.
PROGRAM-ID. HOHOHO.
*****
* FUNCTION:  DISPLAY TODAY'S DATE IN THE FOLLOWING FORMAT: *
*           WWWWWWWW, MMMMMMM DD, YYYY                    *
*                                                     *
*           For example: TUESDAY, AUGUST 12, 2003          *
*                                                     *
*****
ENVIRONMENT DIVISION.
DATA DIVISION.
WORKING-STORAGE SECTION.
01  CHRDATE.
    05 CHRDATE-LENGTH      PIC S9(4) COMP VALUE 10.
    05 CHRDATE-STRING      PIC X(10).
01  PICSTR.
    05 PICSTR-LENGTH       PIC S9(4) COMP.
    05 PICSTR-STRING       PIC X(80).
*
77  LILIAN PIC              S9(9) COMP.
77  FORMATTED-DATE         PIC X(80).
*
PROCEDURE DIVISION.
*****
*   USE LE DATE/TIME CALLABLE SERVICES TO PRINT OUT      *
*   TODAY'S DATE FROM COBOL ACCEPT STATEMENT.            *
*****
ACCEPT CHRDATE-STRING FROM DATE.
*
MOVE "YYMMDD" TO PICSTR-STRING.
MOVE 6 TO PICSTR-LENGTH.
CALL "CEEDAYS" USING CHRDATE , PICSTR , LILIAN , OMITTED.
*
MOVE " WWWWWWWWZ, MMMMMMMMZ DD, YYYY " TO PICSTR-STRING.
MOVE 50 TO PICSTR-LENGTH.
CALL "CEEDATE" USING LILIAN , PICSTR , FORMATTED-DATE ,
    OMITTED.
*
DISPLAY "*****".
DISPLAY FORMATTED-DATE.
DISPLAY "*****".
*
STOP RUN.
```

Part 9. Appendixes

Appendix A. Intermediate results and arithmetic precision

The compiler handles arithmetic statements as a succession of operations performed according to operator precedence, and sets up intermediate fields to contain the results of those operations. The compiler uses algorithms to determine the number of integer and decimal places reserved.

Intermediate results are possible in the following cases:

- In an ADD or SUBTRACT statement that contains more than one operand immediately following the verb
- In a COMPUTE statement that specifies a series of arithmetic operations, or multiple result fields
- In an arithmetic expression contained in a conditional statement or in a reference-modification specification
- In an ADD, SUBTRACT, MULTIPLY, or DIVIDE statement that uses the GIVING option and multiple result fields
- In a statement that uses an intrinsic function as an operand

“Example: calculation of intermediate results” on page 605

The precision of intermediate results depends on whether you compile using the default option ARITH(COMPAT) (referred to as *compatibility mode*) or using ARITH(EXTEND) (referred to as *extended mode*), as explained below.

In compatibility mode, evaluation of arithmetic operations is unchanged from that in releases of IBM COBOL before COBOL for OS/390 & VM Version 2 Release 2:

- A maximum of 30 digits is used for fixed-point intermediate results.
- Floating-point intrinsic functions return long-precision (64-bit) floating-point results.
- Expressions that contain floating-point operands, fractional exponents, or floating-point intrinsic functions are evaluated as if all operands that are not in floating point are converted to long-precision floating point and floating-point operations are used to evaluate the expression.
- Floating-point literals and external floating-point data items are converted to long-precision floating point for processing.

In extended mode, evaluation of arithmetic operations has the following characteristics:

- A maximum of 31 digits is used for fixed-point intermediate results.
- Floating-point intrinsic functions return extended-precision (128-bit) floating-point results.
- Expressions that contain floating-point operands, fractional exponents, or floating-point intrinsic functions are evaluated as if all operands that are not in floating point are converted to extended-precision floating point and floating-point operations are used to evaluate the expression.
- Floating-point literals and external floating-point data items are converted to extended-precision floating point for processing.

RELATED CONCEPTS

"Formats for numeric data" on page 40

"Fixed-point versus floating-point arithmetic" on page 53

RELATED REFERENCES

"Fixed-point data and intermediate results" on page 605

"Floating-point data and intermediate results" on page 610

"Arithmetic expressions in nonarithmetic statements" on page 611

"ARITH" on page 271

Terminology used for intermediate results

In the discussion of the number of integer and decimal places that the compiler reserves for intermediate results, the following terms are used:

i The number of integer places carried for an intermediate result. (If you use the **ROUNDED** phrase, one more integer place might be carried for accuracy if necessary.)

d The number of decimal places carried for an intermediate result. (If you use the **ROUNDED** phrase, one more decimal place might be carried for accuracy if necessary.)

dmax In a particular statement, the largest of the following:

- The number of decimal places needed for the final result field or fields
- The maximum number of decimal places defined for any operand, except divisors or exponents
- The *outer-dmax* for any function operand

inner-dmax

In a reference to a function, the largest of the following:

- The number of decimal places defined for any of its elementary arguments
- The *dmax* for any of its arithmetic expression arguments
- The *outer-dmax* for any of its embedded functions

outer-dmax

The number of decimal places that a function result contributes to operations outside of its own evaluation (for example, if the function is an operand in an arithmetic expression, or an argument to another function).

op1 The first operand in a generated arithmetic statement (in division, the divisor).

op2 The second operand in a generated arithmetic statement (in division, the dividend).

i1, i2 The number of integer places in *op1* and *op2*, respectively.

d1, d2 The number of decimal places in *op1* and *op2*, respectively.

ir The intermediate result when a generated arithmetic statement or operation is performed. (Intermediate results are generated either in registers or storage locations.)

ir1, ir2 Successive intermediate results. (Successive intermediate results might have the same storage location.)

RELATED REFERENCES

ROUNDED phrase (*Enterprise COBOL Language Reference*)

Example: calculation of intermediate results

The following example shows how the compiler performs an arithmetic statement as a succession of operations, storing intermediate results as needed.

COMPUTE $Y = A + B * C - D / E + F ** G$

The result is calculated in the following order:

- | | | |
|------------------------|-----------------|-----------------------|
| 1. Exponentiate F | by G | yielding <i>ir1</i> . |
| 2. Multiply B | by C | yielding <i>ir2</i> . |
| 3. Divide E | into D | yielding <i>ir3</i> . |
| 4. Add A | to <i>ir2</i> | yielding <i>ir4</i> . |
| 5. Subtract <i>ir3</i> | from <i>ir4</i> | yielding <i>ir5</i> . |
| 6. Add <i>ir5</i> | to <i>ir1</i> | yielding Y. |

RELATED CONCEPTS

“Arithmetic expressions” on page 48

RELATED REFERENCES

“Terminology used for intermediate results” on page 604

Fixed-point data and intermediate results

The compiler determines the number of integer and decimal places in an intermediate result as discussed in the following sections.

Addition, subtraction, multiplication, and division

The following table shows the precision theoretically possible as the result of addition, subtraction, multiplication, or division.

Operation	Integer places	Decimal places
+ or -	$(i1 \text{ or } i2) + 1$, whichever is greater	$d1$ or $d2$, whichever is greater
*	$i1 + i2$	$d1 + d2$
/	$i2 + d1$	$(d2 - d1)$ or $dmax$, whichever is greater

You must define the operands of any arithmetic statements with enough decimal places to obtain the accuracy you want in the final result.

The following table shows the number of places the compiler carries for fixed-point intermediate results of arithmetic operations involving addition, subtraction, multiplication, or division in *compatibility mode* (that is, when you compile using the default compiler option ARITH(COMPAT)):

Value of $i + d$	Value of d	Value of $i + dmax$	Number of places carried for ir
<30 =30	Any value	Any value	i integer and d decimal places

Value of $i + d$	Value of d	Value of $i + d_{max}$	Number of places carried for ir
>30	< d_{max} = d_{max}	Any value	30- d integer and d decimal places
	> d_{max}	<30 =30	i integer and 30- i decimal places
		>30	30- d_{max} integer and d_{max} decimal places

The following table shows the number of places the compiler carries for fixed-point intermediate results of arithmetic operations involving addition, subtraction, multiplication, or division in *extended mode* (that is, when you compile using option ARITH(EXTEND)):

Value of $i + d$	Value of d	Value of $i + d_{max}$	Number of places carried for ir
<31 =31	Any value	Any value	i integer and d decimal places
>31	< d_{max} = d_{max}	Any value	31- d integer and d decimal places
	> d_{max}	<31 =31	i integer and 31- i decimal places
		>31	31- d_{max} integer and d_{max} decimal places

Exponentiation

Exponentiation is represented by the expression $op1 ** op2$. Based on the characteristics of $op2$, the compiler handles exponentiation of fixed-point numbers in one of three ways:

- When $op2$ is expressed with decimals, floating-point instructions are used.
- When $op2$ is an integral literal or constant, the value d is computed as

$$d = d1 * |op2|$$
and the value i is computed based on the characteristics of $op1$:
 - When $op1$ is a data-name or variable,

$$i = i1 * |op2|$$
 - When $op1$ is a literal or constant, i is set equal to the number of integers in the value of $op1 ** |op2|$.

In compatibility mode (compilation using ARITH(COMPAT)), the compiler having calculated i and d takes the action indicated in the table below to handle the intermediate results ir of the exponentiation.

Value of $i + d$	Other conditions	Action taken
<30	Any	i integer and d decimal places are carried for ir .
=30	$op1$ has an odd number of digits.	i integer and d decimal places are carried for ir .
	$op1$ has an even number of digits.	Same action as when $op2$ is an integral data-name or variable (shown below). Exception: for a 30-digit integer raised to the power of literal 1, i integer and d decimal places are carried for ir .

Value of $i + d$	Other conditions	Action taken
>30	Any	Same action as when $op2$ is an integral data name or variable (shown below)

In extended mode (compilation using ARITH(EXTEND)), the compiler having calculated i and d takes the action indicated in the table below to handle the intermediate results ir of the exponentiation.

Value of $i + d$	Other conditions	Action taken
<31	Any	i integer and d decimal places are carried for ir .
=31 >31	Any	Same action as when $op2$ is an integral data-name or variable (shown below). Exception: for a 31-digit integer raised to the power of literal 1, i integer and d decimal places are carried for ir .

If $op2$ is negative, the value of 1 is then divided by the result produced by the preliminary computation. The values of i and d that are used are calculated following the division rules for fixed-point data already shown above.

- When $op2$ is an integral data-name or variable, $dmax$ decimal places and $30-dmax$ (compatibility mode) or $31-dmax$ (extended mode) integer places are used. $op1$ is multiplied by itself ($|op2| - 1$) times for nonzero $op2$.

If $op2$ is equal to 0, the result is 1. Division-by-0 and exponentiation SIZE ERROR conditions apply.

Fixed-point exponents with more than nine significant digits are always truncated to nine digits. If the exponent is a literal or constant, an E-level compiler diagnostic message is issued; otherwise, an informational message is issued at run time.

“Example: exponentiation in fixed-point arithmetic”

RELATED REFERENCES

“Terminology used for intermediate results” on page 604

“Truncated intermediate results” on page 608

“Binary data and intermediate results” on page 608

“Floating-point data and intermediate results” on page 610

“Intrinsic functions evaluated in fixed-point arithmetic” on page 608

“ARITH” on page 271

SIZE ERROR phrases (*Enterprise COBOL Language Reference*)

Example: exponentiation in fixed-point arithmetic

The following example shows how the compiler performs an exponentiation to a nonzero integer power as a succession of multiplications, storing intermediate results as needed.

```
COMPUTE Y = A ** B
```

If B is equal to 4, the result is computed as shown below. The values of i and d that are used are calculated following the multiplication rules for fixed-point data and intermediate results (referred to below).

1. Multiply A by A yielding $ir1$.
2. Multiply $ir1$ by A yielding $ir2$.
3. Multiply $ir2$ by A yielding $ir3$.
4. Move $ir3$ to $ir4$.

ir4 has *dmax* decimal places.

Because *B* is positive, *ir4* is moved to *Y*. If *B* were equal to -4, however, an additional step would be performed:

5. Divide *ir4* into 1 yielding *ir5*.

ir5 has *dmax* decimal places, and would then be moved to *Y*.

RELATED REFERENCES

“Terminology used for intermediate results” on page 604

“Fixed-point data and intermediate results” on page 605

Truncated intermediate results

Whenever the number of digits in an intermediate result exceeds 30 in compatibility mode or 31 in extended mode, the compiler truncates to 30 (compatibility mode) or 31 (extended mode) digits as shown in the tables referred to below, and issues a warning. If truncation occurs at run time, a message is issued and the program continues running.

If you want to avoid the truncation of intermediate results that can occur in fixed-point calculations, use floating-point operands (COMP-1 or COMP-2) instead.

RELATED CONCEPTS

“Formats for numeric data” on page 40

RELATED REFERENCES

“Fixed-point data and intermediate results” on page 605

“ARITH” on page 271

Binary data and intermediate results

If an operation that involves binary operands requires intermediate results longer than 18 digits, the compiler converts the operands to internal decimal before performing the operation. If the result field is binary, the compiler converts the result of the operation from internal decimal to binary.

You use binary operands most efficiently when the intermediate results will not exceed nine digits.

RELATED REFERENCES

“Fixed-point data and intermediate results” on page 605

“ARITH” on page 271

Intrinsic functions evaluated in fixed-point arithmetic

The compiler determines the *inner-dmax* and *outer-dmax* values for an intrinsic function from the characteristics of the function.

Integer functions

Integer intrinsic functions return an integer; thus their *outer-dmax* is always zero. For those integer functions whose arguments must all be integers, the *inner-dmax* is thus also always zero.

The following table summarizes the *inner-dmax* and the precision of the function result.

Function	<i>Inner-dmax</i>	Digit precision of function result
DATE-OF-INTEGER	0	8
DATE-TO-YYYYMMDD	0	8
DAY-OF-INTEGER	0	7
DAY-TO-YYYYDDD	0	7
FACTORIAL	0	30 in compatibility mode, 31 in extended mode
INTEGER-OF-DATE	0	7
INTEGER-OF-DAY	0	7
LENGTH	n/a	9
MOD	0	$\min(i1\ i2)$
ORD	n/a	3
ORD-MAX		9
ORD-MIN		9
YEAR-TO-YYYY	0	4
INTEGER		For a fixed-point argument: one more digit than in the argument. For a floating-point argument: 30 in compatibility mode, 31 in extended mode.
INTEGER-PART		For a fixed-point argument: same number of digits as in the argument. For a floating-point argument: 30 in compatibility mode, 31 in extended mode.

Mixed functions

A *mixed* intrinsic function is a function whose result type depends on the type of its arguments. A mixed function is fixed point if all of its arguments are numeric and none of its arguments is floating point. (If any argument of a mixed function is floating point, the function is evaluated with floating-point instructions and returns a floating-point result.) When a mixed function is evaluated with fixed-point arithmetic, the result is integer if all of the arguments are integer; otherwise, the result is fixed point.

For the mixed functions MAX, MIN, RANGE, REM, and SUM, the *outer-dmax* is always equal to the *inner-dmax* (and both are thus zero if all the arguments are integer). To determine the precision of the result returned for these functions, apply the rules for fixed-point arithmetic and intermediate results (as referred to below) to each step in the algorithm.

MAX

1. Assign the first argument to the function result.
2. For each remaining argument, do the following:
 - a. Compare the algebraic value of the function result with the argument.
 - b. Assign the greater of the two to the function result.

MIN

1. Assign the first argument to the function result.
2. For each remaining argument, do the following:

- a. Compare the algebraic value of the function result with the argument.
- b. Assign the lesser of the two to the function result.

RANGE

1. Use the steps for MAX to select the maximum argument.
2. Use the steps for MIN to select the minimum argument.
3. Subtract the minimum argument from the maximum.
4. Assign the difference to the function result.

REM

1. Divide argument one by argument two.
2. Remove all noninteger digits from the result of step 1.
3. Multiply the result of step 2 by argument two.
4. Subtract the result of step 3 from argument one.
5. Assign the difference to the function result.

SUM

1. Assign the value 0 to the function result.
2. For each argument, do the following:
 - a. Add the argument to the function result.
 - b. Assign the sum to the function result.

RELATED REFERENCES

“Terminology used for intermediate results” on page 604
 “Fixed-point data and intermediate results” on page 605
 “Floating-point data and intermediate results”
 “ARITH” on page 271

Floating-point data and intermediate results

Floating-point instructions are used to compute an arithmetic expression if any of the following conditions is true of the expression:

- A receiver or operand is COMP-1, COMP-2, external floating point, or a floating-point literal.
- An exponent contains decimal places.
- An exponent is an expression that contains an exponentiation or division operator, and d_{max} is greater than zero.
- An intrinsic function is a floating-point function.

If any operation in an arithmetic expression is computed in floating-point arithmetic, the entire expression is computed as if all operands were converted to floating point and the operations were performed using floating-point instructions.

In compatibility mode, if an expression is computed in floating-point arithmetic, the precision used to evaluate the arithmetic operations is determined as follows:

- Single precision is used if all receivers and operands are COMP-1 data items and the expression contains no multiplication or exponentiation operations.
- In all other cases, long precision is used.

Whenever long-precision floating point is used for one operation in an arithmetic expression, all operations in the expression are computed as if long floating-point instructions were used.

In extended mode, if an expression is computed in floating-point arithmetic, the precision used to evaluate the arithmetic operations is determined as follows:

- Single precision is used if all receivers and operands are COMP-1 data items and the expression contains no multiplication or exponentiation operations.
- Long precision is used if all receivers and operands are COMP-1 or COMP-2 data items, at least one receiver or operand is a COMP-2 data item, and the expression contains no multiplication or exponentiation operations.
- In all other cases, extended precision is used.

Whenever extended-precision floating point is used for one operation in an arithmetic expression, all operations in the expression are computed as if extended-precision floating-point instructions were used.

Alert: If a floating-point operation has an intermediate result field in which exponent overflow occurs, the job is abnormally terminated.

Exponentiations evaluated in floating-point arithmetic

In compatibility mode, floating-point exponentiations are always evaluated using long floating-point arithmetic. In extended mode, floating-point exponentiations are always evaluated using extended-precision floating-point arithmetic.

The value of a negative number raised to a fractional power is undefined in COBOL. For example, $(-2) ** 3$ is equal to -8, but $(-2) ** (3.000001)$ is undefined. When an exponentiation is evaluated in floating point and there is a possibility that the result is undefined, the exponent is evaluated at run time to determine if it has an integral value. If not, a diagnostic message is issued.

Intrinsic functions evaluated in floating-point arithmetic

In compatibility mode, floating-point intrinsic functions always return a long (64-bit) floating-point value. In extended mode, floating-point intrinsic functions always return an extended-precision (128-bit) floating-point value.

Mixed functions with at least one floating-point argument are evaluated using floating-point arithmetic.

RELATED REFERENCES

“Terminology used for intermediate results” on page 604

“ARITH” on page 271

Arithmetic expressions in nonarithmetic statements

Arithmetic expressions can appear in contexts other than arithmetic statements. For example, you can use an arithmetic expression with the IF or EVALUATE statement. In such statements, the rules for intermediate results with fixed-point data and for intermediate results with floating-point data apply, with the following changes:

- Abbreviated IF statements are handled as though the statements were not abbreviated.
- In an explicit relation condition where at least one of the comparands is an arithmetic expression, *dmax* is the maximum number of decimal places for any

operand of either comparand, excluding divisors and exponents. The rules for floating-point arithmetic apply if any of the following conditions is true:

- Any operand in either comparand is COMP-1, COMP-2, external floating point, or a floating-point literal.
- An exponent contains decimal places.
- An exponent is an expression that contains an exponentiation or division operator, and *dmax* is greater than zero.

For example:

```
IF operand-1 = expression-1 THEN . . .
```

If *operand-1* is a data-name defined to be COMP-2, the rules for floating-point arithmetic apply to *expression-1* even if it contains only fixed-point operands, because it is being compared to a floating-point operand.

- When the comparison between an arithmetic expression and another data item or arithmetic expression does not use a relational operator (that is, there is no explicit relation condition), the arithmetic expression is evaluated without regard to the attributes of its comparand. For example:

```
EVALUATE expression-1  
  WHEN expression-2 THRU expression-3  
  WHEN expression-4  
  . . .  
END-EVALUATE
```

In the statement above, each arithmetic expression is evaluated in fixed-point or floating-point arithmetic based on its own characteristics.

RELATED CONCEPTS

“Fixed-point versus floating-point arithmetic” on page 53

RELATED REFERENCES

“Terminology used for intermediate results” on page 604

“Fixed-point data and intermediate results” on page 605

“Floating-point data and intermediate results” on page 610

IF statement (*Enterprise COBOL Language Reference*)

EVALUATE statement (*Enterprise COBOL Language Reference*)

Conditional expressions (*Enterprise COBOL Language Reference*)

Appendix B. Complex OCCURS DEPENDING ON

Complex OCCURS DEPENDING ON (ODO) is supported as an extension to the COBOL 85 Standard.

The basic forms of complex ODO permitted by the compiler are as follows:

- Variably located item or group: A data item described by an OCCURS clause with the DEPENDING ON phrase is followed by a nonsubordinate data item or group.
- Variably located table: A data item described by an OCCURS clause with the DEPENDING ON phrase is followed by a nonsubordinate data item described by an OCCURS clause.
- Table that has variable-length elements: A data item described by an OCCURS clause contains a subordinate data item described by an OCCURS clause with the DEPENDING ON phrase.
- Index name for a table that has variable-length elements.
- Element of a table that has variable-length elements.

Using complex ODO can make maintaining your code more difficult, and is potentially error prone as discussed in the related tasks below.

“Example: complex ODO”

RELATED TASKS

“Preventing index errors when changing ODO object value” on page 615

“Preventing overlay when adding elements to a variable table” on page 615

RELATED REFERENCES

“Effects of change in ODO object value” on page 614

OCCURS DEPENDING ON clause (*Enterprise COBOL Language Reference*)

Example: complex ODO

The following example illustrates the possible types of occurrence of complex ODO:

```
01 FIELD-A.
  02 COUNTER-1                      PIC S99.
  02 COUNTER-2                      PIC S99.
  02 TABLE-1.
    03 RECORD-1 OCCURS 1 TO 5 TIMES
      DEPENDING ON COUNTER-1        PIC X(3).
    02 EMPLOYEE-NUMBER              PIC X(5). (1)
    02 TABLE-2 OCCURS 5 TIMES      (2) (3)
      INDEXED BY INDX.              (4)
    03 TABLE-ITEM                  PIC 99.  (5)
    03 RECORD-2 OCCURS 1 TO 3 TIMES
      DEPENDING ON COUNTER-2.
    04 DATA-NUM                    PIC S99.
```

Definition: In the example, COUNTER-1 is an *ODO object*, that is, it is the object of the DEPENDING ON clause of RECORD-1. RECORD-1 is said to be an *ODO subject*. Similarly, COUNTER-2 is the ODO object of the corresponding ODO subject, RECORD-2.

The types of complex ODO occurrences shown in the example above are as follows:

- (1) A variably located item: EMPLOYEE-NUMBER is a data item following, but not subordinate to, a variable-length table in the same level-01 record.
- (2) A variably located table: TABLE-2 is a table following, but not subordinate to, a variable-length table in the same level-01 record.
- (3) A table with variable-length elements: TABLE-2 is a table containing a subordinate data item, RECORD-2, whose number of occurrences varies depending on the content of its ODO object.
- (4) An index name, INDX, for a table with variable-length elements.
- (5) An element, TABLE-ITEM, of a table with variable-length elements.

How length is calculated

The length of the variable portion of each record is the product of its ODO object and the length of its ODO subject. For example, whenever a reference is made to one of the complex ODO items shown above, the actual length, if used, is computed as follows:

- The length of TABLE-1 is calculated by multiplying the contents of COUNTER-1 (the number of occurrences of RECORD-1) by 3 (the length of RECORD-1).
- The length of TABLE-2 is calculated by multiplying the contents of COUNTER-2 (the number of occurrences of RECORD-2) by 2 (the length of RECORD-2), and adding the length of TABLE-ITEM.
- The length of FIELD-A is calculated by adding the lengths of COUNTER-1, COUNTER-2, TABLE-1, EMPLOYEE-NUMBER, and TABLE-2 times 5.

Setting values of ODO objects

You must set *every* ODO object in a group before you reference any complex ODO item in the group. For example, before you refer to EMPLOYEE-NUMBER in the code above, you must set COUNTER-1 and COUNTER-2 even though EMPLOYEE-NUMBER does not directly depend on either ODO object for its value.

Restriction: An ODO object cannot be variably located.

Effects of change in ODO object value

If a data item described by an OCCURS clause with the DEPENDING ON option is followed in the same group by one or more nonsubordinate data items (a form of complex ODO), any change in value of the ODO object affects subsequent references to complex ODO items in the record:

- The size of any group containing the relevant ODO clause reflects the new value of the ODO object.
- A MOVE to a group containing the ODO subject is made based on the new value of the ODO object.
- The location of any nonsubordinate items following the item described with the ODO clause is affected by the new value of the ODO object. (To preserve the contents of the nonsubordinate items, move them to a work area before the value of the ODO object changes; then move them back.)

The value of an ODO object can change when you move data to the ODO object or to the group in which it is contained. The value can also change if the ODO object is contained in a record that is the target of a READ statement.

RELATED TASKS

“Preventing index errors when changing ODO object value”

“Preventing overlay when adding elements to a variable table”

Preventing index errors when changing ODO object value

Be careful if you reference a complex-ODO index-name, that is, an index-name for a table with variable-length elements, after having changed the value of the ODO object for a subordinate data item in the table. When you change the value of an ODO object, the byte offset in an associated complex-ODO index is no longer valid because the table length has changed. Unless you take precautions, you will obtain unexpected results if you then code a reference to the index name such as:

- A reference to an element of the table
- A SET statement of the form SET *integer-data-item* TO *index-name* (format 1)
- A SET statement of the form SET *index-name* UP|DOWN BY *integer* (format 2)

To avoid this type of error, take these steps:

1. Save the index item in an integer data item. (Doing so causes an implicit conversion: the integer item receives the table element occurrence number corresponding to the offset in the index.)
2. Change the value of the ODO object.
3. Immediately restore the index item from the integer data item. (Doing so causes an implicit conversion: the index item receives the offset corresponding to the table element occurrence number in the integer item. The offset is computed according to the table length then in effect.)

The following code shows how to save and restore the index-name (seen in “Example: complex ODO” on page 613) when the ODO object COUNTER-2 changes.

```
77 INTEGER-DATA-ITEM-1      PIC 99.
. . .
  SET INDX TO 5.
*   INDX is valid at this point.
  SET INTEGER-DATA-ITEM-1 TO INDX.
*   INTEGER-DATA-ITEM-1 now has the
*   occurrence number corresponding to INDX.
  MOVE NEW-VALUE TO COUNTER-2.
*   INDX is not valid at this point.
  SET INDX TO INTEGER-DATA-ITEM-1.
*   INDX is now valid, containing the offset
*   corresponding to INTEGER-DATA-ITEM-1, and
*   can be used with the expected results.
```

RELATED REFERENCES

SET statement (*Enterprise COBOL Language Reference*)

Preventing overlay when adding elements to a variable table

Be careful if you increase the number of elements in a variable-occurrence table that is followed by one or more nonsubordinate data items in the same group. When you increment the value of the ODO object and add an element to a table, you can inadvertently overlay the variably located data items that follow the table.

To avoid this type of error, do the following:

1. Save the variably located data items that follow the table in another data area.
2. Increment the value of the ODO object.
3. Move data into the new table element (if needed).

Note that the fourth element of VARY-FIELD-1 did not overlay the first element of VARY-FIELD-2.

Appendix C. Converting double-byte character set (DBCS) data

The Language Environment service routines IGZCA2D and IGZCD2A were intended for use in converting alphanumeric data items that contain DBCS data to and from pure DBCS data items in order to reliably perform operations such as STRING, UNSTRING, and reference modification. The service routines continue to be provided for compatibility; however, using national data items and the national conversion operations is now recommended instead for this purpose.

Note that the service routines do not support a code page argument and are not sensitive to the code page specified by the CODEPAGE compiler option.

The DBCS compiler option does not affect the operation of the service routines.

RELATED TASKS

“Converting national data” on page 107

“Processing alphanumeric data items that contain DBCS data” on page 112

RELATED REFERENCES

“DBCS notation”

“Alphanumeric to DBCS data conversion (IGZCA2D)”

“DBCS to alphanumeric data conversion (IGZCD2A)” on page 622

“CODEPAGE” on page 274

DBCS notation

These symbols are used in the DBCS data conversion examples to describe DBCS items:

Symbols	Meaning
< and >	Shift-out (SO) and shift-in (SI), respectively
D0, D1, D2, . . . , Dn	Any DBCS character except for double-byte EBCDIC characters that correspond to single-byte EBCDIC characters
.A, .B, .C, . . .	Any double-byte EBCDIC character that corresponds to a single-byte EBCDIC character; the period (.) represents the value X'42'
A single letter, such as A, B, or s	Any single-byte EBCDIC character

Alphanumeric to DBCS data conversion (IGZCA2D)

The Language Environment IGZCA2D service routine converts alphanumeric data that contains double-byte characters to pure DBCS data.

IGZCA2D syntax

To use the IGZCA2D service routine, pass the following four parameters to the routine by using the CALL statement:

parameter-1

The sending field for the conversion, handled as an alphanumeric data item.

parameter-2

The receiving field for the conversion, handled as a DBCS data item.

You cannot use reference modification with *parameter-2*.

parameter-3

The number of bytes in *parameter-1* to be converted.

It can be the LENGTH OF special register of *parameter-1*, or a 4-byte USAGE IS BINARY data item containing the number of bytes of *parameter-1* to be converted. Shift codes count as 1 byte each.

parameter-4

The number of bytes in *parameter-2* that will receive the converted data.

It can be the LENGTH OF special register of *parameter-2*, or a 4-byte USAGE IS BINARY data item containing the number of bytes of *parameter-2* to receive the converted data.

Usage notes

- You can pass *parameter-1*, *parameter-3*, and *parameter-4* to the routine BY REFERENCE or BY CONTENT, but you must pass *parameter-2* BY REFERENCE.
- The compiler does not perform syntax checking on these parameters. Ensure that the parameters are correctly set and passed in the CALL statement to the conversion routine. Otherwise, results are unpredictable.
- When creating *parameter-2* from *parameter-1*, IGZCA2D makes these changes:
 - Removes the shift codes, leaving the DBCS data unchanged
 - Converts the single-byte (nonspace) EBCDIC character X'nn' to a character represented by X'42nn'
 - Converts the single-byte space (X'40') to DBCS space (X'4040'), instead of X'4240'
- IGZCA2D does not change the contents of *parameter-1*, *parameter-3*, or *parameter-4*.
- The valid range for the contents of *parameter-3* is 1 to 16,777,215, and the valid range for the contents of *parameter-4* is 1 to 15,777,214.

“Example: IGZCA2D” on page 621

RELATED REFERENCES

“IGZCA2D return codes”

IGZCA2D return codes

IGZCA2D sets the RETURN-CODE special register to reflect the status of the conversion, as shown in the table below.

Table 87. IGZCA2D return codes

Return code	Explanation
0	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> .
2	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . <i>parameter-2</i> was padded on the right with DBCS spaces.

Table 87. IGZCA2D return codes (continued)

Return code	Explanation
4	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . The DBCS data placed in <i>parameter-2</i> was truncated on the right.
6	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . A single-byte character in the range X'00' to X'3F' or X'FF' was encountered. The valid single-byte character has been converted into an out-of-range DBCS character.
8	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . A single-byte character in the range X'00' to X'3F' or X'FF' was encountered. The valid single-byte character has been converted into an out-of-range DBCS character. <i>parameter-2</i> was padded on the right with DBCS spaces.
10	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . A single-byte character in the range X'00' to X'3F' or X'FF' was encountered. The valid single-byte character has been converted into an out-of-range DBCS character. The DBCS data in <i>parameter-2</i> was truncated on the right.
12	An odd number of bytes was found between paired shift codes in <i>parameter-1</i> . No conversion occurred.
13	Unpaired or nested shift codes were found in <i>parameter-1</i> . No conversion occurred.
14	<i>parameter-1</i> and <i>parameter-2</i> were overlapping. No conversion occurred.
15	The value provided for <i>parameter-3</i> or <i>parameter-4</i> was out of range. No conversion occurred.
16	An odd number of bytes was coded in <i>parameter-4</i> . No conversion occurred.

Example: IGZCA2D

The following CALL statement converts the alphanumeric data in *alpha-item* to DBCS data. The results of the conversion are placed in *dbcs-item*.

```
CALL "IGZCA2D" USING BY REFERENCE alpha-item dbcs-item
                     BY CONTENT LENGTH OF alpha-item LENGTH OF dbcs-item
```

Suppose the contents of *alpha-item* and *dbcs-item* and the lengths before the conversion are:

```
alpha-item = AB<D1D2D3>CD
dbcs-item   = D4D5D6D7D8D9D0
LENGTH OF alpha-item = 12
LENGTH OF dbcs-item   = 14
```

Then after the conversion, *alpha-item* and *dbcs-item* will contain:

```
alpha-item = AB<D1D2D3>CD
dbcs-item  = .A.BD1D2D3.C.D
```

The content of the RETURN-CODE register is 0.

RELATED REFERENCES

"DBCS notation" on page 619

DBCS to alphanumeric data conversion (IGZCD2A)

The Language Environment IGZCD2A routine converts pure DBCS data to alphanumeric data that can contain double-byte characters.

IGZCD2A syntax

To use the IGZCD2A service routine, pass the following four parameters to the routine using the CALL statement:

parameter-1

The sending field for the conversion, handled as a DBCS data item.

parameter-2

The receiving field for the conversion, handled as an alphanumeric data item.

parameter-3

The number of bytes in *parameter-1* to be converted.

It can be the LENGTH OF special register of *parameter-1*, or a 4-byte USAGE IS BINARY data item containing the number of bytes of *parameter-1* to be converted.

parameter-4

The number of bytes in *parameter-2* that will receive the converted data.

It can be the LENGTH OF special register of *parameter-2*, or a 4-byte USAGE IS BINARY data item containing the number of bytes of *parameter-2* to receive the converted data. Shift codes count as 1 byte each.

Usage notes

- You can pass *parameter-1*, *parameter-3*, and *parameter-4* to the routine BY REFERENCE or BY CONTENT, but you must pass *parameter-2* BY REFERENCE.
- The compiler does not perform syntax checking on these parameters. Ensure that the parameters are correctly set and passed to the conversion routine. Otherwise, results are unpredictable.
- When creating *parameter-2* from *parameter-1*, IGZCD2A makes these changes:
 - Inserts shift codes around DBCS characters that do not correspond to single-byte EBCDIC characters
 - Converts DBCS characters to single-byte characters when the DBCS characters correspond to single-byte EBCDIC characters
 - Converts the DBCS space (X'4040') to a single-byte space (X'40')
- IGZCD2A does not change the contents of *parameter-1*, *parameter-3*, or *parameter-4*.
- If the converted data contains double-byte characters, shift codes are counted in the length of *parameter-2*.
- The valid range for the contents of *parameter-3* is 1 to 16,777,214, and the valid range for the contents of *parameter-4* is 1 to 15,777,215, which is the maximum size of alphanumeric item.

“Example: IGZCD2A” on page 623

RELATED REFERENCES

“IGZCD2A return codes” on page 623

IGZCD2A return codes

IGZCD2A sets the RETURN-CODE special register to reflect the status of the conversion, as shown in the table below.

Table 88. IGZCD2A return codes

Return code	Explanation
0	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> .
2	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . <i>parameter-2</i> was padded on the right with single-byte spaces.
4	<i>parameter-1</i> was converted and the results were placed in <i>parameter-2</i> . <i>parameter-2</i> was truncated on the right. ¹
14	<i>parameter-1</i> and <i>parameter-2</i> were overlapping. No conversion occurred.
15	The value of <i>parameter-3</i> or <i>parameter-4</i> was out of range. No conversion occurred.
16	An odd number of bytes was coded in <i>parameter-3</i> . No conversion occurred.
1. If a truncation occurs within the DBCS characters, the truncation is on an even-byte boundary and a shift-in (SI) is inserted. If necessary, the alphanumeric data is padded with a single-byte space after the shift-in.	

Example: IGZCD2A

The following CALL statement converts the DBCS data in *dbcs-item* to alphanumeric data with double-byte characters. The results of the conversion are placed in *alpha-item*.

```
CALL "IGZCD2A" USING BY REFERENCE dbc-item alpha-item  
BY CONTENT LENGTH OF dbc-item LENGTH OF alpha-item
```

Suppose the contents of *dbcs-item* and *alpha-item* and the lengths before the conversion are:

```
dbcs-item = .A.BD1D2D3.C.D  
alpha-item = sssssssssss  
LENGTH OF dbc-item = 14  
LENGTH OF alpha-item = 12
```

Then after the conversion, *dbcs-item* and *alpha-item* will contain:

```
dbcs-item = .A.BD1D2D3.C.D  
alpha-item = AB<D1D2D3>CD
```

The content of the RETURN-CODE register is 0.

RELATED REFERENCES

"DBCS notation" on page 619

Appendix D. XML reference material

This information describes the XML exception codes that the XML parser and the XML GENERATE statement return in special register XML-CODE. This information also documents which well-formedness constraints from the XML specification that the parser checks.

RELATED REFERENCES

“XML PARSE exceptions that allow continuation”

“XML PARSE exceptions that do not allow continuation” on page 628

“XML GENERATE exceptions” on page 633

“XML conformance” on page 631

XML specification (www.w3c.org/XML/)

XML PARSE exceptions that allow continuation

The following table shows the exception codes that are associated with the XML EXCEPTION event and that the XML parser returns in special register XML-CODE when the parser can continue processing the XML data. That is, the code is within one of the following ranges:

- 1-99
- 100,001-165,535

The table describes each exception and the actions that the parser takes when you request that it continue after the exception. Some of the descriptions use the following terms:

- *Basic document encoding*
- *Document encoding declaration*

For definitions of the terms, see the related task below on understanding the encoding of XML documents.

Table 89. XML PARSE exceptions that allow continuation

Code	Description	Parser action on continuation
1	The parser found an invalid character while scanning white space outside element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
2	The parser found an invalid start of a processing instruction, element, comment, or document type declaration outside element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
3	The parser found a duplicate attribute name.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.

Table 89. XML PARSE exceptions that allow continuation *(continued)*

Code	Description	Parser action on continuation
4	The parser found the markup character ' <code><</code> ' in an attribute value.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
5	The start and end tag names of an element did not match.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
6	The parser found an invalid character in element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
7	The parser found an invalid start of an element, comment, processing instruction, or CDATA section in element content.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
8	The parser found in element content the CDATA closing character sequence <code>]]></code> without the matching opening character sequence <code><![CDATA[</code> .	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
9	The parser found an invalid character in a comment.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
10	The parser found in a comment the character sequence <code>'-'</code> (two hyphens) not followed by <code>'></code> .	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
11	The parser found an invalid character in a processing instruction data segment.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
12	A processing instruction target name was <code>'xml'</code> in lowercase, uppercase, or mixed case.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.

Table 89. XML PARSE exceptions that allow continuation (continued)

Code	Description	Parser action on continuation
13	The parser found an invalid digit in a hexadecimal character reference (of the form ෝ).	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
14	The parser found an invalid digit in a decimal character reference (of the form &#ddd;).	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
15	The encoding declaration value in the XML declaration did not begin with lowercase or uppercase A through Z.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
16	A character reference did not refer to a legal XML character.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
17	The parser found an invalid character in an entity reference name.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
18	The parser found an invalid character in an attribute value.	The parser continues detecting errors until it reaches the end of the document or encounters an error that does not allow continuation. The parser does not signal any further normal events, except for the END-OF-DOCUMENT event.
70	The basic document encoding was EBCDIC, and the CODEPAGE compiler option specified a supported EBCDIC code page, but the document encoding declaration did not specify a supported EBCDIC code page.	The parser uses the encoding specified by the CODEPAGE compiler option.
71	The basic document encoding was EBCDIC, and the document encoding declaration specified a supported EBCDIC encoding, but the CODEPAGE compiler option did not specify a supported EBCDIC code page.	The parser uses the encoding specified by the document encoding declaration.
72	The basic document encoding was EBCDIC, the CODEPAGE compiler option did not specify a supported EBCDIC code page, and the document did not contain an encoding declaration.	The parser uses EBCDIC code page 1140 (USA, Canada, . . . Euro Country Extended Code Page).

Table 89. XML PARSE exceptions that allow continuation (continued)

Code	Description	Parser action on continuation
73	The basic document encoding was EBCDIC, but neither the CODEPAGE compiler option nor the document encoding declaration specified a supported EBCDIC code page.	The parser uses EBCDIC code page 1140 (USA, Canada, . . . Euro Country Extended Code Page).
82	The basic document encoding was ASCII, but the document did not contain an encoding declaration.	The parser uses ASCII code page 819 (ISO-8859-1 Latin 1/Open Systems).
83	The basic document encoding was ASCII, but the document encoding declaration did not specify code page 813, 819, or 920.	The parser uses ASCII code page 819 (ISO-8859-1 Latin 1/Open Systems).
92	The document data item was alphanumeric, but the basic document encoding was Unicode UTF-16.	The parser uses code page 1200 (Unicode UTF-16).
100,001 - 165,535	The CODEPAGE compiler option and the document encoding declaration specified different supported EBCDIC code pages. XML-CODE contains the code page CCSID for the encoding declaration plus 100,000.	If you set XML-CODE to zero before returning from the EXCEPTION event, the parser uses the encoding specified by the CODEPAGE compiler option. If you set XML-CODE to the CCSID for the document encoding declaration (by subtracting 100,000), the parser uses this encoding.

RELATED TASKS

“Understanding the encoding of XML documents” on page 462

“Handling errors in parsing XML documents” on page 465

XML PARSE exceptions that do not allow continuation

With these XML exceptions, no further events are returned from the parser even if you set XML-CODE to zero and return control to the parser after processing the exception. Control is passed to the statement that you specify in the ON EXCEPTION phrase, or to the end of the XML PARSE statement if you did not code an ON EXCEPTION phrase.

Table 90. XML PARSE exceptions that do not allow continuation

Code	Description
100	The parser reached the end of the document while scanning the start of the XML declaration.
101	The parser reached the end of the document while looking for the end of the XML declaration.
102	The parser reached the end of the document while looking for the root element.
103	The parser reached the end of the document while looking for the version information in the XML declaration.
104	The parser reached the end of the document while looking for the version information value in the XML declaration.
106	The parser reached the end of the document while looking for the encoding declaration value in the XML declaration.

Table 90. XML PARSE exceptions that do not allow continuation *(continued)*

Code	Description
108	The parser reached the end of the document while looking for the standalone declaration value in the XML declaration.
109	The parser reached the end of the document while scanning an attribute name.
110	The parser reached the end of the document while scanning an attribute value.
111	The parser reached the end of the document while scanning a character reference or entity reference in an attribute value.
112	The parser reached the end of the document while scanning an empty element tag.
113	The parser reached the end of the document while scanning the root element name.
114	The parser reached the end of the document while scanning an element name.
115	The parser reached the end of the document while scanning character data in element content.
116	The parser reached the end of the document while scanning a processing instruction in element content.
117	The parser reached the end of the document while scanning a comment or CDATA section in element content.
118	The parser reached the end of the document while scanning a comment in element content.
119	The parser reached the end of the document while scanning a CDATA section in element content.
120	The parser reached the end of the document while scanning a character reference or entity reference in element content.
121	The parser reached the end of the document while scanning after the close of the root element.
122	The parser found a possible invalid start of a document type declaration.
123	The parser found a second document type declaration.
124	The first character of the root element name was not a letter, '_', or ':
125	The first character of the first attribute name of an element was not a letter, '_', or ':
126	The parser found an invalid character either in or following an element name.
127	The parser found a character other than '=' following an attribute name.
128	The parser found an invalid attribute value delimiter.
130	The first character of an attribute name was not a letter, '_', or ':
131	The parser found an invalid character either in or following an attribute name.
132	An empty element tag was not terminated by a '>' following the '/':
133	The first character of an element end tag name was not a letter, '_', or ':
134	An element end tag name was not terminated by a '>':
135	The first character of an element name was not a letter, '_', or ':

Table 90. XML PARSE exceptions that do not allow continuation *(continued)*

Code	Description
136	The parser found an invalid start of a comment or CDATA section in element content.
137	The parser found an invalid start of a comment.
138	The first character of a processing instruction target name was not a letter, '_', or ':'.
139	The parser found an invalid character in or following a processing instruction target name.
140	A processing instruction was not terminated by the closing character sequence '?>'.
141	The parser found an invalid character following '&' in a character reference or entity reference.
142	The version information was not present in the XML declaration.
143	'version' in the XML declaration was not followed by '='.
144	The version declaration value in the XML declaration is either missing or improperly delimited.
145	The version information value in the XML declaration specified a bad character, or the start and end delimiters did not match.
146	The parser found an invalid character following the version information value closing delimiter in the XML declaration.
147	The parser found an invalid attribute instead of the optional encoding declaration in the XML declaration.
148	'encoding' in the XML declaration was not followed by '='.
149	The encoding declaration value in the XML declaration is either missing or improperly delimited.
150	The encoding declaration value in the XML declaration specified a bad character, or the start and end delimiters did not match.
151	The parser found an invalid character following the encoding declaration value closing delimiter in the XML declaration.
152	The parser found an invalid attribute instead of the optional standalone declaration in the XML declaration.
153	standalone in the XML declaration was not followed by =.
154	The standalone declaration value in the XML declaration is either missing or improperly delimited.
155	The standalone declaration value was neither 'yes' nor 'no' only.
156	The standalone declaration value in the XML declaration specified a bad character, or the start and end delimiters did not match.
157	The parser found an invalid character following the standalone declaration value closing delimiter in the XML declaration.
158	The XML declaration was not terminated by the proper character sequence '?>', or contained an invalid attribute.
159	The parser found the start of a document type declaration after the end of the root element.
160	The parser found the start of an element after the end of the root element.
315	The basic document encoding was UTF-16 little-endian, which the parser does not support on this platform.
316	The basic document encoding was UCS4, which the parser does not support.

Table 90. XML PARSE exceptions that do not allow continuation (continued)

Code	Description
317	The parser cannot determine the document encoding. The document might be damaged.
320	The document data item was national, but the basic document encoding was EBCDIC.
321	The document data item was national, but the basic document encoding was ASCII.
500-599	Internal error. Please report the error to your service representative.

RELATED TASKS

“Handling errors in parsing XML documents” on page 465

XML conformance

The XML parser that is included in Enterprise COBOL is not a conforming XML processor according to the definition in the XML specification. It does not validate the XML documents that you parse. Although it does check for many well-formedness errors, it does not perform all of the actions required of a nonvalidating XML processor.

In particular, it does not process the internal document type definition (DTD internal subset). Thus it does not supply default attribute values, does not normalize attribute values, and does not include the replacement text of internal entities except for the predefined entities. Instead, it passes the entire document type declaration as the contents of XML-TEXT or XML-NTEXT for the DOCUMENT-TYPE-DESCRIPTOR XML event, which allows the application to perform these actions if required.

The parser optionally allows programs to continue processing an XML document after some errors. The purpose of allowing processing to continue is to facilitate the debugging of XML documents and processing procedures.

Recapitulating the definition in the XML specification, a textual object is a *well-formed* XML document if:

- Taken as a whole, it conforms to the grammar for XML documents.
- It meets all the explicit well-formedness constraints given in the XML specification.
- Each parsed entity (piece of text) that is referenced directly or indirectly within the document is well formed.

The COBOL XML parser does check that documents conform to the XML grammar, except for any document type declaration. The declaration is supplied in its entirety, unchecked, to your application.

The following material is an annotation from the XML specification. The W3C is not responsible for any content not found at the original URL (www.w3.org/TR/REC-xml). All the annotations are non-normative and are shown in *italic*.

Copyright (C) 1994-2001 W3C (R) (Massachusetts Institute of Technology, Institut National de Recherche en Informatique et en Automatique, Keio University), All Rights Reserved. W3C liability, trademark, document use, and software licensing rules apply. (www.w3.org/Consortium/Legal/ipr-notice-20000612)

The XML specification also contains twelve explicit well-formedness constraints. The constraints that the COBOL XML parser checks partly or completely are shown in **bold** type:

1. **Parameter Entities (PEs) in Internal Subset:**
"In the internal DTD subset, parameter-entity references can occur only where markup declarations can occur, not within markup declarations. (This does not apply to references that occur in external parameter entities or to the external subset.)"
The parser does not process the internal DTD subset, so it does not enforce this constraint.
2. **External Subset:**
"The external subset, if any, must match the production for extSubset."
The parser does not process the external subset, so it does not enforce this constraint.
3. **Parameter Entity Between Declarations:**
"The replacement text of a parameter entity reference in a DeclSep must match the production extSubsetDecl."
The parser does not process the internal DTD subset, so it does not enforce this constraint.
4. **Element Type Match:**
"The Name in an element's end-tag must match the element type in the start-tag."
The parser enforces this constraint.
5. **Unique Attribute Specification:**
"No attribute name may appear more than once in the same start-tag or empty-element tag."
The parser partly supports this constraint by checking up to 10 attribute names in a given element for uniqueness. The application can check any attribute names beyond this limit.
6. **No External Entity References:**
"Attribute values cannot contain direct or indirect entity references to external entities."
The parser does not enforce this constraint.
7. **No '<' in Attribute Values:**
"The replacement text of any entity referred to directly or indirectly in an attribute value must not contain a '<'."
The parser does not enforce this constraint.
8. **Legal Character:**
"Characters referred to using character references must match the production for Char."
The parser enforces this constraint.
9. **Entity Declared:**
"In a document without any DTD, a document with only an internal DTD subset which contains no parameter entity references, or a document with standalone='yes', for an entity reference that does not occur within the external subset or a parameter entity, the Name given in the entity reference must match that in an entity declaration that does not occur within the external subset or a parameter entity, except that well-formed documents need not declare any of the following entities: amp, lt, gt, apos, quot. The declaration of a general entity must precede any reference to it which appears in a default value in an attribute-list declaration."

Note that if entities are declared in the external subset or in external parameter entities, a non-validating processor is not obligated to read and process their declarations; for such documents, the rule that an entity must be declared is a well-formedness constraint only if standalone='yes'."

The parser does not enforce this constraint.

10. **Parsed Entity:**

"An entity reference must not contain the name of an unparsed entity. Unparsed entities may be referred to only in attribute values declared to be of type ENTITY or ENTITIES."

The parser does not enforce this constraint.

11. **No Recursion:**

"A parsed entity must not contain a recursive reference to itself, either directly or indirectly."

The parser does not enforce this constraint.

12. **In DTD:**

"Parameter-entity references may only appear in the DTD."

The parser does not enforce this constraint, because the error cannot occur.

The preceding material is an annotation from the XML specification. The W3C is not responsible for any content not found at the original URL (www.w3.org/TR/REC-xml); all these annotations are non-normative. This document has been reviewed by W3C Members and other interested parties and has been endorsed by the Director as a W3C Recommendation. It is a stable document and may be used as reference material or cited as a normative reference from another document. The normative version of the specification is the English version found at the W3C site; any translated document may contain errors from the translation.

RELATED CONCEPTS

"XML parser in COBOL" on page 447

RELATED REFERENCES

XML specification (www.w3c.org/XML/)

2.8 Prolog and document type declaration (*XML specification* at www.w3.org/TR/REC-xml#sec-prolog-dtd)

XML GENERATE exceptions

The following table shows the exception codes that can occur during XML generation. The exception codes are returned in special register XML-CODE. If one of these exceptions occurs, control is passed to the statement in the ON EXCEPTION phrase, or to the end of the XML GENERATE statement if you did not code an ON EXCEPTION phrase.

Table 91. XML GENERATE exceptions

Code	Description
400	The receiver was too small to contain the generated XML document. The COUNT IN data item, if specified, contains the count of character positions that were actually generated.
401	A DBCS data-name contained a character that, when converted to Unicode, was not valid in an XML element name.
402	The first character of a DBCS data-name, when converted to Unicode, was not valid as the first character of an XML element name.
403	The value of an OCCURS DEPENDING ON variable exceeded 16,777,215.

Table 91. XML GENERATE exceptions (continued)

Code	Description
410	The code page specified by the CODEPAGE compiler option is not supported for conversion to Unicode.
411	The code page specified by the CODEPAGE compiler option is not a supported single-byte EBCDIC code page.
600-699	Internal error. Please report the error to your service representative.

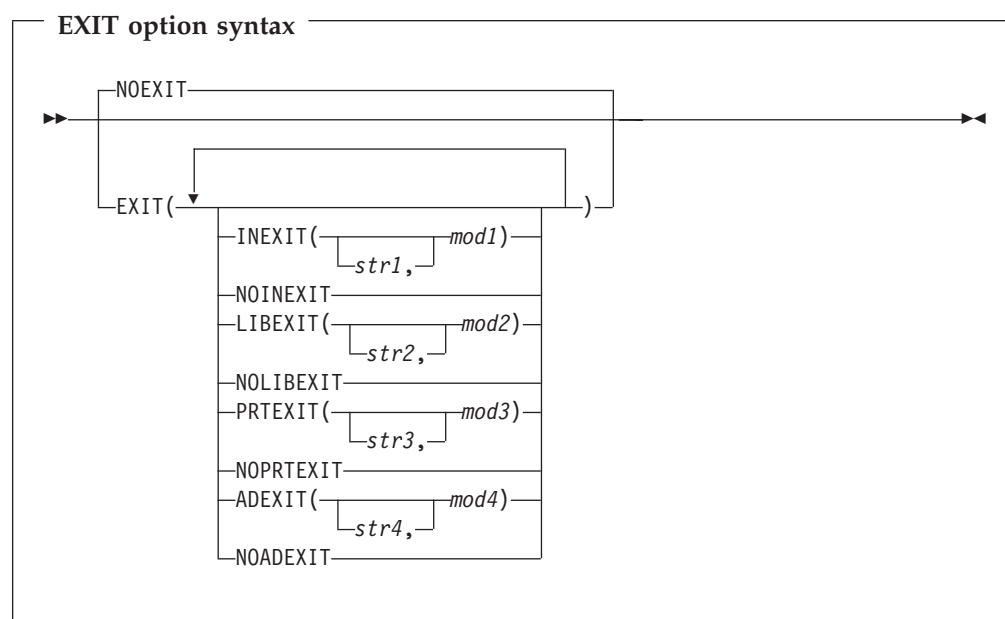
RELATED TASKS

“Handling errors in generating XML output” on page 480

Appendix E. EXIT compiler option

Use the EXIT option to allow the compiler to accept user-supplied modules in place of SYSIN, SYSLIB (or copy library), and SYSPRINT.

For SYSADATA, the ADEXIT suboption provides a module that will be called for each SYSADATA record immediately after the record has been written out to the file.



Default is: NOEXIT

Abbreviations are: EX(INX|NOINX, LIBX|NOLIBX, PRTX|NOPRTX, ADX|NOADX)

If you specify the EXIT option without providing at least one suboption, NOEXIT will be in effect. You can specify the suboptions in any order and separate them by either commas or spaces. If you specify both the positive and negative form of a suboption (INEXIT|NOINEXT, LIBEXIT|NOLIBEXIT, PRTEXTIT|NOPRTEXTIT, or ADEXIT|NOADEXIT), the form specified last takes effect. If you specify the same suboption more than once, the last one specified takes effect.

You can specify the EXIT option only at invocation in the JCL PARM field (under TSO/E, in a command argument) or at installation time. Do not specify the EXIT option in a PROCESS (CBL) statement.

INEXIT(['str1',]mod1)

The compiler reads source code from a user-supplied load module (where *mod1* is the module name), instead of SYSIN.

LIBEXIT(['str2',]mod2)

The compiler obtains copybooks from a user-supplied load module (where *mod2* is the module name), instead of *library-name* or SYSLIB. For use with either COPY or BASIS statements.

PRTEXIT(['str3'],mod3)

The compiler passes printer-destined output to the user-supplied load module (where *mod3* is the module name), instead of SYSPRINT.

ADEXIT(['str4'],mod4)

The compiler passes the SYSADATA output to the user-supplied load module (where *mod4* is the module name).

The module names *mod1*, *mod2*, *mod3*, and *mod4* can refer to the same module.

The suboptions *str1*, *str2*, *str3*, and *str4* are character strings that are passed to the load module. These strings are optional. They can be up to 64 characters in length, and you must enclose them in single quotation marks. Any character is allowed, but included single quotation marks must be doubled, and lowercase characters are folded to uppercase.

If one of *str1*, *str2*, *str3*, or *str4* is specified, the string is passed to the appropriate user-exit module with the following format:

LL	string
----	--------

where LL is a halfword (on a halfword boundary) containing the length of the string.

“Example: INEXIT user exit” on page 645

RELATED TASKS

“Using the user-exit work area”

“Calling from exit modules” on page 637

“Using the EXIT compiler option with CICS and SQL statements” on page 644

RELATED REFERENCES

“Processing of INEXIT” on page 637

“Processing of LIBEXIT” on page 638

“Processing of PRTEXIT” on page 641

“Processing of ADEXIT” on page 642

“Error handling for exit modules” on page 644

Using the user-exit work area

When you use an exit, the compiler provides a user-exit work area where you can save the address of GETMAIN storage obtained by the exit module. This work area allows the module to be reentrant.

The user-exit work area is 4 fullwords residing on a fullword boundary. These fullwords are initialized to binary zeros before the first exit routine is invoked. The address of the work area is passed to the exit module in a parameter list. After initialization, the compiler makes no further reference to the work area.

You need to establish your own conventions for using the work area if more than one exit is active during the compilation. For example, the INEXIT module uses the first word in the work area, the LIBEXIT module uses the second word, the PRTEXIT module uses the third word, and the ADEXIT module uses the fourth word.

RELATED REFERENCES

"Processing of INEXIT"

"Processing of LIBEXIT" on page 638

"Processing of PRTEXTIT" on page 641

"Processing of ADEXIT" on page 642

Calling from exit modules

Use COBOL standard linkage in your exit modules to call COBOL programs or library routines. You need to be aware of these conventions in order to trace the call chain correctly.

When a call is made to a program or to a routine, the registers are set up as follows:

- R1** Points to the parameter list passed to the called program or library routine
- R13** Points to the register save area provided by the calling program or routine
- R14** Holds the return address of the calling program or routine
- R15** Holds the address of the called program or routine

Exit modules must have the RMODE attribute of 24 and the AMODE attribute of ANY.

Processing of INEXIT

The exit module is used to read source code from a user-supplied load module in place of SYSIN.

The processing of INEXIT is as follows:

Table 92. INEXIT processing

Action by compiler	Resulting action by exit module
Loads the exit module (<i>mod1</i>) during initialization	
Calls the exit module with an OPEN operation code (op code)	Prepares its source for processing. Passes the status of the OPEN request back to the compiler.
Calls the exit module with a GET op code when a source statement is needed	Returns either the address and length of the next statement or the end-of-data indication (if no more source statements exist)
Calls the exit module with a CLOSE op code when the end-of-data is presented	Releases any resources that are related to its output

Parameter list for INEXIT

The compiler uses a parameter list to communicate with the exit module. The parameter list consists of 10 fullwords containing addresses, and register 1 contains the address of the parameter list. The return code, data length, and data parameters are placed by the exit module for return to the compiler, and the other items are passed from the compiler to the exit module. The following table describes the contents of the parameter list.

Table 93. INEXIT parameter list

Offset	Contains address of	Description of item
00	User-exit type	Halfword identifying which user exit is to perform the operation. 1=INEXIT
04	Operation code	Halfword indicating the type of operation. 0=OPEN; 1=CLOSE; 2=GET
08	Return code	Fullword, placed by the exit module, indicating the success of the requested operation. 0=Operation was successful 4=End-of-data 12=Operation failed
12	User-exit work area	Four-fullword work area provided by the compiler, for use by the user-exit module
16	Data length	Fullword, placed by the exit module, specifying the length of the record being returned by the GET operation (must be 80)
20	Data or <i>str1</i>	Fullword, placed by the exit module, containing the address of the record in a user-owned buffer, for the GET operation. <i>str1</i> applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string.
24	Not used	(Used only by LIBEXIT)
28	Not used	(Used only by LIBEXIT)
32	Not used	(Used only by LIBEXIT)
36	Not used	(Used only by LIBEXIT)

“Example: INEXIT user exit” on page 645

RELATED TASKS

“Using the EXIT compiler option with CICS and SQL statements” on page 644

RELATED REFERENCES

“Processing of LIBEXIT”

Processing of LIBEXIT

The exit module is used in place of the SYSLIB, or *library-name*, data set. Calls are made to the module by the compiler to obtain copybooks whenever COPY or BASIS statements are encountered.

If LIBEXIT is specified, the LIB compiler option must be in effect.

The processing of LIBEXIT is as follows:

Table 94. LIBEXIT processing

Action by compiler	Resulting action by exit module
Loads the exit module (<i>mod2</i>) during initialization	

Table 94. LIBEXIT processing (continued)

Action by compiler	Resulting action by exit module
Calls the exit module with an OPEN operation code (op code)	Prepares the specified <i>library-name</i> for processing. Passes the status of the OPEN request to the compiler.
Calls the exit module with a FIND op code if the <i>library-name</i> has successfully opened	Establishes positioning at the requested <i>text-name</i> (or <i>basis-name</i>) in the specified <i>library-name</i> ; this place becomes the active copybook. Passes an appropriate return code to the compiler when positioning is complete.
Calls the exit module with a GET op code	Passes the compiler either the length and address of the record to be copied from the active copybook or the end-of-data indicator
Calls the exit module with a CLOSE op code when the end-of-data is presented	Releases any resources that are related to its input

Processing of LIBEXIT with nested COPY statements

Any record from the active copybook can contain a COPY statement. (However, nested COPY statements cannot contain the REPLACING phrase, and a COPY statement with the REPLACING phrase cannot contain nested COPY statements.)

The compiler does not allow recursive calls to *text-name*. That is, a copybook can be named only once in a set of nested COPY statements until the end-of-data for that copybook is reached.

The following table shows how the processing of LIBEXIT changes when there are one or more valid COPY statements that are not nested:

Table 95. LIBEXIT processing with nonnested COPY statements

Action by compiler	Resulting action by exit module
Loads the exit module (<i>mod2</i>) during initialization	
Calls the exit module with an OPEN operation code (op code)	Prepares the specified <i>library-name</i> for processing. Passes the status of the OPEN request to the compiler.
Calls the exit module with a FIND op code if the <i>library-name</i> has successfully opened	Establishes positioning at the requested <i>text-name</i> (or <i>basis-name</i>) in the specified <i>library-name</i> ; this place becomes the active copybook. Passes an appropriate return code to the compiler when positioning is complete.
Calls the exit module with a FIND op code if the <i>library-name</i> has successfully opened	Reestablishes positioning at the previous active copybook. Passes an appropriate return code to the compiler when positioning is complete.
Calls the exit module with a GET op code. Verifies that the same record was passed.	Passes the compiler the same record as was passed previously from this copybook. After verification, passes either the length and address of the record to be copied from the active copybook or the end-of-data indicator.
Calls the exit module with a CLOSE op code when the end-of-data is presented	Releases any resources that are related to its input

The following table shows how the processing of LIBEXIT changes when the compiler encounters a valid nested COPY statement:

Table 96. LIBEXIT processing with nested COPY statements

Action by compiler	Resulting action by exit module
If the requested <i>library-name</i> from the nested COPY statement was not previously opened, calls the exit module with an OPEN op code	Pushes its control information about the active copybook onto a stack. Completes the requested action (OPEN). The newly requested <i>text-name</i> (or <i>basis-name</i>) becomes the active copybook.
Calls the exit module with a FIND op code for the requested new <i>text-name</i>	Pushes its control information about the active copybook onto a stack. Completes the requested action (FIND). The newly requested <i>text-name</i> (or <i>basis-name</i>) becomes the active copybook.
Calls the exit module with a GET op code	Passes the compiler either the length and address of the record to be copied from the active copybook or the end-of-data indicator. At end-of-data, pops its control information from the stack.

Parameter list for LIBEXIT

The compiler uses a parameter list to communicate with the exit module. The parameter list consists of 10 fullwords containing addresses, and register 1 contains the address of the parameter list. The return code, data length, and data parameters are placed by the exit module for return to the compiler; and the other items are passed from the compiler to the exit module. The following table describes the contents of the parameter list used for LIBEXIT.

Table 97. LIBEXIT parameter list

Offset	Contains address of	Description of item
00	User-exit type	Halfword identifying which user exit is to perform the operation. 2=LIBEXIT
04	Operation code	Halfword indicating the type of operation. 0=OPEN; 1=CLOSE; 2=GET; 4=FIND
08	Return code	Fullword, placed by the exit module, indicating the success of the requested operation. 0=Operation was successful 4=End-of-data 12=Operation failed
12	User-exit work area	Four-fullword work area provided by the compiler for use by the user-exit module
16	Data length	Fullword, placed by the exit module, specifying the length of the record being returned by the GET operation (must be 80)
20	Data or <i>str2</i>	Fullword, placed by the exit module, containing the address of the record in a user-owned buffer, for the GET operation. <i>str2</i> applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string.

Table 97. LIBEXIT parameter list (continued)

Offset	Contains address of	Description of item
24	System <i>library-name</i>	Eight-character area containing the <i>library-name</i> from the COPY statement. Processing and conversion rules for a program-name are applied. Padded with blanks if required. Applies to OPEN, CLOSE, and FIND.
28	System <i>text-name</i>	Eight-character area containing the <i>text-name</i> from the COPY statement (<i>basis-name</i> from BASIS statement). Processing and conversion rules for a program name are applied. Padded with blanks if required. Applies only to FIND.
32	Library-name	Thirty-character area containing the full <i>library-name</i> from the COPY statement. Padded with blanks if required, and used as-is (not folded to uppercase). Applies to OPEN, CLOSE, and FIND.
36	Text-name	Thirty-character area containing the full <i>text-name</i> from the COPY statement. Padded with blanks if required, and used as-is (not folded to uppercase). Applies only to FIND.

RELATED TASKS

“Using the EXIT compiler option with CICS and SQL statements” on page 644

Processing of PRTEXTIT

The exit module is used in place of the SYSPRINT data set.

The processing of PRTEXTIT is as follows:

Table 98. PRTEXTIT processing

Action by compiler	Resulting action by exit module
Loads the exit module (<i>mod3</i>) during initialization	
Calls the exit module with an OPEN operation code (op code)	Prepares its output destination for processing. Passes the status of the OPEN request to the compiler.
Calls the exit modules with a PUT op code when a line is to be printed, supplying the address and length of the record that is to be printed	Passes the status of the PUT request to the compiler by a return code. The first byte of the record to be printed contains an ANSI printer control character.
Calls the exit module with a CLOSE op code when the end-of-data is presented	Releases any resources that are related to its output destination

Parameter list for PRTEXTIT

The compiler uses a parameter list to communicate with the exit module. The parameter list consists of 10 fullwords containing addresses, and register 1 contains the address of the parameter list. The return code, data length, and data buffer parameters are placed by the exit module for return to the compiler; and the other items are passed from the compiler to the exit module. The following table describes the contents of the parameter list used for PRTEXTIT.

Table 99. PRTEXT parameter list

Offset	Contains address of	Description of item
00	User-exit type	Halfword identifying which user exit is to perform the operation. 3=PRTEXT
04	Operation code	Halfword indicating the type of operation. 0=OPEN; 1=CLOSE; 3=PUT
08	Return code	Fullword, placed by the exit module, indicating the success of the requested operation. 0=Operation was successful 12=Operation failed
12	User-exit work area	Four-fullword work area provided by the compiler, for use by the user-exit module
16	Data length	Fullword specifying the length of the record being supplied by the PUT operation (the compiler sets this value to 133)
20	Data buffer or <i>str3</i>	Fullword containing the address of the data buffer where the compiler has placed the record to be printed by the PUT operation. <i>str3</i> applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string.
24	Not used	(Used only by LIBEXIT)
28	Not used	(Used only by LIBEXIT)
32	Not used	(Used only by LIBEXIT)
36	Not used	(Used only by LIBEXIT)

RELATED TASKS

“Using the EXIT compiler option with CICS and SQL statements” on page 644

RELATED REFERENCES

“Processing of LIBEXIT” on page 638

Processing of ADEXIT

Use of the ADEXIT module requires:

- Compiler option ADATA to produce SYSADATA output
- DD statement SYSADATA

The processing of ADEXIT is as follows:

Table 100. ADEXIT processing

Action by compiler	Resulting action by exit module
Loads the exit module (<i>mod4</i>) during initialization	
Calls the exit module with an OPEN operation code (op code)	Prepares its output destination for processing. Passes the status of the OPEN request to the compiler.

Table 100. ADEXIT processing (continued)

Action by compiler	Resulting action by exit module
Calls the exit modules with a PUT op code when the compiler has written a SYSADATA record, supplying the address and length of the SYSADATA record	Passes the status of the PUT request to the compiler by a return code
Calls the exit module with a CLOSE op code when the end-of-data is presented	Releases any resources

Parameter list for ADEXIT

The compiler uses a parameter list to communicate with the exit module. The parameter list consists of 10 fullwords containing addresses, and register 1 contains the address of the parameter list. The return code, data length, and data buffer parameters are placed by the exit module for return to the compiler; and the other items are passed from the compiler to the exit module. The following table describes the contents of the parameter list used for ADEXIT.

Table 101. ADEXIT parameter list

Offset	Contains address of	Description of item
00	User-exit type	Halfword identifying which user exit is to perform the operation. 4=ADEXIT
04	Operation code	Halfword indicating the type of operation. 0=OPEN; 1=CLOSE; 3=PUT
08	Return code	Fullword, placed by the exit module, indicating the success of the requested operation. 0=Operation was successful 12=Operation failed
12	User-exit work area	Four-fullword work area provided by the compiler, for use by the user-exit module
16	Data length	Fullword specifying the length of the record being supplied by the PUT operation
20	Data buffer or <i>str4</i>	Fullword containing the address of the data buffer where the compiler has placed the record to be printed by the PUT operation. <i>str4</i> applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string, followed by the string.
24	Not used	(Used only by LIBEXIT)
28	Not used	(Used only by LIBEXIT)
32	Not used	(Used only by LIBEXIT)
36	Not used	(Used only by LIBEXIT)

RELATED TASKS

“Using the EXIT compiler option with CICS and SQL statements” on page 644

RELATED REFERENCES

“Processing of LIBEXIT” on page 638

Error handling for exit modules

The compiler reports an error message whenever an exit module cannot be loaded or an exit module returns an “operation failed” or nonzero return code.

Message IGYSI5008 is written to the operator and the compiler terminates with return code 16 when any of the following happens:

- An exit module cannot be loaded.
- A nonzero return code is received from INEXIT during an OPEN request.
- A nonzero return code is received from PRTEXTIT during an OPEN request.

The exit type and operation (OPEN or LOAD) are identified in the message.

Any other error from INEXIT or PRTEXTIT causes the compiler to terminate.

The compiler detects and reports the following conditions:

- 5203 PUT request to SYSPRINT user exit failed with return code *nn*.
- 5204 Record address not set by *exit-name* user exit.
- 5205 GET request from SYSIN user exit failed with return code *nn*.
- 5206 Record length not set by *exit-name* user exit.

Using the EXIT compiler option with CICS and SQL statements

When you compile using suboptions of the EXIT compiler option and your program contains CICS or SQL statements, the actions that you can take in the exit modules depend on whether you translated the statements using the separate CICS translator and DB2 precompiler, or translate them using the integrated CICS translator and DB2 coprocessor. When you use the integrated translators, you can process EXEC CICS and EXEC SQL statements in the exit modules.

INEXIT

When you translate the EXEC CICS and EXEC SQL statements in a program using the separate CICS translator and DB2 precompiler, and then compile the program using the INEXIT suboption, you can process the COBOL statements generated for the EXEC statements in the INEXIT module. You can change the generated statements in the INEXIT module, although doing so is not supported by IBM.

When you compile a program using the INEXIT suboption and translate the EXEC CICS and EXEC SQL statements using the integrated CICS translator and DB2 coprocessor (enabled using the CICS and SQL compiler options, respectively), you can process the EXEC CICS and EXEC SQL statements in the INEXIT module. The INEXIT module does not get control for the COBOL statements generated for the EXEC statements by the integrated translator and coprocessor.

LIBEXIT

When you compile a program using the LIBEXIT suboption and use the integrated DB2 coprocessor, EXEC SQL INCLUDE statements in the program are processed like COBOL COPY statements. You can process the statements brought in by the EXEC SQL INCLUDE statements in the LIBEXIT module. (If you use the separate DB2 precompiler, you can process the input statements brought in by the EXEC SQL INCLUDE statements only by using the INEXIT suboption.)

When you translate the EXEC CICS statements in a program and its copybooks using the separate CICS translator and then compile the program using the LIBEXIT suboption, you can process the COBOL statements generated for the EXEC CICS statements in the LIBEXIT module.

When you compile a program using the LIBEXIT suboption and translate the EXEC CICS statements using the integrated CICS translator, you can process the EXEC CICS source statements in the LIBEXIT module.

PRTEXTIT

When you translate the EXEC CICS and EXEC SQL statements in a program using the separate CICS translator and DB2 precompiler, and compile the program using the PRTEXTIT suboption, you can process the COBOL SOURCE listing statements generated for the EXEC statements in the PRTEXTIT module.

When you compile a program using the PRTEXTIT suboption and translate the EXEC CICS and EXEC SQL statements using the integrated CICS translator and DB2 coprocessor, you can process the EXEC CICS and EXEC SQL source statements from the SOURCE listing in the PRTEXTIT module. The PRTEXTIT module does not have access to the COBOL source statements generated by the integrated translator and coprocessor.

ADEXIT

When you translate the EXEC CICS and EXEC SQL statements in a program using the separate CICS translator and DB2 precompiler, and compile the program using the ADEXIT suboption, you can process the COBOL SYSADATA source statements generated for the EXEC statements in the ADEXIT module.

When you compile a program using the ADEXIT suboption and translate the EXEC CICS and EXEC SQL statements using the integrated CICS translator and DB2 coprocessor, you can process the EXEC CICS and EXEC SQL source statements in the ADEXIT module. The ADEXIT module does not have access to the COBOL source statements generated by the integrated translator and coprocessor.

RELATED CONCEPTS

"DB2 coprocessor" on page 375

"Integrated CICS translator" on page 364

RELATED TASKS

"Compiling with the SQL option" on page 373

"Compiling with the CICS option" on page 362

RELATED REFERENCES

"Processing of INEXIT" on page 637

"Processing of LIBEXIT" on page 638

"Processing of PRTEXTIT" on page 641

"Processing of ADEXIT" on page 642

Example: INEXIT user exit

The following example shows an INEXIT user-exit module in COBOL.

```
*****
*
* Name:  SKELINX
*
```

```

* Function: Example of an INEXIT user exit written      *
*           in the COBOL language.                      *
*                                                         *
*****

Identification Division.
    Program-ID. Skelinx.

Environment Division.

Data Division.

    WORKING-STORAGE Section.

* *****
* *
* * Local variables.
* *
* *****

    01 Record-Variable    Pic X(80).

* *****
* *
* * Definition of the User-Exit Parameter List, which *
* * is passed from the COBOL compiler to the user exit *
* * module.
* *
* *****

Linkage Section.
    01 Exit-Type          Pic 9(4)   Binary.
    01 Exit-Operation      Pic 9(4)   Binary.
    01 Exit-ReturnCode     Pic 9(9)   Binary.
    01 Exit-WorkArea.
        05 INEXIT-Slot     Pic 9(9)   Binary.
        05 LIBEXIT-Slot    Pic 9(9)   Binary.
        05 PRTEXT-Slot     Pic 9(9)   Binary.
        05 Reserved-Slot   Pic 9(9)   Binary.
    01 Exit-DataLength     Pic 9(9)   Binary.
    01 Exit-DataArea       Pointer.
    01 Exit-Open-Parm      Redefines Exit-DataArea.
        05 String-Len      Pic 9(4)   Binary.
        05 Open-String     Pic X(64).
    01 Exit-Print-Line     Redefines Exit-DataArea Pic X(133).
    01 Exit-LIBEXIT        Pic X(8).
    01 Exit-Systext        Pic X(8).
    01 Exit-CBLLibrary     Pic X(30).
    01 Exit-CBLText        Pic X(30).

*****
*
* Begin PROCEDURE DIVISION
*
* Invoke the section to handle the exit.
*
*****

Procedure Division Using Exit-Type      Exit-Operation
                        Exit-ReturnCode Exit-WorkArea
                        Exit-DataLength Exit-DataArea
                        Exit-LIBEXIT     Exit-Systext
                        Exit-CBLLibrary  Exit-CBLText.

    Evaluate Exit-type
        When (1) Perform Handle-INEXIT
        When (2) Perform Handle-LIBEXIT

```

```

        When (3) Perform Handle-PRTEXIT
        End-Evaluate
        Move 16 To Exit-ReturnCode
        Goback.

*****
*   I N E X I T   E X I T   P R O C E S S O R   *
*****
        Handle-INEXIT.

        Evaluate Exit-Operation
        When (0) Perform INEXIT-Open
        When (1) Perform INEXIT-Close
        When (2) Perform INEXIT-Get
        End-Evaluate

        Move 16 To Exit-ReturnCode
        Goback.

        INEXIT-Open.
        *   -----
        *   Prepare for reading source
        *   -----
        *   Goback.

        INEXIT-Close.
        *   -----
        *   Release resources
        *   -----
        *   Goback.

        INEXIT-Get.
        *   -----
        *   Retrieve next source record
        *   -----

        *   -----
        *   Return the address of the record to the compiler.
        *   -----
        *   Set Exit-DataArea to Address of Record-Variable

        *   -----
        *   Set length of record in User-Exit Parameter List
        *   -----
        *   Move 80 To Exit-DataLength

        Goback.

*****
*   L I B E X I T   P R O C E S S O R           *
*****
        Handle-LIBEXIT.
        Display "**** This module for INEXIT only"
        Move 16 To Exit-ReturnCode
        Goback.

*****
*   P R I N T   E X I T   P R O C E S S O R   *
*****
        Handle-PRTEXIT.
        Display "**** This module for INEXIT only"
        Move 16 To Exit-ReturnCode
        Goback.
*****

        End Program Skelinx.

```

Appendix F. JNI.cpy

This listing shows the copybook JNI.cpy, which you use with OO syntax for Java interoperability. You can use JNI.cpy to access the Java Native Interface (JNI) services from your COBOL programs. This copybook contains:

- Sample COBOL data definitions that correspond to the Java JNI types
- The JNI environment structure JNINativeInterface, which contains function pointers for accessing the JNI callable service functions

JNI.cpy is in the HFS in the include subdirectory of the COBOL install directory (typically /usr/lpp/cobol/include) and is analogous to the header file jni.h that C programmers use to access the JNI.

```
*****
* COBOL declarations for Java native method interoperation      *
*                                                                *
* To use the Java Native Interface callable services from a    *
* COBOL program:                                              *
* 1) Use a COPY statement to include this file into the        *
*    the Linkage Section of the program, e.g.                  *
*    Linkage Section.                                          *
*    Copy JNI                                                  *
* 2) Code the following statements at the beginning of the      *
*    Procedure Division:                                       *
*    Set address of JNIEnv to JNIEnvPtr                        *
*    Set address of JNINativeInterface to JNIEnv               *
*****
*
* Sample JNI type definitions in COBOL
*
*01 jboolean1 pic X.
* 88 jboolean1-true  value X'01' through X'FF'.
* 88 jboolean1-false value X'00'.
*
*01 jbyte1 pic X.
*
*01 jchar1 pic N usage national.
*
*01 jshort1 pic s9(4) comp-5.
*01 jint1  pic s9(9) comp-5.
*01 jlong1 pic s9(18) comp-5.
*
*01 jfloat1 comp-1.
*01 jdouble1 comp-2.
*
*01 jobject1 object reference.
*01 jclass1  object reference.
*01 jstring1 object reference jstring.
*01 jarray1  object reference jarray.
*
*01 jbooleanArray1 object reference jbooleanArray.
*01 jbyteArray1    object reference jbyteArray.
*01 jcharArray1    object reference jcharArray.
*01 jshortArray1   object reference jshortArray.
*01 jintArray1     object reference jintArray.
*01 jlongArray1    object reference jlongArray.
*01 floatArray1    object reference floatArray.
*01 jdoubleArray1  object reference jdoubleArray.
*01 jobjectArray1  object reference jobjectArray.
```

```

* Possible return values for JNI functions.
01 JNI-RC pic S9(9) comp-5.
* success
88 JNI-OK value 0.
* unknown error
88 JNI-ERR value -1.
* thread detached from the VM
88 JNI-EDETACHED value -2.
* JNI version error
88 JNI-EVERSION value -3.
* not enough memory
88 JNI-ENOMEM value -4.
* VM already created
88 JNI-EEXIST value -5.
* invalid arguments
88 JNI-EINVAL value -6.

* Used in ReleaseScalarArrayElements
01 releaseMode pic s9(9) comp-5.
88 JNI-COMMIT value 1.
88 JNI-ABORT value 2.

01 JNIenv pointer.

* JNI Native Method Interface - environment structure.
01 JNINativeInterface.
02 pointer.
02 pointer.
02 pointer.
02 pointer.
02 GetVersion function-pointer.
02 DefineClass function-pointer.
02 FindClass function-pointer.
02 FromReflectedMethod function-pointer.
02 FromReflectedField function-pointer.
02 ToReflectedMethod function-pointer.
02 GetSuperclass function-pointer.
02 IsAssignableFrom function-pointer.
02 ToReflectedField function-pointer.
02 Throw function-pointer.
02 ThrowNew function-pointer.
02 ExceptionOccurred function-pointer.
02 ExceptionDescribe function-pointer.
02 ExceptionClear function-pointer.
02 FatalError function-pointer.
02 PushLocalFrame function-pointer.
02 PopLocalFrame function-pointer.
02 NewGlobalRef function-pointer.
02 DeleteGlobalRef function-pointer.
02 DeleteLocalRef function-pointer.
02 IsSameObject function-pointer.
02 NewLocalRef function-pointer.
02 EnsureLocalCapacity function-pointer.
02 AllocObject function-pointer.
02 NewObject function-pointer.
02 NewObjectV function-pointer.
02 NewObjectA function-pointer.
02 GetObjectClass function-pointer.
02 IsInstanceOf function-pointer.
02 GetMethodID function-pointer.
02 CallObjectMethod function-pointer.
02 CallObjectMethodV function-pointer.
02 CallObjectMethodA function-pointer.
02 CallBooleanMethod function-pointer.
02 CallBooleanMethodV function-pointer.
02 CallBooleanMethodA function-pointer.
02 CallByteMethod function-pointer.

```

02 CallByteMethodV	function-pointer.
02 CallByteMethodA	function-pointer.
02 CallCharMethod	function-pointer.
02 CallCharMethodV	function-pointer.
02 CallCharMethodA	function-pointer.
02 CallShortMethod	function-pointer.
02 CallShortMethodV	function-pointer.
02 CallShortMethodA	function-pointer.
02 CallIntMethod	function-pointer.
02 CallIntMethodV	function-pointer.
02 CallIntMethodA	function-pointer.
02 CallLongMethod	function-pointer.
02 CallLongMethodV	function-pointer.
02 CallLongMethodA	function-pointer.
02 CallFloatMethod	function-pointer.
02 CallFloatMethodV	function-pointer.
02 CallFloatMethodA	function-pointer.
02 CallDoubleMethod	function-pointer.
02 CallDoubleMethodV	function-pointer.
02 CallDoubleMethodA	function-pointer.
02 CallVoidMethod	function-pointer.
02 CallVoidMethodV	function-pointer.
02 CallVoidMethodA	function-pointer.
02 CallNonvirtualObjectMethod	function-pointer.
02 CallNonvirtualObjectMethodV	function-pointer.
02 CallNonvirtualObjectMethodA	function-pointer.
02 CallNonvirtualBooleanMethod	function-pointer.
02 CallNonvirtualBooleanMethodV	function-pointer.
02 CallNonvirtualBooleanMethodA	function-pointer.
02 CallNonvirtualByteMethod	function-pointer.
02 CallNonvirtualByteMethodV	function-pointer.
02 CallNonvirtualByteMethodA	function-pointer.
02 CallNonvirtualCharMethod	function-pointer.
02 CallNonvirtualCharMethodV	function-pointer.
02 CallNonvirtualCharMethodA	function-pointer.
02 CallNonvirtualShortMethod	function-pointer.
02 CallNonvirtualShortMethodV	function-pointer.
02 CallNonvirtualShortMethodA	function-pointer.
02 CallNonvirtualIntMethod	function-pointer.
02 CallNonvirtualIntMethodV	function-pointer.
02 CallNonvirtualIntMethodA	function-pointer.
02 CallNonvirtualLongMethod	function-pointer.
02 CallNonvirtualLongMethodV	function-pointer.
02 CallNonvirtualLongMethodA	function-pointer.
02 CallNonvirtualFloatMethod	function-pointer.
02 CallNonvirtualFloatMethodV	function-pointer.
02 CallNonvirtualFloatMethodA	function-pointer.
02 CallNonvirtualDoubleMethod	function-pointer.
02 CallNonvirtualDoubleMethodV	function-pointer.
02 CallNonvirtualDoubleMethodA	function-pointer.
02 CallNonvirtualVoidMethod	function-pointer.
02 CallNonvirtualVoidMethodV	function-pointer.
02 CallNonvirtualVoidMethodA	function-pointer.
02 GetFieldID	function-pointer.
02 GetObjectField	function-pointer.
02 GetBooleanField	function-pointer.
02 GetByteField	function-pointer.
02 GetCharField	function-pointer.
02 GetShortField	function-pointer.
02 GetIntField	function-pointer.
02 GetLongField	function-pointer.
02 GetFloatField	function-pointer.
02 GetDoubleField	function-pointer.
02 SetObjectField	function-pointer.
02 SetBooleanField	function-pointer.
02 SetByteField	function-pointer.
02 SetCharField	function-pointer.

02 SetShortField	function-pointer.
02 SetIntField	function-pointer.
02 SetLongField	function-pointer.
02 SetFloatField	function-pointer.
02 SetDoubleField	function-pointer.
02 GetStaticMethodID	function-pointer.
02 CallStaticObjectMethod	function-pointer.
02 CallStaticObjectMethodV	function-pointer.
02 CallStaticObjectMethodA	function-pointer.
02 CallStaticBooleanMethod	function-pointer.
02 CallStaticBooleanMethodV	function-pointer.
02 CallStaticBooleanMethodA	function-pointer.
02 CallStaticByteMethod	function-pointer.
02 CallStaticByteMethodV	function-pointer.
02 CallStaticByteMethodA	function-pointer.
02 CallStaticCharMethod	function-pointer.
02 CallStaticCharMethodV	function-pointer.
02 CallStaticCharMethodA	function-pointer.
02 CallStaticShortMethod	function-pointer.
02 CallStaticShortMethodV	function-pointer.
02 CallStaticShortMethodA	function-pointer.
02 CallStaticIntMethod	function-pointer.
02 CallStaticIntMethodV	function-pointer.
02 CallStaticIntMethodA	function-pointer.
02 CallStaticLongMethod	function-pointer.
02 CallStaticLongMethodV	function-pointer.
02 CallStaticLongMethodA	function-pointer.
02 CallStaticFloatMethod	function-pointer.
02 CallStaticFloatMethodV	function-pointer.
02 CallStaticFloatMethodA	function-pointer.
02 CallStaticDoubleMethod	function-pointer.
02 CallStaticDoubleMethodV	function-pointer.
02 CallStaticDoubleMethodA	function-pointer.
02 CallStaticVoidMethod	function-pointer.
02 CallStaticVoidMethodV	function-pointer.
02 CallStaticVoidMethodA	function-pointer.
02 GetStaticFieldID	function-pointer.
02 GetStaticObjectField	function-pointer.
02 GetStaticBooleanField	function-pointer.
02 GetStaticByteField	function-pointer.
02 GetStaticCharField	function-pointer.
02 GetStaticShortField	function-pointer.
02 GetStaticIntField	function-pointer.
02 GetStaticLongField	function-pointer.
02 GetStaticFloatField	function-pointer.
02 GetStaticDoubleField	function-pointer.
02 SetStaticObjectField	function-pointer.
02 SetStaticBooleanField	function-pointer.
02 SetStaticByteField	function-pointer.
02 SetStaticCharField	function-pointer.
02 SetStaticShortField	function-pointer.
02 SetStaticIntField	function-pointer.
02 SetStaticLongField	function-pointer.
02 SetStaticFloatField	function-pointer.
02 SetStaticDoubleField	function-pointer.
02 NewString	function-pointer.
02 GetStringLength	function-pointer.
02 GetStringChars	function-pointer.
02 ReleaseStringChars	function-pointer.
02 NewStringUTF	function-pointer.
02 GetStringUTFLength	function-pointer.
02 GetStringUTFChars	function-pointer.
02 ReleaseStringUTFChars	function-pointer.
02 GetArrayLength	function-pointer.
02 NewObjectArray	function-pointer.
02 GetObjectArrayElement	function-pointer.
02 SetObjectArrayElement	function-pointer.

02 NewBooleanArray	function-pointer.
02 NewByteArray	function-pointer.
02 NewCharArray	function-pointer.
02 NewShortArray	function-pointer.
02 NewIntArray	function-pointer.
02 NewLongArray	function-pointer.
02 NewFloatArray	function-pointer.
02 NewDoubleArray	function-pointer.
02 GetBooleanArrayElements	function-pointer.
02 GetByteArrayElements	function-pointer.
02 GetCharArrayElements	function-pointer.
02 GetShortArrayElements	function-pointer.
02 GetIntArrayElements	function-pointer.
02 GetLongArrayElements	function-pointer.
02 GetFloatArrayElements	function-pointer.
02 GetDoubleArrayElements	function-pointer.
02 ReleaseBooleanArrayElements	function-pointer.
02 ReleaseByteArrayElements	function-pointer.
02 ReleaseCharArrayElements	function-pointer.
02 ReleaseShortArrayElements	function-pointer.
02 ReleaseIntArrayElements	function-pointer.
02 ReleaseLongArrayElements	function-pointer.
02 ReleaseFloatArrayElements	function-pointer.
02 ReleaseDoubleArrayElements	function-pointer.
02 GetBooleanArrayRegion	function-pointer.
02 GetByteArrayRegion	function-pointer.
02 GetCharArrayRegion	function-pointer.
02 GetShortArrayRegion	function-pointer.
02 GetIntArrayRegion	function-pointer.
02 GetLongArrayRegion	function-pointer.
02 GetFloatArrayRegion	function-pointer.
02 GetDoubleArrayRegion	function-pointer.
02 SetBooleanArrayRegion	function-pointer.
02 SetByteArrayRegion	function-pointer.
02 SetCharArrayRegion	function-pointer.
02 SetShortArrayRegion	function-pointer.
02 SetIntArrayRegion	function-pointer.
02 SetLongArrayRegion	function-pointer.
02 SetFloatArrayRegion	function-pointer.
02 SetDoubleArrayRegion	function-pointer.
02 RegisterNatives	function-pointer.
02 UnregisterNatives	function-pointer.
02 MonitorEnter	function-pointer.
02 MonitorExit	function-pointer.
02 GetJavaVM	function-pointer.
02 GetStringRegion	function-pointer.
02 GetStringUTFRegion	function-pointer.
02 GetPrimitiveArrayCritical	function-pointer.
02 ReleasePrimitiveArrayCritical	function-pointer.
02 GetStringCritical	function-pointer.
02 ReleaseStringCritical	function-pointer.
02 NewWeakGlobalRef	function-pointer.
02 DeleteWeakGlobalRef	function-pointer.
02 ExceptionCheck	function-pointer.

RELATED TASKS

“Compiling OO applications under UNIX” on page 257

“Accessing JNI services” on page 527

Appendix G. COBOL SYSADATA file contents

When you use the ADATA compiler option, the compiler produces a file that contains program data. Use this file (instead of the compiler listing) to extract information about the compiled program. For example, you can extract information regarding the compiled program for symbolic debugging tools or cross-reference tools.

“Example: SYSADATA” on page 657

RELATED REFERENCES

“ADATA” on page 270

“Existing compiler options affecting the SYSADATA file”

“SYSADATA record types” on page 656

“SYSADATA record descriptions” on page 658

Existing compiler options affecting the SYSADATA file

The following compiler options might affect the contents of the SYSADATA file.

COMPILE

Using NOCOMPILE(W|E|S) might stop compilation prematurely, resulting in the loss of specific messages.

EVENTS Using EVENTS will have the same result as the ADATA option (that is, with either ADATA or EVENTS or both specified, the SYSADATA file will be produced). (For compatibility.)

EXIT Using INEXIT will prohibit identification of the compilation source file.

LANGUAGE

LANGUAGE controls the message text (Uppercase English, Mixed-Case English, or Japanese). Selection of Japanese could result in DBCS characters written to Error Identification records.

NUM The NUM option will cause the compiler to use the contents of columns 1-6 in the source records for line numbering, rather than generated sequence numbers. Any invalid (nonnumeric) or out-of-sequence numbers will be replaced with a number one higher than that of the previous record.

The following SYSADATA fields contain line numbers whose contents differ depending on the NUM|NONUM setting:

Type	Field	Record
0020	AE_LINE	External Symbol record
0030	ATOK_LINE	Token record
0032	AF_STMT	Source Error record
0038	AS_STMT	Source record
0039	AS_REP_EXP_SLIN	COPY REPLACING record
0039	AS_REP_EXP_ELIN	COPY REPLACING record
0042	ASY_STMT	Symbol record
0044	AX_DEFN	Symbol Cross Reference record

Type	Field	Record
0044	AX_STMT	Symbol Cross Reference record
0046	AN_STMT	Nested Program record

The Type 0038 Source record contains two fields that relate to line numbers and record numbers:

- AS_STMT contains the compiler line number, in both the NUM and NONUM cases.
- AS_CUR_REC# contains the physical source record number.

These two fields can always be used to correlate the compiler line numbers, used in all the above fields, with physical source record numbers.

TEST The TEST option will cause additional object text records to be created that will also affect the contents of the SYSADATA file.

The remaining compiler options have no direct effect on the SYSADATA file, but might trigger generation of additional error messages associated with the specific option, such as FLAGSAA, FLAGSTD, or SSRANGE.

“Example: SYSADATA” on page 657

RELATED REFERENCES

“SYSADATA record types”

“COMPILE” on page 275

“LANGUAGE” on page 287

“NUMBER” on page 292

“TEST” on page 306

SYSADATA record types

The SYSADATA file contains records classified into different record types. Each type of record provides information about the COBOL program being compiled. Each record consists of two parts:

- A 12-byte header section, which has the same structure for all record types
- A variable-length data section, which varies by record type

The header section contains, among other items, the record code that identifies the type of record.

The types of record provided in the associated data file are listed in the following table:

Table 102. SYSADATA record types

Record type	What it does
“Job identification record - X'0000” on page 660	Provides information about the environment used to process the source data
“ADATA identification record - X'0001” on page 661	Provides common information about the records in the SYSADATA file
“Compilation unit start/end record - X'0002” on page 662	Marks the beginning and ending of compilation units in a source file

Table 102. SYSADATA record types (continued)

Record type	What it does
"Options record - X'0010'" on page 662	Describes the compiler options used for the compilation
"External symbol record - X'0020'" on page 672	Describes all external names in the program, definitions and references
"Parse tree record - X'0024'" on page 673	Defines a node in the parse tree of the program
"Token record - X'0030'" on page 687	Defines a source token
"Source error record - X'0032'" on page 687	Describes errors in source program statements
"Source record - X'0038'" on page 688	Describes a single source line
"COPY REPLACING record - X'0039'" on page 688	Describes an instance of text replacement as a result of a match of COPY. . .REPLACING <i>operand-1</i> with text in the copybook being copied in
"Symbol record - X'0042'" on page 689	Describes a single symbol defined in the program. There is one Symbol record for each symbol defined in the program.
"Symbol cross-reference record - X'0044'" on page 700	Describes references to a single symbol
"Nested program record - X'0046'" on page 701	Describes the name and nesting level of a program
"Library record - X'0060'" on page 702	Describes the library files and members used from each library
"Statistics record - X'0090'" on page 703	Describes the statistics about the compilation
"EVENTS record - X'0120'" on page 703	EVENTS records are recorded in the SYSADATA file to provide compatibility with COBOL/370. The EVENTS record data format is identical with that in COBOL/370, with the addition of the standard ADATA header at the beginning of the record and a field indicating the length of the EVENTS record data.

"Example: SYSADATA"

Example: SYSADATA

The following sample shows part of the listing of a COBOL program. If this COBOL program were compiled with the ADATA option, the records produced in the associated data file would be in the sequence as shown below. Other programs might produce records not shown below, which would affect the order of the records.

The following is sample associated data output for a COBOL program:

```

000001      IDENTIFICATION DIVISION.                      AD000020
000002      PROGRAM-ID. AD04202.                          AD000030
000003      ENVIRONMENT DIVISION.                        AD000040
000004      DATA DIVISION.                              AD000050
000005      WORKING-STORAGE SECTION.                     AD000060
000006      77  COMP3-FLD2 pic S9(3)v9.                 AD000070
000007      PROCEDURE DIVISION.                          AD000080
000008          STOP RUN.
```

Type	Description
X'0120'	EVENTS Timestamp record
X'0120'	EVENTS Processor record
X'0120'	EVENTS Fileid record
X'0120'	EVENTS Program record
X'0001'	ADATA Identification record
X'0000'	Job Identification record
X'0010'	Options record
X'0038'	Source record for statement 1 IDENTIFICATION DIVISION.
X'0038'	Source record for statement 2 PROGRAM-ID. AD04202.
X'0038'	Source record for statement 3 ENVIRONMENT DIVISION.
X'0038'	Source record for statement 4 DATA DIVISION.
X'0038'	Source record for statement 5 WORKING-STORAGE SECTION.
X'0038'	Source record for statement 6 77 COMP3-FLD2 pic S9(3)v9.
X'0038'	Source record for statement 7 PROCEDURE DIVISION.
X'0038'	Source record for statement 8 STOP RUN.
X'0020'	External Symbol record for AD04202
X'0044'	Symbol Cross Reference record for STOP
X'0044'	Symbol Cross Reference record for COMP3-FLD2
X'0044'	Symbol Cross Reference record for AD04202
X'0042'	Symbol record for AD04202
X'0042'	Symbol record for COMP3-FLD2
X'0090'	Statistics record
X'0120'	EVENTS FileEnd record

RELATED REFERENCES

“SYSADATA record descriptions”

SYSADATA record descriptions

The formats of the records written to the associated data file are shown in the related references below. In the fields described in each of the record types:

- C** Indicates character (EBCDIC or ASCII) data
- H** Indicates 2-byte binary integer data
- F** Indicates 4-byte binary integer data
- A** Indicates 4-byte binary integer address and offset data
- X** Indicates hexadecimal (bit) data or 1-byte binary integer data

No boundary alignments are implied by any data type, and the implied lengths above might be changed by the presence of a length indicator (Ln). All integer data is in big-endian or little-endian format depending on the indicator bit in the header flag byte. *Big-endian* format means that bit 0 is always the most significant bit and bit *n* is the least significant bit. *Little-endian* refers to “byte-reversed” integers as seen on Intel-based hardware.

All undefined fields and unused values are reserved.

RELATED REFERENCES

"Common header section"
"Job identification record - X'0000'" on page 660
"ADATA identification record - X'0001'" on page 661
"Compilation unit start/end record - X'0002'" on page 662
"Options record - X'0010'" on page 662
"External symbol record - X'0020'" on page 672
"Parse tree record - X'0024'" on page 673
"Token record - X'0030'" on page 687
"Source error record - X'0032'" on page 687
"Source record - X'0038'" on page 688
"COPY REPLACING record - X'0039'" on page 688
"Symbol record - X'0042'" on page 689
"Symbol cross-reference record - X'0044'" on page 700
"Nested program record - X'0046'" on page 701
"Library record - X'0060'" on page 702
"Statistics record - X'0090'" on page 703
"EVENTS record - X'0120'" on page 703

Common header section

The header section, common for all record types. For MVS and VSE, each record is preceded by a 4-byte RDW (record-descriptor word) that is normally used only by access methods and stripped off by download utilities.

The header section is in the following format:

Table 103. SYSADATA common header section

Field	Size	Description
Language code	XL1	16 High Level Assembler
		17 COBOL on all platforms
		40 PL/I on supported platforms

Table 103. **SYSADATA common header section** (continued)

Field	Size	Description
Record type	HL2	The record type, which can be one of the following: X'0000' Job Identification record ¹ X'0001' ADATA Identification record X'0002' Compilation unit start/end record X'0010' Options record ¹ X'0020' External Symbol record X'0024' Parse Tree record X'0030' Token record X'0032' Source Error record X'0038' Source record X'0039' COPY REPLACING record X'0042' Symbol record X'0044' Symbol Cross-Reference record X'0046' Nested Program record X'0060' Library record X'0090' Statistics record ¹ X'0120' EVENTS record
Associated data architecture level	XL1	3 Definition level for the header structure
Flag	XL1	.... ..1. ADATA record integers are in little-endian (Intel) format .... ...1 This record is continued in the next record 1111 11.. Reserved for future use
Associated data record edition level	XL1	Used to indicate a new format for a specific record type, usually 0
Reserved	CL4	Reserved for future use
Associated data field length	HL2	The length in bytes of the data following the header
1. When a batch compilation (sequence of programs) is run with the ADATA option, there will be multiple Job Identification, Options, and Statistics records for each compile.		

The mapping of the 12-byte header does not include the area used for the variable-length record-descriptor word required by the access method on MVS and VSE.

Job identification record - X'0000'

The following table shows the contents of the job identification record:

Table 104. SYSADATA job identification record

Field	Size	Description
Date	CL8	The date of the compilation in the format YYYYMMDD
Time	CL4	The time of the compilation in the format HHMM
Product number	CL8	The product number of the compiler that produced the associated data file
Product version	CL8	The version number of the product that produced the associated data file, in the form V.R.M
PTF level	CL8	The PTF level number of the product that produced the associated data file. (This field will be blank if the PTF number is not available.)
System ID	CL24	The system identification of the system on which the compilation was run
Job name	CL8	The MVS job name of the compilation job
Step name	CL8	The MVS step name of the compilation step
Proc step	CL8	The MVS procedure step name of the compilation procedure step
Number of input files ¹	HL2	The number of input files recorded in this record. The following group of seven fields will occur <i>n</i> times depending on the value in this field.
...Input file number	HL2	The assigned sequence number of the file
...Input file name length	HL2	The length of the following input file name
...Volume serial number length	HL2	The length of the Volume serial number
...Member name length	HL2	The length of the member name
...Input file name	CL(<i>n</i>)	The name of the input file for the compilation
...Volume serial number	CL(<i>n</i>)	The volume serial number of the (first) volume on which the input file resides
...Member name	CL(<i>n</i>)	Where applicable, the name of the member in the input file
<p>1. Where the number of input files would exceed the record size for the associated data file, the record will be continued on the next record. The current number of input files (for that record) will be stored in the record and the record written to the associated data file. The next record will contain the rest of the input files. The count of the number of input files is a count for the current record.</p>		

ADATA identification record - X'0001'

The following table shows the contents of the ADATA identification record:

Table 105. **ADATA identification record**

Field	Size	Description
Time (binary)	XL8	Universal Time (UT) as a binary number of microseconds since midnight Greenwich Mean Time, with the low-order bit representing 1 microsecond. This time can be used as a time-zone-independent time stamp. On the Windows and AIX compilers, only bytes 5-8 of the field are used as a fullword binary field containing the time.
CCSID ¹	XL2	Coded Character Set Identifier
Character Set flags	XL1	X'80' EBCDIC (IBM-037) X'40' ASCII (IBM-850)
Code Page name length	XL2	Length of the Code Page name that follows
Code Page name	CL(<i>n</i>)	Name of the Code Page
<p>1. The appropriate CCS flag will always be set. If the CCSID is set to nonzero, the Code Page name length will be zero. If the CCSID is set to zero, the Code Page name length will be nonzero and the Code Page name will be present.</p>		

Compilation unit start/end record - X'0002'

The following table shows the contents of the compilation unit start/end record:

Table 106. **SYSADATA compilation unit start/end record**

Field	Size	Description
Type	HL2	Compilation unit type, which can be one of the following: X'0000' Start compilation unit X'0001' End compilation unit
Reserved	CL2	Reserved for future use
Reserved	FL4	Reserved for future use

Options record - X'0010'

The following table shows the contents of the options record:

Table 107. **SYSADATA options record**

Field	Size	Description
Option byte 0	XL1	1111 1111 Reserved for future use

Table 107. SYSADATA options record (continued)

Field	Size	Description
Option byte 1	XL1	<p>1... Bit 1 = DECK, Bit 0 = NODECK</p> <p>.1.. Bit 1 = ADATA, Bit 0 = NOADATA</p> <p>..1. Bit 1 = COLLSEQ(EBCDIC), Bit 0 = COLLSEQ(LOCALE | BINARY) (Windows and AIX only)</p> <p>...1 Bit 1 = SEPOBJ, Bit 0 = NOSEPOBJ (Windows and AIX only)</p> <p>.... 1... Bit 1 = NAME, Bit 0 = NONAME</p> <p>.... .1.. Bit 1 = OBJECT, Bit 0 = NOOBJECT</p> <p>.... ..1. Bit 1 = SQL, Bit 0 = NOSQL</p> <p>.... ...1 Bit 1 = CICS, Bit 0 = NOCICS</p>
Option byte 2	XL1	<p>1... Bit 1 = OFFSET, Bit 0 = NOOFFSET (host only)</p> <p>.1.. Bit 1 = MAP, Bit 0 = NOMAP</p> <p>..1. Bit 1 = LIST, Bit 0 = NOLIST</p> <p>...1 Bit 1 = DBCSXREF, Bit 0 = NODBCSXREF</p> <p>.... 1... Bit 1 = XREF(SHORT), Bit 0 = not XREF(SHORT). This flag should be used in combination with the flag at bit 7. XREF(FULL) is indicated by this flag being off and the flag at bit 7 being on.</p> <p>.... .1.. Bit 1 = SOURCE, Bit 0 = NOSOURCE</p> <p>.... ..1. Bit 1 = VBREF, Bit 0 = NOVBREF</p> <p>.... ...1 Bit 1 = XREF, Bit 0 = not XREF. See also flag at bit 4 above.</p>

Table 107. SYSADATA options record (continued)

Field	Size	Description
Option byte 3	XL1	<p>1... Bit 1 = FLAG imbedded diagnostics level specified (a value <i>y</i> is specified as in FLAG(<i>x,y</i>))</p> <p>.1.. Bit 1 = FLAGSTD, Bit 0 = NOFLAGSTD</p> <p>..1. Bit 1 = NUM, Bit 0 = NONUM</p> <p>...1 Bit 1 = SEQUENCE, Bit 0 = NOSEQUENCE</p> <p>.... 1... Bit 1 = SOSI, Bit 0 = NOSOSI (Windows and AIX only)</p> <p>.... .1.. Bit 1 = NSYMBOL(NATIONAL), Bit 0 = NSYMBOL(DBCS)</p> <p>.... ..1. Bit 1 = PROFILE, Bit 0 = NOPROFILE (Windows and AIX only)</p> <p>.... ...1 Bit 1 = WORD, Bit 0 = NOWORD</p>
Option byte 4	XL1	<p>1... Bit 1 = ADV, Bit 0 = NOADV</p> <p>.1.. Bit 1 = APOST, Bit 0 = QUOTE</p> <p>..1. Bit 1 = DYNAM, Bit 0 = NODYNAM</p> <p>...1 Bit 1 = AWO, Bit 0 = NOAWO</p> <p>.... 1... Bit 1 = RMODE specified, Bit 0 = RMODE(AUTO)</p> <p>.... .1.. Bit 1 = RENT, Bit 0 = NORENT</p> <p>.... ..1. Bit 1 = RES - this flag will always be set on for COBOL.</p> <p>.... ...1 Bit 1 = RMODE(24) Bit 0 = RMODE(ANY)</p>

Table 107. SYSADATA options record (continued)

Field	Size	Description
Option byte 5	XL1	<p>1... Reserved for compatibility</p> <p>.1... Bit 1 = OPT, Bit 0 = NOOPT</p> <p>..1. Bit 1 = LIB, Bit 0 = NOLIB</p> <p>...1 Bit 1 = DBCS, Bit 0 = NODBCS</p> <p>.... 1... Bit 1 = OPT(FULL), Bit 0 = not OPT(FULL)</p> <p>.... .1.. Bit 1 = SSRANGE, Bit 0 = NOSSRANGE</p> <p>.... ..1. Bit 1 = TEST, Bit 0 = NOTEST</p> <p>.... ...1 Bit 1 = PROBE, Bit 0 = NOPROBE (Windows only)</p>
Option byte 6	XL1	<p>..1. Bit 1 = NUMPROC(PFD), Bit 0 = NUMPROC(NOPFD)</p> <p>...1 Bit 1 = NUMCLS(ALT), Bit 0 = NUMCLS(PRIM)</p> <p>.... .1.. Bit 1 = BINARY(S390), Bit 0 = BINARY(NATIVE) (Windows and AIX only)</p> <p>.... ..1. Bit 1 = TRUNC(STD), Bit 0 = TRUNC(OPT)</p> <p>.... ...1 Bit 1 = ZWB, Bit 0 = NOZWB</p> <p>11.. 1... Reserved for future use</p>
Option byte 7	XL1	<p>1... Bit 1 = ALLOWCBL, Bit 0 = NOALLOWCBL (Windows and AIX only)</p> <p>.1... Bit 1 = TERM, Bit 0 = NOTERM</p> <p>..1. Bit 1 = DUMP, Bit 0 = NODUMP</p> <p>...1 11.. Reserved</p> <p>.... ..1. Bit 1 = CURRENCY, Bit 0 = NOCURRENCY</p> <p>.... ...1 Reserved</p>

Table 107. SYSADATA options record (continued)

Field	Size	Description
Option byte 8	XL1	1111 1111 Reserved for future use
Option byte 9	XL1	1... Bit 1 = DATA(24), Bit 0 = DATA(31) .1... Bit 1 = FASTSRT, Bit 0 = NOFASTSRT ..1. Bit 1 = SIZE(MAX), Bit 0 = SIZE(<i>nnnn</i>) or SIZE(<i>nnnnK</i>) 1.. Bit 1 = THREAD, Bit 0 = NOTHREAD ...1 1.11 Reserved for future use
Option byte A	XL1	1111 1111 Reserved for future use
Option byte B	XL1	1111 1111 Reserved for future use
Option byte C	XL1	1... Bit 1 = NCOLLSEQ(LOCALE) (workstation only) .1... Reserved for future use ..1. Bit 1 = INTDATE(LILIAN), Bit 0 = INTDATE(ANSI) ...1 Bit 1 = NCOLLSEQ(BINARY) (Windows and AIX only) 1... Bit 1 = CHAR(EBCDIC), Bit 0 = CHAR(NATIVE) (Windows and AIX only) 1.. Bit 1 = FLOAT(HEX), Bit 0 = FLOAT(NATIVE) (Windows and AIX only) 1. Bit 1 = COLLSEQ(BINARY) (Windows and AIX only) 1 Bit 1 = COLLSEQ(LOCALE) (Windows and AIX only)

Table 107. SYSADATA options record (continued)

Field	Size	Description
Option byte D	XL1	<p>1... Bit 1 = DLL Bit 0 = NODLL (host only)</p> <p>.1.. Bit 1 = EXPORTALL, Bit 0 = NOEXPORTALL (host only)</p> <p>..1. Bit 1 = CODEPAGE (host only)</p> <p>...1 Bit 1 = DATEPROC, Bit 0 = NODATEPROC</p> <p>.... 1... Bit 1 = DATEPROC(FLAG), Bit 0 = DATEPROC(NOFLAG)</p> <p>.... .1.. Bit 1 = YEARWINDOW</p> <p>.... ..1. Bit 1 = WSCLEAR, Bit 0 = NOWSCLEAR (Windows and AIX only)</p> <p>.... ...1 Bit 1 = BEOPT, Bit 0 = NOBEOPT (Windows and AIX only)</p>
Option byte E	XL1	<p>1... Bit 1 = DATEPROC(TRIG), Bit 0 = DATEPROC(NOTRIG)</p> <p>.1.. Bit 1 = DIAGTRUNC, Bit 0 = NODIAGTRUNC</p> <p>.... .1.. Bit 1 = LSTFILE(UTF-8), Bit 0 = LSTFILE(LOCALE) (Windows and AIX only)</p> <p>..11 1.11 Reserved for future use</p>
Option byte F	XL1	<p>1111 1111 Reserved for future use</p>
Flag level	XL1	<p>X'00' Flag(I)</p> <p>X'04' Flag(W)</p> <p>X'08' Flag(E)</p> <p>X'0C' Flag(S)</p> <p>X'10' Flag(U)</p> <p>X'FF' Noflag</p>

Table 107. **SYSADATA options record** (continued)

Field	Size	Description
Imbedded diagnostic level	XL1	X'00' Flag(I) X'04' Flag(W) X'08' Flag(E) X'0C' Flag(S) X'10' Flag(U) X'FF' Noflag
FLAGSTD (FIPS) specification	XL1	1... Minimum .1.. Intermediate ..1. High ...1 IBM extensions 1... Level-1 Segmentation 1.. Level-2 Segmentation 1. Debugging 1 Obsolete
Reserved for flagging	XL1	1111 1111 Reserved for future use
Compiler mode	XL1	X'00' Unconditional Nocompile, Nocompile(I) X'04' Nocompile(W) X'08' Nocompile(E) X'0C' Nocompile(S) X'FF' Compile
Space value	CL1	
Data for 3-valued options	XL1	1... NAME(ALIAS) specified .1.. NUMPROC(MIG) specified ..1. TRUNC(BIN) specified ...1 1111 Reserved for future use

Table 107. **SYSADATA options record** (continued)

Field	Size	Description
TEST(hook,sym,sep) suboptions	XL1	1... TEST(ALL,x) .1.. TEST(NONE,x) ..1. TEST(STMT,x) ...1 TEST(PATH,x) 1... TEST(BLOCK,x) 1.. TEST(x,SYM) 1. Bit 1 = SEPARATE, Bit 0 = NOSEPARATE 1 Reserved for TEST suboptions
OUTDD name length	HL2	Length of OUTDD name
RWT ID Length	HL2	Length of Reserved Word Table identifier
LVLINFO	CL4	User-specified LVLINFO data
PGMNAME suboptions	XL1	1... Bit 1 = PGMNAME(COMPAT) .1.. Bit 1 = PGMNAME(LONGUPPER) ..1. Bit 1 = PGMNAME(LONGMIXED) ...1 1111 Reserved for future use
Entry interface suboptions	XL1	1... Bit 1 = EntryInterface(System) (Windows only) .1.. Bit 1 = EntryInterface(OptLink) (Windows only) ..11 1111 Reserved for future use

Table 107. SYSADATA options record (continued)

Field	Size	Description
CallInterface suboptions	XL1	1... Bit 1 = CallInterface(System) (Windows only) .1... Bit 1 = CallInterface(OptLink) (Windows only) ...1 Bit 1 = CallInterface(Cdecl) (Windows only) 1... Bit 1 = CallInterface(System(Desc)) (Windows only) ..1. .111 Reserved for future use
ARITH suboption	XL1	1... Bit 1 = ARITH(COMPAT) .1... Bit 1 = ARITH(EXTEND) 11 1111 Reserved for future use
DBCS Req	FL4	DBCS XREF storage requirement
DBCS ORDPGM length	HL2	Length of name of DBCS Ordering Program
DBCS ENCTBL length	HL2	Length of name of DBCS Encode Table
DBCS ORD TYPE	CL2	DBCS Ordering type
Reserved	CL6	Reserved for future use
Converted SO	CL1	Converted SO hexadecimal value
Converted SI	CL1	Converted SI hexadecimal value
Language id	CL2	This field holds the two-character abbreviation (one of EN, UE, JA, or JP) from the LANGUAGE option.
Reserved	CL8	Reserved for future use
INEXIT name length	HL2	Length of SYSIN user-exit name
PRTEXIT name length	HL2	Length of SYSPRINT user-exit name
LIBEXIT name length	HL2	Length of 'Library' user-exit name
ADEXIT name length	HL2	Length of ADATA user-exit name
CURROPT	CL5	CURRENCY option value
Reserved	CL1	Reserved for future use
YEARWINDOW	HL2	YEARWINDOW option value
CODEPAGE	HL2	CODEPAGE CCSID option value
Reserved	CL50	Reserved for future use
LINECNT	HL2	LINECOUNT value
Reserved	CL2	Reserved for future use

Table 107. **SYSADATA options record** (continued)

Field	Size	Description
BUFSIZE	FL4	BUFSIZE option value
Size value	FL4	SIZE option value
Reserved	FL4	Reserved for future use
Phase residence bits byte 1	XL1	<p>1... Bit 1 = IGYCLIBR in user region</p> <p>.1.. Bit 1 = IGYCSCAN in user region</p> <p>..1. Bit 1 = IGYCDSCN in user region</p> <p>...1 Bit 1 = IGYCGROU in user region</p> <p>.... 1... Bit 1 = IGYCPSCN in user region</p> <p>.... .1.. Bit 1 = IGYCPANA in user region</p> <p>.... ..1. Bit 1 = IGYCFGEN in user region</p> <p>.... ...1 Bit 1 = IGYCPGEN in user region</p>
Phase residence bits byte 2	XL1	<p>1... Bit 1 = IGYCOPTM in user region</p> <p>.1.. Bit 1 = IGYCLSTR in user region</p> <p>..1. Bit 1 = IGYCXREF in user region</p> <p>...1 Bit 1 = IGYCDMAP in user region</p> <p>.... 1... Bit 1 = IGYCASM1 in user region</p> <p>.... .1.. Bit 1 = IGYCASM2 in user region</p> <p>.... ..1. Bit 1 = IGYCDIAG in user region</p> <p>.... ...1 Reserved for future use</p>
Phase residence bits bytes 3 and 4	XL2	Reserved
Reserved	CL8	Reserved for future use
OUTDD name	CL(<i>n</i>)	OUTDD name
RWT	CL(<i>n</i>)	Reserved word table identifier
DBCS ORDPGM	CL(<i>n</i>)	DBCS Ordering program name
DBCS ENCTBL	CL(<i>n</i>)	DBCS Encode table name
INEXIT name	CL(<i>n</i>)	SYSIN user-exit name

Table 107. **SYSADATA options record** (continued)

Field	Size	Description
PRTEXIT name	CL(<i>n</i>)	SYSPRINT user-exit name
LIBEXIT name	CL(<i>n</i>)	'Library' user-exit name
ADEXIT name	CL(<i>n</i>)	ADATA user-exit name

External symbol record - X'0020'

The following table shows the contents of the external symbol record:

Table 108. **SYSADATA external symbol record**

Field	Size	Description
Section type	XL1	<p>X'00' PROGRAM-ID Name Main entry point name</p> <p>X'01' ENTRY Name Secondary entry point name</p> <p>X'02' External Reference Referenced external entry point</p> <p>X'04' N/A for COBOL</p> <p>X'05' N/A for COBOL</p> <p>X'06' N/A for COBOL</p> <p>X'0A' N/A for COBOL</p> <p>X'12' Internal Reference Referenced internal subprogram</p> <p>X'C0' External CLASS Name OO COBOL CLASS definition</p> <p>X'C1' METHOD-ID Name OO COBOL Method definition</p> <p>X'C6' Method Reference OO COBOL Method reference</p> <p>X'FF' N/A for COBOL</p> <p>Types X'12', X'C0', X'C1' and X'C6X' are for COBOL only.</p>
Flags	XL1	N/A for COBOL
Reserved	HL2	Reserved for future use
Symbol-id	FL4	Symbol-id of program that contains the reference (only for types x'02' and x'12')
Line number	FL4	Line number of statement that contains the reference (only for types x'02' and x'12')
Section length	FL4	N/A for COBOL
LD ID	FL4	N/A for COBOL
Reserved	CL8	Reserved for future use
External Name length	HL2	Number of characters in the external name
Alias Name length	HL2	N/A for COBOL
External Name	CL(<i>n</i>)	The external name

Table 108. SYSADATA external symbol record (continued)

Field	Size	Description
Alias Section name	CL(<i>n</i>)	N/A for COBOL

Parse tree record - X'0024'

The following table shows the contents of the parse tree record:

Table 109. SYSADATA parse tree record

Field	Size	Description
Node number	FL4	The node number generated by the compiler, starting at 1
Node type	HL2	The type of the node: 001 Program 002 Class 003 Method
		101 Identification Division 102 Environment Division 103 Data Division 104 Procedure Division 105 End Program/Method/Class
		201 Declaratives body 202 Nondeclaratives body
		301 Section 302 Procedure section
		401 Paragraph 402 Procedure paragraph
		501 Sentence 502 File definition 503 Sort file definition 504 Program name 505 Program attribute 508 ENVIRONMENT DIVISION clause 509 CLASS attribute 510 METHOD attribute 511 USE statement

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		601 Statement 602 Data description clause 603 Data entry 604 File description clause 605 Data entry name 606 Data entry level 607 EXEC entry
		701 EVALUATE subject phrase 702 EVALUATE WHEN phrase 703 EVALUATE WHEN OTHER phrase 704 SEARCH WHEN phrase 705 INSPECT CONVERTING phrase 706 INSPECT REPLACING phrase 707 INSPECT TALLYING phrase 708 PERFORM UNTIL phrase 709 PERFORM VARYING phrase 710 PERFORM AFTER phrase 711 Statement block 712 Scope Terminator 713 INITIALIZE REPLACING phrase 714 EXEC CICS Command 720 DATA DIVISION phrase
		801 Phrase 802 ON phrase 803 NOT phrase 804 THEN phrase 805 ELSE phrase 806 Condition 807 Expression 808 Relative indexing 809 EXEC CICS Option 810 Reserved word 811 INITIALIZE REPLACING category

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		901 Section or paragraph name 902 Identifier 903 Alphabet-name 904 Class-name 905 Condition-name 906 File-name 907 Index-name 908 Mnemonic-name 910 Symbolic-character 911 Literal 912 Function identifier 913 Data-name 914 Special register 915 Procedure reference 916 Arithmetic operator 917 All Procedures 918 INITIALIZE literal (no tokens) 919 ALL literal or figcon 920 Keyword class test name 921 Reserved word at identifier level 922 Unary operator 923 Relational operator
		1001 Subscript 1002 Reference modification
Node subtype	HL2	The subtype of the node. For Section type: 0001 CONFIGURATION Section 0002 INPUT-OUTPUT Section 0003 FILE Section 0004 WORKING-STORAGE Section 0005 LINKAGE Section 0006 LOCAL-STORAGE Section 0007 REPOSITORY Section

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For Paragraph type:
		0001 PROGRAM-ID paragraph
		0002 AUTHOR paragraph
		0003 INSTALLATION paragraph
		0004 DATE-WRITTEN paragraph
		0005 SECURITY paragraph
		0006 SOURCE-COMPUTER paragraph
		0007 OBJECT-COMPUTER paragraph
		0008 SPECIAL-NAMES paragraph
		0009 FILE-CONTROL paragraph
		0010 I-O-CONTROL paragraph
		0011 DATE-COMPILED paragraph
		0012 CLASS-ID paragraph
		0013 METHOD-ID paragraph
		0014 REPOSITORY paragraph
		For Environment Division clause type:
		0001 WITH DEBUGGING MODE
		0002 MEMORY-SIZE
		0003 SEGMENT-LIMIT
		0004 CURRENCY-SIGN
		0005 DECIMAL POINT
		0006 PROGRAM COLLATING SEQUENCE
		0007 ALPHABET
		0008 SYMBOLIC-CHARACTER
		0009 CLASS
		0010 ENVIRONMENT NAME
		0011 SELECT

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For Data description clause type:
		0001 BLANK WHEN ZERO
		0002 DATA-NAME OR FILLER
		0003 JUSTIFIED
		0004 OCCURS
		0005 PICTURE
		0006 REDEFINES
		0007 RENAMES
		0008 SIGN
		0009 SYNCHRONIZED
		0010 USAGE
		0011 VALUE
		0023 GLOBAL
		0024 EXTERNAL

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For File description clause type:
		0001 FILE STATUS
		0002 ORGANIZATION
		0003 ACCESS MODE
		0004 RECORD KEY
		0005 ASSIGN
		0006 RELATIVE KEY
		0007 PASSWORD
		0008 PROCESSING MODE
		0009 RECORD DELIMITER
		0010 PADDING CHARACTER
		0011 BLOCK CONTAINS
		0012 RECORD CONTAINS
		0013 LABEL RECORDS
		0014 VALUE OF
		0015 DATA RECORDS
		0016 LINAGE
		0017 ALTERNATE KEY
		0018 LINES AT TOP
		0019 LINES AT BOTTOM
		0020 CODE-SET
		0021 RECORDING MODE
		0022 RESERVE
		0023 GLOBAL
		0024 EXTERNAL
		0025 LOCK

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For Statement type:
		0002 NEXT SENTENCE
		0003 ACCEPT
		0004 ADD
		0005 ALTER
		0006 CALL
		0007 CANCEL
		0008 CLOSE
		0009 COMPUTE
		0010 CONTINUE
		0011 DELETE
		0012 DISPLAY
		0013 DIVIDE (INTO)
		0113 DIVIDE (BY)
		0014 ENTER
		0015 ENTRY
		0016 EVALUATE
		0017 EXIT
		0018 GO
		0019 GOBACK
		0020 IF
		0021 INITIALIZE
		0022 INSPECT

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		0023 INVOKE
		0024 MERGE
		0025 MOVE
		0026 MULTIPLY
		0027 OPEN
		0028 PERFORM
		0029 READ
		0030 READY
		0031 RELEASE
		0032 RESET
		0033 RETURN
		0034 REWRITE
		0035 SEARCH
		0036 SERVICE
		0037 SET
		0038 SORT
		0039 START
		0040 STOP
		0041 STRING
		0042 SUBTRACT
		0043 UNSTRING
		0044 EXEC SQL
		0144 EXEC CICS
		0045 WRITE
		0046 XML

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For Phrase type:
		0001 INTO
		0002 DELIMITED
		0003 INITIALIZE. .REPLACING
		0004 INSPECT. .ALL
		0005 INSPECT. .LEADING
		0006 SET. .TO
		0007 SET. .UP
		0008 SET. .DOWN
		0009 PERFORM. .TIMES
		0010 DIVIDE. .REMAINDER
		0011 INSPECT. .FIRST
		0012 SEARCH. .VARYING
		0013 MORE-LABELS
		0014 SEARCH ALL
		0015 SEARCH. .AT END
		0016 SEARCH. .TEST INDEX
		0017 GLOBAL
		0018 LABEL
		0019 DEBUGGING
		0020 SEQUENCE
		0021 Reserved for future use
		0022 Reserved for future use
		0023 Reserved for future use
		0024 TALLYING
		0025 Reserved for future use
		0026 ON SIZE ERROR
		0027 ON OVERFLOW
		0028 ON ERROR
		0029 AT END
		0030 INVALID KEY

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		0031 END-OF-PAGE
		0032 USING
		0033 BEFORE
		0034 AFTER
		0035 EXCEPTION
		0036 CORRESPONDING
		0037 Reserved for future use
		0038 RETURNING
		0039 GIVING
		0040 THROUGH
		0041 KEY
		0042 DELIMITER
		0043 POINTER
		0044 COUNT
		0045 METHOD
		0046 PROGRAM
		0047 INPUT
		0048 OUTPUT
		0049 I-O
		0050 EXTEND
		0051 RELOAD
		0052 ASCENDING
		0053 DESCENDING
		0054 DUPLICATES
		0055 NATIVE (USAGE)
		0056 INDEXED
		0057 FROM
		0058 FOOTING
		0059 LINES AT BOTTOM
		0060 LINES AT TOP

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For Function identifier type:
		0001 COS
		0002 LOG
		0003 MAX
		0004 MIN
		0005 MOD
		0006 ORD
		0007 REM
		0008 SIN
		0009 SUM
		0010 TAN
		0011 ACOS
		0012 ASIN
		0013 ATAN
		0014 CHAR
		0015 MEAN
		0016 SQRT
		0017 LOG10
		0018 RANGE
		0019 LENGTH
		0020 MEDIAN
		0021 NUMVAL
		0022 RANDOM
		0023 ANNUITY
		0024 INTEGER
		0025 ORD-MAX
		0026 ORD-MIN
		0027 REVERSE
		0028 MIDRANGE
		0029 NUMVAL-C
		0030 VARIANCE
		0031 FACTORIAL
		0032 LOWER-CASE

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		0033 UPPER-CASE 0034 CURRENT-DATE 0035 INTEGER-PART 0036 PRESENT-VALUE 0037 WHEN-COMPILED 0038 DAY-OF-INTEGERS 0039 INTEGER-OF-DAY 0040 DATE-OF-INTEGERS 0041 INTEGER-OF-DATE 0042 STANDARD-DEVIATION 0043 YEAR-TO-YYYY 0044 DAY-TO-YYYYDDD 0045 DATE-TO-YYYYMMDD 0046 UNDATE 0047 DATEVAL 0048 YEARWINDOW 0049 DISPLAY-OF 0050 NATIONAL-OF
		For Special Register type: 0001 ADDRESS OF 0002 LENGTH OF
		For Keyword Class Test Name type: 0001 ALPHABETIC 0002 ALPHABETIC-LOWER 0003 ALPHABETIC-UPPER 0004 DBCS 0005 KANJI 0006 NUMERIC 0007 NEGATIVE 0008 POSITIVE 0009 ZERO
		For Reserved Word type: 0001 TRUE 0002 FALSE 0003 ANY 0004 THRU

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		For Identifier, Data-name, Index-name, Condition-name or Mnemonic-name type: 0001 REFERENCED 0002 CHANGED 0003 REFERENCED & CHANGED
		For Initialize literal type: 0001 ALPHABETIC 0002 ALPHANUMERIC 0003 NUMERIC 0004 ALPHANUMERIC-EDITED 0005 NUMERIC-EDITED 0006 DBCS/EGCS 0007 NATIONAL
		For Procedure name type: 0001 SECTION 0002 PARAGRAPH
		For Reserved word at identifier level type: 0001 ROUNDED 0002 TRUE 0003 ON 0004 OFF 0005 SIZE 0006 DATE 0007 DAY 0008 DAY-OF-WEEK 0009 TIME 0010 WHEN-COMPILED 0011 PAGE 0012 DATE YYYYMMDD 0013 DAY YYYYDDD
		For Arithmetic Operator type: 0001 PLUS 0002 MINUS 0003 TIMES 0004 DIVIDE 0005 DIVIDE REMAINDER 0006 EXPONENTIATE 0007 NEGATE

Table 109. SYSADATA parse tree record (continued)

Field	Size	Description
		<p>For Relational Operator type:</p> <p>0008 LESS</p> <p>0009 LESS OR EQUAL</p> <p>0010 EQUAL</p> <p>0011 NOT EQUAL</p> <p>0012 GREATER</p> <p>0013 GREATER OR EQUAL</p> <p>0014 AND</p> <p>0015 OR</p> <p>0016 CLASS CONDITION</p> <p>0017 NOT CLASS CONDITION</p>
Parent node number	FL4	The node number of the parent of the node
Left sibling node number	FL4	The node number of the left sibling of the node, if any. If none, the value is zero.
Symbol Id	FL4	<p>The Symbol Id of the node, if it is a user-name of one of the following types:</p> <ul style="list-style-type: none"> • data entry • identifier • file-name • index-name • procedure-name • condition-name • mnemonic-name <p>This value corresponds to the Symbol ID in a Symbol (Type 42) record, except for procedure-names where it corresponds to the Paragraph ID.</p> <p>For all other node types this value is zero.</p>
Section Symbol Id	FL4	<p>The Symbol Id of the section containing the node, if it is a qualified paragraph-name reference. This value corresponds to the Section ID in a Symbol (Type 42) record.</p> <p>For all other node types this value is zero.</p>
First token number	FL4	The number of the first token associated with the node
Last token number	FL4	The number of the last token associated with the node
Reserved	FL4	Reserved for future use
Flags	CL1	<p>Information about the node:</p> <p>X'80' Reserved</p> <p>X'40' Generated node, no tokens</p>
Reserved	CL3	Reserved for future use

Token record - X'0030'

The following table shows the contents of the token record:

Table 110. SYSADATA token record

Field	Size	Description
Token number	FL4	The token number within the source file generated by the compiler, starting at 1. Any copybooks have already been included in the source.
Token code	HL2	The type of token (user-name, literal, reserved word, etc.). For reserved words, the compiler reserved word table values are used. For PICTURE strings, the special code 0000 is used. For (other than the last) piece of a continued token, the special code 3333 is used.
Token length	HL2	The length of the token
Token column	FL4	The starting column number of the token on the source line
Token line	FL4	The line number of the token
Flags	CL1	Information about the token: X'80' Token is continued X'40' Last piece of continued token Note that for PICTURE strings, even if the source token is continued, there will be only one Token record generated. It will have a token code of 0000, the token column and line of the first piece, the length of the complete string, no continuation flags set, and the token text of the complete string.
Reserved	CL7	Reserved for future use
Token text	CL(n)	The actual token string

Source error record - X'0032'

The following table shows the contents of the source error record:

Table 111. SYSADATA source error record

Field	Size	Description
Statement number	FL4	The statement number of the statement in error
Error identifier	CL16	The error message identifier (left-justified and padded with blanks)
Error severity	HL2	The severity of the error
Error message length	HL2	The length of the error message text
Line position	XL1	The line position indicator provided in FIPS messages
Reserved	CL7	Reserved for future use
Error message	CL(n)	The error message text

Source record - X'0038'

The following table shows the contents of the source record:

Table 112. **SYSADATA source record**

Field	Size	Description
Line number	FL4	The listing line number of the source record
Input record number	FL4	The input source record number in the current input file
Primary file number	HL2	The input file's assigned sequence number if this record is from the primary input file. (Refer to the Input file <i>n</i> in the Job identification record).
Library file number	HL2	The library input file's assigned sequence number if this record is from a COPY/BASIS input file. (Refer to the Member File ID <i>n</i> in the Library record.)
Reserved	CL8	Reserved for future use
Parent record number	FL4	The parent source record number. This will be the record number of the COPY/BASIS statement.
Parent primary file number	HL2	The parent file's assigned sequence number if the parent of this record is from the primary input file. (Refer to the Input file <i>n</i> in the Job Identification Record.)
Parent library assigned file number	HL2	The parent library file's assigned sequence number if this record's parent is from a COPY/BASIS input file. (Refer to the COPY/BASIS Member File ID <i>n</i> in the Library record.)
Reserved	CL8	Reserved for future use
Length of source record	HL2	The length of the actual source record following
Reserved	CL10	Reserved for future use
Source record	CL(<i>n</i>)	

COPY REPLACING record - X'0039'

One COPY REPLACING type record will be put out for each time a REPLACING action takes place. That is, whenever *operand-1* of the REPLACING phrase is matched with text in the copybook, a COPY REPLACING TEXT record will be written.

The following table shows the contents of the COPY REPLACING record:

Table 113. **SYSADATA COPY REPLACING record**

Field	Size	Description
Starting line number of REPLACED string	FL4	The listing line number of the start of the text that resulted from the REPLACING
Starting column number of REPLACED string	FL4	The listing column number of the start of the text that resulted from the REPLACING
Ending line number of REPLACED string	FL4	The listing line number of the end of the text that resulted from the REPLACING
Ending column number of REPLACED string	FL4	The listing column number of the end of the text that resulted from the REPLACING

Table 113. **SYSADATA COPY REPLACING record** (continued)

Field	Size	Description
Starting line number of original string	FL4	The source file line number of the start of the text that was changed by the REPLACING
Starting column number of original string	FL4	The source file column number of the start of the text that was changed by the REPLACING
Ending line number of original string	FL4	The source file line number of the end of the text that was changed by the REPLACING
Ending column number of original string	FL4	The source file column number of the end of the text that was changed by the REPLACING

Symbol record - X'0042'

The following table shows the contents of the symbol record:

Table 114. **SYSADATA symbol record**

Field	Size	Description
Symbol ID	FL4	Unique ID of symbol
Line number	FL4	The listing line number of the source record in which the symbol is defined or declared
Level	XL1	True level number of symbol (or relative level number of a data item within a structure). For COBOL, this can be in the range 01-49, 66 (for Renames items), 77, or 88 (for condition items).
Qualification Indicator	XL1	<p>X'00' Unique name; no qualification needed.</p> <p>X'01' This data item needs qualification. The name is not unique within the program. This field applies <i>only</i> when this data item is NOT the level-01 name.</p>
Symbol type	XL1	<p>X'68' Class-name (Class-ID)</p> <p>X'58' Method-name</p> <p>X'40' Data-name</p> <p>X'20' Procedure-name</p> <p>X'10' Mnemonic-name</p> <p>X'08' Program-name</p> <p>X'81' Reserved</p> <p>The following are ORed into the above types, when applicable:</p> <p>X'04' External</p> <p>X'02' Global</p>

Table 114. **SYSADATA symbol record** (continued)

Field	Size	Description
Symbol attribute	XL1	X'01' Numeric
		X'02' Alphanumeric
		X'03' Group
		X'04' Pointer
		X'05' Index data item
		X'06' Index-name
		X'07' Condition
		X'0F' File
		X'10' Sort file
		X'17' Class-name (Repository)
		X'18' Object Reference

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
Clauses	XL1	<p>Clauses specified in symbol definition.</p> <p>For numeric, alphanumeric, group, and index symbols</p> <p>1... Value</p> <p>.1.. Indexed</p> <p>..1. Redefines</p> <p>...1 Renames</p> <p>.... 1... Occurs</p> <p>.... .1.. Has Occurs keys</p> <p>.... ..1. Occurs Depending On</p> <p>.... ...1 Occurs in parent</p> <p>For both file types</p> <p>1... Select</p> <p>.1.. Assign</p> <p>..1. Rerun</p> <p>...1 Same area</p> <p>.... 1... Same record area</p> <p>.... .1.. Recording mode</p> <p>.... ..1. Reserved</p> <p>.... ...1 Record</p>

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
		For mnemonic-name symbols
	01	CSP
	02	C01
	03	C02
	04	C03
	05	C04
	06	C05
	07	C06
	08	C07
	09	C08
	10	C09
	11	C10
	12	C11
	13	C12
	14	S01
	15	S02
	16	S03
	17	S04
	18	S05
	19	CONSOLE
	20	SYSIN/SYSIPT
	22	SYSOUT/SYSLST/SYSLIST
	24	SYSPUNCH/SYSPCH
	26	UPSI-0
	27	UPSI-1
	28	UPSI-2
	29	UPSI-3
	30	UPSI-4
	31	UPSI-5
	32	UPSI-6
	33	UPSI-7
	34	AFP-5A

Table 114. **SYSADATA symbol record** (continued)

Field	Size	Description
Data flags 1	XL1	<p>For both file types, and numeric, alphanumeric, group, and index symbols</p> <p>1... Redefined</p> <p>.1.. Renamed</p> <p>..1. Synchronized</p> <p>...1 Implicitly redefined</p> <p>.... 1... Date field</p> <p>.... .1.. Implicit redefines</p> <p>.... ..1. FILLER</p> <p>.... ...1 Level 77</p>

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
Data flags 2	XL1	<p>For numeric symbols</p> <p>1... Binary</p> <p>.1.. External floating point</p> <p>..1. Internal floating point</p> <p>...1 Packed</p> <p>.... 1... Zoned</p> <p>.... .1.. Scaled negative</p> <p>.... ..1. Numeric edited</p> <p>.... ...1 Reserved for future use</p> <p>For alphanumeric symbols (including Group items)</p> <p>1... Alphabetic</p> <p>.1.. Alphanumeric</p> <p>..1. Alphanumeric edited</p> <p>...1 Group contains its own ODO object</p> <p>.... 1... DBCS item</p> <p>.... .1.. Group variable length</p> <p>.... ..1. EGCS item</p> <p>.... ...1 EGCS edited</p>

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
		<p>For both file types</p> <p>1... Object of ODO in record</p> <p>.1.. Subject of ODO in record</p> <p>..1. Sequential access</p> <p>...1 Random access</p> <p>.... 1... Dynamic access</p> <p>.... .1.. Locate mode</p> <p>.... ..1. Record area</p> <p>.... ...1 Reserved for future use</p> <p>Field will be zero for all other data types.</p>
Data flags 3	XL1	<p>For both file types</p> <p>1... All records are the same length</p> <p>.1.. Fixed length</p> <p>..1. Variable length</p> <p>...1 Undefined</p> <p>.... 1... Spanned</p> <p>.... .1.. Blocked</p> <p>.... ..1. Apply write only</p> <p>.... ...1 Same sort merge area</p> <p>Field will be zero for all other data types.</p>

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
File organization	XL1	<p>For both file types</p> <p>1... QSAM</p> <p>.1.. ASCII</p> <p>..1. Standard label</p> <p>...1 User label</p> <p>.... 1... VSAM sequential</p> <p>.... .1.. VSAM indexed</p> <p>.... ..1. VSAM relative</p> <p>.... ...1 Line Sequential</p> <p>Field will be zero for all other data types.</p>
USAGE clause	FL1	<p>X'00' USAGE IS DISPLAY</p> <p>X'01' USAGE IS COMP-1</p> <p>X'02' USAGE IS COMP-2</p> <p>X'03' USAGE IS PACKED-DECIMAL or USAGE IS COMP-3</p> <p>X'04' USAGE IS BINARY, USAGE IS COMP, or USAGE IS COMP-4</p> <p>X'05' USAGE IS DISPLAY-1</p> <p>X'06' USAGE IS POINTER</p> <p>X'07' USAGE IS INDEX</p> <p>X'08' USAGE IS PROCEDURE-POINTER</p> <p>X'09' USAGE IS OBJECT-REFERENCE</p> <p>X'0B' NATIONAL</p> <p>X'0A' FUNCTION-POINTER</p>
Sign clause	FL1	<p>X'00' No SIGN clause</p> <p>X'01' SIGN IS LEADING</p> <p>X'02' SIGN IS LEADING SEPARATE CHARACTER</p> <p>X'03' SIGN IS TRAILING</p> <p>X'04' SIGN IS TRAILING SEPARATE CHARACTER</p>
Indicators	FL1	<p>X'01' Has JUSTIFIED clause. Right-justified attribute is in effect.</p> <p>X'02' Has BLANK WHEN ZERO clause.</p>

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
Size	FL4	The size of this data item. The actual number of bytes this item occupies in storage. If a DBCS item, the number is in bytes, not characters. For variable-length items, this field will reflect the maximum size of storage reserved for this item by the compiler. Also known as the "Length attribute."
Precision	FL1	The precision of a FIXED or FLOAT data item
Scale	FL1	The scale factor of a FIXED data item. This is the number of digits to the right of the decimal point.
Base locator type	FL1	<p>For host:</p> <p>01 Base Locator File</p> <p>02 Base Locator Working-Storage</p> <p>03 Base Locator Linkage Section</p> <p>05 Base Locator Special regs</p> <p>07 Indexed by variable</p> <p>09 COMREG special reg</p> <p>10 UPSI switch</p> <p>13 Base Locator for Varloc items</p> <p>14 Base Locator for Extern data</p> <p>15 Base Locator Alphanumeric FUNC</p> <p>16 Base Locator Alphanumeric EVAL</p> <p>17 Base Locator for Object data</p> <p>19 Base Locator for Local-Storage</p> <p>20 Factory Data</p> <p>21 XML-TEXT</p> <p>For Windows and AIX:</p> <p>01 Base Locator File</p> <p>02 Base Locator Linkage Section</p> <p>03 Base Locator for Varloc items</p> <p>04 Base Locator for Extern data</p> <p>05 Base Locator for Object data</p> <p>10 Base Locator Working-Storage</p> <p>11 Base Locator Special regs</p> <p>12 Base Locator Alphanumeric FUNC</p> <p>13 Base Locator Alphanumeric EVAL</p> <p>14 Indexed by variable</p> <p>16 COMREG special reg</p> <p>17 UPSI switch</p> <p>22 Base Locator for Local-Storage</p>

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
Date Format	FL1	Date Format: 01 YY 02 YYXX 03 YYYYXX 04 YYYYX 05 YYYY 06 YYYYXX 07 YYYYXXXX 08 YYYYXXX 09 YYX 10 YYYYX 22 XYY 23 XXXYY 24 XXXYY 26 XXXYYY 27 XXXYYYY 28 XXXYYYY 29 XYY 30 XXXYY
Reserved	FL4	Reserved for future use
Addressing information	FL4	For host, the Base Locator number and displacement: Bits 0-4 Unused Bits 5-19 Base Locator (BL) number Bits 20-31 Displacement off Base Locator For Windows and AIX, the W-code SymId.
Structure Displacement	AL4	Offset of symbol within structure. This offset is set to 0 for variably located items.
Parent Displacement	AL4	Byte offset from immediate parent of the item being defined.
Parent ID	FL4	The symbol ID of the immediate parent of the item being defined.
Redefined ID	FL4	The symbol ID of the data item that this item redefines, if applicable.
Start-Renamed ID	FL4	If this item is a 66-level item, the symbol ID of the starting COBOL data item that this item renames. If not a 66-level item, this field is set to 0.
End-Renamed ID	FL4	If this item is a 66-level item, the symbol ID of the ending COBOL data item that this item renames. If not a 66-level item, this field is set to 0.

Table 114. SYSADATA symbol record (continued)

Field	Size	Description
Program Name Symbol ID	FL4	ID of the Program name of the Program or the Class name of the Class where this symbol is defined.
OCCURS Minimum / Paragraph ID	FL4	Minimum value for OCCURS Proc-name ID for a paragraph-name
OCCURS Maximum / Section ID	FL4	Maximum value for OCCURS Proc-name ID for a section-name
Dimensions	FL4	Number of dimensions
Reserved	CL12	Reserved for future use
Value Pairs Count	HL2	Count of value pairs
Symbol name length	HL2	Number of characters in the symbol name
Picture data length for data name	HL2	Number of characters in the picture data—zero if symbol has no associated PICTURE clause. (Length of the PICTURE field.) Length will represent the field as it is found in the source input. This length does not represent the expanded field for picture items containing a replication factor. The maximum COBOL length for a PICTURE string is 50 bytes. Zero in this field indicates no PICTURE specified.
Assignment name length for file name		Number of characters in the external file name if this is a file name. This is the DD name part of the assignment name. Zero if file name and ASSIGN USING specified.
Initial value length for data name	HL2	Number of characters in the symbol value—zero if symbol has no initial value.
External CLASS name length for CLASS-ID		Number of characters in the external CLASS name for CLASS-ID
ODO Symbol name ID for data-name	FL4	If data-name, ID of the ODO symbol name—zero if ODO not specified.
ID of ASSIGN date name if file name		If file-name, Symbol-ID for ASSIGN USING data-name—zero if ASSIGN TO specified
Keys Count	HL2	The number of keys defined
Index Count	HL2	Count of Index symbol IDs; zero if none specified
Symbol name	CL(n)	
Picture data string for data-name	CL(n)	The PICTURE character string <i>exactly</i> as the user types it in. The character string includes all symbols, parentheses, and replication factor.
Assignment-name for file-name		The external file name if this is a file name. This is the DD name part of the assignment name.
Index ID List	(n)FL4	ID of each index symbol name
Keys	(n)XL8	This field contains data describing keys specified for an array. The following three fields are repeated as many times as specified in the Keys Count field.

Table 114. **SYSADATA symbol record** (continued)

Field	Size	Description
...Key Sequence	FL1	Ascending/Descending Indicator. X'00' DESCENDING X'01' ASCENDING
...Filler	CL3	Reserved
...Key ID	FL4	The symbol ID of the data item that is the key field in the array
Initial Value data for data-name External class-name for CLASS-ID	CL(<i>n</i>)	This field contains the data specified in the INITIAL VALUE clause for this symbol. The following four subfields are repeated according to the count in the Value Pairs Count field. The total length of the data in this field is contained in the 'Initial value length' field. The external class-name for CLASS-ID.
...1st value length	HL2	Length of first value
...1st value data	CL(<i>n</i>)	1st value. This field contains the literal (or figurative constant) as it is specified in the VALUE clause in the source file. It includes any beginning and ending delimiters, embedded quotation marks, and SHIFT IN and SHIFT OUT characters. If the literal spans multiple lines, the lines are concatenated into one long string. If a figurative constant is specified, this field contains the actual reserved word, not the value associated with that word.
...2nd value length	HL2	Length of second value—zero if not a THRU value pair
...2nd value data	CL(<i>n</i>)	2nd value. This field contains the literal (or figurative constant) as it is specified in the VALUE clause in the source file. It includes any beginning and ending delimiters, embedded quotation marks, and SHIFT IN and SHIFT OUT characters. If the literal spans multiple lines, the lines are concatenated into one long string. If a figurative constant is specified, this field contains the actual reserved word, not the value associated with that word.

Symbol cross-reference record - X'0044'

The following table shows the contents of the symbol cross-reference record:

Table 115. **SYSADATA symbol cross-reference record**

Field	Size	Description
Symbol length	HL2	The length of the symbol
Statement definition	FL4	The statement number where the symbol is defined or declared For VERB XREF only: Verb count - total number of references to this verb.
Number of references ¹	HL2	The number of references in this record to the symbol following

Table 115. **SYSADATA symbol cross-reference record** (continued)

Field	Size	Description
Cross-reference type	XL1	X'01' Program X'02' Procedure X'03' Verb X'04' Symbol or data-name X'05' Method X'06' Class
Reserved	CL7	Reserved for future use
Symbol name	CL(<i>n</i>)	The symbol. Variable length.
...Reference flag	CL1	For symbol or data-name references: C' ' Blank means reference only C'M' Modification reference flag For Procedure type symbol references: C'A' ALTER (procedure name) C'D' GO TO (procedure name) DEPENDING ON C'E' End of range of (PERFORM) through (procedure name) C'G' GO TO (procedure name) C'P' PERFORM (procedure name) C'T' (ALTER) TO PROCEED TO (procedure name) C'U' use for debugging (procedure name)
...Statement number	XL4	The statement number on which the symbol or verb is referenced
<p>1. The reference flag field and the statement number field occur as many times as the number of references field dictates.</p> <p>For example, if there is a value of 10 in the number of references field, there will be 10 occurrences of the reference flag and statement number pair in the case of data-name, procedure, or program symbols, or 10 occurrences of the statement number in the case of verbs.</p> <p>Where the number of references would exceed the record size for the SYSADATA file, the record is continued on the next record. The continuation flag is set in the common header section of the record.</p>		

Nested program record - X'0046'

The following table shows the contents of the nested program record:

Table 116. **SYSADATA nested program record**

Field	Size	Description
Statement definition	FL4	The statement number that the symbol is defined or declared
Nesting level	XL1	Program Nesting level

Table 116. **SYSADATA nested program record** (continued)

Field	Size	Description
Program attributes	XL1	1... Initial .1... Common ...1. PROCEDURE DIVISION using ...1 1111 Reserved for future use
Reserved	XL1	Reserved for future use
Program name length	XL1	Length of the following field
Program name	CL(<i>n</i>)	The program name

Library record - X'0060'

The following table shows the contents of the library record:

Table 117. **SYSADATA library record**

Field	Size	Description
Number of members ¹	HL2	Count of the number of COPY/INCLUDE code members described in this record
Library name length	HL2	The length of the library name
Library volume length	HL2	The length of the library volume ID
Concatenation number	XL2	Concatenation number of the library
Library ddname length	HL2	The length of the library ddnam
Reserved	CL4	Reserved for future use
Library name	CL(<i>n</i>)	The name of the library from which the COPY/INCLUDE member was retrieved
Library volume	CL(<i>n</i>)	The volume identification of the volume where the library resides
Library ddname	CL(<i>n</i>)	The ddname (or equivalent) used for this library
...COPY/BASIS member file ID ²	HL2	The library file ID of the name following
...COPY/BASIS name length	HL2	The length of the name following
...COPY/BASIS name	CL(<i>n</i>)	The name of the COPY/BASIS member that has been used
<ol style="list-style-type: none"> 1. If 10 COPY members are retrieved from a library, the 'Number of members' field will contain 10 and there will be 10 occurrences of the 'COPY/BASIS member file ID' field, the 'COPY/BASIS name length' field, and the 'COPY/BASIS name' field. 2. If COPY/BASIS members are retrieved from different libraries, a library record is written to the SYSADATA file for each unique library. 		

Statistics record - X'0090'

The following table shows the contents of the statistics record:

Table 118. SYSADATA statistics record

Field	Size	Description
Source records	FL4	The number of source records processed
DATA DIVISION statements	FL4	The number of data division statements processed
PROCEDURE DIVISION statements	FL4	The number of procedure division statements processed
Compilation number	HL2	Batch compilation number
Error severity	XL1	The highest error message severity
Flags	XL1	1... End of Job indicator .1... Class Definition indicator ..11 1111 Reserved for future use
EOJ severity	XL1	The maximum return code for the compile job
Program name length	XL1	The length of the program name
Program name	CL(<i>n</i>)	Program name

EVENTS record - X'0120'

Events records are included in the ADATA file to provide compatibility with previous levels of the compiler.

The following table shows the contents of the EVENTS record:

Table 119. SYSADATA EVENTS record

Field	Size	Description
Header	CL12	Standard ADATA record header
Record length	HL2	Length of following EVENTS record data (excluding this halfword)
EVENTS data	CL(<i>n</i>)	The EVENTS data as previously presented in the SYSEVENT file

Appendix H. Sample programs

This material contains information about the sample programs that are included on your product tape:

- Overview of the programs, including program charts for two of the samples
- Format and sample of the input data
- Sample of reports produced
- Information about how to run the programs
- List of the language elements and concepts that are illustrated

Pseudocode and other comments regarding these programs are included in the program prologue, which you can obtain in a program listing.

The sample programs in this material demonstrate many language elements and concepts of COBOL:

- IGYTCARA is an example of using QSAM files and VSAM indexed files and shows how to use many COBOL intrinsic functions.
- IGYTCARB is an example of using IBM Interactive System Product Facility (ISPF).
- IGYTSALE is an example of using several of the Language Environment callable services features.

RELATED CONCEPTS

"IGYTCARA: batch application"

"IGYTCARB: interactive program" on page 709

"IGYTSALE: nested program application" on page 711

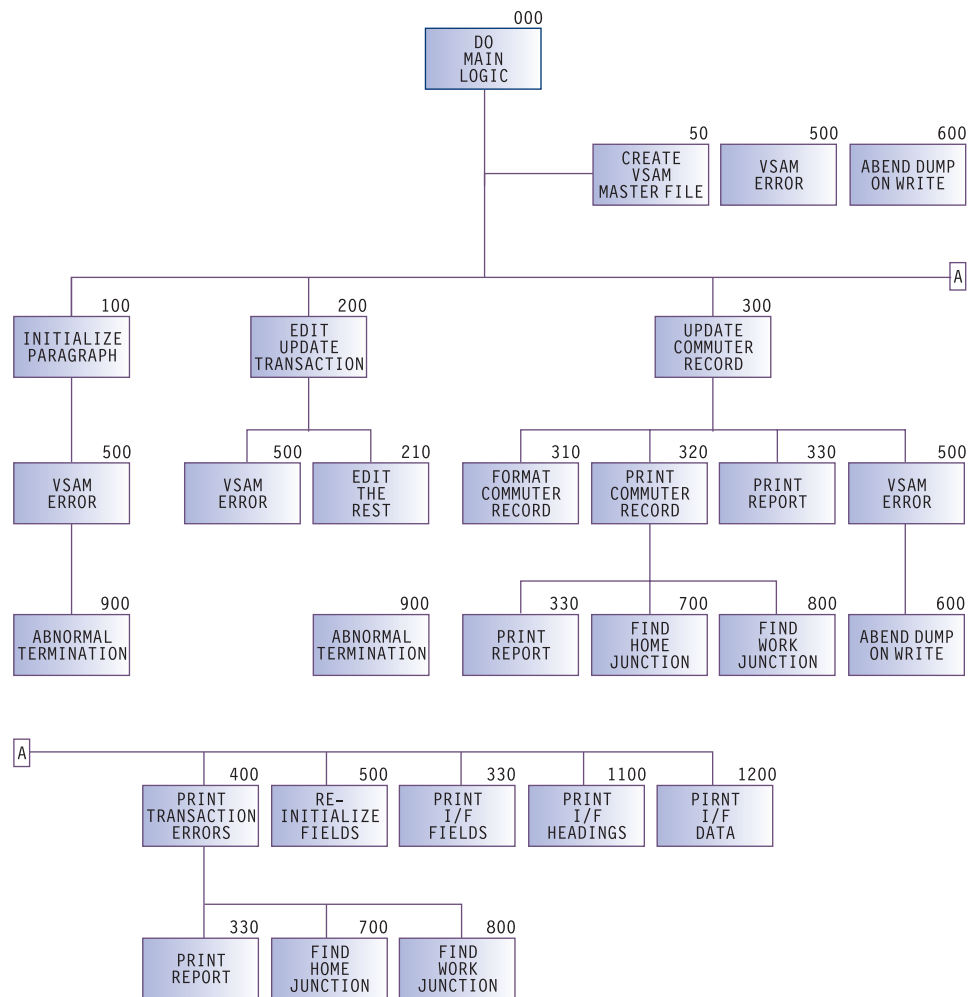
IGYTCARA: batch application

A company with several local offices wants to establish employee carpools. This batch application needs to perform two tasks:

- Produce reports of employees who can share rides from the same home location to the same work location.
- Update the carpool data:
 - Add data for new employees.
 - Change information for participating employees.
 - Delete employee records.
 - List update requests that are not valid.

Using QSAM files and VSAM indexed files, this program validates transaction file entries (sequential file processing) and updates a master file (indexed file processing).

The following diagram shows the parts of the application and how they are organized:



3. Home code
4. Work code
5. Commuter name
6. Home address
7. Home phone
8. Work phone
9. Home location code
10. Work location code
11. Driving status code

The sample below shows a section of the input file:

```
A10111ROBERTS AB1021 CRYSTAL COURTSAN FRANCISCOCA9990141555501904155551387H1W1D
A20212KAHN DE789 EMILY LANE SAN FRANCISCOCA9992141555518904155552589H2W2D
P48899 99ASDFG0005557890123ASDFGHJ T
R10111ROBERTS AB1221 CRYSTAL COURTSAN FRANCISCOCA9990141555501904155551387H1W1D
A20212KAHN DE789 EMILY LANE SAN FRANCISCOCA9992141555518904155552589H2W2D
D20212KAHN DE
D20212KAHN DE
A20212KAHN DE789 EMILY LANE SAN FRANCISCOCA9992141555518904155552589H2W2D
A10111BONNICK FD1025 FIFTH AVENUE SAN FRANCISCOCA9990541555595904155557895H8W3
A10111PETERSON SW435 THIRD AVENUE SAN FRANCISCOCA9990541555546904155553717H3W4
. . .
```

Report produced by IGYTCARA

The following sample shows the first page of the output report produced by IGYTCARA. Your actual output might vary slightly in appearance, depending on your system.

1REPORT #: IGYTCAR1				COMMUTER FILE UPDATE LIST				PAGE #: 1	
-PROGRAM #: IGYTCAR1				RUN TIME: 01:40				RUN DATE: 11/24/2003	
TRANS CODE	RE-CORD TYPE	SHIFT HOME CODE	WORK CODE	COMPUTER NAME	HOME ADDRESS	HOME PHONE WORK PHONE	HOME LOCATION JUNCTION	STA-TUS CODE	TRANS. ERROR
A	NEW	1	01 11	ROBERTS	AB 1021 CRYSTAL COURT SAN FRANCISCO CA 99901	(415) 555-0190 (415) 555-1387	RODNEY/CRYSTAL BAYFAIR PLAZA	D	
A	NEW	2	02 12	KAHN	DE 789 EMILY LANE SAN FRANCISCO CA 99921	(415) 555-1890 (415) 555-2589	COYOTE 14TH STREET/166TH AVENUE	D	
P		4	88 99			(000) 555-7890 (123) ASDFG	HOME CODE ' ' NOT FOUND. ASD-FGHJ WORK CODE ' ' NOT FOUND.	T	
									TRANSACT. CODE SHIFT CODE HOME LOC. CODE WORK LOC. CODE LAST NAME INITIALS ADDRESS CITY STATE CODE ZIPCODE HOME PHONE WORK PHONE HOME JUNCTION WORK JUNCTION DRIVING STATUS
R	OLD	1	01 11	ROBERTS	AB 1021 CRYSTAL COURT SAN FRANCISCO CA 99901	(415) 555-0190 (415) 555-1387	RODNEY/CRYSTAL BAYFAIR PLAZA	D	
	NEW	1	01 11	ROBERTS	AB 1221 CRYSTAL COURT SAN FRANCISCO CA 99901	(415) 555-0190 (415) 555-1387	RODNEY/CRYSTAL BAYFAIR PLAZA	D	
A		2	02 12	KAHN	DE 789 EMILY LANE SAN FRANCISCO CA 99921	(415) 555-1890 (415) 555-2589	COYOTE 14TH STREET/166TH AVENUE	D	DUPLICATE REC.
D	OLD	2	02 12	KAHN	DE 789 EMILY LANE SAN FRANCISCO CA 99921	(415) 555-1890 (415) 555-2589	COYOTE 14TH STREET/166TH AVENUE	D	
D		2	02 12	KAHN	DE				REC. NOT FOUND
A	NEW	2	02 12	KAHN	DE 789 EMILY LANE SAN FRANCISCO CA 99921	(415) 555-1890 (415) 555-2589	COYOTE 14TH STREET/166TH AVENUE	D	
A	NEW	1	01 11	BONNICK	FD 1025 FIFTH AVENUE SAN FRANCISCO CA 99905	(415) 555-9590 (415) 555-7895	RODNEY 17TH FREEWAY SAN LEANDRO		
A	NEW	1	01 11	PETERSON	SW 435 THIRD AVENUE	(415) 555-4690	RODNEY/THIRD AVENUE		

Preparing to run IGYTCARA

All the files required by the IGYTCARA program are supplied on the product installation tape. These files (IGYTCARA, IGYTCODE, and IGYTRANX) are located in the IGY.V3R3M0.SIGYSAMP data set.

Data set and procedure names can be changed at installation time. You should check with your system programmer to verify these names.

Do not change these options on the CBL statement in the source file for IGYTCARA:

```
NOADV
NODYNAM
NONAME
NONUMBER
QUOTE
SEQUENCE
```

With these options in effect, the program will not cause any diagnostic messages to be issued. You can use the sequence number string in the source file to search for the language elements used.

RELATED CONCEPTS

“IGYTCARA: batch application” on page 705

RELATED TASKS

“Running IGYTCARA”

RELATED REFERENCES

“Input data for IGYTCARA” on page 706

“Report produced by IGYTCARA” on page 707

“Language elements and concepts that are illustrated” on page 720

Running IGYTCARA

The procedure provided here does a combined compile, link-edit, and run of the IGYTCARA program. If you want only to compile or only to compile and link-edit the program, you need to change the IGYWCLG cataloged procedure.

To run IGYTCARA under z/OS, use JCL to define a VSAM cluster and compile the program. Insert the information specific to your system and installation in the fields that are shown in lowercase letters (accounting information, volume serial number, unit name, cluster prefix). These examples use the name IGYTCAR.MASTFILE; you can use another name if you want to.

1. Use this JCL to create the required VSAM cluster:

```
//CREATE JOB (acct-info), 'IGYTCAR CREATE VSAM', MSGLEVEL=(1,1),
// TIME=(0,29)
//CREATE EXEC PGM=IDCAMS
//VOL1 DD VOL=SER=your-volume-serial, UNIT=your-unit, DISP=SHR
//SYSPRINT DD SYSOUT=A
//SYSIN DD *
DELETE your-prefix.IGYTCAR.MASTFILE -
FILE(VOL1) -
PURGE
DEFINE CLUSTER -
(NAME(your-prefix.IGYTCAR.MASTFILE) -
VOLUME(your-volume-serial) -
FILE(VOL1) -
INDEXED -
```

```

        RECSZ(80 80) -
        KEYS(16 0) -
        CYLINDERS(2))
/*

```

To remove any existing cluster, a DELETE is issued before the VSAM cluster is created.

2. Use the following JCL to compile, link-edit, and run the IGYTCARA program:

```

//IGYTCARA JOB (acct-info), 'IGYTCAR',MSGLEVEL=(1,1),TIME=(0,29)
//TEST EXEC IGYWCLG
//COBOL.SYSLIB DD DSN=IGY.V3R3M0.SIGYSAMP,DISP=SHR
//COBOL.SYSIN DD DSN=IGY.V3R3M0.SIGYSAMP(IGYTCARA),DISP=SHR
//GO.SYSOUT DD SYSOUT=A
//GO.COMMUTR DD DSN=your-prefix.IGYTCAR.MASTFILE,DISP=SHR
//GO.LOCCODE DD DSN=IGY.V3R3M0.SIGYSAMP(IGYTCODE),DISP=SHR
//GO.UPDTRANS DD DSN=IGY.V3R3M0.SIGYSAMP(IGYTRANX),DISP=SHR
//GO.UPDPRINT DD SYSOUT=A,DCB=BLKSIZE=133
//

```

RELATED TASKS

Chapter 10, “Processing VSAM files,” on page 147

RELATED REFERENCES

“Compile, link-edit, and run procedure (IGYWCLG)” on page 221

IGYTCARB: interactive program

The IGYTCARB program contains an interactive program for entering the carpool data through a screen, using IBM Interactive System Productivity Facility (ISPF) to invoke Dialog Manager and Enterprise COBOL. It creates a file that could be used as input for a carpool listing or matching program such as IGYTCARA.

The input data for IGYTCARB is the same as that for IGYTCARA. IGYTCARB lets you append to the information in your input file by using an ISPF panel. An example of the panel used by IGYTCARB is shown below:

```

----- CARPOOL DATA ENTRY -----
                New Data Entry
Type =====> -                               A, R, or D      A
Shift =====> -                               1, 2, or 3      1
Home Code ==> --                               2 Chars        01
Work Code ==> --                               2 Chars        11
Name =====> -----                           9 Chars        POPOWICH
Initials ==> --                               2 Chars         AD
Address ==> -----                           18 Chars        134 SIXTH AVENUE
City =====> -----                          13 Chars        SAN FRANCISCO
State =====> --                               2 Chars         CA
Zip Code ==> -----                           5 Chars         99903
Home Phone => -----                          10 Chars        4155553390
Work Phone => -----                          10 Chars        4155557855
Home Jnc code > --                             2 Chars         H3
Work Jnc Code > --                             2 Chars         W7
Commuter Stat > -                             D, R or blank

```

RELATED TASKS

“Preparing to run IGYTCARB”

Preparing to run IGYTCARB

Run IGYTCARB using Interactive System Productivity Facility (ISPF).

All the files required by the IGYTCARB program are supplied on the product installation tape. These files (IGYTCARB, IGYTRANB, and IGYTPNL) are located in the IGY.V3R3M0.SIGYSAMP data set.

Data set and procedure names can be changed at installation time. Check with your system programmer to verify these names.

Do not change these options on the CBL card in the source file for IGYTCARB:

NONUMBER
QUOTE
SEQUENCE

With these options in effect, the program will not cause any diagnostic messages to be issued. You can use the sequence number string in the source file to search for language elements.

RELATED CONCEPTS

“IGYTCARB: interactive program” on page 709

RELATED TASKS

“Running IGYTCARB”

RELATED REFERENCES

“Language elements and concepts that are illustrated” on page 720

Running IGYTCARB

The following procedure does a combined compile, link-edit, and run of the IGYTCARB program. If you want only to compile or only to compile and link-edit the program, you need to change the procedure.

To run IGYTCARB under z/OS, do the following steps:

1. Using the ISPF editor, change the ISPF/PDF Primary Option Panel (ISR@PRIM) or some other panel to include the IGYTCARB invocation. Panel ISR@PRIM is in your site’s PDF panel data set (normally ISRPLIB).

The following example shows an ISR@PRIM panel modified, in two identified locations, to include the IGYTCARB invocation. If you add or change an option in the upper portion of the panel definition, you must also add or change the corresponding line on the lower portion of the panel.

```
%----- ISPF/PDF PRIMARY OPTION PANEL -----+
%OPTION ==>_ZCMD
%
% 0 +ISPF PARMS - Specify terminal and user parameters +USERID - &ZUSER
% 1 +BROWSE - Display source data or output listings +TIME - &ZTIME
% 2 +EDIT - Create or change source data +TERMINAL - &ZTERM
% 3 +UTILITIES - Perform utility functions +PF KEYS - &ZKEYS
% 4 +FOREGROUND - Invoke language processors in foreground
% 5 +BATCH - Submit to batch for language processing
% 6 +COMMAND - Enter TSO or Workstation commands
% 7 +DIALOG TEST - Perform dialog testing
% 8 +LM UTILITIES- Perform library management utility functions
% C +IGYTCARB - Run IGYTCARB UPDATE TRANSACTION PROGRAM (1)
% T +TUTORIAL - Display information about ISPF/PDF
% X +EXIT - Terminate using console, log, and list defaults
%
%
%+Enter%END+command to terminate ISPF.
%
%)INIT
% .HELP = ISR00003
```

```

&ZPRIM = YES          /* ALWAYS A PRIMARY OPTION MENU */
&ZHTOP = ISR00003     /* TUTORIAL TABLE OF CONTENTS */
&ZHINDEX = ISR91000   /* TUTORIAL INDEX - 1ST PAGE */
VPUT (ZHTOP,ZHINDEX) PROFILE
)PROC
&Z1 = TRUNC(&ZCMD,1)
IF (&Z1 &notsym.= '.' )
  &ZSEL = TRANS( TRUNC (&ZCMD,'.')
    0,'PANEL(ISPOPTA)'
    1,'PGM(ISRBRO) PARM(ISRBRO01)'
    2,'PGM(ISREDIT) PARM(P,ISREDM01)'
    3,'PANEL(ISRUTIL)'
    4,'PANEL(ISRFPA)'
    5,'PGM(ISRJB1) PARM(ISRJPA) NOCHECK'
    6,'PGM(ISRPCC)'
    7,'PGM(ISRYXDR) NOCHECK'
    8,'PANEL(ISRLPRIM)'
    C,'PGM(IGYTCARB)'
    T,'PGM(ISPTUTOR) PARM(ISR00000)'
    ,',',
    X,'EXIT'
    *,'?')
  &ZTRAIL = .TRAIL
  IF (&Z1 = '.') .msg = ISPD141
)END

```

As indicated by (1) in this example, you add IGYTCARB to the upper portion of the panel by entering:

```
% C +IGYTCARB - Run IGYTCARB UPDATE TRANSACTION PROGRAM
```

You add the corresponding line on the lower portion of the panel, indicated by (2), by entering:

```
C,'PGM(IGYTCARB)'
```

2. Place ISR@PRIM (or your other modified panel) and IGYTPNL in a library and make this library the first library in the ISPLLIB concatenation.
3. Comment sequence line IB2200 and uncomment sequence line IB2210 in IGYTCARB. (The OPEN EXTEND verb is supported under z/OS.)
4. Compile and link-edit IGYTCARB and place the resulting load module in your LOADLIB.
5. Allocate ISPLLIB using the following command:
 ALLOCATE FILE(ISPLLIB) DATASET(DSN1, SYS1.COBLIB, DSN2) SHR REUSE
 Here DSN1 is the library name of the LOADLIB from step 4. DSN2 is your installed ISPLLIB.
6. Allocate the input and output data sets using the following command:
 ALLOCATE FILE(UPDTRANS) DA('IGY.V3R3M0.SIGYSAMP(IGYTRANB)) SHR REUSE
7. Allocate ISPLLIB using the following command:
 ALLOCATE FILE(ISPLLIB) DATASET(DSN3, DSN4) SHR REUSE
 Here DSN3 is the library containing the modified panels. DSN4 is the ISPF panel library.
8. Invoke IGYTCARB using your modified panel.

RELATED REFERENCES

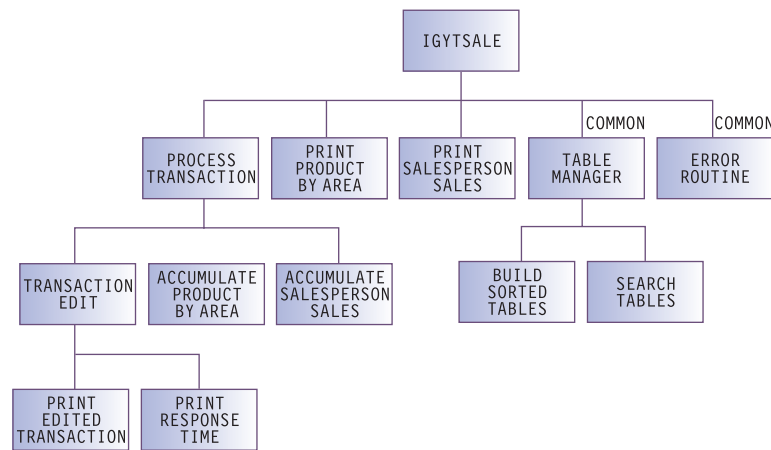
ISPF Dialog Developer's Guide and Reference

IGYTSALE: nested program application

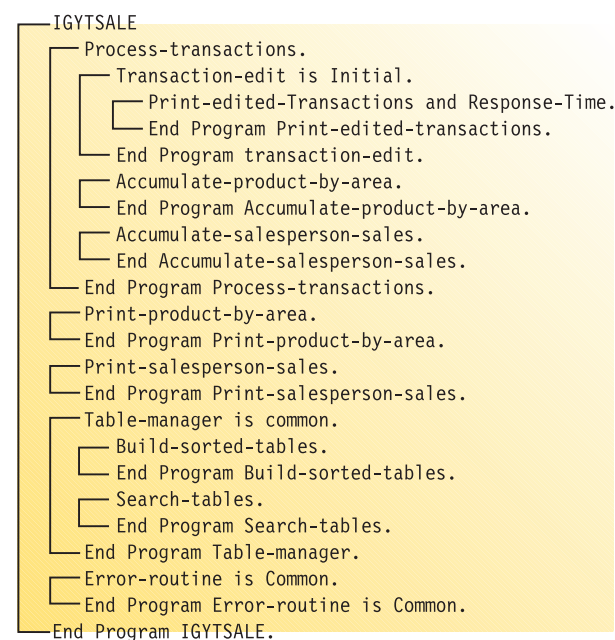
A sporting goods distributor wants to track product sales and sales commissions. This nested program application needs to perform the following tasks:

1. Keep a record of the product line, customers, and number of salespeople. This data is stored in a file called IGYTABLE.
2. Maintain a file that records valid transactions and transaction errors. All transactions that are not valid are flagged, and the results are printed in a report. Transactions to be processed are in a file called IGYTRANA.
3. Process transactions and report sales by location.
4. Record an individual's sales performance and commission and print the results in a report.
5. Report the sale and shipment dates in local time and UTC (Universal Time Coordinate), respectively, and calculate the response time.

The following diagram shows the parts of the application as a hierarchy:



The following diagram shows how the parts are nested:



RELATED TASKS

“Preparing to run IGYTSale” on page 719

RELATED REFERENCES

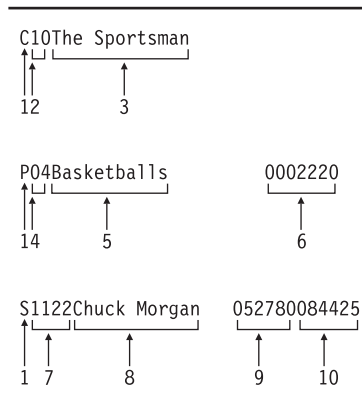
"Input data for IGYTSALE"

"Reports produced by IGYTSALE" on page 715

"Language elements and concepts that are illustrated" on page 720

Input data for IGYTSALE

As input to our program, the distributor collected information about its customers, salespeople, and products, coded the information, and produced an input file. This input file, called IGYTABLE, is loaded into three separate tables for use during transaction processing. The format of the file is as follows, with an explanation of the items below:



1. Record type
2. Customer code
3. Customer name
4. Product code
5. Product description
6. Product unit price
7. Salesperson number
8. Salesperson name
9. Date of hire
10. Commission rate

The value of field 1 (C, P, or S) determines the format of the input record. The following sample shows a section of IGYTABLE:

```
S1111Edyth Phillips 062484042327
S1122Chuck Morgan 052780084425
S1133Art Tung 022882061728
S1144Billy Jim Bob 010272121150
S1155Chris Preston 122083053377
S1166Al Willie Roz 111276100000
P01Footballs 0000620
P02Football Equipment 0032080
P03Football Uniform 0004910
P04Basketballs 0002220
P05Basketball Rim/Board0008830
P06Basketball Uniform 0004220
C01L. A. Sports
C02Gear Up
C03Play Outdoors
C04Sports 4 You
C05Sports R US
```

• • •

form

10

9. Q

order

• • •

Reports produced by IGYTSALE

The following figures are samples of IGYTSALE output. The program records the following data in reports:

- Transaction errors
- Sales by product and area
- Individual sales performance and commissions
- Response time between the sale date and the date the sold products are shipped

Your output might vary slightly in appearance, depending on your system.

“Example: IGYTSALE transaction errors” on page 716

“Example: IGYTSALE sales analysis by product by area” on page 717

“Example: IGYTSALE sales and commissions” on page 718

“Example: IGYTSALE response time from sale to ship” on page 719

Example: IGYTSALE transaction errors

The following sample of IGYTSALE output shows transaction errors in the last column.

Day of Report: Monday			C O B O L		S P O R T S		11/24/2003	03:12	Page: 1
					Invalid Edited Transactions				
Sales Order	Inv. Items	Sales Time Stamp	Sales Area	Sales Pers	Cust. Code	Product And Quantity Sold	Ship Date Stamp		
	4	19990324591515	SAN DIEGO	116	15	60200132200110522045100	Error Descriptions		
							-Sales order number is missing		
							-Date of sale time stamp is invalid		
							-Salesperson number not numeric		
							-Product code not in product-table		
							-Date of ship time stamp is invalid		
B11117	3	19901201070833	SAN Diego	1165	66	330200132200120522041100	19901203	Error Descriptions	
								-Sales area not in area-table	
								-Salesperson not in sales-per-table	
								-Customer code not in customer-table	
								-Product code not in product-table	
								-Quantity sold not numeric	
B11123	9	19901110123314	SAN DIEGO	1166	09	260200270500110522250100140010	19901114	Error Descriptions	
								-Invoiced items is invalid	
								-Product and quantity not checked	
								-Date of ship time stamp is invalid	
B11124	2	19901313510000	SAN DIEGO	1166	11	1 0200042200120a22141100		Error Descriptions	
								-Date of sale time stamp is invalid	
								-Product code is invalid	
								-Date of ship time stamp is invalid	
133		81119110000	LOS ANGELES	1166	10	040112110210160321251104		Error Descriptions	
								-Sales order number is invalid	
								-Invoiced items is invalid	
								-Date of sale time stamp is invalid	
								-Product and quantity not checked	
								-Date of ship time stamp is invalid	
C11133	4	1990111944		1166	10	040112110210160321251104		Error Descriptions	
								-Date of sale time stamp is invalid	
								-Sales area is missing	
								-Date of ship time stamp is invalid	
C11138	4	19901117091530	LOS ANGELES	1155		113200102010260321250004	19901119	Error Descriptions	
								-Customer code is invalid	
D00009	9	19901201222222	CNTRL COAST	115	19	141 1131221	19901202	Error Descriptions	
								-Invoiced items is invalid	

Example: IGYTSALE sales analysis by product by area

The following sample of IGYTSALE output shows sales by product and area.

Day of Report: Monday		C O B O L S P O R T S		11/24/2003 03:12		Page: 1		
Sales Analysis By Product By Area								
		CNTRL COAST	CNTRL VALLEY	Areas of Sale LOS ANGELES	NORTH COAST	SAN DIEGO	SF BAY AREA	Product Totals
=====								
Product Number 04								
Basketballs				433		2604	5102	8139
Units Sold				22.20		22.20	22.20	
Unit Price				\$9,612.60		\$57,808.80	\$113,264.40	\$180,685.80
Amount of Sale								

Product Number 05								
Basketball Rim/Board			9900	2120	11	2700		14731
Units Sold			88.30	88.30	88.30	88.30		
Unit Price			\$874,170.00	\$187,196.00	\$971.30	\$238,410.00		\$1,300,747.30
Amount of Sale								

Product Number 06								
Basketball Uniform					990	200	200	1390
Units Sold					42.20	42.20	42.20	
Unit Price					\$41,778.00	\$8,440.00	\$8,440.00	\$58,658.00
Amount of Sale								

Product Number 10								
Baseball Cage								
Units Sold	45		3450	16	200		3320	7031
Unit Price	890.00		890.00	890.00	890.00		890.00	
Amount of Sale	\$40,050.00		\$3,070,500.00	\$14,240.00	\$178,000.00		\$2,954,800.00	\$6,257,590.00

Product Number 11								
Baseball Uniform								
Units Sold	10003		3578		2922		2746	19249
Unit Price	45.70		45.70		45.70		45.70	
Amount of Sale	\$457,137.10		\$163,514.60		\$133,535.40		\$125,492.20	\$879,679.30

Product Number 12								
Softballs								
Units Sold	10	137	2564	13	2200		22	4946
Unit Price	1.40	1.40	1.40	1.40	1.40		1.40	
Amount of Sale	\$14.00	\$191.80	\$3,589.60	\$18.20	\$3,080.00		\$30.80	\$6,924.40

Product Number 13								
Softball Bats								
Units Sold	3227		3300	1998	5444		99	14068
Unit Price	12.60		12.60	12.60	12.60		12.60	
Amount of Sale	\$40,660.20		\$41,580.00	\$25,174.80	\$68,594.40		\$1,247.40	\$177,256.80

Product Number 14								
Softball Gloves								
Units Sold	1155		136	3119	3833		5152	13395
Unit Price	12.00		12.00	12.00	12.00		12.00	
Amount of Sale	\$13,860.00		\$1,632.00	\$37,428.00	\$45,996.00		\$61,824.00	\$160,740.00

Product Number 15								
Softball Cage								
Units Sold	997	99	2000		2400			5496
Unit Price	890.00	890.00	890.00		890.00			
Amount of Sale	\$887,330.00	\$88,110.00	\$1,780,000.00		\$2,136,000.00			\$4,891,440.00

Product Number 16								
Softball Uniform								
Units Sold	44		465	16	6165		200	6890
Unit Price	45.70		45.70	45.70	45.70		45.70	
Amount of Sale	\$2,010.80		\$21,250.50	\$731.20	\$281,740.50		\$9,140.00	\$314,873.00

Product Number 25								
RacketBalls								
Units Sold	1001	10003	1108	8989	200		522	21823
Unit Price	0.60	0.60	0.60	0.60	0.60		0.60	
Amount of Sale	\$600.60	\$6,001.80	\$664.80	\$5,393.40	\$120.00		\$313.20	\$13,093.80

Product Number 26								
Racketball Rackets								
Units Sold	21		862	194	944		31	2052
Unit Price	12.70		12.70	12.70	12.70		12.70	
Amount of Sale	\$266.70		\$10,947.40	\$2,463.80	\$11,988.80		\$393.70	\$26,060.40

Total Units Sold	16503	20139	20016	15346	29812		17394 *	119210 *
Total Sales	\$1,441,929.40	\$968,473.60	\$5,290,487.50	\$128,198.70	\$3,163,713.90		\$3,274,945.70 *	\$14,267,748.80 *

Example: IGYTSALE sales and commissions

The following sample of IGYTSALE output shows sales performance and commissions by salesperson.

Day of Report: Monday		C O B O L		S P O R T S		11/24/2003	03:12	Page: 1
Salesperson: Billy Jim Bob				Sales and Commission Report				
Customers:	Number of Orders	Products Ordered	Total for Order	Discount (if any)	Discount Amount	Commission Earned		
-----	-----	-----	-----	-----	-----	-----		
Sports Stop	3	10117	\$6,161.40	2.25%	\$138.63	\$746.45		
The Sportsman	1	99	\$88,110.00	5.06%	\$4,458.36	\$10,674.52		
Sports Play	1	9900	\$874,170.00	7.59%	\$66,349.50	\$105,905.69		
Totals:	5	20116	\$968,441.40		\$70,946.49	\$117,326.66		
-----	-----	-----	-----	-----	-----	-----		
Salesperson: Willie Al Roz	Number of Orders	Products Ordered	Total for Order	Discount (if any)	Discount Amount	Commission Earned		
Customers:	-----	-----	-----	-----	-----	-----		
Winners Club	4	13998	\$1,572,775.90	7.59%	\$119,373.69	\$157,277.59		
Winning Sports	1	3222	\$48,777.20	3.38%	\$1,648.66	\$4,877.72		
The Sportsman	1	1747	\$27,415.50	3.38%	\$926.64	\$2,741.55		
Play Outdoors	1	2510	\$18,579.60	3.38%	\$627.99	\$1,857.96		
Totals:	7	21477	\$1,667,548.20		\$122,576.98	\$166,754.82		
-----	-----	-----	-----	-----	-----	-----		
Salesperson: Art Tung	Number of Orders	Products Ordered	Total for Order	Discount (if any)	Discount Amount	Commission Earned		
Customers:	-----	-----	-----	-----	-----	-----		
Sports Stop	1	23	\$32.20	2.25%	\$.72	\$1.98		
Winners Club	2	16057	\$2,274,885.00	7.59%	\$172,663.77	\$140,424.10		
Gear Up	1	3022	\$107,144.00	7.59%	\$8,132.22	\$6,613.78		
Sports Club	1	22	\$279.40	2.25%	\$6.28	\$17.24		
Sports Fans Shop	1	1044	\$20,447.30	3.38%	\$691.11	\$1,262.17		
L. A. Sports	1	1163	\$979,198.10	7.59%	\$74,321.13	\$60,443.94		
Totals:	7	21331	\$3,381,986.00		\$255,815.23	\$208,763.21		
-----	-----	-----	-----	-----	-----	-----		
Salesperson: Chuck Morgan	Number of Orders	Products Ordered	Total for Order	Discount (if any)	Discount Amount	Commission Earned		
Customers:	-----	-----	-----	-----	-----	-----		
Sports Play	3	7422	\$3,817,245.40	7.59%	\$289,728.92	\$322,270.94		
Sports 4 You	1	3022	\$398,335.40	7.59%	\$30,233.65	\$33,629.46		
The Sportsman	1	3022	\$285,229.40	7.59%	\$21,648.91	\$24,080.49		
Sports 4 Winners	1	1100	\$68,509.40	5.06%	\$3,466.57	\$5,783.90		
Sports Club	1	12027	\$1,324,256.10	7.59%	\$100,511.03	\$111,800.32		
Totals:	7	26593	\$5,893,575.70		\$445,589.08	\$497,565.11		
-----	-----	-----	-----	-----	-----	-----		
Salesperson: Chris Preston	Number of Orders	Products Ordered	Total for Order	Discount (if any)	Discount Amount	Commission Earned		
Customers:	-----	-----	-----	-----	-----	-----		
Playing Ball	1	5535	\$1,939,219.10	7.59%	\$147,186.72	\$103,509.69		
Play Sports	1	5675	\$225,130.80	7.59%	\$17,087.42	\$12,016.80		
Winners Club	1	631	\$14,069.70	2.25%	\$316.56	\$750.99		
The Jock Shop	1	2332	\$28,716.60	3.38%	\$970.62	\$1,532.80		
Totals:	4	14173	\$2,207,136.20		\$165,561.32	\$117,810.28		
-----	-----	-----	-----	-----	-----	-----		
Salesperson: Edyth Phillips	Number of Orders	Products Ordered	Total for Order	Discount (if any)	Discount Amount	Commission Earned		
Customers:	-----	-----	-----	-----	-----	-----		
Sports Play	2	3575	\$92,409.90	5.06%	\$4,675.94	\$3,911.43		
Winning Sports	1	11945	\$56,651.40	5.06%	\$2,866.56	\$2,397.88		
Totals:	3	15520	\$149,061.30		\$7,542.50	\$6,309.31		
Grand Totals:	33	119210	\$14,267,748.80		\$1,068,031.60	\$1,114,529.39		

Example: IGYTSALE response time from sale to ship

The following sample of IGYTSALE output shows response time between the sale date in the United States and the date the sold products are shipped to Europe.

```
Day of Report: Monday    COBOL SPORTS    11/24/2003    03:12    Page: 1
                        Response Time from USA Sale to European Ship
Prod   Units   Sale Date/Time(PST)   Ship Date   Ship   Response Time
Code   Sold    YYYYMMDD   HHMMSS     YYYYMMDD   Day      Days
-----
25     9999     19900226   010101     19900228   WED      .95
15      99      19900310   100530     19900403   TUE     23.57
05     9900     19900418   222409     19900419   THU      .06
25      4      19900523   151010     19900623   SAT    30.36
04     1100     19901110   003301     19901114   WED      2.97
12      23      19901114   003205     19901117   SAT      1.97
14     5111     19900118   101527     19900120   SAT      1.57
04     5102     19901201   132013     19901203   MON      1.44
04      300     19901221   191544     19901223   SUN      1.19
05      500     19901210   211544     19901214   FRI      3.11
04      100     19901211   000816     19901213   THU      .99
25      100     19901201   131544     19901203   MON      1.44
25      100     19901112   073312     19901113   TUE      .68
14     1111     19901214   012510     19901216   SUN      .94
26      22      19901110   000034     19901113   TUE      1.99
12     2000     19901110   154100     19901113   TUE      2.34
04     1104     19901110   175001     19901113   TUE      2.25
12      114     19901229   115522     19901230   SUN      .50
15     2000     19901110   190113     19901114   WED      3.20
10     1440     19901112   001500     19901115   THU      1.98
25     1104     19901118   120101     19901119   MON      .49
25      4      19901118   110030     19901119   MON      .54
12     144     19901114   010510     19901119   MON      3.95
14     112     19901119   010101     19901122   THU      1.95
26     321     19901117   173945     19901119   MON      1.26
13     1221     19901101   135133     19901102   FRI      .42
10      22      19901029   210000     19901030   TUE      .12
14      35      19901130   160500     19901201   SAT      .32
11     9005     19901211   050505     19901212   WED      .78
06      990     19900511   214409     19900515   TUE      3.09
13     1998     19900712   150100     19900716   MON      3.37
26      31      19901010   185559     19901011   THU      .21
14      30      19901210   195500     19901212   WED      1.17
```

Preparing to run IGYTSALE

All the files required by the IGYTSALE program are supplied on the product installation tape. These files (IGYTSALE, IGYTCRC, IGYTPRC, IGYTSRC, IGYTABLE, IGYTRANA) are located in the IGY.V3R3M0.SIGYSAMP data set.

Data set and procedure names can be changed at installation time. Check with your system programmer to verify these names.

Do not change these options on the CBL card in the source file for IGYTSALE:

```
LIB
NONUMBER
SEQUENCE
NONUMBER
QUOTE
```

With these options in effect, the program might not cause any diagnostic messages to be issued. You can use the sequence number string in the source file to search for the language elements used.

When you run IGYTSALE, the following messages are printed to the SYSOUT data set:

```
Program IGYTSALE Begins
There were 00041 records processed in this program
Program IGYTSALE Normal End
```

RELATED CONCEPTS

“IGYTSALE: nested program application” on page 711

RELATED TASKS

“Running IGYTSALE”

RELATED REFERENCES

“Input data for IGYTSALE” on page 713

“Reports produced by IGYTSALE” on page 715

“Language elements and concepts that are illustrated”

Running IGYTSALE

The following procedure does a combined compile, link-edit, and run of the IGYTSALE program. If you want only to compile or only to compile and link-edit the program, you need to change the IGYWCLG cataloged procedure.

Use the following JCL to compile, link-edit, and run the IGYTSALE program. Insert the information for your system or installation in the fields that are shown in lowercase letters (accounting information).

```
//IGYTSALE JOB (acct-info), 'IGYTSALE',MSGLEVEL=(1,1),TIME=(0,29)
//TEST EXEC IGYWCLG
//COBOL.SYSLIB DD DSN=IGY.V3R3M0.SIGYSAMP,DISP=SHR
//COBOL.SYSIN DD DSN=IGY.V3R3M0.SIGYSAMP(IGYTSALE),DISP=SHR
//GO.SYSOUT DD SYSOUT=A
//GO.IGYTABLE DD DSN=IGY.V3R3M0.SIGYSAMP(IGYTABLE),DISP=SHR
//GO.IGYTRANS DD DSN=IGY.V3R3M0.SIGYSAMP(IGYTRANA),DISP=SHR
//GO.IGYPRINT DD SYSOUT=A,DCB=BLKSIZE=133
//GO.IGYPRT2 DD SYSOUT=A,DCB=BLKSIZE=133
//
```

Language elements and concepts that are illustrated

To find the applicable language element for a sample program, locate the abbreviation for that program in the sequence string:

Sample program	Abbreviation
IGYTCARA	IA
IGYTCARB	IB
IGYTSALE	IS

The following table lists the language elements and programming concepts that the sample programs illustrate. The language element or concept is described, and the sequence string is shown. The sequence string is the special character string that appears in the sequence field of the source file. You can use this string as a search argument for locating the elements in the listing.

Language element or concept	Sequence string
ACCEPT . . . FROM DAY-OF-WEEK	IS0900
ACCEPT . . . FROM DATE	IS0901
ACCEPT . . . FROM TIME	IS0902

Language element or concept	Sequence string
ADD . . . TO	IS4550
AFTER ADVANCING	IS2700
AFTER PAGE	IS2600
ALL	IS4200
ASSIGN	IS1101
AUTHOR	IA0040
CALL	IS0800
Callable services (Language Environment)	
CEEDATM - format date or time output	IS0875, IS2575
CEEDCOD - feedback code check from service call	IS0905
CEEGMTO - UTC offset from local time	IS0904
CEELOCT - local date and time	IS0850
CEESECS - convert timestamp to seconds	IS2350, IS2550
CLOSE files	IS1900
Comma, semicolon, and space interchangeable	IS3500, IS3600
COMMON statement for nested programs	IS4600
Complex OCCURS DEPENDING ON	IS0700, IS3700
COMPUTE	IS4501
COMPUTE ROUNDED	IS4500
CONFIGURATION SECTION	IA0970
CONFIGURATION SECTION (optional)	IS0200
CONTINUE statement	IA5310, IA5380
COPY statement	IS0500
DATA DIVISION (optional)	IS5100
Data validation	IA5130-6190
Do-until (PERFORM . . . TEST AFTER)	IA4900-5010, IA7690-7770
Do-while (PERFORM . . . TEST BEFORE)	IS1660
END-ADD	IS2900
END-COMPUTE	IS4510
END-EVALUATE	IA6590, IS2450
END-IF	IS1680
END-MULTIPLY	IS3100
END-PERFORM	IS1700
END PROGRAM	IA9990
END-READ	IS1800
END-SEARCH	IS3400
ENVIRONMENT DIVISION (optional)	IS0200
Error handling, termination of program	IA4620, IA5080, IA7800-7980
EVALUATE statement	IA6270-6590
EVALUATE . . . ALSO	IS2400
EXIT PROGRAM not only statement in paragraph	IS2000
Exponentiation	IS4500

Language element or concept	Sequence string
EXTERNAL clause	IS1200
FILE-CONTROL entry for sequential file	IA1190-1300
FILE-CONTROL entry for VSAM indexed file	IA1070-1180
FILE SECTION (optional)	IS0200
FILE STATUS code check	IA4600-4630, IA4760-4790
FILLER (optional)	IS0400
Flags, level-88, definition	IA1730-1800, IA2440-2480, IA2710
Flags, level-88, testing	IA4430, IA5200-5250
FLOATING POINT	IS4400
GLOBAL statement	IS0300
INITIAL statement for nested programs	IS2300
INITIALIZE	IS2500
Initializing a table in the DATA DIVISION	IA2920-4260
Inline PERFORM statement	IA4410-4520
I-O-CONTROL paragraphs (optional)	IS0200
INPUT-OUTPUT SECTION (optional)	IS0200
Intrinsic functions: CURRENT-DATE MAX MEAN MEDIAN MIN STANDARD-DEVIATION UPPER-CASE VARIANCE WHEN-COMPILED	IA9005 IA9235 IA9215 IA9220 IA9240 IA9230 IA9015 IA9225 IA9000
IS (optional in all clauses)	IS0700
LABEL RECORDS (optional)	IS1150
LINKAGE SECTION	IS4900
Mixing of indexes and subscripts	IS3500
Mnemonic names	IA1000
MOVE	IS0903
MOVE CORRESPONDING statement	IA4810, IA4830
MULTIPLY . . . GIVING	IS3000
Nested IF statement, using END-IF	IA5460-5830
Nested program	IS1000
NEXT SENTENCE	IS4300
NOT AT END	IS1600
NULL	IS4800
OBJECT-COMPUTER (optional)	IS0200
OCCURS DEPENDING ON	IS0710
ODO uses maximum length for receiving item	IS1550
OPEN EXTEND	IB2210

Language element or concept	Sequence string
OPEN INPUT	IS1400
OPEN OUTPUT	IS1500
ORGANIZATION (optional)	IS1100
Page eject	IA7180-7210
Parenthesis in abbreviated conditions	IS4850
PERFORM . . . WITH TEST AFTER (Do-until)	IA4900-5010, IA7690-7770
PERFORM . . . WITH TEST BEFORE (Do-while)	IS1660
PERFORM . . . UNTIL	IS5000
PERFORM . . . VARYING statement	IA7690-7770
POINTER function	IS4700
Print file FD entry	IA1570-1620
Print report	IA7100-7360
PROCEDURE DIVISION . . . USING	IB1320-IB1650
PROGRAM-ID (30 characters allowed)	IS0120
READ . . . INTO . . . AT END	IS1550
REDEFINES statement	IA1940, IA2060, IA2890, IA3320
Reference modification	IS2425
Relational operator <= (less than or equal)	IS4400
Relational operator >= (greater than or equal)	IS2425
Relative subscripting	IS4000
REPLACE	IS4100
SEARCH statement	IS3300
SELECT	IS1100
Sequence number can contain any character	IA, IB, IS
Sequential file processing	IA4480-4510, IA4840-4870
Sequential table search, using PERFORM	IA7690-7770
Sequential table search, using SEARCH	IA5270-5320, IA5340-5390
SET INDEX	IS3200
SET . . . TO TRUE statement	IA4390, IA4500, IA4860, IA4980
SOURCE-COMPUTER (optional)	IS0200
SPECIAL-NAMES paragraph (optional)	IS0200
STRING statement	IA6950, IA7050
Support for lowercase letters	IS0100
TALLY	IS1650
TITLE statement for nested programs	IS0100
Update commuter record	IA6200-6610
Update transaction work value spaces	IB0790-IB1000
USAGE BINARY	IS1300
USAGE PACKED-DECIMAL	IS1301
Validate elements	IB0810, IB0860, IB1000
VALUE with OCCURS	IS0600

Language element or concept	Sequence string
VALUE SPACE (S)	IS0601
VALUE ZERO (S) (ES)	IS0600
Variable-length table control variable	IA5100
Variable-length table definition	IA2090-2210
Variable-length table loading	IA4840-4990
VSAM indexed file key definition	IA1170
VSAM return-code display	IA7800-7900
WORKING-STORAGE SECTION	IS0250

Notices

This information was developed for products and services offered in the U.S.A. IBM may not offer the products, services, or features discussed in this document in other countries. Consult your local IBM representative for information on the products and services currently available in your area. Any reference to an IBM product, program, or service is not intended to state or imply that only that IBM product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any IBM intellectual property right may be used instead. However, it is the user's responsibility to evaluate and verify the operation of any non-IBM product, program, or service.

IBM may have patents or pending patent applications covering subject matter described in this document. The furnishing of this document does not give you any license to these patents. You can send license inquiries, in writing, to:

IBM Corporation
J46A/G4
555 Bailey Avenue
San Jose, CA 95141-1003
U.S.A.

For license inquiries regarding double-byte (DBCS) information, contact the IBM Intellectual Property Department in your country or send inquiries, in writing, to:

IBM World Trade Asia Corporation
Licensing
2-31 Roppongi 3-chome, Minato-ku
Tokyo 106, Japan

The following paragraph does not apply to the United Kingdom or any other country where such provisions are inconsistent with local law:

INTERNATIONAL BUSINESS MACHINES CORPORATION PROVIDES THIS PUBLICATION "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some states do not allow disclaimer of express or implied warranties in certain transactions, therefore, this statement may not apply to you.

This information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. IBM may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

Any references in this publication to non-IBM Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this IBM product and use of those Web sites is at your own risk.

If you are viewing this information in softcopy, the photographs and color illustrations may not appear.

Trademarks

The following terms are trademarks of International Business Machines Corporation in the United States, or other countries, or both:

AIX
BookManager
CICS
CICS/ESA
COBOL/370
DB2
DFSMS
DFSORT
IBM
IMS
IMS/ESA
Language Environment
MVS
OS/390
RACF
System/390
WebSphere
zSeries
z/OS

Intel is a registered trademark of Intel Corporation in the United States and/or other countries.

Java and all Java-based trademarks are trademarks of Sun Microsystems, Inc. in the United States, other countries, or both.

Microsoft, Windows, and Windows NT are trademarks of Microsoft Corporation in the United States and/or other countries.

Pentium is a registered trademark of Intel Corporation in the United States and/or other countries.

Unicode™ is a trademark of the Unicode® Consortium.

UNIX is a registered trademark of The Open Group in the United States and other countries.

Other company, product or service names may be the trademarks or service marks of others.

Glossary

The terms in this glossary are defined in accordance with their meaning in COBOL. These terms might or might not have the same meaning in other languages.

This glossary includes terms and definitions from the following publications:

- *ANSI INCITS 23-1985, Programming languages - COBOL*, as amended by *ANSI INCITS 23a-1989, Programming Languages - COBOL - Intrinsic Function Module for COBOL*, and *ANSI INCITS 23b-1993, Programming Languages - Correction Amendment for COBOL*
- *ANSI X3.172-2002, American National Standard Dictionary for Information Systems*

American National Standard definitions are preceded by an asterisk (*).

This glossary includes definitions developed by Sun Microsystems, Inc. for their Java and J2EE glossaries. When Sun is the source of a definition, that is indicated.

A

* **abbreviated combined relation condition.** The combined condition that results from the explicit omission of a common subject or a common subject and common relational operator in a consecutive sequence of relation conditions.

abend. Abnormal termination of a program.

above the 16-MB line. Storage above the so-called 16-MB line (or boundary) but below the 2-GB bar. This storage is addressable only in 31-bit mode. Before IBM introduced the MVS/XA architecture in the 1980s, the virtual storage for a program was limited to 16 MB. Programs that have been compiled with a 24-bit mode can address only 16 MB of space, as though they were kept under an imaginary storage line. Since VS COBOL II, a program that has been compiled with a 31-bit mode can be above the 16-MB line.

* **access mode.** The manner in which records are to be operated upon within a file.

* **actual decimal point.** The physical representation, using the decimal point characters period (.) or comma (,), of the decimal point position in a data item.

* **alphabet-name.** A user-defined word, in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION, that assigns a name to a specific character set or collating sequence or both.

* **alphabetic character.** A letter or a space character.

* **alphanumeric character.** Any character in the character set of the computer.

* **alphanumeric function.** A function whose value is composed of a string of one or more characters from the character set of the computer.

alphanumeric item. A data item that is described with USAGE DISPLAY and a PICTURE character-string that includes the symbol X.

alphanumeric literal. A literal that has an opening delimiter from the following set: ', ", X', X", Z', or Z". The string of characters can include any character in the character set of the computer.

* **alternate record key.** A key, other than the prime record key, whose contents identify a record within an indexed file.

ANSI (American National Standards Institute). An organization that consists of producers, consumers, and general-interest groups and establishes the procedures by which accredited organizations create and maintain voluntary industry standards in the United States.

argument. (1) An identifier, a literal, an arithmetic expression, or a function-identifier that specifies a value to be used in the evaluation of a function. (2) An operand of the USING phrase of a CALL or INVOKE statement, used for passing values to a called program or an invoked method.

* **arithmetic expression.** An identifier of a numeric elementary item, a numeric literal, such identifiers and literals separated by arithmetic operators, two arithmetic expressions separated by an arithmetic operator, or an arithmetic expression enclosed in parentheses.

* **arithmetic operation.** The process caused by the execution of an arithmetic statement, or the evaluation of an arithmetic expression, that results in a mathematically correct solution to the arguments presented.

* **arithmetic operator.** A single character, or a fixed two-character combination that belongs to the following set:

Character	Meaning
+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Exponentiation

* **arithmetic statement.** A statement that causes an arithmetic operation to be executed. The arithmetic statements are ADD, COMPUTE, DIVIDE, MULTIPLY, and SUBTRACT.

array. An aggregate that consists of data objects, each of which can be uniquely referenced by subscripting. An array is roughly analogous to a COBOL table.

* **ascending key.** A key upon the values of which data is ordered, starting with the lowest value of the key up to the highest value of the key, in accordance with the rules for comparing data items.

ASCII. American National Standard Code for Information Interchange. The standard code uses a coded character set that is based on 7-bit coded characters (8 bits including parity check). The standard is used for information interchange between data processing systems, data communication systems, and associated equipment. The ASCII set consists of control characters and graphic characters.

Extension: IBM has defined an extension to ASCII code (characters 128-255).

assignment-name. A name that identifies the organization of a COBOL file and the name by which it is known to the system.

* **assumed decimal point.** A decimal point position that does not involve the existence of an actual character in a data item. The assumed decimal point has logical meaning but no physical representation.

* **AT END condition.** A condition that is caused during the execution of a READ, RETURN, or SEARCH statement under certain conditions:

- A READ statement runs on a sequentially accessed file when no next logical record exists in the file, or when the number of significant digits in the relative record number is larger than the size of the relative key data item, or when an optional input file is not present.
- A RETURN statement runs when no next logical record exists for the associated sort or merge file.
- A SEARCH statement runs when the search operation terminates without satisfying the condition specified in any of the associated WHEN phrases.

B

basic document encoding. For an XML document, one of the following encoding categories that the XML parser determines by examining the first few bytes of the document:

- ASCII
- EBCDIC
- Unicode UTF-16, either big-endian or little-endian
- Other unsupported encoding
- No recognizable encoding

big-endian. The default format that the mainframe and the AIX workstation use to store binary data. In this format, the least significant digit of binary data is at the highest address. Compare with *little-endian*.

binary item. A numeric data item that is represented in binary notation (on the base 2 numbering system). The decimal equivalent consists of the decimal digits 0 through 9, plus an operational sign. The leftmost bit of the item is the operational sign.

binary search. A dichotomizing search in which, at each step of the search, the set of data elements is divided by two; some appropriate action is taken in the case of an odd number.

* **block.** A physical unit of data that is normally composed of one or more logical records. For mass storage files, a block can contain a portion of a logical record. The size of a block has no direct relationship to the size of the file within which the block is contained or to the size of the logical records that are either contained within the block or that overlap the block. Synonymous with *physical record*.

breakpoint. A place in a computer program, usually specified by an instruction, where external intervention or a monitor program can interrupt the program as it runs.

Btrieve file system. A key-indexed record management system that allows applications to manage records by key value, sequential access method, or random access method. IBM COBOL supports COBOL sequential and indexed file input-output language through Btrieve (available from Pervasive Software). You can use the Btrieve file system to access files created by CICS Transaction Server for Windows.

buffer. A portion of storage that is used to hold input or output data temporarily.

built-in function. See *intrinsic function*.

business method. A method of an enterprise bean that implements the business logic or rules of an application. (Sun)

byte. A string that consists of a certain number of bits, usually eight, treated as a unit, and representing a character or a control function.

byte order mark (BOM). A Unicode character that can be used at the start of UTF-16 or UTF-32 text to indicate the byte order of subsequent text; the byte order can be either *big-endian* or *little-endian*.

bytecode. Machine-independent code that is generated by the Java compiler and executed by the Java interpreter. (Sun)

C

callable services. In Language Environment, a set of services that a COBOL program can invoke by using the conventional Language Environment-defined call interface. All programs that share the Language Environment conventions can use these services.

called program. A program that is the object of a CALL statement. At run time the called program and calling program are combined to produce a *run unit*.

* **calling program.** A program that executes a CALL to another program.

case structure. A program-processing logic in which a series of conditions is tested in order to choose between a number of resulting actions.

cataloged procedure. A set of job control statements that are placed in a partitioned data set called the procedure library (SYS1.PROCLIB). You can use cataloged procedures to save time and reduce errors in coding JCL.

CCSID. See *coded character set identifier*.

century window. A 100-year interval within which any two-digit year is unique. Several types of century window are available to COBOL programmers:

- For windowed date fields, you use the YEARWINDOW compiler option.
- For the windowing intrinsic functions DATE-T0-YYYYMMDD, DAY-T0-YYYYDDD, and YEAR-T0-YYYY, you specify the century window with *argument-2*.
- For Language Environment callable services, you specify the century window in CEESCEN.

* **character.** The basic indivisible unit of the language.

character encoding unit. A unit of data that corresponds to one code point in a coded character set. One or more character encoding units are used to represent a character in a coded character set. Also known as *encoding unit*.

For USAGE NATIONAL, a character encoding unit corresponds to one 2-byte code point of UTF-16.

For USAGE DISPLAY, a character encoding unit corresponds to a byte.

For USAGE DISPLAY-1, a character encoding unit corresponds to a 2-byte code point in the DBCS character set.

character position. The amount of physical storage or presentation space required to hold or present one character. The term applies to any class of character. For specific classes of characters, the following terms apply:

- *Alphanumeric character position*, for characters represented in usage DISPLAY
- *DBCS character position*, for DBCS characters represented in usage DISPLAY-1
- *National character position*, for characters represented in usage NATIONAL; synonymous with character encoding unit for UTF-16

character set. A collection of elements that are used to represent textual information, but for which no coded representation is assumed. See also *coded character set*.

character string. A sequence of contiguous characters that form a COBOL word, a literal, a PICTURE character string, or a comment-entry. A character string must be delimited by separators.

checkpoint. A point at which information about the status of a job and the system can be recorded so that the job step can be restarted later.

* **class.** The entity that defines common behavior and implementation for zero, one, or more objects. The objects that share the same implementation are considered to be objects of the same class. Classes can be defined hierarchically, allowing one class to inherit from another.

* **class condition.** The proposition (for which a truth value can be determined) that the content of an item is wholly alphabetic, is wholly numeric, is wholly DBCS, is wholly Kanji, or consists exclusively of the characters that are listed in the definition of a class-name.

* **class definition.** The COBOL source unit that defines a class.

class hierarchy. A tree-like structure that shows relationships among object classes. It places one class at the top and one or more layers of classes below it. Synonymous with *inheritance hierarchy*.

* **class identification entry.** An entry in the CLASS-ID paragraph of the IDENTIFICATION DIVISION; this entry contains clauses that specify the class-name and assign selected attributes to the class definition.

class-name (object-oriented). The name of an object-oriented COBOL class definition.

* **class-name (of data).** A user-defined word that is defined in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION; this word assigns a name to the proposition (for which a truth value can be defined) that the content of a data item consists exclusively of the characters that are listed in the definition of the class-name.

class object. The run-time object that represents a class.

* **clause.** An ordered set of consecutive COBOL character strings whose purpose is to specify an attribute of an entry.

client. In object-oriented programming, a program or method that requests services from one or more methods in a class.

* **COBOL character set.** The set of characters used in writing COBOL syntax. The complete COBOL character set consists of the characters listed below:

Character	Meaning
0,1, . . . ,9	Digit
A,B, . . . ,Z	Uppercase letter
a,b, . . . ,z	Lowercase letter
	Space
+	Plus sign
-	Minus sign (hyphen)
*	Asterisk
/	Slant (virgule, slash)
=	Equal sign
\$	Currency sign
,	Comma (decimal point)
;	Semicolon
.	Period (decimal point, full stop)
"	Quotation mark
(	Left parenthesis
)	Right parenthesis
>	Greater than symbol
<	Less than symbol
:	Colon

* **COBOL word.** See *word*.

code page. An assignment of graphic characters and control function meanings to all code points. For example, one code page could assign characters and meanings to 256 code points for 8-bit code, and another code page could assign characters and meanings to 128 code points for 7-bit code. For example, one of the IBM code pages for English on the workstation is IBM-850 and on the host is IBM-1047. A *coded character set*.

code point. A unique bit pattern that is defined in a coded character set (code page). Code points are assigned to graphic characters in a coded character set.

coded character set. A set of unambiguous rules that establish a character set and the relationship between the characters of the set and their coded representation. Examples of coded character sets are the character sets as represented by ASCII or EBCDIC code pages or by the UTF-16 encoding scheme for Unicode.

coded character set identifier (CCSID). A number in the range 1 to 65,535 that includes a specific set of identifiers for the encoding scheme, character set, and code page, and other information that uniquely identifies the coded graphic character representation.

* **collating sequence.** The sequence in which the characters that are acceptable to a computer are ordered for purposes of sorting, merging, comparing, and for processing indexed files sequentially.

* **column.** A byte position within a print line or within a reference format line. The columns are numbered from 1, by 1, starting at the leftmost position of the line and extending to the rightmost position of the line. A column holds one single-byte character.

* **combined condition.** A condition that is the result of connecting two or more conditions with the AND or the OR logical operator. See also *condition* and *negated combined condition*.

* **comment-entry.** An entry in the IDENTIFICATION DIVISION that can be any combination of characters from the character set of the computer.

* **comment line.** A source program line represented by an asterisk (*) in the indicator area of the line and any characters from the character set of the computer in area A and area B of that line. The comment line serves only for documentation. A special form of comment line represented by a slant (/) in the indicator area of the line and any characters from the character set of the computer in area A and area B of that line causes page ejection before printing the comment.

* **common program.** A program that, despite being directly contained within another program, can be called from any program directly or indirectly contained in that other program.

compatible date field. The meaning of the term *compatible*, when applied to date fields, depends on the COBOL division in which the usage occurs:

- DATA DIVISION

Two date fields are compatible if they have identical USAGE and meet at least one of the following conditions:

- They have the same date format.
- Both are windowed date fields, where one consists only of a windowed year, DATE FORMAT YY.
- Both are expanded date fields, where one consists only of an expanded year, DATE FORMAT YYYY.

- One has DATE FORMAT YYXXXX, and the other has YYYY.
- One has DATE FORMAT YYYYXXXX, and the other has YYYYXX.

A windowed date field can be subordinate to a data item that is an expanded date group. The two date fields are compatible if the subordinate date field has USAGE DISPLAY, starts two bytes after the start of the group expanded date field, and the two fields meet at least one of the following conditions:

- The subordinate date field has a DATE FORMAT pattern with the same number of Xs as the DATE FORMAT pattern of the group date field.
- The subordinate date field has DATE FORMAT YY.
- The group date field has DATE FORMAT YYYYXXXX and the subordinate date field has DATE FORMAT YYYY.

- **PROCEDURE DIVISION**

Two date fields are compatible if they have the same date format except for the year part, which can be windowed or expanded. For example, a windowed date field with DATE FORMAT YYXXX is compatible with:

- Another windowed date field with DATE FORMAT YYXXX
- An expanded date field with DATE FORMAT YYYYXXX

* **compile.** (1) To translate a program expressed in a high-level language into a program expressed in an intermediate language, assembly language, or a computer language. (2) To prepare a machine-language program from a computer program written in another programming language by making use of the overall logic structure of the program, or generating more than one computer instruction for each symbolic statement, or both, as well as performing the function of an assembler.

* **compile time.** The time at which COBOL source code is translated, by a COBOL compiler, to a COBOL object program.

compiler. A program that translates source code written in a higher-level language into machine-language object code.

compiler-directing statement. A statement that causes the compiler to take a specific action during compilation. The compiler-directing statements are COPY and REPLACE.

compiler-directive.

* **complex condition.** A condition in which one or more logical operators act upon one or more conditions. See also *condition*, *negated simple condition*, and *negated combined condition*.

complex ODO. Certain forms of the OCCURS DEPENDING ON clause:

- Variably located item or group: A data item described by an OCCURS clause with the DEPENDING ON option is followed by a nonsubordinate data item or group.
- Variably located table: A data item described by an OCCURS clause with the DEPENDING ON option is followed by a nonsubordinate data item described by an OCCURS clause.
- Table with variable-length elements: A data item described by an OCCURS clause contains a subordinate data item described by an OCCURS clause with the DEPENDING ON option.
- Index name for a table with variable-length elements.
- Element of a table with variable-length elements.

component. (1) A functional grouping of related files. (2) In object-oriented programming, a reusable object or program that performs a specific function and is designed to work with other components and applications. JavaBeans is Sun Microsystems, Inc.'s architecture for creating components.

* **computer-name.** A system-name that identifies the computer where the program is to be compiled or run.

condition. An exception that has been enabled, or recognized, by Language Environment and thus is eligible to activate user and language condition handlers. Any alteration to the normal programmed flow of an application. Conditions can be detected by the hardware or the operating system and result in an interrupt. They can also be detected by language-specific generated code or language library code.

* **condition.** A status of a program at run time for which a truth value can be determined. When used in these language specifications in or in reference to 'condition' (*condition-1*, *condition-2*, . . .) of a general format, the term refers to a conditional expression that consists of either a simple condition optionally parenthesized or a combined condition (consisting of the syntactically correct combination of simple conditions, logical operators, and parentheses) for which a truth value can be determined. See also *simple condition*, *complex condition*, *negated simple condition*, *combined condition*, and *negated combined condition*.

* **conditional expression.** A simple condition or a complex condition specified in an EVALUATE, IF, PERFORM, or SEARCH statement. See also *simple condition* and *complex condition*.

* **conditional phrase.** A phrase that specifies the action to be taken upon determination of the truth value of a condition that results from the execution of a conditional statement.

* **conditional statement.** A statement that specifies that the truth value of a condition is to be determined

and that the subsequent action of the object program depends on this truth value.

* **conditional variable.** A data item one or more values of which has a condition-name assigned to it.

* **condition-name.** A user-defined word that assigns a name to a subset of values that a conditional variable can assume; or a user-defined word assigned to a status of an implementor-defined switch or device.

* **condition-name condition.** The proposition (for which a truth value can be determined) that the value of a conditional variable is a member of the set of values attributed to a condition-name associated with the conditional variable.

* **CONFIGURATION SECTION.** A section of the ENVIRONMENT DIVISION that describes overall specifications of source and object programs and class definitions.

CONSOLE. A COBOL environment-name associated with the operator console.

* **contiguous items.** Items that are described by consecutive entries in the DATA DIVISION, and that bear a definite hierarchic relationship to each other.

copybook. A file or library member that contains a sequence of code that is included in the source program at compile time using the COPY statement. The file can be created by the user, supplied by COBOL, or supplied by another product. Synonymous with *copy file*.

* **counter.** A data item used for storing numbers or number representations in a manner that permits these numbers to be increased or decreased by the value of another number, or to be changed or reset to zero or to an arbitrary positive or negative value.

cross-reference listing. The portion of the compiler listing that contains information on where files, fields, and indicators are defined, referenced, and modified in a program.

currency-sign value. A character string that identifies the monetary units stored in a numeric-edited item. Typical examples are \$, USD, and EUR. A currency-sign value can be defined by either the CURRENCY compiler option or the CURRENCY SIGN clause in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION. If the CURRENCY SIGN clause is not specified and the NOCURRENCY compiler option is in effect, the dollar sign (\$) is used as the default currency-sign value. See also *currency symbol*.

currency symbol. A character used in a PICTURE clause to indicate the position of a currency sign value in a numeric-edited item. A currency symbol can be defined by either the CURRENCY compiler option or the CURRENCY SIGN clause in the SPECIAL-NAMES paragraph of the ENVIRONMENT DIVISION. If the CURRENCY SIGN clause is

not specified and the NOCURRENCY compiler option is in effect, the dollar sign (\$) is used as the default currency sign value and currency symbol. Multiple currency symbols and currency sign values can be defined. See also *currency sign value*.

* **current record.** In file processing, the record that is available in the record area associated with a file.

* **current volume pointer.** A conceptual entity that points to the current volume of a sequential file.

D

* **data clause.** A clause, appearing in a data description entry in the DATA DIVISION of a COBOL program, that provides information describing a particular attribute of a data item.

* **data description entry.** An entry in the DATA DIVISION of a COBOL program that is composed of a level-number followed by a data-name, if required, and then followed by a set of data clauses, as required.

DATA DIVISION. The division of a COBOL program or method that describes the data to be processed by the program or method: the files to be used and the records contained within them; internal working-storage records that will be needed; data to be made available in more than one program in the COBOL run unit.

* **data item.** A unit of data (excluding literals) defined by a COBOL program or by the rules for function evaluation.

* **data-name.** A user-defined word that names a data item described in a data description entry. When used in the general formats, data-name represents a word that must not be reference-modified, subscripted, or qualified unless specifically permitted by the rules for the format.

date field. Any of the following:

- A data item whose data description entry includes a DATE FORMAT clause.
- A value returned by one of the following intrinsic functions:

DATE-OF-INTEGER
DATE-TO-YYYYMMDD
DATEVAL
DAY-OF-INTEGER
DAY-TO-YYYYDDD
YEAR-TO-YYYY
YEARWINDOW

- The conceptual data items DATE, DATE YYYYMMDD, DAY, and DAY YYYYDDD of the ACCEPT statement.

- The result of certain arithmetic operations (for details, see Arithmetic with date fields in *Enterprise COBOL Language Reference*).

The term *date field* refers to both *expanded date field* and *windowed date field*. See also *nondate*.

date format. The date pattern of a date field, specified in either of the following ways:

- Explicitly, by the DATE FORMAT clause or DATEVAL intrinsic function argument-2
- Implicitly, by statements and intrinsic functions that return date fields (for details, see Date field in *Enterprise COBOL Language Reference*)

DBCS. See *double-byte character set (DBCS)*.

Debug Perspective. A view within WebSphere Studio Enterprise Developer that enables you to detect and diagnose errors in programs that run on systems accessible through a network connection or that run on your workstation. The Debug Perspective uses a graphical user interface where you can issue commands to control the execution (remote or local) of your program.

* **debugging line.** Any line with a D in the indicator area of the line.

* **debugging section.** A section that contains a USE FOR DEBUGGING statement.

* **declarative sentence.** A compiler-directing sentence that consists of a single USE statement terminated by the separator period.

* **declaratives.** A set of one or more special-purpose sections, written at the beginning of the PROCEDURE DIVISION, the first of which is preceded by the key word DECLARATIVE and the last of which is followed by the key words END DECLARATIVES. A declarative is composed of a section header, followed by a USE compiler-directing sentence, followed by a set of zero, one, or more associated paragraphs.

* **de-edit.** The logical removal of all editing characters from a numeric-edited data item in order to determine the unedited numeric value of the item.

* **delimited scope statement.** Any statement that includes its explicit scope terminator.

* **delimiter.** A character or a sequence of contiguous characters that identify the end of a string of characters and separate that string of characters from the following string of characters. A delimiter is not part of the string of characters that it delimits.

dependent region. In IMS, the MVS virtual storage region that contains message-driven programs, batch programs, or online utilities.

* **descending key.** A key upon the values of which data is ordered starting with the highest value of key down to the lowest value of key, in accordance with the rules for comparing data items.

digit. Any of the numerals from 0 through 9. In COBOL, the term is not used to refer to any other symbol.

* **digit position.** The amount of physical storage required to store a single digit. This amount can vary depending on the usage specified in the data description entry that defines the data item.

* **direct access.** The facility to obtain data from storage devices or to enter data into a storage device in such a way that the process depends only on the location of that data and not on a reference to data previously accessed.

* **division.** A collection of zero, one, or more sections or paragraphs, called the division body, that are formed and combined in accordance with a specific set of rules. Each division consists of the division header and the related division body. There are four divisions in a COBOL program: Identification, Environment, Data, and Procedure.

* **division header.** A combination of words followed by a separator period that indicates the beginning of a division. The division headers are:

IDENTIFICATION DIVISION.
ENVIRONMENT DIVISION.
DATA DIVISION.
PROCEDURE DIVISION.

DLL. See *dynamic link library (DLL)*.

DLL application. An application that references imported programs, functions, or variables.

DLL linkage. A CALL in a program that has been compiled with the DLL and NODYNAM options; the CALL resolves to an exported name in a separate module, or to an INVOKE of a method that is defined in a separate module.

do construct. In structured programming, a DO statement is used to group a number of statements in a procedure. In COBOL, an inline PERFORM statement functions in the same way.

do-until. In structured programming, a do-until loop will be executed at least once, and until a given condition is true. In COBOL, a TEST AFTER phrase used with the PERFORM statement functions in the same way.

do-while. In structured programming, a do-while loop will be executed if, and while, a given condition is true. In COBOL, a TEST BEFORE phrase used with the PERFORM statement functions in the same way.

document type definition (DTD). The grammar for a class of XML documents. See *XML type definition*.

double-byte character set (DBCS). A set of characters in which each character is represented by 2 bytes. Languages such as Japanese, Chinese, and Korean, which contain more symbols than can be represented by 256 code points, require double-byte character sets. Because each character requires 2 bytes, entering, displaying, and printing DBCS characters requires hardware and supporting software that are DBCS-capable.

*** dynamic access.** An access mode in which specific logical records can be obtained from or placed into a mass storage file in a nonsequential manner and obtained from a file in a sequential manner during the scope of the same OPEN statement.

dynamic CALL. A CALL *literal* statement in a program that has been compiled with the DYNAM and NODLL options, or a CALL *identifier* statement in a program that has been compiled with the NODLL option.

dynamic link library (DLL). A file that contains executable code and data that are bound to a program at load time or run time, rather than during linking. Several applications can share the code and data in a DLL simultaneously. Although a DLL is not part of the executable (.EXE) file for a program, it can be required for an .EXE file to run properly.

dynamic storage area (DSA). Dynamically acquired storage composed of a register save area and an area available for dynamic storage allocation (such as program variables). A DSA is allocated upon invocation of a program or function and persists for the duration of the invocation instance. DSAs are generally allocated within stack segments managed by Language Environment.

E

*** EBCDIC (Extended Binary-Coded Decimal Interchange Code).** A coded character set based on 8-bit coded characters.

EBCDIC character. Any one of the symbols included in the EBCDIC (Extended Binary-Coded-Decimal Interchange Code) set.

edited data item. A data item that has been modified by suppressing zeros or inserting editing characters or both.

*** editing character.** A single character or a fixed two-character combination belonging to the following set:

Character	Meaning
	Space
0	Zero

Character	Meaning
+	Plus
-	Minus
CR	Credit
DB	Debit
Z	Zero suppress
*	Check protect
\$	Currency sign
,	Comma (decimal point)
.	Period (decimal point)
/	Slant (virgule, slash)

EJB. See *Enterprise JavaBeans*.

EJB container. A container that implements the EJB component contract of the J2EE architecture. This contract specifies a run-time environment for enterprise beans that includes security, concurrency, life cycle management, transaction, deployment, and other services. An EJB container is provided by an EJB or J2EE server. (Sun)

EJB server. Software that provides services to an EJB container. An EJB server can host one or more EJB containers. (Sun)

element (text element). One logical unit of a string of text, such as the description of a single data item or verb, preceded by a unique code identifying the element type.

*** elementary item.** A data item that is described as not being further logically subdivided.

encapsulation. In object-oriented programming, the technique that is used to hide the inherent details of an object. The object provides an interface that queries and manipulates the data without exposing its underlying structure. Synonymous with *information hiding*.

enclave. When running under Language Environment, an enclave is analogous to a run unit. An enclave can create other enclaves by a LINK and the use of the system() function of C.

encoding unit. See *character encoding unit*.

end class marker. A combination of words, followed by a separator period, that indicates the end of a COBOL class definition. The end class marker is:
END CLASS *class-name*.

end method marker. A combination of words, followed by a separator period, that indicates the end of a COBOL method definition. The end method marker is:
END METHOD *method-name*.

* **end of PROCEDURE DIVISION.** The physical position of a COBOL source program after which no further procedures appear.

* **end program marker.** A combination of words, followed by a separator period, that indicates the end of a COBOL source program. The end program marker is:

END PROGRAM *program-name*.

enterprise bean. A component that implements a business task and resides in an EJB container. (Sun)

Enterprise JavaBeans. A component architecture defined by Sun Microsystems, Inc. for the development and deployment of object-oriented, distributed, enterprise-level applications.

* **entry.** Any descriptive set of consecutive clauses terminated by a separator period and written in the IDENTIFICATION DIVISION, ENVIRONMENT DIVISION, or DATA DIVISION of a COBOL program.

* **environment clause.** A clause that appears as part of an ENVIRONMENT DIVISION entry.

ENVIRONMENT DIVISION. One of the four main component parts of a COBOL program, class definition, or method definition. The ENVIRONMENT DIVISION describes the computers where the source program is compiled and those where the object program is run. It provides a linkage between the logical concept of files and their records, and the physical aspects of the devices on which files are stored.

environment-name. A name, specified by IBM, that identifies system logical units, printer and card punch control characters, report codes, program switches or all of these. When an environment-name is associated with a mnemonic-name in the ENVIRONMENT DIVISION, the mnemonic-name can be substituted in any format in which such substitution is valid.

environment variable. Any of a number of variables that define some aspect of the computing environment, and are accessible to programs that operate in that environment. Environment variables can affect the behavior of programs that are sensitive to the environment in which they operate.

EXE. See *executable file (EXE)*.

executable file (EXE). A file that contains programs or commands that perform operations or actions to be taken.

execution time. See *run time*.

execution-time environment. See *run-time environment*.

expanded date field. A date field containing an expanded (four-digit) year. See also *date field* and *expanded year*.

expanded year. A date field that consists only of a four-digit year. Its value includes the century: for example, 1998. Compare with *windowed year*.

* **explicit scope terminator.** A reserved word that terminates the scope of a particular PROCEDURE DIVISION statement.

exponent. A number that indicates the power to which another number (the base) is to be raised. Positive exponents denote multiplication; negative exponents denote division; and fractional exponents denote a root of a quantity. In COBOL, an exponential expression is indicated with the symbol ** followed by the exponent.

* **expression.** An arithmetic or conditional expression.

* **extend mode.** The state of a file after execution of an OPEN statement, with the EXTEND phrase specified for that file, and before the execution of a CLOSE statement, without the REEL or UNIT phrase for that file.

Extensible Markup Language. See *XML*.

extensions. COBOL syntax and semantics supported by IBM compilers in addition to those described in Standard COBOL 85.

external code page. For XML documents, the value specified by the CODEPAGE compiler option.

* **external data.** The data that is described in a program as external data items and external file connectors.

* **external data item.** A data item that is described as part of an external record in one or more programs of a run unit and that can be referenced from any program in which it is described.

* **external data record.** A logical record that is described in one or more programs of a run unit and whose constituent data items can be referenced from any program in which they are described.

external decimal item. A format for representing numbers in which the digit is contained in bits 4 through 7 and the sign is contained in bits 0 through 3 of the rightmost byte. Bits 0 through 3 of all other bytes contain 1 (hex F). For example, the decimal value of +123 is represented as 1111 0001 1111 0010 1111 0011. Synonymous with *zoned decimal item*.

* **external file connector.** A file connector that is accessible to one or more object programs in the run unit.

external floating-point item. A format for representing numbers in which a real number is represented by a pair of distinct numerals. In a floating-point representation, the real number is the product of the fixed-point part (the first numeral), and

a value obtained by raising the implicit floating-point base to a power denoted by the exponent (the second numeral). For example, a floating-point representation of the number 0.0001234 is: 0.1234 -3, where 0.1234 is the mantissa and -3 is the exponent.

external program. The outermost program. A program that is not nested.

* **external switch.** A hardware or software device, defined and named by the implementor, which is used to indicate that one of two alternate states exists.

F

factory data. Data that is allocated once for a class and shared by all instances of the class. Factory data is declared in the WORKING-STORAGE SECTION of the DATA DIVISION in the FACTORY paragraph of the class definition, and is equivalent to Java private static data.

factory method. A method that is supported by a class independently of an object instance. Factory methods are declared in the FACTORY paragraph of the class definition, and are equivalent to Java public static methods. They are typically used to customize the creation of objects.

* **figurative constant.** A compiler-generated value referenced through the use of certain reserved words.

* **file.** A collection of logical records.

* **file attribute conflict condition.** An unsuccessful attempt has been made to execute an input-output operation on a file and the file attributes, as specified for that file in the program, do not match the fixed attributes for that file.

* **file clause.** A clause that appears as part of any of the following DATA DIVISION entries: file description entry (FD entry) and sort-merge file description entry (SD entry).

* **file connector.** A storage area that contains information about a file and is used as the linkage between a file-name and a physical file and between a file-name and its associated record area.

FILE-CONTROL paragraph. A paragraph in the ENVIRONMENT DIVISION in which the data files for a given source unit are declared.

* **file control entry.** A SELECT clause and all its subordinate clauses that declare the relevant physical attributes of a file.

* **file description entry.** An entry in the FILE SECTION of the DATA DIVISION that is composed of the level indicator FD, followed by a file-name, and then followed by a set of file clauses as required.

* **file-name.** A user-defined word that names a file connector described in a file description entry or a sort-merge file description entry within the FILE SECTION of the DATA DIVISION.

* **file organization.** The permanent logical file structure established at the time that a file is created.

* **file position indicator.** A conceptual entity that contains the value of the current key within the key of reference for an indexed file, or the record number of the current record for a sequential file, or the relative record number of the current record for a relative file, or indicates that no next logical record exists, or that an optional input file is not present, or that the AT END condition already exists, or that no valid next record has been established.

* **FILE SECTION.** The section of the DATA DIVISION that contains file description entries and sort-merge file description entries together with their associated record descriptions.

file system. The collection of files that conform to a specific set of data-record and file-description protocols, and a set of programs that manage these files.

* **fixed file attributes.** Information about a file that is established when a file is created and that cannot subsequently be changed during the existence of the file. These attributes include the organization of the file (sequential, relative, or indexed), the prime record key, the alternate record keys, the code set, the minimum and maximum record size, the record type (fixed or variable), the collating sequence of the keys for indexed files, the blocking factor, the padding character, and the record delimiter.

* **fixed-length record.** A record associated with a file whose file description or sort-merge description entry requires that all records contain the same number of bytes.

fixed-point item. A numeric data item defined with a PICTURE clause that specifies the location of an optional sign, the number of digits it contains, and the location of an optional decimal point. The format can be either binary, packed decimal, or external decimal.

floating-point item. A numeric data item that contains a fraction and an exponent. Its value is obtained by multiplying the fraction by the base of the numeric data item raised to the power that the exponent specifies.

* **format.** A specific arrangement of a set of data.

* **function.** A temporary data item whose value is determined at the time the function is referenced during the execution of a statement.

* **function-identifier.** A syntactically correct combination of character strings and separators that

references a function. The data item represented by a function is uniquely identified by a function-name with its arguments, if any. A function-identifier can include a reference-modifier. A function-identifier that references an alphanumeric function can be specified anywhere in the general formats that an identifier can be specified, subject to certain restrictions. A function-identifier that references an integer or numeric function can be referenced anywhere in the general formats that an arithmetic expression can be specified.

function-name. A word that names the mechanism whose invocation, along with required arguments, determines the value of a function.

function-pointer data item. A data item in which a pointer to an entry point can be stored. A data item defined with the `USAGE IS FUNCTION-POINTER` clause contains the address of a function entry point. Typically used to communicate with C and Java programs.

G

garbage collection. The automatic freeing by the Java run-time system of the memory for objects that are no longer referenced.

* **global name.** A name that is declared in only one program but that can be referenced from the program and from any program contained within the program. Condition-names, data-names, file-names, record-names, report-names, and some special registers can be global names.

global reference. A reference to an object that is outside the scope of a method.

* **group item.** A data item that is composed of subordinate data items.

H

header label. (1) A file label or data set label that precedes the data records on a unit of recording media. (2) Synonym for *beginning-of-file label*.

hide. To redefine a factory or static method (inherited from a parent class) in a subclass.

hierarchical file system. A collection of files and directories that are organized in a hierarchical structure and can be accessed by using UNIX System Services.

* **high-order end.** The leftmost character of a string of characters.

hiperspace. In a z/OS environment, a range of up to 2 GB of contiguous virtual storage addresses that a program can use as a buffer.

I

IBM COBOL extension. COBOL syntax and semantics supported by IBM compilers in addition to those described in Standard COBOL 85.

ICU. See *International Components for Unicode (ICU)*.

IDENTIFICATION DIVISION. One of the four main component parts of a COBOL program, class definition, or method definition. The IDENTIFICATION DIVISION identifies the program name, class name, or method name. The IDENTIFICATION DIVISION can include the following documentation: author name, installation, or date.

* **identifier.** A syntactically correct combination of character strings and separators that names a data item. When referencing a data item that is not a function, an identifier consists of a data-name, together with its qualifiers, subscripts, and reference-modifier, as required for uniqueness of reference. When referencing a data item that is a function, a function-identifier is used.

IGZCBSO. The Enterprise COBOL bootstrap routine. It must be link-edited with any module that contains a Enterprise COBOL program.

* **imperative statement.** A statement that either begins with an imperative verb and specifies an unconditional action to be taken or is a conditional statement that is delimited by its explicit scope terminator (delimited scope statement). An imperative statement can consist of a sequence of imperative statements.

* **implicit scope terminator.** A separator period that terminates the scope of any preceding unterminated statement, or a phrase of a statement that by its occurrence indicates the end of the scope of any statement contained within the preceding phrase.

* **index.** A computer storage area or register, the content of which represents the identification of a particular element in a table.

* **index data item.** A data item in which the values associated with an index-name can be stored in a form specified by the implementor.

indexed data-name. An identifier that is composed of a data-name, followed by one or more index-names enclosed in parentheses.

* **indexed file.** A file with indexed organization.

* **indexed organization.** The permanent logical file structure in which each record is identified by the value of one or more keys within that record.

indexing. Synonymous with *subscripting* using index-names.

* **index-name.** A user-defined word that names an index associated with a specific table.

inheritance. A mechanism for using the implementation of a class as the basis for another class. By definition, the inheriting class conforms to the inherited classes. Enterprise COBOL does not support *multiple inheritance*; a subclass has exactly one immediate superclass.

inheritance hierarchy. See *class hierarchy*.

* **initial program.** A program that is placed into an initial state every time the program is called in a run unit.

* **initial state.** The state of a program when it is first called in a run unit.

inline. In a program, instructions that are executed sequentially, without branching to routines, subroutines, or other programs.

* **input file.** A file that is opened in the input mode.

* **input mode.** The state of a file after execution of an OPEN statement, with the INPUT phrase specified, for that file and before the execution of a CLOSE statement, without the REEL or UNIT phrase for that file.

* **input-output file.** A file that is opened in the I-O mode.

* **INPUT-OUTPUT SECTION.** The section of the ENVIRONMENT DIVISION that names the files and the external media required by an object program or method and that provides information required for transmission and handling of data at run time.

* **input-output statement.** A statement that causes files to be processed by performing operations on individual records or on the file as a unit. The input-output statements are ACCEPT (with the identifier phrase), CLOSE, DELETE, DISPLAY, OPEN, READ, REWRITE, SET (with the TO ON or TO OFF phrase), START, and WRITE.

* **input procedure.** A set of statements, to which control is given during the execution of a SORT statement, for the purpose of controlling the release of specified records to be sorted.

instance data. Data that defines the state of an object. The instance data introduced by a class is defined in the WORKING-STORAGE SECTION of the DATA DIVISION in the OBJECT paragraph of the class definition. The state of an object also includes the state of the instance variables introduced by classes that are inherited by the current class. A separate copy of the instance data is created for each object instance.

* **integer.** (1) A numeric literal that does not include any digit positions to the right of the decimal point. (2) A numeric data item defined in the DATA DIVISION that

does not include any digit positions to the right of the decimal point. (3) A numeric function whose definition provides that all digits to the right of the decimal point are zero in the returned value for any possible evaluation of the function.

integer function. A function whose category is numeric and whose definition does not include any digit positions to the right of the decimal point.

Interactive System Productivity Facility (ISPF). An IBM software product that provides a menu-driven interface for the TSO or VM user. ISPF includes library utilities, a powerful editor, and dialog management.

interlanguage communication (ILC). The ability of routines written in different programming languages to communicate. ILC support allows the application developer to readily build applications from component routines written in a variety of languages.

intermediate result. An intermediate field that contains the results of a succession of arithmetic operations.

* **internal data.** The data that is described in a program and excludes all external data items and external file connectors. Items described in the LINKAGE SECTION of a program are treated as internal data.

* **internal data item.** A data item that is described in one program in a run unit. An internal data item can have a global name.

internal decimal item. A format in which each byte in a field except the rightmost byte represents two numeric digits. The rightmost byte contains one digit and the sign. For example, the decimal value +123 is represented as 0001 0010 0011 1111. Synonymous with *packed decimal item*.

* **internal file connector.** A file connector that is accessible to only one object program in the run unit.

International Components for Unicode (ICU). An open source development project sponsored, supported, and used by IBM. ICU libraries provide robust and full-featured Unicode services on a wide variety of platforms, including

* **intra-record data structure.** The entire collection of groups and elementary data items from a logical record that a contiguous subset of the data description entries defines. These data description entries include all entries whose level-number is greater than the level-number of the first data description entry describing the intra-record data structure.

intrinsic function. A predefined function, such as a commonly used arithmetic function, called by a built-in function reference.

* **invalid key condition.** A condition, at run time, caused when a specific value of the key associated with an indexed or relative file is determined to be not valid.

* **I-O-CONTROL.** The name of an ENVIRONMENT DIVISION paragraph in which object program requirements for rerun points, sharing of same areas by several data files, and multiple file storage on a single input-output device are specified.

* **I-O-CONTROL entry.** An entry in the I-O-CONTROL paragraph of the ENVIRONMENT DIVISION; this entry contains clauses that provide information required for the transmission and handling of data on named files during the execution of a program.

* **I-O mode.** The state of a file after execution of an OPEN statement, with the I-O phrase specified, for that file and before the execution of a CLOSE statement without the REEL or UNIT phase for that file.

* **I-O status.** A conceptual entity that contains the two-character value indicating the resulting status of an input-output operation. This value is made available to the program through the use of the FILE STATUS clause in the file control entry for the file.

is-a. A relationship that characterizes classes and subclasses in an inheritance hierarchy. Subclasses that have an is-a relationship to a class inherit from that class.

ISPF. See *Interactive System Productivity Facility (ISPF)*.

iteration structure. A program processing logic in which a series of statements is repeated while a condition is true or until a condition is true.

J

J2EE. See *Java 2 Platform, Enterprise Edition (J2EE)*.

Java 2 Platform, Enterprise Edition (J2EE). An environment for developing and deploying enterprise applications, defined by Sun Microsystems, Inc. The J2EE platform consists of a set of services, application programming interfaces (APIs), and protocols that provide the functionality for developing multitiered, Web-based applications. (Sun)

Java batch-processing program (JBP). An IMS batch-processing program that has access to online databases and output message queues. JBPs run online, but like programs in a batch environment, they are started with JCL or in a TSO session.

Java batch-processing region. An IMS dependent region in which only Java batch-processing programs are scheduled.

Java Database Connectivity (JDBC). A specification from Sun Microsystems that defines an API that enables Java programs to access databases.

Java message-processing program (JMP). An IMS Java application program that is driven by transactions and has access to online IMS databases and message queues.

Java message-processing region. An IMS dependent region in which only Java message-processing programs are scheduled.

Java Native Interface (JNI). A programming interface that allows Java code that runs inside a Java virtual machine (JVM) to interoperate with applications and libraries written in other programming languages.

Java virtual machine (JVM). A software implementation of a central processing unit that runs compiled Java programs.

JavaBeans. A portable, platform-independent, reusable component model. (Sun)

JBP. See *Java batch-processing program (JBP)*.

JDBC. See *Java Database Connectivity (JDBC)*.

JMP. See *Java message-processing program (JMP)*.

job control language (JCL). A control language used to identify a job to an operating system and to describe the job's requirements.

JVM. See *Java virtual machine (JVM)*.

K

K. When referring to storage capacity, two to the tenth power; 1024 in decimal notation.

* **key.** A data item that identifies the location of a record, or a set of data items that serve to identify the ordering of data.

* **key of reference.** The key, either prime or alternate, currently being used to access records within an indexed file.

* **keyword.** A reserved word or function-name whose presence is required when the format in which the word appears is used in a source program.

kilobyte (KB). One kilobyte equals 1024 bytes.

L

* **language-name.** A system-name that specifies a particular programming language.

Language Environment-conforming. A characteristic of compiler products (such as Enterprise COBOL, COBOL for OS/390 & VM, COBOL for MVS & VM, C/C++ for MVS & VM, PL/I for MVS & VM) that produce object code conforming to the Language Environment conventions.

last-used state. A state that a program is in if its internal values remain the same as when the program was exited (the values are not reset to their initial values).

* **letter.** A character belonging to one of the following two sets:

1. Uppercase letters: A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z
2. Lowercase letters: a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z

* **level indicator.** Two alphabetic characters that identify a specific type of file or a position in a hierarchy. The level indicators in the DATA DIVISION are: CD, FD, and SD.

* **level-number.** A user-defined word (expressed as a two-digit number) that indicates the hierarchical position of a data item or the special properties of a data description entry. Level-numbers in the range from 1 through 49 indicate the position of a data item in the hierarchical structure of a logical record. Level-numbers in the range 1 through 9 can be written either as a single digit or as a zero followed by a significant digit. Level-numbers 66, 77, and 88 identify special properties of a data description entry.

* **library-name.** A user-defined word that names a COBOL library that the compiler is to use for compiling a given source program.

* **library text.** A sequence of text words, comment lines, the separator space, or the separator pseudo-text delimiter in a COBOL library.

Lilian date. The number of days since the beginning of the Gregorian calendar. Day one is Friday, October 15, 1582. The Lilian date format is named in honor of Luigi Lilio, the creator of the Gregorian calendar.

* **linage-counter.** A special register whose value points to the current position within the page body.

link. (1) The combination of the link connection (the transmission medium) and two link stations, one at each end of the link connection. A link can be shared among multiple links in a multipoint or token-ring configuration. (2) To interconnect items of data or portions of one or more computer programs; for example, linking object programs by a linkage editor to produce an executable file.

LINKAGE SECTION. The section in the DATA DIVISION of the called program or invoked method that describes data items available from the calling program or invoking method. Both the calling program or invoking method and the called program or invoked method can refer to these data items

linker. A term that refers to either the DFSMS linkage editor or the DFSMS binder.

literal. A character string whose value is specified either by the ordered set of characters comprising the string or by the use of a figurative constant.

little-endian. The default format that Intel hardware uses to store binary data. In this format, the most significant digit is at the highest address. Compare with *big-endian*.

local reference. A reference to an object that is within the scope of your method.

locale. A set of attributes for a program execution environment that indicates culturally sensitive considerations, such as character code page, collating sequence, date and time format, monetary value representation, numeric value representation, or language.

* **LOCAL-STORAGE SECTION.** The section of the DATA DIVISION that defines storage that is allocated and freed on a per-invocation basis, depending on the value assigned in the VALUE clauses.

* **logical operator.** One of the reserved words AND, OR, or NOT. In the formation of a condition, either AND, or OR, or both can be used as logical connectives. NOT can be used for logical negation.

* **logical record.** The most inclusive data item. The level-number for a record is 01. A record can be either an elementary item or a group of items. Synonymous with *record*.

* **low-order end.** The rightmost character of a string of characters.

M

main program. In a hierarchy of programs and subroutines, the first program that receives control when the programs are run within a process.

makefile. A text file that contains a list of the files for your application. The make utility uses this file to update the target files with the latest changes.

* **mass storage.** A storage medium in which data can be organized and maintained in both a sequential manner and a nonsequential manner.

* **mass storage device.** A device that has a large storage capacity, such as a magnetic disk.

* **mass storage file.** A collection of records that is stored in a mass storage medium.

MBCS. See *multibyte character set (MBCS)*.

* **megabyte (MB).** One megabyte equals 1,048,576 bytes.

* **merge file.** A collection of records to be merged by a MERGE statement. The merge file is created and can be used only by the merge function.

message-processing program (MPP). An IMS application program that is driven by transactions and has access to online IMS databases and message queues.

message queue. The data set on which messages are queued before being processed by an application program or sent to a terminal.

method. Procedural code that defines an operation supported by an object and that is executed by an INVOKE statement on that object.

* **method definition.** The COBOL source code that defines a method.

* **method identification entry.** An entry in the METHOD-ID paragraph of the IDENTIFICATION DIVISION; this entry contains a clause that specifies the method-name.

method invocation. A communication from one object to another that requests the receiving object to execute a method.

method-name. The name of an object-oriented operation. When used to invoke the method, the name can be a literal or a data item. When used in the METHOD-ID paragraph to define the method, the name must be a literal.

* **mnemonic-name.** A user-defined word that is associated in the ENVIRONMENT DIVISION with a specified implementor-name.

module definition file. A file that describes the code segments within a load module.

MPP. See *message-processing program (MPP)*.

multibyte character set (MBCS). A coded character set that is composed of characters represented in a varying number of bytes. Examples are: EUC (Extended Unix Code), UTF-8, and character sets composed of a mixture of single-byte and double-byte EBCDIC or ASCII characters.

multitasking. A mode of operation that provides for the concurrent, or interleaved, execution of two or more tasks.

multithreading. Concurrent operation of more than one path of execution within a computer. Synonymous with *multiprocessing*.

N

name. A word (composed of not more than 30 characters) that defines a COBOL operand.

national character. An encoding unit of UTF-16 or a character represented in one encoding unit of UTF-16.

national data item. A data item that is described implicitly or explicitly as USAGE NATIONAL.

* **native character set.** The implementor-defined character set associated with the computer specified in the OBJECT-COMPUTER paragraph.

* **native collating sequence.** The implementor-defined collating sequence associated with the computer specified in the OBJECT-COMPUTER paragraph.

native method. A Java method with an implementation that is written in another programming language, such as COBOL.

* **negated combined condition.** The NOT logical operator immediately followed by a parenthesized combined condition. See also *condition* and *combined condition*.

* **negated simple condition.** The NOT logical operator immediately followed by a simple condition. See also *condition* and *simple condition*.

nested program. A program that is directly contained within another program.

* **next executable sentence.** The next sentence to which control will be transferred after execution of the current statement is complete.

* **next executable statement.** The next statement to which control will be transferred after execution of the current statement is complete.

* **next record.** The record that logically follows the current record of a file.

* **noncontiguous items.** Elementary data items in the WORKING-STORAGE SECTION and LINKAGE SECTION that bear no hierarchic relationship to other data items.

nondate. Any of the following:

- A data item whose date description entry does not include the DATE FORMAT clause
- A literal
- A date field that has been converted using the UNDATE function
- A reference-modified date field
- The result of certain arithmetic operations that can include date field operands; for example, the difference between two compatible date fields

null. A figurative constant that is used to assign, to pointer data items, the value of an address that is not valid. NULLS can be used wherever NULL can be used.

* **numeric character.** A character that belongs to the following set of digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

numeric-edited item. A data item that contains numeric data in a form suitable for use in printed output. It can consist of external decimal digits from 0 through 9, the decimal separator, commas, the currency sign, sign control characters, and other editing characters.

* **numeric function.** A function whose class and category are numeric but that for some possible evaluation does not satisfy the requirements of integer functions.

* **numeric item.** A data item whose description restricts its content to a value represented by characters chosen from the digits 0 through 9. If signed, the item can also contain a +, -, or other representation of an operational sign.

* **numeric literal.** A literal composed of one or more numeric characters that can contain a decimal point or an algebraic sign, or both. The decimal point must not be the rightmost character. The algebraic sign, if present, must be the leftmost character.

O

object. An entity that has state (its data values) and operations (its methods). An object is a way to encapsulate state and behavior. Each object in the class is said to be an instance of the class.

object code. Output from a compiler or assembler that is itself executable machine code or is suitable for processing to produce executable machine code.

* **OBJECT-COMPUTER.** The name of an ENVIRONMENT DIVISION paragraph in which the computer environment, where the object program is run, is described.

* **object computer entry.** An entry in the OBJECT-COMPUTER paragraph of the ENVIRONMENT DIVISION; this entry contains clauses that describe the computer environment in which the object program is to be executed.

object deck. A portion of an object program suitable as input to a linkage editor. Synonymous with *object module* and *text deck*.

object instance. See *object*.

object module. Synonym for *object deck* or *text deck*.

* **object of entry.** A set of operands and reserved words, within a DATA DIVISION entry of a COBOL program, that immediately follows the subject of the entry.

object-oriented programming. A programming approach based on the concepts of encapsulation and inheritance. Unlike procedural programming techniques, object-oriented programming concentrates

on the data objects that comprise the problem and how they are manipulated, not on how something is accomplished.

object program. A set or group of executable machine-language instructions and other material designed to interact with data to provide problem solutions. In this context, an object program is generally the machine language result of the operation of a COBOL compiler on a source program or class definition. Where there is no danger of ambiguity, the word *program* can be used in place of *object program*.

object reference. A value that identifies an instance of a class. If the class is not specified, the object reference is universal and can apply to instances of any class.

* **object time.** The time at which an object program is executed. Synonymous with *run time*.

* **obsolete element.** A COBOL language element in Standard COBOL 85 that was deleted from Standard COBOL 2002.

ODO object. In the example below, X is the object of the OCCURS DEPENDING ON clause (ODO object).

```
WORKING-STORAGE SECTION
01  TABLE-1.
    05  X                      PICS9.
    05  Y OCCURS 3 TIMES
        DEPENDING ON X      PIC X.
```

The value of the ODO object determines how many of the ODO subject appear in the table.

ODO subject. In the example above, Y is the subject of the OCCURS DEPENDING ON clause (ODO subject). The number of Y ODO subjects that appear in the table depends on the value of X.

* **open mode.** The state of a file after execution of an OPEN statement for that file and before the execution of a CLOSE statement without the REEL or UNIT phrase for that file. The particular open mode is specified in the OPEN statement as either INPUT, OUTPUT, I-O, or EXTEND.

* **operand.** (1) The general definition of operand is "the component that is operated upon." (2) For the purposes of this document, any lowercase word (or words) that appears in a statement or entry format can be considered to be an operand and, as such, is an implied reference to the data indicated by the operand.

operation. A service that can be requested of an object.

* **operational sign.** An algebraic sign that is associated with a numeric data item or a numeric literal, to indicate whether its value is positive or negative.

* **optional file.** A file that is declared as being not necessarily present each time the object program is run.

The object program causes an interrogation for the presence or absence of the file.

* **optional word.** A reserved word that is included in a specific format only to improve the readability of the language. Its presence is optional to the user when the format in which the word appears is used in a source unit.

* **output file.** A file that is opened in either output mode or extend mode.

* **output mode.** The state of a file after execution of an OPEN statement, with the OUTPUT or EXTEND phrase specified, for that file and before the execution of a CLOSE statement without the REEL or UNIT phrase for that file.

* **output procedure.** A set of statements to which control is given during execution of a SORT statement after the sort function is completed, or during execution of a MERGE statement after the merge function reaches a point at which it can select the next record in merged order when requested.

overflow condition. A condition that occurs when a portion of the result of an operation exceeds the capacity of the intended unit of storage.

overload. To define a method with the same name as another method that is available in the same class, but with a different signature. See also *signature*.

override. To redefine an instance method (inherited from a parent class) in a subclass.

P

package. A group of related Java classes, which can be imported individually or as a whole.

packed-decimal item. See *internal decimal item*.

* **padding character.** An alphanumeric character that is used to fill the unused character positions in a physical record.

page. A vertical division of output data that represents a physical separation of the data. The separation is based on internal logical requirements or external characteristics of the output medium or both.

* **page body.** That part of the logical page in which lines can be written or spaced or both.

* **paragraph.** In the PROCEDURE DIVISION, a paragraph-name followed by a n period and by zero, one, or more sentences. In the IDENTIFICATION DIVISION and ENVIRONMENT DIVISION, a paragraph header followed by zero, one, or more entries.

* **paragraph header.** A reserved word, followed by the separator period, that indicates the beginning of a

paragraph in the IDENTIFICATION DIVISION and ENVIRONMENT DIVISION. The permissible paragraph headers in the IDENTIFICATION DIVISION are:

PROGRAM-ID. (Program IDENTIFICATION DIVISION)
CLASS-ID. (Class IDENTIFICATION DIVISION)
METHOD-ID. (Method IDENTIFICATION DIVISION)
AUTHOR.
INSTALLATION.
DATE-WRITTEN.
DATE-COMPILED.
SECURITY.

The permissible paragraph headers in the ENVIRONMENT DIVISION are:

SOURCE-COMPUTER.
OBJECT-COMPUTER.
SPECIAL-NAMES.
REPOSITORY. (Program or Class
CONFIGURATION SECTION)
FILE-CONTROL.
I-O-CONTROL.

* **paragraph-name.** A user-defined word that identifies and begins a paragraph in the PROCEDURE DIVISION.

parameter. (1) Data passed between a calling program and a called program. (2) A data element in the USING phrase of a method invocation. Arguments provide additional information that the invoked method can use to perform the requested operation.

Persistent Reusable JVM. A JVM that can be serially reused for transaction processing by resetting the JVM between transactions. The reset phase restores the JVM to a known initialization state.

* **phrase.** An ordered set of one or more consecutive COBOL character strings that form a portion of a COBOL procedural statement or of a COBOL clause.

* **physical record.** See *block*.

pointer data item. A data item in which address values can be stored. Data items are explicitly defined as pointers with the USAGE IS POINTER clause. ADDRESS OF special registers are implicitly defined as pointer data items. Pointer data items can be compared for equality or moved to other pointer data items.

port. (1) To modify a computer program to enable it to run on a different platform. (2) In the Internet suite of protocols, a specific logical connector between the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP) and a higher-level protocol or application. A port is identified by a port number.

portability. The ability to transfer an application program from one application platform to another with relatively few changes to the source program.

preinitialization. The initialization of the COBOL run-time environment in preparation for multiple calls

from programs, especially non-COBOL programs. The environment is not terminated until an explicit termination.

* **prime record key.** A key whose contents uniquely identify a record within an indexed file.

* **priority-number.** A user-defined word that classifies sections in the PROCEDURE DIVISION for purposes of segmentation. Segment numbers can contain only the characters 0 through 9. A segment number can be expressed as either one or two digits.

private. As applied to factory data or instance data, accessible only by methods of the class that defines the data.

* **procedure.** A paragraph or group of logically successive paragraphs, or a section or group of logically successive sections, within the PROCEDURE DIVISION.

* **procedure branching statement.** A statement that causes the explicit transfer of control to a statement other than the next executable statement in the sequence in which the statements are written in the source code. The procedure branching statements are: ALTER, CALL, EXIT, EXIT PROGRAM, GO TO, MERGE (with the OUTPUT PROCEDURE phrase), PERFORM and SORT (with the INPUT PROCEDURE or OUTPUT PROCEDURE phrase), XML PARSE.

PROCEDURE DIVISION. The COBOL division that contains instructions for solving a problem.

procedure integration. One of the functions of the COBOL optimizer is to simplify calls to performed procedures or contained programs.

PERFORM procedure integration is the process whereby a PERFORM statement is replaced by its performed procedures. Contained program procedure integration is the process where a call to a contained program is replaced by the program code.

* **procedure-name.** A user-defined word that is used to name a paragraph or section in the PROCEDURE DIVISION. It consists of a paragraph-name (which can be qualified) or a section-name.

procedure-pointer data item. A data item in which a pointer to an entry point can be stored. A data item defined with the USAGE IS PROCEDURE-POINTER clause contains the address of a procedure entry point. Typically used to communicate with COBOL and Language Environment programs.

process. The course of events that occurs during the execution of all or part of a program. Multiple processes can run concurrently, and programs that run within a process can share resources.

program. (1) A sequence of instructions suitable for processing by a computer. Processing may include the

use of a compiler to prepare the program for execution, as well as a run-time environment to execute it. (2) A logical assembly of one or more interrelated modules. Multiple copies of the same program can be run in different processes.

* **program identification entry.** In the PROGRAM-ID paragraph of the IDENTIFICATION DIVISION, an entry that contains clauses that specify the program-name and assign selected program attributes to the program.

* **program-name.** In the IDENTIFICATION DIVISION and the end program marker, a user-defined word or alphanumeric literal that identifies a COBOL source program.

project environment. The central location where you launch your COBOL tools such as the editor and job monitor and work with COBOL files or data sets.

* **pseudo-text.** A sequence of text words, comment lines, or the separator space in a source program or COBOL library bounded by, but not including, pseudo-text delimiters.

* **pseudo-text delimiter.** Two contiguous equal sign characters (==) used to delimit pseudo-text.

* **punctuation character.** A character that belongs to the following set:

Character	Meaning
,	Comma
;	Semicolon
:	Colon
.	Period (full stop)
"	Quotation mark
(	Left parenthesis
)	Right parenthesis
	Space
=	Equal sign

Q

QSAM (queued sequential access method). An extended version of the basic sequential access method (BSAM). When this method is used, a queue is formed of input data blocks that are awaiting processing or of output data blocks that have been processed and are awaiting transfer to auxiliary storage or to an output device.

* **qualified data-name.** An identifier that is composed of a data-name followed by one or more sets of either of the connectives OF and IN followed by a data-name qualifier.

* **qualifier.** (1) A data-name or a name associated with a level indicator that is used in a reference either together with another data-name (which is the name of

an item that is subordinate to the qualifier) or together with a condition-name. (2) A section-name that is used in a reference together with a paragraph-name specified in that section. (3) A library-name that is used in a reference together with a text-name associated with that library.

R

* **random access.** An access mode in which the program-specified value of a key data item identifies the logical record that is obtained from, deleted from, or placed into a relative or indexed file.

* **record.** See *logical record*.

* **record area.** A storage area allocated for the purpose of processing the record described in a record description entry in the FILE SECTION of the DATA DIVISION. In the FILE SECTION, the current number of character positions in the record area is determined by the explicit or implicit RECORD clause.

* **record description.** See *record description entry*.

* **record description entry.** The total set of data description entries associated with a particular record. Synonymous with *record description*.

record key. A key whose contents identify a record within an indexed file.

* **record-name.** A user-defined word that names a record described in a record description entry in the DATA DIVISION of a COBOL program.

* **record number.** The ordinal number of a record in the file whose organization is sequential.

recording mode. The format of the logical records in a file. Recording mode can be F (fixed length), V (variable length), S (spanned), or U (undefined).

recursion. A program calling itself or being directly or indirectly called by a one of its called programs.

recursively capable. A program is recursively capable (can be called recursively) if the RECURSIVE attribute is on the PROGRAM-ID statement.

reel. A discrete portion of a storage medium, the dimensions of which are determined by each implementor that contains part of a file, all of a file, or any number of files. Synonymous with *unit* and *volume*.

reentrant. The attribute of a program or routine that allows more than one user to share a single copy of a load module.

* **reference format.** A format that provides a standard method for describing COBOL source programs.

reference modification. A method of defining a new alphanumeric data item by specifying the leftmost character and length relative to the leftmost character of another alphanumeric data item.

* **reference-modifier.** A syntactically correct combination of character strings and separators that defines a unique data item. It includes a delimiting left parenthesis separator, the leftmost character position, a colon separator, optionally a length, and a delimiting right parenthesis separator.

* **relation.** See *relational operator* or *relation condition*.

* **relation character.** A character that belongs to the following set:

Character	Meaning
>	Greater than
<	Less than
=	Equal to

* **relation condition.** The proposition (for which a truth value can be determined) that the value of an arithmetic expression, data item, nonnumeric literal, or index-name has a specific relationship to the value of another arithmetic expression, data item, nonnumeric literal, or index name. See also *relational operator*.

* **relational operator.** A reserved word, a relation character, a group of consecutive reserved words, or a group of consecutive reserved words and relation characters used in the construction of a relation condition. The permissible operators and their meanings are:

Character	Meaning
IS GREATER THAN	Greater than
IS >	Greater than
IS NOT GREATER THAN	Not greater than
IS NOT >	Not greater than
IS LESS THAN	Less than
IS <	Less than
IS NOT LESS THAN	Not less than
IS NOT <	Not less than
IS EQUAL TO	Equal to
IS =	Equal to
IS NOT EQUAL TO	Not equal to
IS NOT =	Not equal to
IS GREATER THAN OR EQUAL TO	Greater than or equal to
IS >=	Greater than or equal to
IS LESS THAN OR EQUAL TO	Less than or equal to
IS <=	Less than or equal to

- * **relative file.** A file with relative organization.
- * **relative key.** A key whose contents identify a logical record in a relative file.
- * **relative organization.** The permanent logical file structure in which each record is uniquely identified by an integer value greater than zero, which specifies the logical ordinal position of the record in the file.
- * **relative record number.** The ordinal number of a record in a file whose organization is relative. This number is treated as a numeric literal that is an integer.
- * **reserved word.** A COBOL word that is specified in the list of words that can be used in a COBOL source program, but that must not appear in the program as a user-defined word or system-name.
- * **resource.** A facility or service, controlled by the operating system, that an executing program can use.
- * **resultant identifier.** A user-defined data item that is to contain the result of an arithmetic operation.

reusable environment. A reusable environment is created when you establish an assembler program as the main program by using either the old COBOL interfaces for preinitialization (functions ILBOSTP0 and IGZERRE, and the RTEREUS run-time option), or the Language Environment interface, CEEPIPI.

ring. In the COBOL editor, a set of files that are available for editing so that you can easily move between them.

routine. A set of statements in a COBOL program that causes the computer to perform an operation or series of related operations. In Language Environment, refers to either a procedure, function, or subroutine.

* **routine-name.** A user-defined word that identifies a procedure written in a language other than COBOL.

* **run time.** The time at which an object program is executed. Synonymous with *object time*.

run-time environment. The environment in which a COBOL program executes.

* **run unit.** A stand-alone object program, or several object programs, that interact via COBOL CALL or INVOKE statements and function at run time as an entity.

S

SBCS. See *single-byte character set (SBCS)*.

scope terminator. A COBOL reserved word that marks the end of certain PROCEDURE DIVISION statements. It can be either explicit (END-ADD, for example) or implicit (separator period).

* **section.** A set of zero, one or more paragraphs or entities, called a section body, the first of which is preceded by a section header. Each section consists of the section header and the related section body.

* **section header.** A combination of words followed by a separator period that indicates the beginning of a section in any of these divisions: ENVIRONMENT, DATA, or PROCEDURE. In the ENVIRONMENT DIVISION and DATA DIVISION, a section header is composed of reserved words followed by a separator period. The permissible section headers in the ENVIRONMENT DIVISION are:
CONFIGURATION SECTION.
INPUT-OUTPUT SECTION.

The permissible section headers in the DATA DIVISION are:

FILE SECTION.
WORKING-STORAGE SECTION.
LOCAL-STORAGE SECTION.
LINKAGE SECTION.

In the PROCEDURE DIVISION, a section header is composed of a section-name, followed by the reserved word SECTION, followed by a separator period.

* **section-name.** A user-defined word that names a section in the PROCEDURE DIVISION.

selection structure. A program processing logic in which one or another series of statements is executed, depending on whether a condition is true or false.

* **sentence.** A sequence of one or more statements, the last of which is terminated by a separator period.

* **separately compiled program.** A program that, together with its contained programs, is compiled separately from all other programs.

* **separator.** A character or two or more contiguous characters used to delimit character strings.

* **separator comma.** A comma (,) followed by a space used to delimit character strings.

* **separator period.** A period (.) followed by a space used to delimit character strings.

* **separator semicolon.** A semicolon (;) followed by a space used to delimit character strings.

sequence structure. A program processing logic in which a series of statements is executed in sequential order.

* **sequential access.** An access mode in which logical records are obtained from or placed into a file in a consecutive predecessor-to-successor logical record sequence determined by the order of records in the file.

* **sequential file.** A file with sequential organization.

* **sequential organization.** The permanent logical file structure in which a record is identified by a predecessor-successor relationship established when the record is placed into the file.

serial search. A search in which the members of a set are consecutively examined, beginning with the first member and ending with the last.

session bean. In EJB, an enterprise bean that is created by a client and that usually exists only for the duration of a single client/server session. (Sun)

* **77-level-description-entry.** A data description entry that describes a noncontiguous data item with the level-number 77.

* **sign condition.** The proposition (for which a truth value can be determined) that the algebraic value of a data item or an arithmetic expression is either less than, greater than, or equal to zero.

signature. (1) The name of an operation and its parameters. (2) The name of a method and the number and types of its formal parameters.

* **simple condition.** Any single condition chosen from the set:

- Relation condition
- Class condition
- Condition-name condition
- Switch-status condition
- Sign condition

See also *condition* and *negated simple condition*.

single-byte character set (SBCS). A set of characters in which each character is represented by a single byte. See also *ASCII* and *EBCDIC (Extended Binary-Coded Decimal Interchange Code)*.

slack bytes. Bytes inserted between data items or records to ensure correct alignment of some numeric items. Slack bytes contain no meaningful data. In some cases, they are inserted by the compiler; in others, it is the responsibility of the programmer to insert them. The *SYNCHRONIZED* clause instructs the compiler to insert slack bytes when they are needed for proper alignment. Slack bytes between records are inserted by the programmer.

* **sort file.** A collection of records to be sorted by a *SORT* statement. The sort file is created and can be used by the sort function only.

* **sort-merge file description entry.** An entry in the *FILE SECTION* of the *DATA DIVISION* that is composed of the level indicator *SD*, followed by a file-name, and then followed by a set of file clauses as required.

* **SOURCE-COMPUTER.** The name of an *ENVIRONMENT DIVISION* paragraph in which the computer environment, where the source program is compiled, is described.

* **source computer entry.** An entry in the *SOURCE-COMPUTER* paragraph of the *ENVIRONMENT DIVISION*; this entry contains clauses that describe the computer environment in which the source program is to be compiled.

* **source item.** An identifier designated by a *SOURCE* clause that provides the value of a printable item.

source program. Although a source program can be represented by other forms and symbols, in this document the term always refers to a syntactically correct set of COBOL statements. A COBOL source program commences with the *IDENTIFICATION DIVISION* or a *COPY* statement and terminates with the end program marker, if specified, or with the absence of additional source program lines.

source unit. A unit of COBOL source code that can be separately compiled: a program or a class definition. Also known as a *compilation unit*.

* **special character.** A character that belongs to the following set:

Character	Meaning
+	Plus sign
-	Minus sign (hyphen)
*	Asterisk
/	Slant (virgule, slash)
=	Equal sign
\$	Currency sign
,	Comma (decimal point)
;	Semicolon
.	Period (decimal point, full stop)
"	Quotation mark
(	Left parenthesis
)	Right parenthesis
>	Greater than symbol
<	Less than symbol
:	Colon

SPECIAL-NAMES. The name of an *ENVIRONMENT DIVISION* paragraph in which environment-names are related to user-specified mnemonic-names.

* **special names entry.** An entry in the *SPECIAL-NAMES* paragraph of the *ENVIRONMENT DIVISION*; this entry provides means for specifying the currency sign; choosing the decimal point; specifying symbolic characters; relating implementor-names to user-specified mnemonic-names; relating alphabet-names to character sets or collating sequences; and relating class-names to sets of characters.

* **special registers.** Certain compiler-generated storage areas whose primary use is to store information produced in conjunction with the use of a specific COBOL feature.

Standard COBOL 85. The COBOL language defined by the following standards:

- *ANSI INCITS 23-1985, Programming languages - COBOL*, as amended by *ANSI INCITS 23a-1989, Programming Languages - COBOL - Intrinsic Function Module for COBOL* and *ANSI INCITS 23b-1993, Programming Languages - Correction Amendment for COBOL*
- *ISO 1989:1985, Programming languages - COBOL*, as amended by *ISO/IEC 1989/AMD1:1992, Programming languages - COBOL: Intrinsic function module* and *ISO/IEC 1989/AMD2:1994, Programming languages - Correction and clarification amendment for COBOL*

* **statement.** A syntactically valid combination of words, literals, and separators, beginning with a verb, written in a COBOL source program.

structured programming. A technique for organizing and coding a computer program in which the program comprises a hierarchy of segments, each segment having a single entry point and a single exit point. Control is passed downward through the structure without unconditional branches to higher levels of the hierarchy.

* **subclass.** A class that inherits from another class. When two classes in an inheritance relationship are considered together, the subclass is the inheritor or inheriting class; the superclass is the inheritee or inherited class.

* **subject of entry.** An operand or reserved word that appears immediately following the level indicator or the level-number in a DATA DIVISION entry.

* **subprogram.** See *called program*.

* **subscript.** An occurrence number that is represented by either an integer, a data-name optionally followed by an integer with the operator + or -, or an index-name optionally followed by an integer with the operator + or -, that identifies a particular element in a table. A subscript can be the word ALL when the subscripted identifier is used as a function argument for a function allowing a variable number of arguments.

* **subscripted data-name.** An identifier that is composed of a data-name followed by one or more subscripts enclosed in parentheses.

* **superclass.** A class that is inherited by another class. See also *subclass*.

surrogate pair. In the UTF-16 format of Unicode, a pair of encoding units that together represents a single

Unicode character. The first unit of the pair is called a *high surrogate* and the second a *low surrogate*. The code value of a high surrogate is in the range X'D800' through X'DBFF'. The code value of a low surrogate is in the range X'DC00' through X'DFFF'. Surrogate pairs provide for more characters than the 65,536 characters that fit in the Unicode 16-bit coded character set.

switch-status condition. The proposition (for which a truth value can be determined) that an UPSI switch, capable of being set to an on or off status, has been set to a specific status.

* **symbolic-character.** A user-defined word that specifies a user-defined figurative constant.

syntax. (1) The relationship among characters or groups of characters, independent of their meanings or the manner of their interpretation and use. (2) The structure of expressions in a language. (3) The rules governing the structure of a language. (4) The relationship among symbols. (5) The rules for the construction of a statement.

* **system-name.** A COBOL word that is used to communicate with the operating environment.

T

* **table.** A set of logically consecutive items of data that are defined in the DATA DIVISION by means of the OCCURS clause.

* **table element.** A data item that belongs to the set of repeated items comprising a table.

text deck. Synonym for *object deck* or *object module*.

* **text-name.** A user-defined word that identifies library text.

* **text word.** A character or a sequence of contiguous characters between margin A and margin R in a COBOL library, source program, or pseudo-text that is any of the following characters:

- A separator, except for space; a pseudo-text delimiter; and the opening and closing delimiters for nonnumeric literals. The right parenthesis and left parenthesis characters, regardless of context within the library, source program, or pseudo-text, are always considered text words.
- A literal including, in the case of nonnumeric literals, the opening quotation mark and the closing quotation mark that bound the literal.
- Any other sequence of contiguous COBOL characters except comment lines and the word COPY bounded by separators that are neither a separator nor a literal.

thread. A stream of computer instructions (initiated by an application within a process) that is in control of a process.

token. In the COBOL editor, a unit of meaning in a program. A token can contain data, a language keyword, an identifier, or other part of the language syntax.

top-down design. The design of a computer program using a hierarchic structure in which related functions are performed at each level of the structure.

top-down development. See *structured programming*.

trailer-label. (1) A file or data set label that follows the data records on a unit of recording medium. (2) Synonym for *end-of-file label*.

troubleshoot. To detect, locate, and eliminate problems in using computer software.

* **truth value.** The representation of the result of the evaluation of a condition in terms of one of two values: true or false.

typed object reference. A data-name that can refer only to an object of a specified class or any of its subclasses.

U

* **unary operator.** A plus (+) or a minus (-) sign that precedes a variable or a left parenthesis in an arithmetic expression and that has the effect of multiplying the expression by +1 or -1, respectively.

Unicode. A universal character encoding standard that supports the interchange, processing, and display of text that is written in any of the languages of the modern world. There are multiple encoding schemes to represent Unicode, including UTF-8, UTF-16, and UTF-32. Enterprise COBOL supports Unicode using UTF-16 in big-endian format as the representation for the national data type.

unit. A module of direct access, the dimensions of which are determined by IBM.

universal object reference. A data-name that can refer to an object of any class.

unrestricted storage. Storage below the 2-GB bar. It can be above or below the 16-MB line. If it is above the 16-MB line, it is addressable only in 31-bit mode.

* **unsuccessful execution.** The attempted execution of a statement that does not result in the execution of all the operations specified by that statement. The unsuccessful execution of a statement does not affect any data referenced by that statement, but can affect status indicators.

UPSI switch. A program switch that performs the functions of a hardware switch. Eight are provided: UPSI-0 through UPSI-7.

* **user-defined word.** A COBOL word that must be supplied by the user to satisfy the format of a clause or statement.

V

* **variable.** A data item whose value can be changed by execution of the object program. A variable used in an arithmetic expression must be a numeric elementary item.

* **variable-length record.** A record associated with a file whose file description or sort-merge description entry permits records to contain a varying number of character positions.

* **variable-occurrence data item.** A variable-occurrence data item is a table element that is repeated a variable number of times. Such an item must contain an OCCURS DEPENDING ON clause in its data description entry or be subordinate to such an item.

* **variably located group.** A group item following, and not subordinate to, a variable-length table in the same record.

* **variably located item.** A data item following, and not subordinate to, a variable-length table in the same record.

* **verb.** A word that expresses an action to be taken by a COBOL compiler or object program.

VSAM file system. A file system that supports COBOL sequential, relative, and indexed organizations.

volume. A module of external storage. For tape devices it is a reel; for direct-access devices it is a unit.

volume switch procedures. System-specific procedures that are executed automatically when the end of a unit or reel has been reached before end-of-file has been reached.

W

Web service. A modular application that performs specific tasks and is accessible through open protocols like HTTP and SOAP.

white space. Characters that introduce space into a document. They are:

- Space
- Horizontal tabulation
- Carriage return
- Line feed

- Next line

as named in the Unicode Standard.

windowed date field. A date field containing a windowed (two-digit) year. See also *date field* and *windowed year*.

windowed year. A date field that consists only of a two-digit year. This two-digit year can be interpreted using a century window. For example, 05 could be interpreted as 2005. See also *century window*. Compare with *expanded year*.

* **word.** A character string of not more than 30 characters that forms a user-defined word, a system-name, a reserved word, or a function-name.

* **WORKING-STORAGE SECTION.** The section of the DATA DIVISION that describes working-storage data items, composed either of noncontiguous items or working-storage records or of both.

workstation. A generic term for computers used by end users including personal computers, 3270 terminals, intelligent workstations, and UNIX terminals. Often a workstation is connected to a mainframe or to a network.

wrapper. An object that provides an interface between object-oriented code and procedure-oriented code. Using wrappers allows programs to be reused and accessed by other systems.

X

x. The symbol in a PICTURE clause that can hold any character in the character set of the computer.

XML. Extensible Markup Language. A standard metalanguage for defining markup languages that was derived from and is a subset of SGML. XML omits the more complex and less-used parts of SGML and makes it much easier to write applications to handle document types, author and manage structured information, and transmit and share structured information across diverse computing systems. The use of XML does not require the robust applications and processing that is necessary for SGML. XML is developed under the auspices of the World Wide Web Consortium (W3C).

XML data. Data that is organized into a hierarchical structure with XML elements. The data definitions are defined in XML element type declarations.

XML declaration. XML text that specifies characteristics of the XML document such as the version of XML being used and the encoding of the document.

XML document. A data object that is well formed as defined by the W3C XML specification.

XML type definition. An XML element that contains or points to markup declarations that provide a grammar for a class of documents. This grammar is known as a document type definition, or DTD.

Y

year field expansion. Explicitly expanding date fields that contain two-digit years to contain four-digit years in files and databases and then using these fields in expanded form in programs. This is the only method for assuring reliable date processing for applications that have used two-digit years.

Z

zoned decimal item. See *external decimal item*.

List of resources

Enterprise COBOL for z/OS

Compiler and Run-Time Migration Guide, GC27-1409

Customization Guide, GC27-1410

Debug Tool Reference and Messages, SC18-9010

Debug Tool User's Guide, SC18-9012

Fact Sheet, GC27-1407

Language Reference, SC27-1408

Licensed Program Specifications, GC27-1411

Programming Guide, SC27-1412

Related publications

CICS Transaction Server for z/OS

Application Programming Guide, SC34-5993

Application Programming Reference, SC34-5994

Customization Guide, SC34-5989

External Interfaces Guide, SC34-6006

z/OS C/C++

Programming Guide, SC09-4765

Run-Time Library Reference, SA22-7821

DB2 UDB for z/OS and OS/390

Application Programming and SQL Guide, SC26-9933

Command Reference, SC26-9934

SQL Reference, SC26-9944

z/OS DFSMS

Access Method Services for Catalogs, SC26-7394

Checkpoint/Restart, SC26-7401

Macro Instructions for Data Sets, SC26-7408

Program Management, SC27-1130

Using Data Sets, SC26-7410

Utilities, SC26-7414

DFSORT

Application Programming Guide, SC33-4035

Installation and Customization, SC33-4034

IMS

Application Programming: Database Manager, SC27-1286

Application Programming: Design Guide, SC27-1287

Application Programming: EXEC DLI Commands for CICS and IMS, SC27-1288

Application Programming: Transaction Manager, SC27-1289

IMS Connect Guide and Reference, SC27-0946

IMS Java User's Guide, SC27-1296

z/OS ISPF

Dialog Developer's Guide and Reference, SC34-4821

User's Guide Vol. 1, SC34-4822

User's Guide Vol. 2, SC34-4823

z/OS Language Environment

Concepts Guide, SA22-7567

Customization, SA22-7564

Debugging Guide, GA22-7560

Programming Guide, SA22-7561

Programming Reference, SA22-7562

Run-Time Messages, SA22-7566

Run-Time Migration Guide, GA22-7565

Writing Interlanguage Communication Applications,
SA22-7563

z/OS MVS

JCL Reference, SA22-7597

JCL User's Guide, SA22-7598

System Commands, SA22-7627

z/OS TSO/E

Command Reference, SA22-7782

Primer, SA22-7787

User's Guide, SA22-7794

z/OS UNIX System Services

Command Reference, SA22-7802

Programming: Assembler Callable Services Reference,
SA22-7803

User's Guide, SA22-7801

z/Architecture

Principles of Operation, SA22-7832

Softcopy publications for z/OS

The following collection kit contains z/OS and
related product publications:

z/OS CD Collection Kit, SK3T-4269

Unicode and character representation

Unicode, www.unicode.org/

*Character Data Representation Architecture Reference
and Registry*, SC09-2190

z/OS Support for Unicode: Using Conversion Services,
SA22-7649

Java

The Java Language Specification, Second Edition, by
Gosling et al., [java.sun.com/docs/books/jls/
second_edition/html/j.title.doc.html](http://java.sun.com/docs/books/jls/second_edition/html/j.title.doc.html)

The Java Native Interface, [java.sun.com/j2se/
1.3/docs/guide/jni/index.html](http://java.sun.com/j2se/1.3/docs/guide/jni/index.html)

Java 2 on the OS/390 and z/OS Platforms,
[www.ibm.com/servers/eserver/zseries/
software/java/](http://www.ibm.com/servers/eserver/zseries/software/java/)

The Java 2 Enterprise Edition Developer's Guide,
java.sun.com/j2ee/j2sdkee/devguide1_2_1.pdf

*New IBM Technology featuring Persistent Reusable
Java Virtual Machines*, [www.ibm.com/servers/
eserver/zseries/software/java/pdf/jtc0a100.pdf](http://www.ibm.com/servers/eserver/zseries/software/java/pdf/jtc0a100.pdf)

WebSphere Application Server for z/OS

Assembling J2EE Applications, SA22-7836

XML

XML specification, www.w3c.org/XML/

Index

Special characters

- _BPX_SHAREAS environment
 - variable 387
- _CEE_ENVFILE environment
 - variable 263, 385
- _CEE_RUNOPTS environment
 - variable 383, 385
- _IGZ_SYSOUT environment variable
 - setting 385
 - writing to stdout/stderr 31
- # cob2 option 254
- b cob2 option 253
- c cob2 command 253
- comprc_ok cob2 option 253
- e cob2 option
 - specifying entry point 253
- g cob2 option
 - TEST option 253
- I cob2 option
 - searching copybooks 253
- l cob2 option
 - specifying archive library name 254
- L cob2 option
 - specifying archive library path 254
- o cob2 option
 - specifying output file 254
- q cob2 option
 - specifying compiler options 254
- v cob2 option 254
- ! character, hexadecimal values 464
- .adt file 270
- .asm file 289
- .wlist file 289
- *CBL statement 317
- *CONTROL statement 317
- [character, hexadecimal values 464
-] character, hexadecimal values 464
- | character, hexadecimal values 464
- # character, hexadecimal values 464

Numerics

- 16-MB line
 - IMS programs 362
 - performance options 589
- 24-bit addressing mode 34
- 31-bit addressing mode 34
 - dynamic call 399
- 5203 - 5206 conditions 644
- 64-bit addressing
 - no support 34

A

- a extension with cob2 254
- a.out file from cob2 254
- abends, compile-time 281
- ACCEPT statement
 - assigning input 29
 - reading from stdin 29

- access method services
 - build alternate indexes in
 - advance 171
 - defining VSAM data sets, z/OS 166
 - loading a VSAM data set 159
- accessibility
 - of Enterprise COBOL xv
 - of this book xv
 - using z/OS xv
- ADATA compiler option 271
- adding records
 - to line-sequential files 179
 - to QSAM files 131
 - to VSAM files 162
- ADDRESS special register, CALL statement 412
- addresses
 - incrementing 417
 - NULL value 416
 - passing between programs 416
 - passing entry point addresses 407
- addressing mode 34
- ADEXIT suboption of EXIT compiler option 636, 642
- ADMODE attribute
 - with multithreading 443
- adt extension with cob2 254
- ADV compiler option 271
- AIXBLD run-time option
 - affect on performance 593
- ALL subscript 49, 73
- ALL31 run-time option
 - AMODE switching 399
 - multioption interaction 34
- ALLOCATE command (TSO)
 - compiler data sets 229
 - with HFS files 230
- allocating data sets under TSO 229
- allocation of files
 - description 117
 - line-sequential 177
 - QSAM 134
 - VSAM 169
- ALPHABET clause, establishing collating sequence 8
- alphabetic data
 - comparing to national 111
- alphanumeric data
 - comparing to national 111
- alphanumeric date fields,
 - contracting 574
- alphanumeric literal
 - alphanumeric to DBCS
 - conversion 619
 - conversion of mixed
 - DBCS/EBCDIC 619
 - DBCS to alphanumeric
 - conversion 622
 - with double-byte characters 619
- alternate collating sequence 9, 190
- alternate entry point 409
- alternate index
 - creating 167
 - example of 168
 - password for 165
 - path 167, 168
 - performance considerations 171
- ALTERNATE RECORD KEY 167
- alternate reserved-word table
 - CICS 366
 - specifying 313
- AMODE
 - assigned for EXIT modules 637
 - description 34
 - switching 399
- AMP parameter 169
- ANNUITY intrinsic function 52
- ANSI85 translator option 365
- APIs, UNIX and POSIX
 - calling 386
- APOST compiler option 299
- APPLY WRITE-ONLY clause 12
- arguments
 - describing in calling program 413
 - specifying OMITTED 414
 - testing for OMITTED 414
 - testing for OMITTED arguments 414
- ARITH compiler option 271
- arithmetic
 - COMPUTE statement simpler to code 47
 - error handling 203
 - with intrinsic functions 48
- arithmetic comparisons 54
- arithmetic evaluation
 - data format conversion 43
 - examples 53, 55
 - fixed-point versus floating-point 53
 - intermediate results 603
 - performance tips 581
 - precedence 48, 605
 - precision 603
- arithmetic expression
 - as reference modifier 94
 - description of 48
 - in nonarithmetic statement 611
 - in parentheses 48
 - with MLE 569
- arithmetic operation
 - with MLE 565, 569
- arrays
 - in COBOL 33
 - Java 532
- ASCII
 - alphabet, QSAM 144
 - converting to EBCDIC 98
 - file labels 145
 - job control language (JCL) 144
 - record formats, QSAM 144
 - standard labels 145
 - tape files, QSAM 144
 - user labels 145

- ASCII files
 - CODE-SET clause 14
 - OPTCD= parameter in DCB 14
- asm file 289
- assembler
 - expansion of PROCEDURE DIVISION 340
 - from LIST option 586
 - programs
 - calls from (in CICS) 361
 - compiling from 231
 - listing of 289, 586
- ASSIGN clause
 - corresponds to ddname 10
 - QSAM files 120
- assigning values 25
- assistive technologies xv
- Associated Data File
 - creating 237
- assumed century window for nondates 564
- asynchronous signals
 - with multithreading 443
- AT END (end-of-file) 206
- ATTACH macro 231
- attribute methods 499
- ATTRIBUTE-CHARACTER XML
 - event 453
- ATTRIBUTE-CHARACTERS XML
 - event 452
- ATTRIBUTE-NAME XML event 452
- ATTRIBUTE-NATIONAL-CHARACTER XML event 453
- automatic restart 549
- avoiding coding errors 579
- AWO compiler option
 - APPLY-WRITE ONLY clause
 - performance 12
 - description 272
 - performance considerations 589

B

- backward branches 580
- Base class
 - equating to java.lang.Object 491
 - using for java.lang.Object 490
- base cluster name 168
- base locator 336, 337
- basic document encoding 463
- basis libraries 235
- BASIS statement 317
- batch compilation
 - description 241
 - LANGUAGE option
 - example 244
 - precedence of options
 - example 243
- big-endian 105
- binary data item
 - general description 41
 - intermediate results 608
 - synonyms 39
 - using efficiently 41, 581
- binary search of a table 72
- binding OO applications 262
 - example 263

- BLOCK CONTAINS clause
 - FILE SECTION entry 14
 - no meaning for VSAM files 154
 - QSAM files 121, 127
- block size
 - ASCII files 144
 - QSAM files 127
 - fixed length 121
 - record layout 123
 - using DCB 135
 - variable length 122
 - system determined 127
 - system-determined 235
- blocking factor 121
- blocking QSAM files 127
- blocking records 127
- BPXBATCH utility
 - calling UNIX programs 384
 - running OO applications 262
- branch, implicit 83
- buffer, best use of 12
- buffers, obtaining for QSAM 140
- BUFOFF= 144
- BUFSIZE compiler option 273
- byte order mark 105
- byte-stream files
 - processing with QSAM 140

C

- C/C++ programs
 - with COBOL DLLs 434
- CALL command (TSO) 229
- CALL identifier
 - making from DLLs 429
- CALL statement
 - AMODE processing 399
 - BY CONTENT 411
 - BY REFERENCE 412
 - BY VALUE 411
 - CICS restrictions 361
 - effect of DYNAM compiler
 - option 282
 - effect of EXIT option on registers 637
 - exception condition 213
 - for error handling 213
 - function-pointer 408
 - handling of programs name in 297
 - identifier 399
 - overflow condition 213
 - to alternate entry points 409
 - to invoke Language Environment
 - callable services 599
 - USING 413
 - using DYNAM compiler option 399
 - using NODYNAM compiler
 - option 399
 - with CANCEL 398
 - with ON EXCEPTION 213
 - with ON OVERFLOW 20, 213
- calls
 - 31-bit addressing mode 399
 - AMODE switching for 24-bit programs 399
 - between COBOL and non-COBOL programs 393
 - between COBOL programs 393, 396

- calls (*continued*)
 - CICS restrictions 361
 - dynamic 397
 - dynamic performance 401
 - exception condition 213
 - interlanguage 393
 - LINKAGE SECTION 414
 - overflow condition 213
 - passing arguments 413
 - passing data 411
 - receiving parameters 413
 - recursive 407
 - specifying OMITTED arguments 414
 - static 397
 - static performance 401
 - to JNI services 527
 - to Language Environment callable services 599
- CANCEL statement
 - handling of programs name in 297
 - with dynamic CALL 398
- case structure 77
- cataloged procedure
 - JCL for compiling 218
 - to compile (IGYWC) 219
 - to compile and link-edit (IGYWCL) 220
 - to compile, link-edit, run (IGYWCLG) 221
 - to compile, load, run (IGYWCG) 222
 - to compile, prelink, link-edit (IGYWCPL) 223
 - to compile, prelink, link-edit, run (IGYWCPLG) 224
 - to compile, prelink, load, run (IGYWCPLG) 226
 - to prelink and link-edit (IGYWPL) 226
- cbl extension with cob2 254
- CBL statement 238, 317
- CBLPSHPOP run-time option 367
- CBLQDA run-time option 130
- CCSID
 - conflict 469
 - definition 105
 - of PARSE statement 449
 - of XML document 449, 463
 - of XML documents 463
- century window
 - assumed for nondates 564
 - fixed 556
 - sliding 556
- chained list processing 416, 417
- changing
 - characters to numbers 97
 - file-name 11
 - title on source listing 7
- CHAR intrinsic function 99
- character set 105
- CHECK(OFF) run-time option 589
- checking for valid data
 - conditional expressions 79
 - numeric 46
- checkpoint
 - COBOL 85 Standard 546
 - designing 546
 - messages generated during 548

- checkpoint (*continued*)
 - methods 545
 - multiple 546, 548
 - record data set 547
 - restart data sets 551
 - restart during DFSORT 198
 - restart job control sample 551
 - restrictions 546
 - single 546
 - disk 547
 - tape 547
- Chinese GB 18030 data
 - converting 110
 - processing 110
- CHKPT keyword 198
- CICS
 - CALL statement 361
 - calls 361
 - CICS HANDLE 367
 - example 368
 - LABEL value 367
 - CICS option 362
 - COBOL 85 Standard
 - considerations 365
 - coding input 360
 - coding output 360
 - coding programs to run under 359
 - coding restrictions 359
 - command-level interface 359
 - commands and the PROCEDURE DIVISION 359
 - compiler restrictions 359, 364
 - compiling under integrated translator 364
 - compiling under separate translator 365
 - developing programs for 359
 - in a multithreaded environment 442
 - integrated translator 364
 - macro-level interface 359
 - performance considerations 592
 - reserved-word table 366
 - restrictions
 - OO programs 485
 - under z/OS 362
 - sorting 199
 - statements
 - EXIT compiler option and 644
 - system date 360
- CICS compiler option
 - description 273
 - multioption interaction 269
 - restriction in OO programs 485
- CICS ECI
 - return code 362
- CISZ (control interval size), performance
 - considerations 171, 593
- CKPT keyword 198
- class
 - defining 488
 - definition of 485
 - factory data 515
 - instance data 492
 - name
 - external 491, 503
 - in a program 490
 - object 514
- class (*continued*)
 - obtaining reference with JNI 528
- class condition
 - coding 79
 - numeric 46
 - test 79, 323
- CLASSPATH environment variable 260, 262, 385
- client
 - defining 502
 - definition of 502
- CLOSE statement
 - line-sequential files 177
 - QSAM 129
 - VSAM 155
- closing files
 - line-sequential 179
 - multithreading serialization 440
 - QSAM 132
 - multithreading 133
 - VSAM 163
 - multithreading 163
- closing files, automatic
 - line-sequential 179
 - QSAM 132
 - VSAM 163
- cluster, VSAM 166
- cob2 command
 - compiling and linking with 251
 - examples 252
 - description 253
 - examples 252
 - input and output 254
 - options 253
 - with Java and OO 257
- COBJVMINIOPTIONS environment variable 260, 385
- COBOL
 - and Java 527
 - binding 262
 - compiling under UNIX 257
 - compiling using JCL or TSO/E 261
 - linking 258
 - running 259, 263
 - structuring applications 524
 - under IMS 378
 - object-oriented
 - binding 262
 - compiling under UNIX 257
 - compiling using JCL or TSO/E 261
 - linking 258
 - under IMS 378
- COBOL 85 Standard
 - checkpoints 546
 - considerations for CICS 365
 - required compiler options 269
 - required run-time options 269
- COBOL client, example 518
- COBOL DLL programs, calling 432
- COBOL language usage with SQL
 - statements 372, 373
- COBOL terms 23
- COBOPT environment variable 249
- code
 - copy 595
- code (*continued*)
 - optimized 586, 588
- code page
 - conflict 469
 - definition of 105
 - euro currency support 56
 - hexadecimal values of special characters 464
 - of XML document 469
 - specifying 274, 464
- code point 105
- CODE-SET clause 14
- coded characters sets
 - XML documents 463
- CODEPAGE compiler option
 - description 274
 - for national literals 107
 - with conversions 108
- coding
 - class definition 488
 - clients 502
 - condition tests 80
 - constructor methods 516
 - DATA DIVISION 12
 - decisions 75
 - efficiently 579
 - ENVIRONMENT DIVISION 7
 - EVALUATE statement 77
 - factory definition 514
 - factory methods 516
 - file input/output (overview) 113
 - IDENTIFICATION DIVISION 5
 - IF statement 75
 - input 360
 - input/output overview 116
 - input/output statements
 - for line-sequential files 177
 - for QSAM files 129
 - for VSAM files 155
 - instance methods 493, 513
 - interoperable data types 532
 - loops 83
 - OO programs 485
 - output 360
 - PROCEDURE DIVISION 18
 - programs to run under IMS 377
 - restrictions for programs for CICS 359
 - restrictions for programs for IMS 377
 - subclass definition 510
 - tables 59
 - techniques 12, 579
 - test conditions 80
- collating sequence
 - alternate 9
 - ASCII 8
 - EBCDIC 8
 - HIGH-VALUE 8
 - ISO 7-bit code 8
 - LOW-VALUE 8
 - MERGE 8
 - NATIVE 8
 - nonnumeric comparisons 8
 - SEARCH ALL 8
 - SORT 8
 - specifying 8
 - symbolic characters in the 10

- collating sequence (*continued*)
 - the ordinal position of a character 99
- columns in tables 59
- COMMENT XML event 452
- COMMON attribute 6, 403
- COMP (COMPUTATIONAL) 41
- COMP-1 (COMPUTATIONAL-1) 42, 582
- COMP-2 (COMPUTATIONAL-2) 42, 582
- COMP-3 (COMPUTATIONAL-3) 42
- COMP-4 (COMPUTATIONAL-4) 41
- COMP-5 (COMPUTATIONAL-5) 41
- comparing
 - national and alphabetic or alphanumeric 111
 - national and group 111
 - national and numeric 111
 - national data 111
 - object references 505
 - of date fields 560
- COMPAT suboption of PGMNAME 297
- compatibility mode 37, 603
- compatible dates
 - in comparisons 560
 - with MLE 561
- compilation
 - COBOL 85 Standard 269
 - results 239
 - statistics 334
 - with HFS files 220
- COMPILE compiler option
 - description 275
 - use NOCOMPILE to find syntax errors 326
- compile-time considerations
 - compiler directed errors 246
 - display compile and link steps 254
 - error message severity 247
 - executing compile and link steps after display 254
- compile-time dump, generating 281
- compile-time error messages
 - choosing severity to be flagged 328
 - determining what severity level to produce 284
 - embedding in source listing 328
- compiler
 - calculation of intermediate results 604
 - generating list of error messages 246
 - invoking in the UNIX shell 251
 - examples 252
 - limits 12
- compiler data sets
 - in the HFS 218, 228
 - input and output 233
 - required for compilation 233
 - SYSADATA (ADATA records) 237
 - SYSDEBUG (debug records) 237
 - SYSIN (source code) 235
 - SYSJAVA 237
 - SYSLIB (libraries) 235
 - SYSLIN (object code) 236
 - SYSOUT (listing) 236
 - SYSPUNCH (object code) 236
 - SYSTEM (messages) 236
 - with cob2 254
- compiler error messages
 - from exit modules 644
 - sending to terminal 236
- compiler listings
 - getting 331
- compiler messages
 - analyzing 572
- compiler options
 - ADATA 271
 - APOST 299
 - ARITH 271
 - AWO 272
 - AWO and performance 589
 - BUFSIZE 273
 - CICS 273
 - CODEPAGE 274
 - COMPILE 275
 - conflicting 269
 - CURRENCY 276
 - DATA 277
 - DATEPROC 278
 - DBCS 279
 - DECK 279
 - DIAGTRUNC 280
 - DLL 281
 - DUMP 281
 - DYNAM 282, 589
 - EXIT 283, 635
 - EXPORTALL 283
 - FASTSRT 193, 284, 589
 - FLAG 284, 328
 - FLAGSTD 285
 - for debugging 325
 - IMS, recommended for 377
 - in effect 343
 - INTDATE 287
 - LANGUAGE 287
 - example in batch compilation 244
 - LIB 288
 - LINECOUNT 289
 - LIST 289, 331, 334
 - MAP 290, 330, 331, 334
 - NAME 291
 - NOCOMPILE 326
 - NOFASTSRT 195
 - NSYMBOL 291
 - NUMBER 292, 332
 - NUMPROC 293
 - NUMPROC(PFD) 589
 - NUMPROC(PFD|NOPFD|MIG) 45
 - OBJECT 294
 - OFFSET 294, 334
 - on compiler invocation 334
 - OPTIMIZE 295, 586, 589
 - OUTDD 296
 - performance considerations 589
 - PGMNAME 297
 - precedence in batch compilation
 - example 243
 - precedence of 238
 - QUOTE 299
 - RENT 299, 589
 - RMODE 300
 - RMODE and performance 589
 - SEQUENCE 301, 327
 - settings for COBOL 85 Standard 269
 - signature bytes 343
- compiler options (*continued*)
 - SIZE 302
 - SOURCE 302, 331
 - SPACE 303
 - specifying 238
 - PROCESS (CBL) statement 238
 - specifying under TSO 239
 - specifying under UNIX 250
 - specifying under z/OS 239
 - SQL 303, 373
 - SSRANGE 304, 327, 589
 - status 334
 - TERMINAL 305
 - TEST 306, 334, 355, 589
 - THREAD 309
 - TRUNC 310, 589
 - under CICS 362
 - under IMS and CICS 362
 - VBREF 313, 331
 - WORD 313
 - XREF 314, 329
 - YEARWINDOW 315
 - ZWB 316
- compiler-directing statements
 - description 317
 - list 20
 - overview 20
- compiling
 - batch 241
 - control of 238
 - data sets for 233
 - from an assembler program 231
 - OO applications
 - example 259, 263
 - under UNIX 257
 - using JCL or TSO/E 261
 - under TSO 229
 - under UNIX 249
 - under z/OS 217
 - using shell script 255
 - using the cob2 command 251
 - examples 252
 - with cataloged procedures 218
 - compile 219
 - compile and link-edit 220
 - compile, link-edit, run 221
 - compile, load, run 222
 - compile, prelink, link-edit 223
 - compile, prelink, link-edit, run 224
 - compile, prelink, load, run 226
 - with JCL (job control language) 217
- compiling and linking in the UNIX
 - shell 251
 - examples 252
 - OO applications
 - example 259
- completion code, sort 192
- complex OCCURS DEPENDING ON
 - basic forms of 613
 - complex ODO item 613
 - variably located data item 614
 - variably located group 614
- computation
 - arithmetic data items 581
 - constant data items 580
 - duplicate 581

- computation (*continued*)
 - subscript 584
- COMPUTATIONAL (COMP) 41
- COMPUTATIONAL-1 (COMP-1) 42, 582
- COMPUTATIONAL-2 (COMP-2) 42, 582
- COMPUTATIONAL-3 (COMP-3)
 - date fields, potential problems 574
 - description 42
- COMPUTATIONAL-4 (COMP-4) 41
- COMPUTATIONAL-5 (COMP-5) 41
- computer, describing 7
- concatenating data items 87
- condition handling 132, 163, 597
 - in input or output procedures 187
- condition testing 80
- condition-name 563
- conditional expression
 - EVALUATE statement 76
 - IF statement 75
 - PERFORM statement 84
- conditional statement
 - in EVALUATE statement 76
 - list of 19
 - overview 19
 - with NOT phrase 20
 - with object references 505
- CONFIGURATION SECTION 7
- conflicting compiler options 269
- conformance requirements
 - RETURNING phrase 507
 - USING phrase 507
- conformance to COBOL 85 Standard
 - required compiler options 269
- constants
 - computations 580
 - data items 580
 - description 24
 - figurative 25
- contained program integration 587
- CONTENT-CHARACTER XML
 - event 454
- CONTENT-CHARACTERS XML
 - event 454
- CONTENT-NATIONAL-CHARACTER XML event 454
- continuation
 - entry 197
 - of program 204
 - syntax checking 275
- CONTINUE statement 76
- contracting alphanumeric dates 574
- control
 - in nested programs 403
 - program flow 75
 - transfer 394
- control interval size (CISZ), performance considerations 171, 593
- CONTROL statement 317
- converting data items
 - between code pages 98
 - characters to numbers 97
 - Chinese GB 18030 110
 - data formats 43
 - INSPECT statement 95
 - national data
 - exceptions 108
 - with ACCEPT 30

- converting data items (*continued*)
 - national data (*continued*)
 - with DISPLAY 30
 - with DISPLAY-OF 108
 - with MOVE 107
 - with NATIONAL-OF 108
 - reversing order of characters 97
 - to integers 95
 - to uppercase or lowercase 97
 - UTF-8 109
 - with intrinsic functions 97
- converting files to expanded date form, example 559
- coprocessor, DB2 375
- copy libraries
 - COPY statement 317
 - data set 233
 - example 596
 - search order 318
 - specifying 235
 - SYSLIB 235
 - UNIX search order 250, 253
- COPY statement
 - example 596
 - nested 595, 639
 - UNIX considerations 318
 - z/OS considerations 235
- copybook
 - description 317
 - obtaining from user-supplied module 635
 - searching for 253, 318
 - using 595
- COUNT IN phrase 481
- counting
 - data items 95
 - generated XML characters 472
- counting data items 95
- creating
 - Associated Data File 237
 - line-sequential files, z/OS 177
 - object code 236
 - objects 508
 - QSAM files, z/OS 134, 135
 - SYSJAVA data set 237
- cross-reference
 - data and procedure names 329
 - embedded 331
 - list 314
 - program-name 353
 - special definition symbols 354
 - verb list 313
 - verbs 331
- CRP (file position indicator) 157, 160
- CURRENCY compiler option 276
- currency signs
 - euro 56
 - hexadecimal literals 56
 - multiple-character 55
 - using 55
- CURRENT-DATE intrinsic function 52

D

- D format record 122, 123
- DASD (direct-access storage device) 171

- data
 - concatenating 87
 - converting, alphanumeric to DBCS 619
 - converting, DBCS to alphanumeric 619
 - efficient execution 579
 - format conversion 43
 - format, numeric types 39
 - grouping 415
 - incompatible 46
 - joining 87
 - naming 14
 - numeric 37
 - passing 411
 - record size 14
 - splitting 89
 - validating 46
- data and procedure name cross-reference, description 329
- data areas, dynamic 282
- DATA compiler option
 - description 277
 - influencing data location 35
 - multioption interaction 34
 - performance considerations 589
 - when passing data 35
- data definition 336
- data description entry 13
- DATA DIVISION
 - client 504
 - coding 12
 - description 12
 - entries for line-sequential files 176
 - entries for QSAM files 120
 - entries for VSAM files 154
 - factory data 515
 - factory method 516
 - FD entry 12
 - FILE SECTION 12
 - instance data 492, 512
 - instance method 495
 - items present in 345
 - limits 12
 - LINKAGE SECTION 17
 - listing 331
 - mapping of items 290, 331
 - OCCURS clause 59
 - restrictions 12
 - signature bytes 345
 - WORKING-STORAGE SECTION 12
- data item
 - alphanumeric with double-byte characters 619
 - coding Java types 531
 - common, in subprogram linkage 413
 - concatenating 87
 - converting characters to numbers 97
 - converting to uppercase or lowercase 97
 - converting with INSPECT 95
 - converting with intrinsic functions 97
 - counting 95
 - DBCS 619
 - evaluating with intrinsic functions 99

- data item (*continued*)
 - finding the smallest or largest in
 - group 99
 - index 62
 - map 239
 - numeric 37
 - reference modification 93
 - referencing substrings 93
 - replacing 95
 - reversing characters 97
 - splitting 89
 - unused 295, 337
 - variably located 614
- data manipulation
 - DBCS data 619
 - nonnumeric data 87
- DATA RECORDS clause 14
- data set
 - alternate data set names 231
 - checkpoint record 547
 - checkpoint/restart 551
 - defining with environment
 - variable 117
 - JAVAERR 263
 - JAVAIN 263
 - JAVAOUT 263
 - names, alternate 232
 - output 236
 - source code 235
 - SYSADATA 237
 - SYSDEBUG 237
 - SYSIN 235
 - SYSJAVA 237
 - SYSLIB 235
 - SYSLIN 236
 - SYSPRINT 236
 - SYSPUNCH 236
 - SYSTEM 236
 - used interchangeably for file 7
- data sets
 - required for compilation, z/OS 233
 - used for compilation 233
- data-definition attribute codes 336
- data-name
 - cross-reference 352
 - cross-reference list 239
 - in MAP listing 336
 - OMITTED 14
 - password for VSAM files 164
- date and time operations
 - Language Environment callable
 - services 597
- date arithmetic 569
- date comparisons 560
- date field expansion
 - advantages 556
 - description 558
- date fields
 - potential problems 574
- date operations
 - intrinsic functions 33
- date processing with internal bridges
 - advantages 556
- date windowing
 - advantages 556
 - example 562
 - how to control 571
- date windowing (*continued*)
 - MLE approach 556
 - when not supported 562
- DATE-COMPILED paragraph 5
- DATE-OF-INTEGGER intrinsic
 - function 52
- DATEPROC compiler option
 - analyzing warning-level diagnostic
 - messages 572
 - description 278
- DATEVAL intrinsic function 571
- DB2
 - COBOL language usage with SQL
 - statements 372, 373
 - coding considerations 371
 - coprocessor 375
 - options 373
 - return codes 373
 - SQL DECLARE statement 372
 - SQL INCLUDE statement 371
 - SQL statements 371
- DBCS
 - comparison 79
 - compiler option 269, 279
 - converting 112, 619
 - encoding 107
 - user-defined words in XREF
 - output 329
- DBCS compiler option
 - for Java interoperability 257, 261
 - for OO COBOL 257, 261
- DBCSXREF 330
- dbg extension with cob2 254
- DCB 129
- DD control statement
 - AMP parameter 169
 - ASCII tape files 144
 - creating line-sequential files 177
 - creating QSAM files 134, 135
 - DCB overrides data set label 135
- define file 10
- defining sort data sets 187
- JAVAERR 263
- JAVAIN 263
- JAVAOUT 263
- RLS parameter 170
- SYSADATA 237
- SYSDEBUG 237
- SYSIN 235
- SYSJAVA 237
- SYSLIB 235
- SYSLIN 236
- SYSPRINT 236
- SYSPUNCH 236
- ddname definition 10
- deadlock
 - in I/O error declarative 207
- Debug Tool
 - compiler options for maximum
 - support 355
 - description 321
- debugging
 - and performance 307
 - approaches 321
 - defining data set 237
 - dynamic 308
 - useful compiler options 325
- debugging (*continued*)
 - using COBOL language features 322
- debugging, language features
 - class test 323
 - debugging declaratives 324
 - file status keys 323
 - INITIALIZE statements 323
 - scope terminators 322
 - SET statements 323
- DECK compiler option 279
- declarative procedures
 - EXCEPTION/ERROR 207
 - with multithreading 207
 - LABEL 142
 - USE FOR DEBUGGING 324
- deferred restart 549
- defining
 - debug data set 237
 - files, overview 10, 113
 - libraries 235
 - line-sequential files
 - to z/OS 177
 - QSAM files
 - to z/OS 134, 135
 - sort files
 - under z/OS 187
 - VSAM files 166
 - to z/OS 166
- DELETE statement
 - compiler-directing 317
 - multithreading serialization 440
 - VSAM, coding 155
- deleting records from VSAM file 163
- delimited scope statement
 - description of 19
 - nested 21
- DEPENDING ON option 122, 155
- depth in tables 60
- developing programs for CICS 359
- device
 - classes 233
 - requirements 233
- DFCOMMAREA parameter for
 - CALL 361
- DFHEIBLK parameter for CALL 361
- DFSORT
 - using 187
- diagnostic messages
 - from millennium language
 - extensions 572
- diagnostics, program 334
- DIAGTRUNC compiler option 280
- direct-access
 - direct indexing 63
 - file organization 114
 - storage device (DASD) 171
- directories
 - adding a path to 253
 - where error listing file is written 246
- DISK compiler option 267
- DISPLAY (USAGE IS)
 - encoding 107
 - external decimal 40
- DISPLAY statement
 - directing output 296
 - displaying data values 30
 - interaction with OUTDD 31

- DISPLAY statement (*continued*)
 - using in debugging 322
 - writing to stdout/stderr 31
- DISPLAY-OF intrinsic function
 - using 108
 - with XML document 464
- DLL compiler option
 - description 281
 - for Java interoperability 257, 261
 - for OO COBOL 257, 261
 - multioption interaction 269
- DLL igzjava.x
 - binding with 262
 - example 263
 - linking with 258
 - example 259
- DLL libjvm.x
 - binding with 262
 - example 263
 - linking with 258
 - example 259
 - with EBCDIC services 538
- DLLs (see dynamic link libraries) 425
- do loop 84
- do-until 84
- do-while 84
- document encoding declaration 463
- DOCUMENT-TYPE-DECLARATION
 - XML event 451
- documentation of program 7
- DSA memory map 340
- dump
 - with DUMP compiler option 239
- DUMP compiler option
 - description 281
 - multioption interaction 269
 - output 239
- duplicate computations 581
- DYNAM compiler option
 - description 282
 - performance considerations 589
- dynamic calls
 - using with DLL linkage 430
- dynamic data areas, allocating
 - storage 35
- dynamic debugging 308
- dynamic file allocation 117, 130
- dynamic link libraries
 - about 425
 - compiling 426
 - creating 425
 - creating for OO 258
 - for Java interoperability 258
 - in OO COBOL applications 434
 - linking 427
 - prelinking 429
 - search order for in HFS 430
 - using CALL indentifer with 429
 - using with C/C++ programs 434
 - using with dynamic calls 430
 - using with Java interoperability 259
 - using with OO 259

E

- E-level error message 247, 328

- EBCDIC
 - code pages supported in XML
 - documents 463
 - converting to ASCII 98
 - JNI services 537
- ECI calls and register 15 362
- efficiency of coding 579
- EJECT statement 317
- embedded cross-reference
 - description 331
 - example 353
- embedded error messages 328
- embedded MAP summary 330, 337
- empty VSAM file, opening 158
- enclave 393
- encoding
 - description 107
 - language characters 105
 - XML documents 462
 - XML output 480
- encoding declaration
 - preferable to omit 464
 - specifying 465
- ENCODING-DECLARATION XML
 - event 451
- END-OF-CDATA-SECTION XML
 - event 455
- END-OF-DOCUMENT XML event 456
- END-OF-ELEMENT XML event 453
- end-of-file phrase (AT END) 206
- enhancing XML output 476
 - example 477
- ENTER statement 317
- entry point
 - alternate 409
 - ENTRY label 394, 409
 - passing entry addresses of 407
 - procedure-pointer data item 407
- ENTRY statement
 - handling of programs name in 297
- ENVAR run-time option 263
- ENVIRONMENT DIVISION
 - class 490
 - client 503
 - collating sequence coding 8
 - CONFIGURATION SECTION 7
 - description 7
 - entries for line-sequential files 175
 - entries for QSAM files 119
 - entries for VSAM files 149
 - INPUT-OUTPUT SECTION 7
 - instance method 495
 - items present in, program
 - initialization code 346
 - signature bytes 346
 - subclass 512
- environment variables
 - _BPX_SHAREAS 387
 - _CEE_ENVFILE 263, 385
 - _CEE_RUNOPTS 383, 385
 - _IGZ_SYSOUT 385
 - and copybooks 318
 - CLASSPATH 260, 262, 385
 - COBJVMINITOPTIONS 260, 385
 - COBOPT 249
 - defining files, example 10
 - defining line-sequential files 177

- environment variables (*continued*)
 - defining QSAM files 134
 - example of setting and accessing 385
 - LIBPATH 260, 262, 385
 - library-name 250, 317
 - PATH 262, 385
 - setting and accessing 384
 - setting for the compiler 249
 - STEPLIB 251, 385
 - SYSLIB 250, 257
 - text-name 250, 317
 - using to allocate files 117
- environment-name 7
- ERRMSG, for generating list of error
 - messages 246
- error
 - arithmetic 203
 - compiler options, conflicting 269
 - handling 201
 - handling for input-output 118
 - listing 239
 - message table, example 66
 - messages, compiler 246
 - choosing severity to be
 - flagged 328
 - embedding in source listing 328
 - sending to terminal 236
 - processing, line-sequential files 180
 - processing, QSAM files 133
 - processing, VSAM files 164
- error messages
 - compiler-directed 246
 - correcting 245
 - determining what severity level to
 - produce 284
 - format 246
 - from exit modules 644
 - generating a list of 246
 - location in listing 246
 - severity levels 247
- ESDS (entry-sequenced data sets)
 - file access mode 153
- euro currency sign 56
- EVALUATE statement
 - case structure 76, 77
 - structured programming 579
- evaluating data item contents
 - class test 46, 79
 - INSPECT statement 95
 - intrinsic functions 99
- exception condition 213
- exception handling
 - with Java 528
- EXCEPTION XML event 456
- EXCEPTION/ERROR declarative
 - description 207
 - file status key 209
 - line-sequential error processing 180
 - QSAM error processing 133
 - VSAM error processing 164
- EXEC control statement 548
- EXIT compiler option
 - considerations for SQL and CICS
 - statements 644
 - description 283
 - using 635
 - with the DUMP compiler option 269

- exit modules
 - called for SYSADATA data set 642
 - error messages generated 644
 - loading and invoking 637
 - used in place of library-name 638
 - used in place of SYSLIB 638
 - used in place of SYSPRINT 641
- EXIT PROGRAM statement
 - in subprogram 394
 - with multithreading 394
- expanded IF statement 75
- explicit scope terminator 21
- exponentiation
 - evaluated in fixed-point arithmetic 606
 - evaluated in floating-point arithmetic 611
 - performance tips 582
- EXPORTALL compiler option
 - description 283
 - multioption interaction 269
- extended mode 37, 603
- external class-name 491, 503
- EXTERNAL clause
 - example for files 421, 422
 - for data items 420
 - for files 13
 - used for input/output 421
- external code page
 - definition 463
- external data
 - obtaining storage for 35
 - sharing 420
 - storage location of 35
- external decimal data item 40
- external file 13, 421
- external floating-point data item 40

F

- F format record 121
- factoring expressions 580
- factory data
 - defining 515
 - definition of 485
 - making it accessible 515
 - private 515
- factory definition, coding 514
- factory methods
 - defining 516
 - definition of 485
 - hiding 517
 - invoking 517
 - using to wrap procedural programs 523
- FACTORY paragraph
 - factory data 515
 - factory methods 516
- factory section, defining 514
- FASTSRT compiler option
 - description 284
 - improving sort performance 193, 589
 - information message 193
 - requirements 193
- FD (file description) entry 14
- figurative constants
 - definition 25

- figurative constants (*continued*)
 - national characters as 106
- file access mode
 - dynamic 153
 - example 154
 - for indexed files (KSDS) 153
 - for relative files (RRDS) 153
 - for sequential files (ESDS) 153
 - performance considerations 171
 - random 153
 - sequential 153
 - summary table of 115, 149
- file allocation 117
- file availability
 - VSAM files under z/OS 165
- file conversion
 - with millennium language extensions 558
- file description (FD) entry 14
- file extensions
 - for error messages listing 246
- file name
 - change 11
- file organization
 - comparison of ESDS, KSDS, RRDS 148
 - indexed 113, 150
 - line-sequential 175
 - overview 113
 - QSAM 119
 - relative 113
 - relative-record 151
 - sequential 113, 150
 - summary table of 115
 - VSAM 148
- file position indicator (CRP) 157, 160
- FILE SECTION
 - BLOCK CONTAINS clause 14
 - CODE-SET clause 14
 - DATA RECORDS clause 14
 - description 13
 - EXTERNAL clause 13
 - FD entry 14
 - GLOBAL clause 13
 - LABEL RECORDS clause 14
 - LINAGE clause 14
 - OMITTED 14
 - RECORD CONTAINS clause 14
 - record description 13
 - RECORD IS VARYING 14
 - RECORDING MODE clause 14
 - VALUE OF 14
- FILE STATUS clause
 - description 118
 - line-sequential error processing 180
 - NOFASTSRT error processing 195
 - QSAM error processing 133
 - using 208
 - VSAM error processing 164
 - VSAM file loading 159
 - with VSAM return code 209
- file status code
 - 02 161
 - 05 158
 - 35 158
 - 37 129
 - 39 130, 137, 140, 158

- file status code (*continued*)
 - 49 162
 - 90 128
 - 92 386
 - using 203
- file status key
 - checking for successful OPEN 208, 209
 - importance of in VSAM 164
 - set for error handling 118, 323
 - to check for I/O errors 208
 - used with VSAM return code 209
- file-name
 - specification 14
- FILEDEF command
 - ASCII tape files 144
- files
 - associating program files to external files 7
 - COBOL coding
 - DATA DIVISION entries 120, 154, 176
 - ENVIRONMENT DIVISION entries 119, 149, 175
 - input/output statements 129, 155, 177
 - overview 116
 - defining to operating system 10
 - describing 13
 - description of optional 130, 158
 - identifying to z/OS 134, 135, 166, 177
 - improving sort performance 193
 - labels 145
 - overview 114
 - processing
 - line-sequential 175
 - QSAM 119
 - VSAM 147
 - usage explanation 11
 - used interchangeably for data set 7
 - with multithreading 440
- finding
 - date of compilation 102
 - largest or smallest data item 99
 - length of data items 101
- fixed century window 556
- fixed-length records
 - format 154
 - QSAM 121
 - VSAM 148, 154
- fixed-point arithmetic
 - comparisons 54
 - evaluation 53
 - example evaluations 55
 - exponentiation 606
- fixed-point data
 - binary 41
 - conversions between fixed- and floating-point data 44
 - external decimal 40
 - intermediate results 605
 - packed-decimal 42
 - planning use of 581
- FLAG compiler option
 - compiler output 328
 - description 284

- FLAG compiler option (*continued*)
 - using 328
- flags and switches 80
- FLAGSTD compiler option 285
- floating-point arithmetic
 - comparisons 54
 - evaluation 53
 - example evaluations 55
 - exponentiation 611
- floating-point data
 - conversions between fixed- and floating-point data 44
 - external floating point 40
 - intermediate results 610
 - internal 42
 - planning use of 581
- format of record
 - fixed-length 121, 154
 - for QSAM ASCII tape 144
 - format D 122, 123, 144
 - format F 121, 144
 - format S 125
 - format U 126, 144
 - format V 122, 123, 144
 - spanned 125
 - undefined 126
 - variable-length 122, 123, 155
- formatted dump 201
- freeing object instances 509
- full date field expansion
 - advantages 556
- function-pointer data item
 - addressing JNI services 649
 - CALL statement 408
 - calling DLL program
 - example 432
 - SET function-pointer 407
 - versus procedure-pointer 408

G

- garbage collection 510
- generating XML output 471
- get and set methods 499
- GETMAIN, saving address of 636
- GLOBAL clause for files 13, 17
- global names 406
- GO TO MORE-LABELS 142
- GOBACK statement
 - in main program 394
 - in subprogram 394
 - with multithreading 394
- group item
 - comparing to national 111
 - variably located 614
- grouping data 415

H

- header on listing 7
- HEAP run-time option
 - influencing data location 35
 - multioption interaction 34
- hexadecimal literal
 - as currency sign 56
 - national 106

- hiding factory methods 517
- hierarchical file system (HFS)
 - compiler data sets 220
 - defining file with environment variable 117
 - processing files with QSAM 140
 - reading file with ACCEPT 29
 - search order for DLLs in 430
 - writing file with DISPLAY 31
- hierarchy of compiler options under z/OS 238

I

- I-level error message 247, 328
- IDENTIFICATION DIVISION
 - class 490
 - CLASS-ID paragraph 490, 511
 - client 502
 - coding 5
 - DATE-COMPILED paragraph 5
 - errors 5
 - listing header example 7
 - method 494
 - PROGRAM-ID paragraph 5
 - required paragraphs 5
 - subclass 511
 - TITLE statement 7
- IF statement
 - coding 75
 - nested 76
 - with null branch 75
- IGZBRDGE macro
 - with multithreading 443
- IGZCA2D service routine 619
- IGZCD2A service routine 622
- igzjava.x
 - binding with 262
 - example 263
 - linking with 258
 - example 259
- IGZEOPT module
 - with multithreading 443
- IGZETUN module
 - with multithreading 443
- IGZSRCD data set 197
- imperative statement, list 19
- implicit scope terminator 21
- IMS
 - COBOL-Java interoperability
 - accessing databases 380
 - calling a COBOL method from a Java application 378
 - calling a Java method from a COBOL application 379
 - coding programs under 7, 377
 - coding restrictions 377
 - performance considerations 593
 - recommended compiler options 377
- incompatible data 46
- incrementing addresses 417
- index
 - data item 63
 - key, detecting faulty 212
 - range checking 327
 - table 62
- index-name subscripting 63

- indexed file organization 113, 150
- indexing
 - example 67
 - preferred to subscripting 583
 - tables 63
- INEXIT suboption of EXIT option 635, 637
- inheritance hierarchy, definition of 487
- INITIAL attribute 6, 395, 398
- INITIALIZE statement
 - examples 26
 - loading table values 64
 - using for debugging 323
- initializing
 - a table 64
 - instance data 508
- inline PERFORM 83
- input
 - coding for line-sequential files 177
 - coding for QSAM files 129
 - coding for VSAM files 155
 - coding in CICS 360
 - from files 113
 - to compiler, under z/OS 233
- input procedure
 - coding 184
 - FASTSRT option not effective 193
 - requires RELEASE or RELEASE FROM 184
 - restrictions 187
- INPUT-OUTPUT SECTION 7
- input/output
 - checking for errors 208
 - coding overview 116
 - controlling with FASTSRT option 284
 - logic flow after error 203
 - overview 113
 - processing errors
 - line-sequential files 180
 - QSAM files 133, 203
 - VSAM files 164, 203
- input/output coding
 - AT END (end-of-file) phrase 206
 - checking for successful operation 208
 - checking VSAM return codes 209
 - detecting faulty index key 212
 - error handling techniques 203
 - EXCEPTION/ERROR
 - declaratives 207
- INSERT statement 317
- INSPECT statement 95
- inspecting data 95
- instance
 - creating 508
 - definition of 485
 - deleting 509
- instance data
 - defining 492, 512
 - definition of 485
 - making it accessible 499
 - private 492
- instance methods
 - defining 493, 513
 - definition of 485
 - invoking overridden 507
 - overloading 498
 - overriding 497

- INTDATE compiler option 287
- INTEGER intrinsic function 95
- INTEGER-OF-DATE intrinsic function 52
- integrated CICS translator 364
- interactive program, example 709
- Interactive System Productivity Facility (ISPF) 709
- interlanguage communication
 - and PL/I tasking 393
 - between COBOL and Java 527
 - subprograms 393
 - under CICS 361
 - with multithreading 393
- interlanguage communication (ILC) 393
- intermediate results 603
- internal bridges
 - advantages 556
 - example 558
 - for date processing 557
- internal floating-point data
 - bytes required 42
 - defining 42
 - uses for 42
- interoperable data types 532
- intrinsic functions
 - as reference modifier 95
 - converting character data items 97
 - DATEVAL 571
 - evaluating data items 99
 - example of
 - ANNUITY 52
 - CHAR 99
 - CURRENT-DATE 52
 - DISPLAY-OF 109
 - INTEGER 95
 - INTEGER-OF-DATE 52
 - LENGTH 51, 100, 101
 - LOG 53
 - LOWER-CASE 97
 - MAX 51, 74, 100
 - MEAN 53
 - MEDIAN 53, 74
 - MIN 95
 - NATIONAL-OF 109
 - NUMVAL 97
 - NUMVAL-C 51, 97
 - ORD 99
 - ORD-MAX 74, 100
 - PRESENT-VALUE 52
 - RANGE 53, 74
 - REM 53
 - REVERSE 97
 - SQRT 53
 - SUM 74
 - UPPER-CASE 97
 - WHEN-COMPILED 102
 - intermediate results 608, 611
 - introduction to 32
 - nesting 33
 - numeric functions
 - differences from Language Environment callable services 50
 - equivalent Language Environment callable services 49
 - examples of 49

- intrinsic functions (*continued*)
 - numeric functions (*continued*)
 - nested 49
 - special registers as arguments 49
 - table elements as arguments 49
 - type of integer, floating-point, mixed 48
 - uses for 48
 - processing table elements 73
 - simplifying coding 595
 - UNDATE 571
- INVALID KEY phrase 212
- INVOKE statement
 - use with PROCEDURE DIVISION RETURNING 419
 - using to create objects 508
 - using to invoke methods 506
 - with ON EXCEPTION 506, 518
- invoking
 - COBOL UNIX programs 383
 - factory or static methods 517
 - instance methods 506
 - Language Environment callable services 599
- ISAM data set 147
- ISPF (Interactive System Productivity Facility) 709

J

- J2EE client
 - example 539
 - running 260
- Java
 - and COBOL 527
 - binding 262
 - compiling under UNIX 257
 - compiling using JCL or TSO/E 261
 - linking 258
 - running 259, 263
 - structuring applications 524
 - array classes 531
 - arrays
 - declaring 532
 - example 535
 - manipulating 534
 - boolean array 532
 - boolean type 532
 - byte array 532
 - byte type 532
 - char array 532
 - char type 532
 - class types 532
 - double array 533
 - double type 532
 - example
 - exception handling 529
 - J2EE client 539
 - processing an array 535
 - exception
 - catching 529
 - example 529
 - handling 528
 - throwing 529
 - float array 533
 - float type 532

- Java (*continued*)
 - global references 530
 - JNI services 531
 - managing 530
 - object 530
 - passing 530
 - int array 532
 - int type 532
 - interoperability 527
 - interoperable data types, coding 532
 - jstring class 531
 - local references 530
 - deleting 530
 - freeing 530
 - JNI services 531
 - managing 530
 - object 530
 - passing 530
 - per multithreading 530
 - saving 530
 - long array 532
 - long type 532
 - methods
 - access control 531
 - object array 532
 - record class 531
 - running with COBOL 259, 263
 - sharing data with 531
 - short array 532
 - short type 532
 - string array 533
 - strings
 - declaring 532
 - manipulating 536
- Java virtual machine
 - exceptions 529
 - initializing 260
 - object references 530
- java.lang.Object
 - referring to as Base 490
- javac command 257
- JAVAEERR data set 263
- JAVAIN data set 263
- JVAOUT data set 263
- JCL
 - ASCII tape files 144
 - cataloged procedures 218
 - checkpoint/restart sample 551
 - FASTSORT requirement 193
 - for compiling 217
 - for compiling with HFS 220
 - for line-sequential files 177
 - for OO applications 261
 - example 263
 - for QSAM files 135
 - for Sort 187
 - for VSAM data sets 169
- JNI
 - accessing services 527
 - comparing object references 505
 - converting local references to global 508
 - EBCDIC services 537
 - environment structure 527
 - addressability for 528
 - exception handling services 528
 - Java array services 534

JNI (*continued*)
 Java string services 536
 obtaining class object reference 528
 restrictions when using 528
 Unicode services 536
 JNI.cpy
 for compiling 257
 for JNINativeInterface 527
 listing 649
 JNIEnvPtr special register 527
 JNINativeInterface
 environment structure 527
 JNI.cpy 527
 job resubmission 551
 job stream 393
 jstring Java class 531

K

keyboard navigation xv
 KSDS (key-sequenced data sets)
 file access mode 153
 organization 150

L

LABEL declarative
 description 317
 GO TO MORE-LABELS 142
 handling user labels 142
 LABEL RECORDS clause
 FILE SECTION entry 14
 LABEL= 144
 labels
 ASCII file 145
 format, standard 143
 processing, QSAM files 141
 standard user 143
 LANGUAGE compiler option 287
 Language Environment callable services
 condition handling 597
 corresponding intrinsic functions 50
 date and time computations 597
 differences from intrinsic
 functions 50
 dynamic storage services 597
 equivalent intrinsic functions 49
 example of using 600
 feedback code 599
 for date and time computations 49
 for mathematics 49
 invoking with a CALL statement 599
 mathematics 597
 message handling 597
 national language support 597
 overview 597
 return code 599
 RETURN-CODE special register 599
 sample list of 598
 types of 597
 language features for debugging
 DISPLAY statements 322
 large block interface 128
 last-used state 395
 LENGTH intrinsic function 99
 example 51, 101

LENGTH intrinsic function (*continued*)
 variable-length results 100
 versus LENGTH OF special
 register 101
 with national data 101
 length of data items, finding 101
 LENGTH OF special register
 passing 412
 using 101
 level definition 336
 level-88 item
 conditional expressions 79
 for windowed date fields 563
 restriction 563
 switches and flags 80
 LIB compiler option
 description and syntax 288
 LIBEXIT suboption of EXIT option 635,
 638
 libjvm.x
 binding with 262
 example 263
 linking with 258
 example 259
 with EBCDIC services 538
 LIBPATH environment variable 260, 262,
 385
 library
 BASIS 235
 COPY 235
 defining 235
 directory entry 231
 specifying path for 317
 library-name
 alternative if not specified 253
 when not used 638
 library-name environment variable 250
 limits of the compiler 12
 LINAGE clause 14
 line number 335
 line-sequential files
 adding records to 179
 allowable control characters 176
 blocking 13
 closing 179
 closing to prevent reopening 178
 DATA DIVISION entries 176
 ENVIRONMENT DIVISION
 entries 175
 input/output error processing 180
 input/output statements for 177
 opening 178
 processing files 175
 reading from 178
 reading records from 178
 sort and merge 181
 under z/OS
 creating files 177
 DD statement for 177
 defining 177
 environment variable for 177
 job control language (JCL) 177
 writing to 178
 LINECOUNT compiler option 289
 LINK macro 231
 LINKAGE SECTION
 description 414

LINKAGE SECTION (*continued*)
 run unit 17
 with recursive calls 17
 with the THREAD option 17
 linker
 CICS 364
 passing information to 253
 linking OO applications
 under UNIX 258
 example 259
 using JCL or TSO/E 262
 example 263
 LIST compiler option
 assembler code for source
 program 340
 compiler output 341, 343
 conflict with OFFSET option 331
 description 289
 DSA memory map 340, 351
 getting output 331
 location and size of
 WORKING-STORAGE 352
 multioption interaction 269
 reading output 340
 symbols used in output 338
 TGT memory map 340
 list of resources 751
 listings
 assembler expansion of PROCEDURE
 DIVISION 340
 data and procedure name
 cross-reference 329
 embedded error messages 328
 generating a short listing 331
 line numbers, user-supplied 332
 sorted cross-reference of program
 names 353
 terms used in MAP output 338
 literals 24
 little-endian 105
 loading a table dynamically 64
 local names 406
 local references, converting to global 508
 LOCAL-STORAGE SECTION
 client 504
 comparison with
 WORKING-STORAGE 15, 504
 determining location 35
 LOG intrinsic function 53
 logical record
 description 113
 fixed-length format 121, 154
 QSAM 120
 variable-length format 122, 123, 155
 LONGMIXED suboption of
 PGMNAME 298
 LONGUPPER suboption of
 PGMNAME 298
 loops
 coding 83
 conditional 84
 do 84
 in a table 85
 performed a definite number of
 times 84
 LOWER-CASE intrinsic function 97
 lst extension with cob2 254

LST file extension 246

M

main program

- and subprograms 394

- dynamic CALL 397

- parameter list in UNIX 388

main storage, allocating to buffers 273

MAP compiler option

- data items and relative addresses 239

- description 290

- embedded MAP summary 331

- example 336, 340

- nested program map 331

 - example 340

- symbols used in output 338

- terms used in output 338

- using 330, 331

mapping of DATA DIVISION items 331

mathematics

- intrinsic functions 49, 53

- Language Environment callable

- services 50, 597

MAX intrinsic function

- example 51, 74

- using 100

MEAN intrinsic function 53, 74

MEDIAN intrinsic function 53, 74

memory map

- DSA 340

- TGT 340

memory map, TGT

- example 350

merge

- concepts 182

- description 181

- files, describing 183

- line-sequential files 181

- pass control statements to 197

- storage use 197

- successful 192

- with multitasking 181

MERGE statement

- description 182

message handling, Language

- Environment callable services 597

messages

- compile-time error

 - choosing severity to be

 - flagged 328

 - embedding in source listing 328

- compiler error

 - sending to terminal 236

- compiler-directed 246

- determining what severity level to

- produce 284

- from exit modules 644

- generating a list of 246

- severity levels 247

METHOD-ID paragraph 494

methods

- constructor 516

- factory 516

- hiding factory 517

- instance 493, 513

- invoking 506, 517

methods (*continued*)

- invoking superclass 507

- Java access control 531

- obtaining passed arguments 497

- overloading 498

- overriding 497, 517

- PROCEDURE DIVISION

- RETURNING 420

- returning a value from 497

- signature 494

millennium language extensions

- assumed century window 564

- compatible dates 561

- concepts 554

- date windowing 553

- DATEPROC compiler option 278

- nondates 565

- objectives 555

- principles 554

- YEARWINDOW compiler option 315

MIN intrinsic function 95, 100

mixed DBCS/EBCDIC literal

- alphanumeric to DBCS

- conversion 619

- DBCS to alphanumeric

- conversion 622

MLE 554

mnemonic-name

- SPECIAL-NAMES paragraph 7

modules, exit

- loading and invoking 637

MOVE statement

- using 27

- with national items 28, 107

MSGFILE run-time option 296

multiple currency signs

- example 56

- using 55

multiple inheritance, not permitted 488, 511

multiple thread environment, running in 309

multitasking

- merge under 181

- sort under 181

multithreading

- AMODE setting 443

- asynchronous signals 443

- choosing data section 437

- in an OO client 504

- closing QSAM files 133

- closing VSAM files 163

- COBOL programs 437

- coding file I/O 440

- control transfer issues 439

- example of file I/O usage 441

- EXIT PROGRAM statement 394

- GOBACK statement 394

- I/O error declaratives 207

- IGZBRDGE 443

- IGZEOPT 443

- IGZETUN 443

- interlanguage communication 393

- limitations on COBOL 442

- nested programs 442

- older compilers 443

- overview 437

multithreading (*continued*)

- preinitializing 440

- preparing COBOL programs for 437

- recursion 439

- recursive requirement 442

- reentrancy 442

- reentrancy requirement 442

- run-time restrictions 443

- STOP RUN statement 394

- synchronizing access to

- resources 442

- terminology 438

- THREAD compiler option

 - restrictions under 309

 - when to choose 439

- UPSI switches 443

- with PL/I tasks 393

N

NAME compiler option

- description 291

- using 5

name declaration

- searching for 406

naming

- files 10

- programs 5

national

- literal 106

national comparison 79

national data

- comparing to alphabetic or

- alphanumeric 111

- comparing to groups 111

- comparing to numeric 111

- converting 107

- Chinese GB 18030 110

- example 109

- exceptions 108

- UTF-8 109

- DISPLAY-OF intrinsic 108

- in conditional expression 111

- in XML document 462

- input with ACCEPT 30

- joining 87

- LENGTH intrinsic function 101

- LENGTH OF special register 101

- MOVE statement 28

- NATIONAL-OF intrinsic 108

- output with DISPLAY 30

- reference modification 93

- specifying 106

- splitting 89

- tallying and replacing 95

national language support

- LANGUAGE compiler option 287

national languages

- run-time use 103

NATIONAL-OF intrinsic function

- using 108

- with XML document 464

nested COPY statement 595, 639

nested delimited scope statements 21

nested IF statement

- coding 76

- CONTINUE statement 76

- nested IF statement (*continued*)
 - EVALUATE statement preferred 76
 - with null branches 76
- nested intrinsic functions 49
- nested program integration 587
- nested program map
 - description 331
 - example 340
- nested programs
 - calling 403
 - conventions for using 403
 - description 404
 - map 331, 340
 - scope of names 406
 - transfer of control 403
- nesting level
 - program 335, 340
 - statement 335
- NOCOMPILE compiler option
 - use of to find syntax errors 326
- NODYNAM compiler option
 - under CICS 361
- NOFASTSRT compiler option 195, 198
- nondates
 - with MLE 565
- Notices 725
- NSYMBOL compiler option
 - description 291
 - for national data items 106
 - for national literals 106
- null branch 76
- null-terminated strings 91, 415
- NUMBER compiler option
 - description 292
 - for debugging 332
- NUMCLS installation option 46
- numeric class test 46
- numeric comparison 79
- numeric data
 - binary
 - USAGE IS BINARY 41
 - USAGE IS COMPUTATIONAL (COMP) 41
 - USAGE IS COMPUTATIONAL-4 (COMP-4) 41
 - USAGE IS COMPUTATIONAL-5 (COMP-5) 41
 - comparing to national 111
 - conversions between fixed- and floating-point data 44
 - defining 37
 - editing symbols 38
 - external decimal
 - USAGE IS DISPLAY 40
 - external floating-point
 - USAGE IS DISPLAY 40
 - format conversions between fixed- and floating-point 43
 - internal floating-point
 - USAGE IS COMPUTATIONAL-1 (COMP-1) 42
 - USAGE IS COMPUTATIONAL-2 (COMP-2) 42
 - packed-decimal
 - USAGE IS COMPUTATIONAL-3 (COMP-3) 42

- numeric data (*continued*)
 - packed-decimal (*continued*)
 - USAGE IS PACKED-DECIMAL 42
 - PICTURE clause 37, 38
 - storage formats 39
 - zoned decimal
 - USAGE IS DISPLAY 40
- numeric editing symbol 38
- numeric intrinsic functions
 - differences from Language Environment callable services 50
 - equivalent Language Environment callable services 49
 - example of
 - ANNUITY 52
 - CURRENT-DATE 52
 - INTEGER 95
 - INTEGER-OF-DATE 52
 - LENGTH 51, 100
 - LOG 53
 - MAX 51, 74, 100
 - MEAN 53
 - MEDIAN 53, 74
 - MIN 95
 - NUMVAL 97
 - NUMVAL-C 51, 97
 - ORD 99
 - ORD-MAX 74
 - PRESENT-VALUE 52
 - RANGE 53, 74
 - REM 53
 - SQRT 53
 - SUM 74
 - nested 49
 - special registers as arguments 49
 - table elements as arguments 49
 - types of integer, floating-point, mixed 48
 - uses for 48
- numeric-edited data item 38
- NUMPROC compiler option
 - affected by NUMCLS 46
 - description 293
 - effect on sign processing 45
 - performance considerations 590
- NUMVAL intrinsic function 97
- NUMVAL-C intrinsic function
 - example 51
 - using 97

O

- o extension with cob2 254
- object
 - creating 508
 - definition of 485
 - deleting 509
- object code
 - compilation and listing 239
 - creating 236
 - generating 275
 - producing in 80-column card 279
- OBJECT compiler option
 - description 294
 - multioption interaction 269
- object instances, definition of 485

- OBJECT paragraph
 - instance data 492, 512
 - instance methods 493
- object references
 - comparing 505
 - converting from local to global 508
 - setting 505
 - typed 504
 - universal 504
- OBJECT-COMPUTER paragraph 7
- object-oriented COBOL
 - binding 262
 - example 263
 - compiling
 - under UNIX 257
 - using JCL or TSO/E 261
 - DLLs in 434
 - IMS
 - accessing databases 380
 - calling a COBOL method from a Java application 378
 - calling a Java method from a COBOL application 379
 - linking 258
 - example 259
 - preparing applications
 - under UNIX 258
 - using JCL or TSO/E 262
 - restrictions
 - CICS compiler option 485
 - DYNAM compiler option 282
 - EXEC CICS statements 485
 - EXEC SQL statements 485
 - SQL compiler option 485
 - running
 - under UNIX 259
 - using JCL or TSO/E 263
 - writing OO programs 485
- objectives of millennium language extensions 555
- OCCURS clause 59, 584
- OCCURS DEPENDING ON (ODO) clause
 - complex 613
 - initializing ODO elements 70
 - optimization 584
 - simple 68
 - variable-length records 122, 155
 - variable-length tables 68
- OFFSET compiler option
 - description 294
 - multioption interaction 269
 - output 354
- OMITTED clause, FILE SECTION 14
- OMITTED LE parameters 599
- OMITTED phrase for omitting arguments 414
- ON EXCEPTION phrase
 - INVOKE statement 506, 518
- ON SIZE ERROR
 - with windowed date fields 569
- OPEN operation code 637
- OPEN statement
 - file availability 130, 158, 178
 - file status key 208
 - line-sequential files 177
 - QSAM files 129

- OPEN statement (*continued*)
 - VSAM files 155
- opening files
 - line-sequential 178
 - multithreading serialization 440
 - QSAM 130
 - VSAM 158
- optimization
 - avoid ALTER statement 580
 - avoid backward branches 580
 - BINARY data items 581
 - consistent data 582
 - constant computations 580
 - constant data items 580
 - contained program integration 587
 - duplicate computations 581
 - effect of compiler options on 588
 - effect on parameter passing 413
 - effect on performance 579
 - factor expressions 580
 - index computations 584
 - indexing 583
 - nested program integration 587
 - OCCURS DEPENDING ON 584
 - out-of-line PERFORM 580
 - packed-decimal data items 582
 - performance implications 584
 - procedure integration 587
 - structured programming 579
 - subscript computations 584
 - subscripting 583
 - table elements 583
 - top-down programming 580
 - unreachable code 587
 - unused data items 295, 337
- OPTIMIZE compiler option
 - description 295
 - effect on parameter passing 413
 - effect on performance 586
 - multioption interaction 269
 - performance considerations 589
 - using 586
- optimizer 586, 588
- optional files 130, 158
- ORD intrinsic function 99
- ORD-MAX intrinsic function 74, 100
- ORD-MIN intrinsic function 100
- order of evaluation
 - arithmetic operators 48, 605
 - compiler options 269
- out-of-line PERFORM 83
- OUTDD compiler option
 - DD not allocated 31
 - description 296
 - interaction with DISPLAY 31
- output
 - coding for line-sequential files 177
 - coding for QSAM files 129
 - coding for VSAM files 155
 - coding in CICS 360
 - data set 236
 - from compiler, under z/OS 233
 - to files 113
- output file with cob2 254
- output procedure
 - FASTSRT option not effective 193

- output procedure (*continued*)
 - requires RETURN or RETURN INTO statement 185
 - restrictions 187
 - using 185
- overflow condition 202, 213
- overloading instance methods 498
- overriding
 - factory methods 517
 - instance methods 497

P

- PACKED-DECIMAL
 - synonym 39
- packed-decimal data item
 - date fields, potential problems 574
 - description 42
 - using efficiently 42, 582
- page
 - control 132
 - depth 14
 - header 334
 - customized 334, 335
- paragraph
 - grouping 85
 - introduction 19
- parameter list
 - for ADEXIT 642
 - for INEXIT 637
 - for LIBEXIT 640
 - for PRTEXIT 641
 - main program in UNIX 388
- parameters
 - describing in called program 413
- parsing
 - XML documents 447, 449
- passing data between programs
 - addresses 416
 - BY CONTENT 411
 - BY REFERENCE 411
 - BY VALUE 411
 - called program 413
 - calling program 413
 - EXTERNAL data 420
 - JNI services 528
 - language used 413
 - OMITTED arguments 414
 - options considerations 35
 - with Java 531
- password
 - alternate index 165
 - example 165
 - VSAM files 164
- PASSWORD clause 164
- PATH environment variable 262, 385
- path name
 - for copybook search 253, 317
- PERFORM statement
 - ...THRU 85
 - coding loops 83
 - for a table 66
 - indexing 63
 - inline 83
 - out-of-line 83
 - performed a definite number of times 84

- PERFORM statement (*continued*)
 - TEST AFTER 84
 - TEST BEFORE 84
 - TIMES 84
 - UNTIL 84
 - VARYING 85
 - VARYING WITH TEST AFTER 85
 - WITH TEST AFTER ... UNTIL 84
 - WITH TEST BEFORE ... UNTIL 84
- performance
 - AIXBLD run-time option 593
 - and debugging 307
 - APPLY WRITE-ONLY clause 12
 - arithmetic expressions 582
 - blocking QSAM files 127
 - CBLPSHPOP run-time option 367
 - CICS environment 592
 - coding 579
 - coding tables 583
 - compiler option
 - AWO 589
 - DYNAM 589
 - FASTSRT 589
 - NUMPROC 45, 589
 - OPTIMIZE 586, 589
 - RENT 589
 - RMODE 589
 - SSRANGE 589
 - TEST 589
 - THREAD 310
 - TRUNC 310, 589
 - data usage 581
 - effect of compiler options on 588
 - effects of buffer size 273
 - exponentiations 582
 - IMS environment 377, 593
 - OCCURS DEPENDING ON 584
 - of calls 401
 - optimizer 586, 588
 - planning arithmetic evaluations 581
 - programming style 579
 - run-time considerations 367, 579
 - table handling 584
 - tape, QSAM 128
 - variable subscript data format 62
 - VSAM file considerations 171
 - worksheet 592
- period, as scope terminator 21
- PGMNAME compiler option 297
- physical
 - block 113
 - record 14, 113
- PICTURE clause
 - determining symbol used 276
 - numeric data 37
- PL/I tasking
 - POSIX run-time option 442
 - with COBOL 393
- pointer data item
 - description 33
 - incrementing addresses with 417
 - NULL value 416
 - used to pass addresses 416
 - used to process chained list 416, 417
- porting your program 38
- POSIX
 - calling APIs 386

POSIX (*continued*)
 threads 442
POSIX run-time option
 affect on DLL search order 430
 use in OO applications 263
potential problems with date fields 574
precedence
 arithmetic operators 48, 605
 compiler options under z/OS 238
preferred sign 45
preinitializing
 with multithreading 440
prelinking cataloged procedure
 compile, prelink, link-edit 223
 compile, prelink, link-edit, run 224
 compile, prelink, load, run 226
 prelink and link-edit 226
PRESENT-VALUE intrinsic function 52
preserving original sequence in a
 sort 191
priority numbers, segmentation 589
procedure and data name cross-reference,
 description 329
PROCEDURE DIVISION
 additional information 348
 client 502
 description 18
 in subprograms 415
 instance method 496
 RETURNING 18
 signature bytes 346, 348
 statements
 compiler-directing 20
 conditional 19
 delimited scope 19
 imperative 19
 terminology 18
 USING 18
 verbs present in 346
PROCEDURE DIVISION RETURNING
 methods, use of 420
procedure integration 587
procedure-pointer data item
 entry address for entry point 407
 passing parameters to callable
 services 407
 SET procedure-pointer 407
 versus function-pointer 408
 with DLLs 431
PROCESS (CBL) statement
 batch compiling 242
 conflicting options in 269
 precedence 238
PROCESS statement 238
processes 438
processing
 chained list 416, 417
 labels for QSAM files 141
 tables 66
 using indexing 67
 using subscripting 66
PROCESSING-INSTRUCTION-DATA
 XML event 454
PROCESSING-INSTRUCTION-TARGET
 XML event 453
producing XML output 471

program
 attribute codes 340
 compiling under UNIX 249
 compiling under z/OS 217
 compiling using cob2 251
 examples 252
 decisions
 EVALUATE statement 76
 IF statement 75
 loops 84
 PERFORM statement 84
 switches and flags 80
 developing for UNIX 383
 diagnostics 334
 initialization code 341
 limitations 579
 main 394
 nesting level 335
 reentrant 409
 restarting 548
 signature information bytes 343
 statistics 334
 structure 5
 subprogram 394
PROGRAM COLLATING SEQUENCE
 clause 8
program names
 handling of case 297
 specifying 5
program processing table 361
program termination
 actions taken in main and
 subprogram 394
 statements 394
PROGRAM-ID paragraph
 coding 5
 COMMON attribute 6
 INITIAL attribute 6
program-name cross-reference 353
protecting VSAM files 164
PRTEXIT suboption of EXIT option 636,
 641

Q

QSAM files
 adding records to 131
 ASCII tape file 144
 ASSIGN clause 120
 BLOCK CONTAINS clause 127
 block size 127
 blocking enhances performance 127
 blocking records 127, 140
 closing 132
 closing to prevent reopening 130
 DATA DIVISION entries 120
 ENVIRONMENT DIVISION
 entries 119
 input/output error processing 133,
 203
 input/output statements for 129
 label processing 141
 obtaining buffers for 140
 opening 130
 processing 119
 processing files in reverse order 130
 processing HFS files 140

QSAM files (*continued*)
 replacing records 131
 retrieving 136
 striped extended-format 139
 tape performance 128
 under z/OS
 creating files 134, 135
 DD statement for 134, 135
 defining 134, 135
 environment variable for 134
 file availability 130
 job control language (JCL) 135
 updating files 131
 writing to a printer 131
QUOTE compiler option 299

R

random numbers, generating 50
RANGE intrinsic function 53, 74
RD parameter 548
READ INTO. . . 155
READ NEXT statement 155
READ statement
 line-sequential files 177
 multithreading serialization 440
 QSAM 129
 VSAM 155
reading records
 a block 127
 to line-sequential files 178
reading records from VSAM files
 dynamically 160
 randomly 160
 sequentially 160
receiving field 89
record
 description 13
 format 113
 fixed-length 121, 154
 format D 122, 123, 144
 format F 121, 144
 format S 125
 format U 126, 144
 format V 122, 123, 144
 QSAM ASCII tape 144
 spanned 125
 undefined 126
 variable-length 122, 123, 155
RECORD CONTAINS clause
 FILE SECTION entry 14
RECORDING MODE clause
 fixed-length records, QSAM 121
 QSAM files 14
 to specify record format 120
 variable-length records, QSAM 122,
 123
recursive calls
 and the LINKAGE SECTION 17
 coding 407
 identifying 6
reentrant programs 409
reference modification
 example 94
 national data 93
 out-of-range values 93
 tables 62, 93

- reference modifier
 - arithmetic expression as 94
 - intrinsic function as 95
 - variables as 93
- register 15 and CICS 362
- registers, affected by EXIT compiler option 637
- relation condition 79
- relative file organization 113
- RELEASE FROM statement
 - compared to RELEASE 184
 - example 184
- RELEASE statement
 - compared to RELEASE FROM 184
 - with SORT 184
- REM intrinsic function 53
- RENT compiler option
 - description 299
 - for Java interoperability 257, 261
 - for OO COBOL 257, 261
 - influencing addressability 35
 - multioption interaction 34
 - performance considerations 589
 - when passing data 35
- REPLACE statement 317
- replacing
 - data items 95
 - records in QSAM file 131
 - records in VSAM file 162
- REPOSITORY paragraph
 - class 490
 - client 503
 - coding 7
 - subclass 512
- representation
 - data 46
 - sign 45
- RERUN clause
 - checkpoint/restart 198
- reserved-word table
 - alternate, CICS 314, 366
- residency mode 34
- restart
 - automatic 549
 - deferred 549
 - routine 545
- restarting a program 548
- restrictions
 - CICS coding 7
 - coding programs for CICS 359
 - coding programs for IMS 377
 - IMS coding 7, 362
 - input/output procedures 187
 - OO programs 485
 - subscripting 62
 - using EXEC SQL under IMS 380
- resubmitting a job 551
- return code
 - compiler 247
 - feedback code from Language Environment services 599
 - from CICS ECI 362
 - from DB2 373
 - RETURN-CODE special register 419, 599
 - VSAM files 209

- return code (*continued*)
 - when control returns to operating system 419
- RETURN INTO statement 185
- RETURN statement 185
- RETURN-CODE special register
 - considerations for DB2 373
 - not set by INVOKE 507
 - value after call to Language Environment service 599
 - when control returns to operating system 419
- RETURNING phrase
 - INVOKE statement 507
 - methods, use of 420
 - PROCEDURE DIVISION header 497
- REVERSE intrinsic function 97
- reverse order of tape files 130
- reversing characters 97
- REWRITE statement
 - multithreading serialization 440
 - QSAM 129
 - VSAM 155
- RLS parameter 170
- RMODE
 - assigned for EXIT modules 637
 - description 34
- RMODE compiler option
 - description 300
 - influencing addressability 34
 - multioption interaction 34
 - performance considerations 589
 - when passing data 35
- Rotational Position Sensing feature 129
- ROUNDED phrase 604
- rows in tables 60
- RRDS (relative-record data sets)
 - file access mode 153
 - fixed-length records 148
 - organization 150, 151
 - performance considerations 171
 - simulating variable-length records 152
 - variable-length records 148
- run time
 - changing file-name 11
 - multithreading restrictions 443
 - performance considerations 579
- run unit
 - description 393
 - role in multithreading 438
- run-time options
 - affecting DATA compiler option 35
 - AIXBLD 593
 - ALL31 399
 - CBLP SHPOP 367
 - CHECK(OFF) 589
 - COBOL 85 Standard conformance 269
 - ENVAR 263
 - MSGFILE 296
 - POSIX
 - DLL search order 430
 - use in OO applications 263
 - SIMVRD 152
 - specifying under UNIX 383

- run-time options (*continued*)
 - TRAP
 - closing files in line-sequential 179
 - closing files in QSAM 132
 - closing files in VSAM 163
 - ON SIZE ERROR 203
- running OO applications
 - under UNIX 259
 - using JCL or TSO/E 263

S

- S format record 125
- S-level error message 247, 328
- sample programs 705
- scope of names 406
- scope terminator
 - aids in debugging 322
 - explicit 19, 21
 - implicit 21
- SEARCH ALL statement
 - binary search 72
 - indexing 63, 71
 - ordered table 72
- search order
 - DLLs in the HFS 430
- SEARCH statement
 - examples 71
 - indexing 63
 - nesting 71
 - serial search 71
- searching a table 71
- searching for name declarations 406
- section
 - declarative 22
 - description of 18
 - grouping 85
 - segmentation 589
- SELECT clause
 - ASSIGN clause 10
 - naming files 10
 - vary input-output file 11
- SELECT OPTIONAL 130, 158
- SELF 505
- sending field 89
- sentence 19
- separate digit sign 38
- SEQUENCE compiler option 301, 327
- sequential file organization 113
- sequential storage device 114
- serial search 71
- serialization
 - of files with multithreading 440
- SERVICE LABEL statement 317
- SET condition-name TO TRUE statement
 - example 84, 85
 - switches and flags 81
- SET statement
 - for function-pointer data items 408
 - for procedure-pointer data items 408
 - handling of programs name in 297
 - setting object references 505
 - using for debugging 323
- setting
 - switches and flags 81
- sharing
 - data 406, 420

- sharing (*continued*)
 - with Java 531
 - files 13, 406, 421
- sharing data 17
- short listing, example 332
- sign condition 79, 567
- sign representation 45
- signature
 - definition of 494
 - must be unique 494
- signature bytes
 - compiler options in effect 343
 - DATA DIVISION 345
 - ENVIRONMENT DIVISION 346
 - PROCEDURE DIVISION 346, 348
- SIMVRD run-time option 152
- SIZE compiler option 302
- size of printed page, control 132
- skip a block of records 127
- sliding century window 556
- sort
 - alternate collating sequence 190
 - checkpoint/restart 198
 - completion code 192
 - concepts 182
 - controlling behavior of 195
 - criteria 188
 - data sets needed, z/OS 187
 - DD statements, defining z/OS data sets 187
 - description 181
 - FASTSRT compiler option 193
 - files, describing 183
 - input procedures 184
 - line-sequential files 181
 - more than one 182
 - NOFASTSRT compiler option 195
 - output procedures 185
 - pass control statements to 197
 - performance 193
 - preserving original sequence 191
 - restrictions on input/output procedures 187
 - special registers 195
 - storage use 197
 - successful 192
 - terminating 192
 - under CICS 199
 - under z/OS 187
 - variable-length records 188
 - windowed date fields 191
 - with multitasking 181
 - workspace 198
- Sort File Description (SD) entry
 - example 183
- SORT statement
 - description 188
 - restrictions for CICS applications 199
 - under CICS 199
- SORT-CONTROL special register 196
- SORT-CORE-SIZE special register 196
- SORT-FILE-SIZE special register 196
- SORT-MESSAGE special register 196
- SORT-MODE-SIZE special register 196
- SORT-RETURN special register 192, 196
- SORTCKPT DD statement 198
- SOURCE and NUMBER output,
 - example 335
- source code
 - compiler data set (z/OS) 235
 - line number 335, 336, 340
 - listing, description 331
 - program listing 239
- SOURCE compiler option 302, 331
- SOURCE-COMPUTER paragraph 7
- SPACE compiler option 303
- spanned record format 125
- spanned records 125
- special feature specification 7
- special register
 - ADDRESS 412
 - arguments in intrinsic functions 49
 - JNIEnvPtr 527
 - LENGTH OF 101, 412
 - SORT-RETURN 192
 - WHEN-COMPILED 102
 - XML-CODE 456
 - XML-EVENT 456
 - XML-NTEXT 457
 - XML-TEXT 456
- SPECIAL-NAMES paragraph
 - coding 7
 - QSAM files 144
- splitting data items 89
- SQL compiler option
 - description 303
 - multioption interaction 269
 - restriction in OO programs 485
 - using 373
- SQL INCLUDE statement 371
- SQL statements
 - EXIT compiler option and 644
 - use for DB2 services 371
- SQLCA 371
- SQLCODE 373
- SQLSTATE 373
- SQRT intrinsic function 53
- SSRANGE compiler option
 - CHECK(OFF) run-time option 589
 - description 304
 - performance considerations 589
 - using 327
- STACK run-time option
 - influencing data location 35
 - multioption interaction 34
- STANDALONE-DECLARATION XML
 - event 451
- STANDARD clause, FD entry 14
- standard label format 143
- standard label, QSAM 145
- START statement
 - multithreading serialization 440
 - VSAM 155
- START-OF-CDATA-SECTION XML
 - event 455
- START-OF-DOCUMENT XML event 451
- START-OF-ELEMENT XML event 452
- statement
 - compiler-directing 20
 - conditional 19
 - definition 19
 - delimited scope 19
 - explicit scope terminator 21
- statement (*continued*)
 - imperative 19
 - implicit scope terminator 21
 - nesting level 335
- static call statement 397
- static data areas, allocating storage 35
- static data, definition of 485
- static methods
 - definition of 485
 - invoking 517
- statistics
 - intrinsic functions 53
- stderr
 - directing DISPLAY 31
 - setting DISPLAY to 385
- stdin
 - reading with ACCEPT 29
- stdout
 - directing DISPLAY 31
 - setting DISPLAY to 385
- STEPLIB environment variable 251, 385
- STOP RUN statement
 - in main program 394
 - in subprogram 394
 - with multithreading 394
- storage
 - device
 - direct-access 114
 - sequential 114
 - management, Language Environment
 - callable services 597
 - mapping 331
 - use during sort 197
- STRING statement
 - example of 88
 - overflow condition 202
 - using 87
 - with DBCS data 619
- strings
 - Java 532
 - manipulating 536
 - null-terminated 415
- striped extended-format QSAM file 139
- structured programming 580
- structuring OO applications 524
- subclass
 - definition of 510
 - instance data 512
- subprogram
 - and main program 394
 - description 394
 - linkage 393, 401
 - common data items 413
 - PROCEDURE DIVISION in 415
 - termination
 - effects 394
- subscript
 - computations 584
 - range checking 327
- subscripting
 - example of processing a table 66
 - index-names 63
 - literal 61
 - reference modification 62
 - relative 62
 - restrictions 62
 - variable 61

- substrings
 - reference modification 93
 - referencing table items 93
- SUM intrinsic function 74
- SUPER 508
- surrogate values 110
- switch-status condition 79
- switches and flags
 - defining 80
 - description 80
 - resetting 81
- SYMBOLIC CHARACTERS clause 10
- symbolic constant 580
- syntax errors
 - finding with NOCOMPILE compiler option 326
- SYSADATA
 - output 271
 - records, exit module 642
 - SYSADATA data set 237
- SYSADATA file
 - example 657
 - file contents 655
 - record descriptions 658
 - record types 656
- SYSDEBUG data set
 - defining 237
 - use of 307
- SYSIN data set
 - defining 235
 - description 233
 - user exit error message 644
- SYSJAVA data set 237
- SYSLIB data set
 - defining 235
 - description 233
 - when not used 638
- SYSLIB environment variable 250, 257
- SYSLIN data set 236
- SYSPRINT data set
 - defining 236
 - description 233
 - when not used 641
- SYSPUNCH data set
 - description 233, 236
 - requirements for DECK compiler option 279
- system date
 - under CICS 360
- system dump 202
- system-determined block size 127, 235
- system-name 7
- SYSTEM data set
 - defining 236
 - description 233
 - sending messages to 305
- SYSUT data set 233

T

- table
 - assigning values 65
 - columns 59
 - compare to array 33
 - defining 59
 - depth 60
 - description 33
- table (*continued*)
 - dynamically loading 64
 - efficient coding 583, 584
 - handling 59
 - identical element specifications 583
 - index 62
 - initialize 64
 - intrinsic functions 73
 - loading values in 64
 - looping through 85
 - making reference 61
 - one-dimensional 59
 - reference modification 62
 - referencing table entry substrings 93
 - rows 60
 - searching 71
 - subscripts 61
 - three-dimensional 60
 - two-dimensional 60
 - variable-length 68
- TALLYING option 96
- tape files
 - performance 128
 - reverse order 130
- TERMINAL compiler option 305
- terminal, sending messages to 305
- termination 394
- terminology
 - VSAM 147
- terms used in MAP output 338
- test
 - conditions 84
 - data 79
 - numeric operand 79
 - UPSI switch 79
- TEST AFTER 84
- TEST BEFORE 84
- TEST compiler option
 - description 306
 - for full advantage of Debug Tool 355
 - multioption interaction 269
 - performance considerations 589
- text-name environment variable 250
- TGT memory map
 - description 340
 - example 350
- THREAD compiler option
 - and the LINKAGE SECTION 17
 - description 309
 - for Java interoperability 257, 261
 - for OO COBOL 257, 261
- threading consideration 383
- TITLE statement
 - controlling header on listing 7
- top-down programming
 - constructs to avoid 580
- TRACK OVERFLOW option 129
- trademarks 726
- transferring control
 - between COBOL and non-COBOL programs 393
 - between COBOL programs 396, 403
 - called program 394
 - calling program 394
 - main and subprograms 394
 - nested programs 404
- transforming COBOL data to XML 471

- TRAP run-time option
 - closing line-sequential files 179
 - closing QSAM files 132
 - closing VSAM files 163
 - ON SIZE ERROR 203
- TRUNC compiler option
 - description 310
 - performance considerations 589
- TSO
 - ALLOCATE command 229
 - CALL command 229
 - compiling under 229
 - SYSTEM for compiler messages 236
- tuning considerations, performance 588, 589
- typed object references 504

U

- U format record 126
- U-level error message 247, 328
- UNDATE intrinsic function 571
- undefined record format
 - description 126
 - layout 126
 - QSAM 144
 - requesting 126
- unfilled tracks 129
- Unicode
 - description 105
 - encoding 107
 - JNI services 536
 - run-time support 103
 - using with DB2 372
- universal object references 504
- UNIX
 - accessing environment variables 384
 - example 385
 - accessing main parms 388
 - example 388
 - calling APIs 386
 - compiler environment variables 249
 - compiling from script 255
 - compiling OO applications 257
 - example 259
 - compiling under 249
 - copybook search order 250, 253, 318
 - copybooks 318
 - developing programs 383
 - execution environments 383
 - linking OO applications 258
 - example 259
 - preparing OO applications 258
 - example 259
 - running OO applications 259
 - running programs 383
 - setting environment variables 384
 - example 385
 - sort and merge 181
 - specifying compiler options 250
- UNIX APIs
 - calling 386
- UNKNOWN-REFERENCE-IN-ATTRIBUTE XML event 455
- UNKNOWN-REFERENCE-IN-CONTENT XML event 455
- unreachable code 587

- UNSTRING statement
 - example 89
 - overflow condition 202
 - using 89
 - with DBCS data 619
- updating VSAM records 161
- UPPER-CASE intrinsic function 97
- uppercase 97
- UPSI switches
 - with multithreading 443
- USAGE clause
 - incompatible data 46
 - IS INDEX 63
 - OBJECT REFERENCE 504
- USE . . . LABEL declarative 142
- USE AFTER STANDARD LABEL 145
- USE FOR DEBUGGING declaratives 324
- USE statement 317
- user label
 - exits 145
 - QSAM 145
 - standard 143
- user-defined condition 79
- user-exit work area 636
- user-label track 142
- USING phrase
 - INVOKE statement 507
 - PROCEDURE DIVISION header 497
- UTF-16
 - encoding for national data 105
- UTF-8 data
 - converting 109
 - for ASCII invariant characters 105
 - processing 109

V

- V format record 122, 123
- valid data
 - numeric 46
- VALUE clause
 - assigning table values 65
 - data description entry 65
 - large literals with COMP-5 42
 - large, with TRUNC(BIN) 311
- VALUE IS NULL 416
- VALUE OF clause 14
- variable
 - as reference modifier 93
 - description 23
- variable-length records
 - OCCURS DEPENDING ON (ODO)
 - clause 584
 - QSAM 122, 123
 - sorting 188
 - VSAM 148, 155
- variable-length table 68
- variables, environment
 - library-name 317
- variably located data item 614
- variably located group 614
- VBREF compiler option
 - description 313
 - output example 355
 - using 331
- verb cross-reference listing
 - description 331

- verbs used in program 331
- VERSION-INFORMATION XML
 - event 451
- VSAM files
 - adding records to 162
 - allocating with environment
 - variable 169
 - closing 163
 - coding input/output statements 155
 - comparison of file organizations 148
 - creating alternate indexes 167
 - DATA DIVISION entries 154
 - deleting records from 163
 - dynamically loading 159
- ENVIRONMENT DIVISION
 - entries 149
- error processing 203
- file position indicator (CRP) 157, 160
- file status key 164
- input/output error processing 164
- loading randomly 159
- loading records into 158
- opening 158
- performance considerations 171
- processing files 147
- protecting with password 164
- reading records from 160
- replacing records in 162
- return codes 209
- under z/OS
 - defining data sets 166
 - file availability 165
 - JCL 169
 - RLS mode 170
- updating records 161
- with Access Method Services 159

- VSAM terminology
- BDAM data set 147
- comparison to non-VSAM terms 147
- ESDS for QSAM 147
- KSDS for ISAM 147
- RRDS for BDAM 147

W

- W-level error message 247, 328
- WHEN phrase
 - EVALUATE statement 77
 - SEARCH statement 71
- WHEN-COMPILED intrinsic function
 - example 102
 - versus WHEN-COMPILED special
 - register 102
- WHEN-COMPILED special register 102
- windowed date fields 191
- wlist file 289
- WORD compiler option 313
- work data sets 233
- WORKING-STORAGE SECTION 15
 - client 504
 - comparison with
 - LOCAL-STORAGE 15, 504
 - factory data 515
 - finding location and size of 352
 - instance data 492, 512
 - instance method 495
 - multithreading considerations 504

- WORKING-STORAGE SECTION
 - (continued)
 - storage location for data 277
- workspace
 - use during sort 198
- wrapper, definition of 523
- wrapping procedure-oriented
 - programs 523
- write a block of records 127
- WRITE ADVANCING statement 132
- WRITE statement
 - line-sequential files 177
 - multithreading serialization 440
 - QSAM 129
 - VSAM 155

X

- x extension with cob2 254
- XML declaration
 - restriction 449
 - specifying encoding declaration 465
- XML document
 - accessing 449
 - basic document encoding 463
 - code-page-sensitive characters 464
 - coded character sets 463
 - document encoding declaration 463
 - encoding 462, 480
 - enhancing 476
 - example 477
 - external code page 463
 - generating 471
 - example 473
 - handling parsing errors 465
 - national language 462
 - parser 447
 - parsing 449
 - example 460
 - processing 447
 - specifying code page 464
 - supported EBCDIC code pages 463
 - XML declaration 449
- XML event
 - ATTRIBUTE-CHARACTER 453
 - ATTRIBUTE-CHARACTERS 452
 - ATTRIBUTE-NAME 452
 - ATTRIBUTE-NATIONAL-CHARACTER 453
 - COMMENT 452
 - CONTENT-CHARACTER 454
 - CONTENT-CHARACTERS 454
 - CONTENT-NATIONAL-CHARACTER 454
 - DOCUMENT-TYPE-DECLARATION 451
 - ENCODING-DECLARATION 451
 - END-OF-CDATA-SECTION 455
 - END-OF-DOCUMENT 456
 - END-OF-ELEMENT 453
 - EXCEPTION 456
 - PROCESSING-INSTRUCTION-DATA 454
 - PROCESSING-INSTRUCTION-TARGET 453
 - STANDALONE-DECLARATION 451
 - START-OF-CDATA-SECTION 455

- XML event (*continued*)
 - START-OF-DOCUMENT 451
 - START-OF-ELEMENT 452
 - UNKNOWN-REFERENCE-IN-ATTRIBUTE 455
 - UNKNOWN-REFERENCE-IN-CONTENT 455
 - VERSION-INFORMATION 451
- XML events
 - description 447
 - processing 450
 - processing procedure 449
- XML exception codes
 - for generating 481, 633
 - for parsing
 - handleable 625
 - not handleable 628
- XML GENERATE statement
 - COUNT IN 481
 - NOT ON EXCEPTION 473
 - ON EXCEPTION 480
- XML generation
 - counting generated characters 472
 - description 471
 - enhancing output 476
 - example 477
 - example 473
 - handling errors 480
 - ignored data items 472
 - overview 471
- XML output
 - encoding 480
 - enhancing 476
 - example 477
 - generating 471
 - example 473
- XML PARSE statement
 - description 447
 - NOT ON EXCEPTION 465
 - ON EXCEPTION 465
 - using 449
- XML parser
 - conformance 631
 - description 447
- XML parsing
 - CCSID conflict 469
 - code-page conflict 469
 - description 449
 - overview 447
 - special registers 456
 - terminating 468
 - XML declaration 449
- XML processing procedure
 - example 460
 - specifying 449
 - using special registers 456
 - writing 456
- XML-CODE special register
 - description 456
 - using in generating 473
 - using in parsing 447
 - with generating exceptions 480
 - with parsing exceptions 465
- XML-EVENT special register
 - description 456
 - using 447, 450
- XML-NTEXT special register 457

- XML-NTEXT special register (*continued*)
 - using 447
- XML-TEXT special register 456
 - using 447
- XREF compiler option 314, 329
- XREF output
 - data-name cross-references 352
 - program-name cross-references 353

Y

- year field expansion 558
- year windowing
 - advantages 556
 - how to control 571
 - MLE approach 556
 - when not supported 562
- year-last date fields 560
- YEARWINDOW compiler option
 - description 315
 - effect on sort/merge 196

Z

- z/OS
 - compiling under 217
- zero comparison 567
- zoned decimal 40
- ZWB compiler option 316

Readers' Comments — We'd Like to Hear from You

Enterprise COBOL for z/OS
Programming Guide
Version 3 Release 3

Publication No. SC27-1412-02

Overall, how satisfied are you with the information in this book?

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Overall satisfaction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How satisfied are you that the information in this book is:

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Accurate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Easy to find	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Easy to understand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Well organized	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Applicable to your tasks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please tell us how we can improve this book:

Thank you for your responses. May we contact you? ☐ Yes ☐ No

When you send comments to IBM, you grant IBM a nonexclusive right to use or distribute your comments in any way it believes appropriate without incurring any obligation to you.

Name

Address

Company or Organization

Phone No.



Cut or Fold
Along Line

Fold and Tape

Please do not staple

Fold and Tape



NO POSTAGE
NECESSARY
IF MAILED IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 40 ARMONK, NEW YORK

POSTAGE WILL BE PAID BY ADDRESSEE

IBM Corporation
H150/090
555 Bailey Avenue
San Jose, CA
U.S.A. 95141-9989



Fold and Tape

Please do not staple

Fold and Tape

Cut or Fold
Along Line



Program Number: 5655-G53

Printed in USA

SC27-1412-02

