COBOL for AIX



Programming Guide

Version 2.0

SC18-9256-00

COBOL for AIX



Programming Guide

Version 2.0

SC18-9256-00

Note!
Before using this information and the product it supports, be sure to read the general information under "Notices" on page 681.

First Edition (June 2004)

This edition applies to Version 2.0 of IBM(R) COBOL for AIX(R) (program number 5724-H44) and to all subsequent releases and modifications until otherwise indicated in new editions. Make sure 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 1995, 2004. All rights reserved.
US Government Users Restricted Rights – Use, duplication or disclosure restricted by GSA ADP Schedule Contract with IBM Corp.

Contents

Tables xi

Preface xiii

About this document xiii
- Accessibility of this document xiii
- How this document will help you xiii
- Abbreviated terms xiii
- How to read syntax diagrams xiv
- How examples are shown xv
- Related information xv

How to send your comments xv

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 6

Describing the computing environment 7
- Example: FILE-CONTROL paragraph 7
- Specifying the collating sequence 8
- Defining symbolic characters 9
- Defining a user-defined class 10
- Identifying files to the operating system 10

Describing the data 11
- Using data in input and output operations . . . 11
- Comparison of WORKING-STORAGE and LOCAL-STORAGE 13
- Using data from another program 14

Processing the data 15
- How logic is divided in the PROCEDURE DIVISION 16
- Declaratives 20

Chapter 2. Using data 21

Using variables, structures, literals, and constants . 21
- Variables 21
- Data structure: data items and group items. . . 21
- Literals 22
- Constants 22
- Figurative constants 23

Assigning values to data items 23
- Examples: initializing data items 24
- Initializing a structure (INITIALIZE) 25
- Assigning values to elementary or group data items (MOVE) 26
- Assigning arithmetic results (MOVE or COMPUTE) 26
- Assigning input from a screen or file (ACCEPT) 27

Displaying values on a screen or in a file (DISPLAY) 28

Using intrinsic functions (built-in functions) . . . 28
- Types of intrinsic functions 29
- Nesting functions 29

Using tables (arrays) and pointers 30

Chapter 3. Working with numbers and arithmetic 31

Defining numeric data. 31

Displaying numeric data 32

Controlling how numeric data is stored 33

Formats for numeric data. 34
- External decimal (DISPLAY) items. 34
- External floating-point (DISPLAY) items 34
- Binary (COMP) items 35
- Native binary (COMP-5) items 35
- Packed-decimal (COMP-3) items 36
- Floating-point (COMP-1 and COMP-2) items . . 36
- Examples: numeric data and internal representation 36

Data format conversions 38
- Conversions and precision 39

Sign representation and processing 39

Checking for incompatible data (numeric class test) 40

Performing arithmetic 41
- COMPUTE and other arithmetic statements . . 41
- Arithmetic expressions 41
- Numeric intrinsic functions 42
- Examples: numeric intrinsic functions 43

Fixed-point versus floating-point arithmetic . . . 45
- Floating-point evaluations 46
- Fixed-point evaluations 46
- Arithmetic comparisons (relation conditions) . . 46
- Examples: fixed-point and floating-point evaluations 47

Using currency signs 47
- Example: multiple currency signs 48

Chapter 4. Handling tables 51

Defining a table (OCCURS) 51

Nesting tables 52
- Subscripting 52
- Indexing 53

Referring to an item in a table 53
- Subscripting 54
- Indexing 55

Putting values into a table 56
- Loading a table dynamically. 56
- Initializing a table (INITIALIZE) 56
- Assigning values when you define a table (VALUE) 57
- Example: PERFORM and subscripting 58
- Example: PERFORM and indexing. 59

Creating variable-length tables (DEPENDING ON) 60
- Loading a variable-length table. 61
- Assigning values to a variable-length table . . . 62

Searching a table 62

© Copyright IBM Corp. 1995, 2004

Doing a serial search (SEARCH) 63
Doing a binary search (SEARCH ALL) 64
Processing table items using intrinsic functions . . 65
Example: intrinsic functions 65

Chapter 5. Selecting and repeating program actions 67
Selecting program actions 67
Coding a choice of actions 67
Coding conditional expressions 71
Repeating program actions 75
Choosing inline or out-of-line PERFORM . . . 75
Coding a loop 76
Coding a loop through a table 77
Executing multiple paragraphs or sections . . . 77

Chapter 6. Handling strings 79
Joining data items (STRING) 79
Example: STRING statement. 79
Splitting data items (UNSTRING) 81
Example: UNSTRING statement 81
Manipulating null-terminated strings 83
Example: null-terminated strings 84
Referring to substrings of data items 84
Reference modifiers. 85
Example: arithmetic expressions as reference modifiers 86
Example: intrinsic functions as reference modifiers 87
Tallying and replacing data items (INSPECT) . . . 87
Examples: INSPECT statement 87
Converting data items (intrinsic functions) 88
Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE) 89
Converting to reverse order (REVERSE) 89
Converting to numbers (NUMVAL, NUMVAL-C) 89
Converting from one code page to another . . . 90
Evaluating data items (intrinsic functions) 91
Evaluating single characters for collating sequence 91
Finding the largest or smallest data item . . . 91
Finding the length of data items 93
Finding the date of compilation 94

Chapter 7. Enabling programs for international environments 95
Processing character data in an international environment 95
Unicode and encoding of language characters . . 97
Using national data (Unicode) in COBOL . . . 98
Converting national data 100
Processing UTF-8 data 101
Processing Chinese GB 18030 data 102
Comparing national data items 102
Coding for use of DBCS support 104
Declaring DBCS data 104
Specifying DBCS literals 105
Testing for valid DBCS characters 106
Processing alphanumeric data items that contain DBCS data 106
Setting the locale 106
Code page 107
Messages 107
Collating sequence 107
How locale is determined 108
Controlling the collating sequence 110
Locales and code pages supported 112
Accessing the locale and code-page values in effect 115

Chapter 8. Processing files 119
Identifying files. 119
Identifying VSAM files 120
Identifying Encina SFS files. 120
Identifying STL files 121
Identifying RSD files 121
File system 121
VSAM file system 122
SFS file system 122
STL file system 123
RSD file system 125
Enabling COBOL applications to access SFS files 126
Example: accessing SFS files 127
Improving SFS performance 129
Protecting against errors when opening files . . . 131
Specifying a file organization and access mode . . 131
File organization and access mode 131
Setting up a field for file status 135
Describing the structure of a file in detail 135
Coding input and output statements for files . . . 136
Example: COBOL coding for files. 136
File position indicator 138
Opening a file 138
Reading records from a file. 141
Adding records to a file 142
Replacing records in a file 143
Deleting records from a file. 143
PROCEDURE DIVISION statements used to update files 144

Chapter 9. Sorting and merging files 147
Sort and merge process 147
Describing the sort or merge file 148
Describing the input to sorting or merging . . . 148
Example: describing sort and input files for SORT 149
Coding the input procedure 150
Describing the output from sorting or merging . . 150
Coding the output procedure 151
Restrictions on input and output procedures . . . 151
Requesting the sort or merge 152
Setting sort or merge criteria 153
Choosing alternate collating sequences 153
Example: sorting with input and output procedures 154
Determining whether the sort or merge was successful 154
Sort and merge error numbers. 155
Stopping a sort or merge operation prematurely 156

Chapter 10. Handling errors 157
Handling errors in joining and splitting strings . . 157
Handling errors in arithmetic operations 158
Example: checking for division by zero. 158
Handling errors in input and output operations 159
Using the end-of-file condition (AT END) . . . 160
Coding ERROR declaratives 161
Using file status keys. 161
Using file system return codes. 163
Coding INVALID KEY phrases 164
Handling errors when calling programs 165

Part 2. Compiling, linking, running, and debugging your program . . . 167

Chapter 11. Compiling, linking, and running programs 169
Setting environment variables 169
Setting environment variables in the command shell 169
Setting environment variables in a .profile file 170
Setting environment variables in a program . . 170
Precedence of environment variables 170
Compiler environment variables 170
Run-time environment variables 172
Example: setting and accessing environment variables 178
Compiling programs 178
Compiling from the command line 179
Compiling using shell scripts 180
Compiling for SFS files 180
Specifying compiler options with the PROCESS (CBL) statement 181
Modifying the default compiler configuration 182
Correcting errors in your source program 184
Severity codes for compiler error messages . . 184
Generating a list of compiler error messages . . 185
cob2, cob2_j, cob2_r, and cob2_r4 options 186
Options that apply to compiling 186
Options that apply to linking 187
Options that apply to both compiling and linking 188
Linking programs 189
Passing options to the linker 189
Linker input and output files 191
Correcting errors in linking. 193
Running programs 193
Redistributing COBOL for AIX library components 194

Chapter 12. Compiling, linking, and running OO applications 195
Compiling OO applications. 195
Preparing OO applications 196
Example: compiling and linking a COBOL class definition. 197
Running OO applications 197
Running OO applications that start with a main method 198
Running OO applications that start with a COBOL program 198

Chapter 13. Compiler options 199
ADATA 201
ARITH 201
BINARY 202
CALLINT 202
CHAR. 203
COLLSEQ 205
COMPILE 206
CURRENCY. 207
DATEPROC 208
DIAGTRUNC 209
DYNAM 210
ENTRYINT 210
EXIT 211
Character string formats. 212
User-exit work area 212
Parameter list for exit modules 212
Using INEXIT 213
Using LIBEXIT 214
Using PRTEXIT. 215
Using ADEXIT 215
FLAG 216
FLAGSTD 217
FLOAT 218
LIB 219
LINECOUNT 220
LIST 220
LSTFILE 221
MAP 221
MAXMEM 222
NCOLLSEQ 223
NSYMBOL 223
NUMBER 224
OPTIMIZE 225
PGMNAME 226
PGMNAME(UPPER) 226
PGMNAME(MIXED) 227
PROFILE 227
QUOTE/APOST 227
SEPOBJ 228
Batch compilation 228
SEQUENCE 229
SIZE 230
SOSI 230
SOURCE 231
SPACE 232
SPILL 232
SQL 233
SSRANGE 233
TERMINAL 234
TEST 234
THREAD. 235
TRUNC 236
TRUNC example 1 237
TRUNC example 2 238
VBREF 238
WSCLEAR 239
XREF 239

YEARWINDOW 240
ZWB 241

Chapter 14. Compiler-directing statements 243

Chapter 15. Run-time options 249
CHECK 249
DEBUG 250
ERRCOUNT 250
FILESYS 250
TRAP 251
UPSI 252

Chapter 16. Debugging 253
Debugging with source language 253
Tracing program logic 253
Finding and handling input-output errors . . . 254
Validating data 255
Finding uninitialized data 255
Generating information about procedures . . . 255
Debugging using compiler options 257
Finding coding errors 258
Finding line sequence problems 258
Checking for valid ranges 258
Selecting the level of error to be diagnosed . . 259
Finding program entity definitions and references 261
Listing data items 262
Using the debugger 262
Getting listings 263
Example: short listing 264
Example: SOURCE and NUMBER output . . . 266
Example: MAP output 266
Example: XREF output - data-name cross-references 270
Example: VBREF compiler output 272
Debugging with messages that have offset information 272
Debugging user exits 273
Debugging assembler routines 273

Part 3. Accessing databases . . . 275

Chapter 17. Programming for a DB2 environment 277
DB2 coprocessor 277
Coding SQL statements 278
Using SQL INCLUDE with the DB2 coprocessor 278
Using binary items 278
Using national items 279
Determining the success of SQL statements . . 279
Starting DB2 before compiling 279
Compiling with the SQL option 279
Separating SQL suboptions 280
Using package and bind file-names 280
Ignored options 280

Chapter 18. Developing COBOL programs for CICS 281
Coding COBOL applications to run under CICS 281
Coding for ASCII-EBCDIC differences 282
Getting the system date under CICS. 282
Making dynamic calls under CICS 283
Accessing SFS data 284
Calling between COBOL and C/C++ under CICS 284
Compiling and running CICS programs 285
Selecting run-time options 285
Debugging CICS programs 285

Chapter 19. Open Database Connectivity (ODBC) 287
Comparison of ODBC and embedded SQL . . . 287
Background 288
Installing and configuring software for ODBC . . 288
Coding ODBC calls from COBOL: overview . . . 288
Using data types appropriate for ODBC . . . 288
Passing pointers as arguments in ODBC calls 289
Accessing function return values in ODBC calls 291
Testing bits in ODBC calls 291
Using COBOL copybooks for ODBC APIs 292
Example: sample program using ODBC copybooks 293
Example: copybook for ODBC procedures . . . 294
Example: copybook for ODBC data definitions 297
ODBC names truncated or abbreviated for COBOL 297
Compiling and linking programs that make ODBC calls 299

Part 4. Using XML and COBOL together 301

Chapter 20. Processing XML input 303
XML parser in COBOL 303
Accessing XML documents 304
Parsing XML documents 305
Processing XML events 306
Writing procedures to process XML 312
Understanding the encoding of XML documents 318
Coded character sets for XML documents . . . 319
Specifying the code page 320
Handling errors in parsing XML documents . . . 321
Unhandled exceptions 323
Handling exceptions 323
Terminating XML parsing 323
Code-page conflict exception 324

Chapter 21. Producing XML output 327
Generating XML output 327
Example: generating XML 329
Enhancing XML output 332
Example: enhancing XML output 333
Controlling the encoding of generated XML output 336
Handling errors in generating XML output . . . 336

Part 5. Developing object-oriented programs 339

Chapter 22. Writing object-oriented programs 341
Example: accounts 342
Subclasses 343
Defining a class 344
CLASS-ID paragraph for defining a class . . . 346
REPOSITORY paragraph for defining a class 346
WORKING-STORAGE SECTION for defining class instance data 348
Example: defining a class 349
Defining a class instance method 349
METHOD-ID paragraph for defining a class instance method 350
INPUT-OUTPUT SECTION for defining a class instance method 351
DATA DIVISION for defining a class instance method 351
PROCEDURE DIVISION for defining a class instance method 352
Overriding an instance method 353
Overloading an instance method 354
Coding attribute (get and set) methods 355
Example: defining a method 356
Defining a client 357
REPOSITORY paragraph for defining a client 358
DATA DIVISION for defining a client 359
Comparing and setting object references . . . 360
Invoking methods (INVOKE) 361
Creating and initializing instances of classes . . 364
Freeing instances of classes 365
Example: defining a client 365
Defining a subclass 366
CLASS-ID paragraph for defining a subclass 367
REPOSITORY paragraph for defining a subclass 367
WORKING-STORAGE SECTION for defining subclass instance data 368
Defining a subclass instance method 368
Example: defining a subclass (with methods) 369
Defining a factory section 370
WORKING-STORAGE SECTION for defining factory data 371
Defining a factory method 371
Example: defining a factory (with methods) . . 374
Wrapping procedure-oriented COBOL programs 379
Structuring OO applications 379
Examples: COBOL applications that you can run using the java command 380

Chapter 23. Communicating with Java methods 383
Accessing JNI services 383
Handling Java exceptions 385
Managing local and global references 386
Java access controls 387
Sharing data with Java 387
Coding interoperable data types in COBOL and Java 388
Declaring arrays and strings for Java 389
Manipulating Java arrays 390
Manipulating Java strings 392

Part 6. Working with more complex applications 395

Chapter 24. Porting applications between platforms 397
Getting mainframe applications to compile . . . 397
Choosing the right compiler options. 397
Allowing for language features of mainframe COBOL 397
Using the COPY statement to help port programs 398
Getting mainframe applications to run: overview 399
Fixing differences caused by data representations 399
Fixing environment differences that affect portability 401
Fixing differences caused by language elements 402
Writing code to run on the mainframe 402
Language features not supported by mainframe compilers. 402
Compiler options not supported by the mainframe compilers 402
Names not supported on other platforms . . . 403
Differences with THREAD 403
Writing applications that are portable between the AIX and Windows-based workstations 403

Chapter 25. Using subprograms . . . 405
Main programs, subprograms, and calls 405
Ending and reentering main programs or subprograms 406
Calling nested COBOL programs 406
Nested programs 407
Example: structure of nested programs 408
Scope of names. 409
Calling nonnested COBOL programs 410
CALL identifier and CALL literal. 410
Calling between COBOL and C/C++ programs . . 411
Initializing environments 411
Passing data 411
Collapsing stack frames and terminating run units or processes 411
Handling exceptions 412
COBOL and C/C++ data types 412
Example: COBOL program calling C/C++ functions 413
Example: C/C++ programs that are called by and call COBOL programs 414
Example: COBOL program called by a C/C++ program 415
Example: results of compiling and running examples 415
Making recursive calls 416

Passing return codes 416
RETURN-CODE values with nonthreaded support 416
RETURN-CODE values with threaded support 416

Chapter 26. Sharing data 417
Passing data 417
Describing arguments in the calling program 418
Describing parameters in the called program 418
Testing for OMITTED arguments 419
Coding the LINKAGE SECTION 419
Coding the PROCEDURE DIVISION for passing arguments 420
Grouping data to be passed 420
Handling null-terminated strings 421
Using pointers to process a chained list . . . 421
Using procedure and function pointers 424
Passing return code information 425
Understanding the RETURN-CODE special register 425
Using PROCEDURE DIVISION RETURNING 425
Specifying CALL . . . RETURNING 425
Sharing data by using the EXTERNAL clause. . . 425
Sharing files between programs (external files) . . 426
Example: using external files 426
Using command-line arguments 429
Example: command-line arguments without -host option 430
Example: command-line arguments with -host option 430

Chapter 27. Building shared libraries 433
Static linking and shared libraries 433
How the linker resolves references to shared libraries 434
Example: creating a sample shared library. . . 434
Example: creating a makefile for the sample shared library 437
Example: calling shared libraries using CALL identifier 437
Example: COBOL program calling COBOL and C shared libraries 439

Chapter 28. Preparing COBOL programs for multithreading 441
Multithreading 441
Working with language elements with multithreading 442
Working with elements that have run-unit scope 443
Working with elements that have program invocation instance scope 443
Scope of COBOL language elements with multithreading 443
Choosing THREAD to support multithreading . . 444
Transferring control with multithreading 445
Using cancel with threaded programs 445
Ending a program 445
Preinitializing the COBOL environment . . . 445
Handling COBOL limitations with multithreading 446
Example: using COBOL in a multithreaded environment. 446
Source code for thrcob.c 446
Source code for subd.cbl. 447
Source code for sube.cbl 448

Chapter 29. Preinitializing the COBOL run-time environment 449
Initializing persistent COBOL environment . . . 449
Terminating preinitialized COBOL environment 450
Example: preinitializing the COBOL environment 451

Chapter 30. Processing two-digit-year dates 455
Millennium language extensions (MLE) 456
Principles and objectives of these extensions . . 456
Resolving date-related logic problems 457
Using a century window 458
Using internal bridging 459
Moving to full field expansion. 460
Using year-first, year-only, and year-last date fields 462
Compatible dates 463
Example: comparing year-first date fields . . . 464
Using other date formats 464
Example: isolating the year 464
Manipulating literals as dates 465
Assumed century window 466
Treatment of nondates 467
Setting triggers and limits 467
Example: using limits 468
Using sign conditions 469
Sorting and merging by date 469
Example: sorting by date and time 470
Performing arithmetic on date fields. 471
Allowing for overflow from windowed date fields 471
Specifying the order of evaluation 472
Controlling date processing explicitly 473
Using DATEVAL 473
Using UNDATE 473
Example: DATEVAL 474
Example: UNDATE 474
Analyzing and avoiding date-related diagnostic messages 474
Avoiding problems in processing dates 476
Avoiding problems with packed-decimal fields 476
Moving from expanded to windowed date fields 476

Part 7. Improving performance and productivity 479

Chapter 31. Tuning your program . . . 481
Using an optimal programming style 481
Using structured programming 482
Factoring expressions. 482
Using symbolic constants 482
Grouping constant computations 482
Grouping duplicate computations 483
Choosing efficient data types 483

Computational data items 483
Consistent data types. 484
Arithmetic expressions 484
Exponentiations 484
Handling tables efficiently 485
Optimization of table references 486
Optimizing your code 488
Optimization 488
Choosing compiler features to enhance performance. 489
Performance-related compiler options 490
Evaluating performance 491

Chapter 32. Simplifying coding 493
Eliminating repetitive coding 493
Example: using the COPY statement. 494
Manipulating dates and times 495
Getting feedback 495
Handling conditions 495
Example: manipulating dates 496
Example: formatting dates for output 496
Feedback token. 497
Picture character terms and strings 498
Example: date-and-time picture strings 500
Century window 501

Part 8. Appendixes 503

Appendix A. Summary of differences with host COBOL. 505
Compiler options 505
Data representation 505
External decimal data 505
Packed-decimal data 505
Floating-point data 506
National data 506
EBCDIC and ASCII data. 506
Code-page determination for data conversion 506
DBCS character strings 506
Environment variables 507
File specification 507
Interlanguage communication (ILC) 507
Input and output 508
Run-time options 508
Source code line size 508
Language elements 508

Appendix B. zSeries host data type considerations 511
CICS access 511
Date and time callable services 511
Floating-point overflow exceptions 511
DB2 511
Object-oriented syntax for Java interoperability . . 511
Distributed Computing Environment applications 512
File data 512
SORT 512

Appendix C. Intermediate results and arithmetic precision 513
Terminology used for intermediate results. . . . 514
Example: calculation of intermediate results . . . 515
Fixed-point data and intermediate results 515
Addition, subtraction, multiplication, and division 515
Exponentiation 516
Example: exponentiation in fixed-point arithmetic 517
Truncated intermediate results. 518
Binary data and intermediate results 518
Intrinsic functions evaluated in fixed-point arithmetic 518
Integer functions 518
Mixed functions 519
Floating-point data and intermediate results . . . 520
Exponentiations evaluated in floating-point arithmetic 521
Intrinsic functions evaluated in floating-point arithmetic 521
Arithmetic expressions in nonarithmetic statements 521

Appendix D. Complex OCCURS DEPENDING ON 523
Example: complex ODO. 523
How length is calculated 524
Setting values of ODO objects 524
Effects of change in ODO object value 524
Preventing index errors when changing ODO object value 525
Preventing overlay when adding elements to a variable table 525

Appendix E. Date and time callable services. 529
CEECBLDY—convert date to COBOL integer format. 531
CEEDATE—convert Lilian date to character format 534
CEEDATM—convert seconds to character timestamp 538
CEEDAYS—convert date to Lilian format 542
CEEDYWK—calculate day of week from Lilian date 545
CEEGMT—get current Greenwich Mean Time . . 547
CEEGMTO—get offset from Greenwich Mean Time to local time. 549
CEEISEC—convert integers to seconds 551
CEELOCT—get current local date or time 554
CEEQCEN—query the century window 556
CEESCEN—set the century window. 557
CEESECI—convert seconds to integers 559
CEESECS—convert timestamp to seconds 562
CEEUTC—get coordinated universal time 566
IGZEDT4—get current date. 566

Appendix F. XML reference material 569
XML PARSE exceptions that allow continuation 569

XML PARSE exceptions that do not allow continuation . . . 573
XML conformance . . . 575
XML GENERATE exceptions . . . 578

Appendix G. JNI.cpy . . . 579

Appendix H. COBOL SYSADATA file contents . . . 585
Existing compiler options affecting the SYSADATA file . . . 585
SYSADATA record types . . . 586
Example: SYSADATA . . . 587
SYSADATA record descriptions . . . 588
Common header section . . . 589
Job identification record - X'0000' . . . 590
ADATA identification record - X'0001' . . . 591
Compilation unit start/end record - X'0002' . . . 592
Options record - X'0010' . . . 592
External symbol record - X'0020' . . . 602
Parse tree record - X'0024' . . . 603
Token record - X'0030' . . . 617
Source error record - X'0032' . . . 617
Source record - X'0038' . . . 618
COPY REPLACING record - X'0039' . . . 618
Symbol record - X'0042' . . . 619
Symbol cross-reference record - X'0044' . . . 630
Nested program record - X'0046' . . . 631
Library record - X'0060' . . . 632
Statistics record - X'0090' . . . 633
EVENTS record - X'0120' . . . 633

Appendix I. Run-time messages . . . 635

Notices . . . 681
Trademarks . . . 682

Glossary . . . 683

List of resources . . . 707
COBOL for AIX . . . 707
Related publications . . . 707

Index . . . 709

Tables

1. **FILE SECTION entries** 12
2. **Assignment to data items in a program** 23
3. **Ranges in value of COMP-5 data items** 35
4. **Internal representation of binary numeric items** 37
5. **Internal representation of native numeric items** 37
6. **Internal representation of numeric items when CHAR(EBCDIC) and FLOAT(HEX) are in effect** 38
7. **Order of evaluation of arithmetic operators** 42
8. **Numeric intrinsic functions** 43
9. **COBOL statements and national data** . . . 95
10. **Intrinsic functions and national data** 96
11. **Encoding and size of alphanumeric and national data** 99
12. **DBCS classes and categories** 104
13. **Intrinsic functions that are sensitive to collating sequence** 111
14. **Supported locales and code pages** 113
15. **STL file system return codes** 124
16. **STL file system adapter open routine return codes** 125
17. **File organization and access mode** 132
18. **Valid COBOL statements for sequential files** 139
19. **Valid COBOL statements for line-sequential files** 140
20. **Valid COBOL statements for indexed and relative files** 140
21. **Statements used when writing records to a file** 142
22. **PROCEDURE DIVISION statements used to update files** 144
23. **Sort and merge error numbers** 155
24. **TZ environment parameter variables** 177
25. **Output from the cob2 command** 180
26. **Examples of compiler-option syntax in a shell script** 180
27. **Stanza attributes** 183
28. **Severity codes for compiler error messages** 185
29. **Common linker options** 190
30. **Default file-names assumed by the linker** 193
31. **Commands for compiling and linking a class definition** 196
32. **java command options for customizing the JVM** 198
33. **Compiler options** 199
34. **Effect of comparand data type and collating sequence on comparisons** 206
35. **Parameter list for exit modules** 212
36. **Run-time options** 249
37. **Severity levels of compiler messages** 259
38. **Using compiler options to get listings** 263
39. **Terms and symbols used in MAP output** 268
40. **ODBC C types and corresponding COBOL declarations** 288
41. **ODBC copybooks** 292
42. **ODBC names truncated or abbreviated for COBOL** 297
43. **Special registers used by the XML parser** 312
44. **Aliases for XML encoding declarations** 321
45. **Encoding of generated XML output** 336
46. **Structure of class definitions** 344
47. **Structure of instance method definitions** 349
48. **Structure of COBOL clients** 358
49. **Structure of factory definitions** 370
50. **Structure of factory method definitions** 372
51. **JNI services for local and global references** 387
52. **Interoperable data types in COBOL and Java** 388
53. **Interoperable arrays and strings in COBOL and Java** 389
54. **Noninteroperable array types in COBOL and Java** 390
55. **JNI array services** 390
56. **Services that convert between jstring references and national data** 393
57. **Services that convert between jstring references and UTF-8 data** 393
58. **Language features that differ from mainframe COBOL** 397
59. **ASCII contrasted with EBCDIC** 399
60. **IEEE contrasted with hexadecimal** 400
61. **COBOL and C/C++ data types** 412
62. **Methods for passing data in the CALL statement** 417
63. **Scope of COBOL language elements with multithreading** 443
64. **Advantages and disadvantages of Year 2000 solutions** 458
65. **Performance-related compiler options** 490
66. **Performance-tuning worksheet** 492
67. **Picture character terms and strings** 498
68. **Japanese Eras** 500
69. **Examples of date-and-time picture strings** 500
70. **Language differences between Enterprise COBOL for z/OS and COBOL for AIX** . . . 508
71. **Maximum floating-point values** 511
72. **Date and time callable services** 529
73. **Date and time intrinsic functions** 530
74. **CEECBLDY symbolic conditions** 532
75. **CEEDATE symbolic conditions** 535
76. **CEEDATM symbolic conditions** 539
77. **CEEDAYS symbolic conditions** 543
78. **CEEDYWK symbolic conditions** 545
79. **CEEGMT symbolic conditions** 548
80. **CEEGMTO symbolic conditions** 550
81. **CEEISEC symbolic conditions** 552
82. **CEELOCT symbolic conditions** 555
83. **CEEQCEN symbolic conditions** 556
84. **CEESCEN symbolic conditions** 558
85. **CEESECI symbolic conditions** 560
86. **CEESECS symbolic conditions** 563

© Copyright IBM Corp. 1995, 2004

87. **XML PARSE exceptions that allow continuation** 569
88. **XML PARSE exceptions that do not allow continuation** 573
89. **XML GENERATE exceptions** 578
90. **SYSADATA record types** 586
91. **SYSADATA common header section** 589
92. **SYSADATA job identification record** 591
93. **ADATA identification record** 592
94. **SYSADATA compilation unit start/end record** 592
95. **SYSADATA options record** 592
96. **SYSADATA external symbol record** 602
97. **SYSADATA parse tree record** 603
98. **SYSADATA token record** 617
99. **SYSADATA source error record** 617
100. **SYSADATA source record** 618
101. **SYSADATA COPY REPLACING record** 618
102. **SYSADATA symbol record** 619
103. **SYSADATA symbol cross-reference record** 630
104. **SYSADATA nested program record** 631
105. **SYSADATA library record** 632
106. **SYSADATA statistics record** 633
107. **SYSADATA EVENTS record** 633
108. **Run-time messages** 635

Preface

About this document

Welcome to IBM COBOL for AIX, IBM's COBOL compiler and run time for AIX!

There are some differences between host and workstation COBOL. For details on language and system differences between COBOL for AIX and Enterprise COBOL for z/OS(R), see Appendix A, "Summary of differences with host COBOL," on page 505.

Accessibility of this document

The XHTML format of this document 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 or 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, compile, link-edit, and run your IBM COBOL for AIX 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 COBOL to meet your programming objectives and not on the definition of the COBOL language. For complete information on COBOL syntax, see *COBOL for AIX Language Reference*.

This document also assumes familiarity with AIX. For information on AIX, see your operating system documentation.

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 table below.

Term used	Long form
CICS(R)	IBM TXSeries(R)
COBOL for AIX	IBM COBOL for AIX
DB2(R)	Database 2(TM)
RSD	Record sequential delimited file system
STL	Standard language file system

The e-server zSeries(R) and the S/390(R) hardware are referred to collectively throughout this document as "zSeries."

In addition to these abbreviated terms, the term "COBOL 85 Standard" is used in this document to refer to the combination of the following standards:

- ISO 1989:1985, Programming languages - COBOL

© Copyright IBM Corp. 1995, 2004

- 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 they appear and are listed in the glossary at the back of this document.

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.

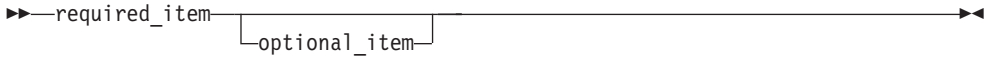
  The **—->** symbol indicates that the syntax diagram is continued on the next line.

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

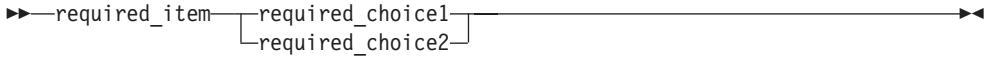
  The **—-><** symbol indicates the end of a syntax diagram.

  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).

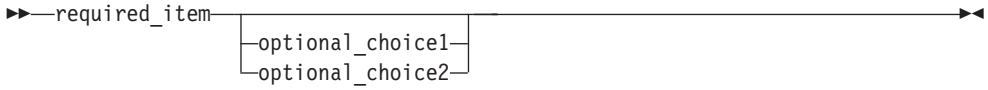
- Optional items appear below the main path.



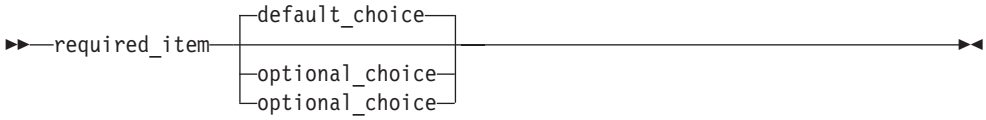
- If you can choose from two or more items, they appear vertically, in a stack. If you must choose one of the items, one item of the stack appears on the main path.



  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 all lowercase letters (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.

Related information

The information in this *Programming Guide* is available online in the IBM AIX Compiler Information Center at publib.boulder.ibm.com/infocenter/comphelp/index.jsp. The Information Center also has all the COBOL language reference information and the information for using the debugger. You might also want to check the list of resources online or in this document.

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 COBOL for AIX documentation, contact us in one of these ways:

- Fill out the Readers' Comments Form at the back of this document, and return it by mail or give it to an IBM representative. If there is no form at the back of this document, address your comments to:

IBM Corporation
J87/D325
555 Bailey Avenue
San Jose, CA 95141-1003
USA

- Use the Online Readers' Comments 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 COBOL for AIX, and, if applicable, the specific location (for example, the 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 6
Describing the computing environment 7
Example: FILE-CONTROL paragraph 7
Specifying the collating sequence 8
Example: specifying the collating sequence . . 8
Defining symbolic characters 9
Defining a user-defined class 10
Identifying files to the operating system 10
Varying the input or output file at run time 10
Describing the data 11
Using data in input and output operations . . . 11
FILE SECTION entries. 12
Comparison of WORKING-STORAGE and LOCAL-STORAGE 13
Example: storage sections. 13
Using data from another program 14
Sharing data in separately compiled programs 15
Sharing data in nested programs 15
Sharing data in recursive or multithreaded programs 15
Processing the data 15
How logic is divided in the PROCEDURE DIVISION 16
Imperative statements 17
Conditional statements 17
Compiler-directing statements 18
Scope terminators 18
Declaratives 20

Chapter 2. Using data 21
Using variables, structures, literals, and constants . 21
Variables 21
Data structure: data items and group items. . . 21
Literals 22
Constants 22
Figurative constants 23
Assigning values to data items 23
Examples: initializing data items 24
Initializing a structure (INITIALIZE) 25
Assigning values to elementary or group data items (MOVE) 26
Assigning arithmetic results (MOVE or COMPUTE) 26
Assigning input from a screen or file (ACCEPT) 27
Displaying values on a screen or in a file (DISPLAY) 28
Using intrinsic functions (built-in functions) . . . 28
Types of intrinsic functions 29
Nesting functions 29
Using tables (arrays) and pointers 30

Chapter 3. Working with numbers and arithmetic 31
Defining numeric data. 31
Displaying numeric data 32
Controlling how numeric data is stored 33
Formats for numeric data. 34
External decimal (DISPLAY) items. 34
External floating-point (DISPLAY) items 34
Binary (COMP) items 35
Native binary (COMP-5) items 35
Packed-decimal (COMP-3) items 36
Floating-point (COMP-1 and COMP-2) items . . 36
Examples: numeric data and internal representation 36
Data format conversions 38
Conversions and precision 39
Conversions that preserve precision 39
Conversions that result in rounding 39
Sign representation and processing 39
Checking for incompatible data (numeric class test) 40
Performing arithmetic 41
COMPUTE and other arithmetic statements . . 41
Arithmetic expressions 41
Numeric intrinsic functions 42
Nesting functions and arithmetic expressions 43
ALL subscripting and special registers . . . 43
Examples: numeric intrinsic functions 43
General number handling 43
Date and time 44
Finance. 44
Mathematics 45
Statistics 45
Fixed-point versus floating-point arithmetic . . . 45
Floating-point evaluations 46
Fixed-point evaluations 46
Arithmetic comparisons (relation conditions) . . 46
Examples: fixed-point and floating-point evaluations 47
Using currency signs 47
Example: multiple currency signs 48

Chapter 4. Handling tables. 51
Defining a table (OCCURS) 51
Nesting tables 52
Subscripting 52
Indexing 53
Referring to an item in a table 53
Subscripting 54
Indexing 55
Putting values into a table 56
Loading a table dynamically. 56
Initializing a table (INITIALIZE) 56
Assigning values when you define a table (VALUE) 57
Initializing each table item individually . . . 57
Initializing a table at the 01 level 57
Initializing all occurrences of a table element 57

© Copyright IBM Corp. 1995, 2004

Example: PERFORM and subscripting 58
Example: PERFORM and indexing. 59
Creating variable-length tables (DEPENDING ON) 60
Loading a variable-length table 61
Assigning values to a variable-length table . . . 62
Searching a table 62
Doing a serial search (SEARCH) 63
Example: serial search 63
Doing a binary search (SEARCH ALL) 64
Example: binary search 64
Processing table items using intrinsic functions . . 65
Example: intrinsic functions 65

Chapter 5. Selecting and repeating program actions 67
Selecting program actions 67
Coding a choice of actions 67
Using nested IF statements 68
Using the EVALUATE statement 69
Coding conditional expressions. 71
Switches and flags 72
Defining switches and flags 72
Example: switches 73
Example: flags 73
Resetting switches and flags. 73
Example: set switch on 74
Example: set switch off 74
Repeating program actions 75
Choosing inline or out-of-line PERFORM . . . 75
Example: inline PERFORM statement. . . . 76
Coding a loop 76
Coding a loop through a table 77
Executing multiple paragraphs or sections . . . 77

Chapter 6. Handling strings 79
Joining data items (STRING) 79
Example: STRING statement. 79
STRING program results 80
Splitting data items (UNSTRING) 81
Example: UNSTRING statement 81
UNSTRING program results. 82
Manipulating null-terminated strings. 83
Example: null-terminated strings 84
Referring to substrings of data items 84
Reference modifiers. 85
Example: arithmetic expressions as reference modifiers 86
Example: intrinsic functions as reference modifiers 87
Tallying and replacing data items (INSPECT) . . . 87
Examples: INSPECT statement 87
Converting data items (intrinsic functions) 88
Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE). 89
Converting to reverse order (REVERSE) 89
Converting to numbers (NUMVAL, NUMVAL-C) 89
Converting from one code page to another . . . 90
Evaluating data items (intrinsic functions) 91
Evaluating single characters for collating sequence 91
Finding the largest or smallest data item . . . 91
MAX and MIN 91
ORD-MAX and ORD-MIN 92
Returning variable-length results with alphanumeric functions 92
Finding the length of data items 93
Finding the date of compilation 94

Chapter 7. Enabling programs for international environments 95
Processing character data in an international environment 95
Unicode and encoding of language characters . . 97
Using national data (Unicode) in COBOL . . . 98
National data items. 98
National literals 98
National characters as figurative constants . . 99
Storage of national data 99
Converting national data 100
Converting alphanumeric and integer to national data (MOVE) 100
Converting alphanumeric to national data (NATIONAL-OF) 100
Converting national to alphanumeric data (DISPLAY-OF) 100
Example: converting national data 101
Processing UTF-8 data 101
Processing Chinese GB 18030 data 102
Comparing national data items 102
Comparing national operands 103
Comparing national and numeric operands 103
Comparing national and alphabetic or alphanumeric operands 103
Comparing national and group operands . . 104
Coding for use of DBCS support 104
Declaring DBCS data. 104
Specifying DBCS literals. 105
Using ALL 105
Comparing literals. 105
Testing for valid DBCS characters 106
Processing alphanumeric data items that contain DBCS data 106
Setting the locale 106
Code page 107
Messages. 107
Collating sequence 107
How locale is determined 108
Environment variables 109
Locale value format 109
System settings. 110
Controlling the collating sequence 110
Alphanumeric collating sequence. 110
DBCS collating sequence. 111
National collating sequence. 111
Intrinsic functions that are sensitive to collating sequence 111
Locales and code pages supported 112
Accessing the locale and code-page values in effect 115
Example: get and convert a code-page ID . . 116

Chapter 8. Processing files 119

Identifying files 119
Identifying VSAM files 120
Identifying Encina SFS files 120
Identifying STL files 121
Identifying RSD files 121
File system 121
VSAM file system 122
SFS file system 122
STL file system 123
STL file system return codes 124
RSD file system 125
Enabling COBOL applications to access SFS files 126
Example: accessing SFS files 127
COBOL file descriptions 127
sfsadmin commands 128
export commands 129
Improving SFS performance 129
Enabling client-side caching 129
Reducing the frequency of saving changes 130
Protecting against errors when opening files . . . 131
Specifying a file organization and access mode . . 131
File organization and access mode 131
Sequential file organization 132
Line-sequential file organization 132
Indexed file organization 133
Relative file organization 133
Sequential access 133
Random access 134
Dynamic access 134
File input-output limitations 134
Setting up a field for file status 135
Describing the structure of a file in detail 135
Coding input and output statements for files . . . 136
Example: COBOL coding for files 136
File position indicator 138
Opening a file 138
Valid COBOL statements for sequential files 139
Valid COBOL statements for line-sequential files 139
Valid COBOL statements for indexed and relative files 140
Reading records from a file 141
Statements used when writing records to a file 142
Adding records to a file 142
Adding records sequentially 142
Adding records randomly or dynamically 143
Replacing records in a file 143
Deleting records from a file 143
PROCEDURE DIVISION statements used to update files 144

Chapter 9. Sorting and merging files 147
Sort and merge process 147
Describing the sort or merge file 148
Describing the input to sorting or merging . . . 148
Example: describing sort and input files for SORT 149
Coding the input procedure 150
Describing the output from sorting or merging . . 150
Coding the output procedure 151
Restrictions on input and output procedures . . . 151
Requesting the sort or merge 152
Setting sort or merge criteria 153
Choosing alternate collating sequences 153
Example: sorting with input and output procedures 154
Determining whether the sort or merge was successful 154
Sort and merge error numbers 155
Stopping a sort or merge operation prematurely 156

Chapter 10. Handling errors 157
Handling errors in joining and splitting strings . . 157
Handling errors in arithmetic operations 158
Example: checking for division by zero 158
Handling errors in input and output operations 159
Using the end-of-file condition (AT END) . . . 160
Coding ERROR declaratives 161
Using file status keys 161
Example: file status key 162
Using file system return codes 163
STL file system 163
VSAM file system 163
Example: checking file system return codes 163
Coding INVALID KEY phrases 164
INVALID KEY and ERROR declaratives . . 165
NOT INVALID KEY 165
Example: FILE STATUS and INVALID KEY 165
Handling errors when calling programs 165

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 11
"Processing the data" on page 15
"Defining a class" on page 344
"Defining a class instance method" on page 349
"Structuring OO applications" on page 379

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.  05/07/2004.
Date-Compiled. 05/14/2004.
```

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.

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 6
"Identifying a program as recursive" on page 6
"Marking a program as callable by containing programs" on page 6
"Setting a program to an initial state" on page 6

© Copyright IBM Corp. 1995, 2004

RELATED REFERENCES
Compiler limits (*COBOL for AIX Language Reference*)
Conventions for program names (*COBOL for AIX 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.

RELATED TASKS
"Sharing data in recursive or multithreaded programs" on page 15
"Making recursive calls" on page 416

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 407

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. Example:

```
PP 5724-H44 IBM COBOL for AIX 2.0.0   Date 05/14/2004 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 (*COBOL for AIX 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 corresponding system file name, directly or indirectly.
- Optionally identify the file system (for example, VSAM or STL file system) associated with the file. You can also do this at run time.
- Provide information about how the file is accessed.

"Example: FILE-CONTROL paragraph"

RELATED TASKS

"Specifying the collating sequence" on page 8
"Defining symbolic characters" on page 9
"Defining a user-defined class" on page 10
"Identifying files to the operating system" on page 10

RELATED REFERENCES

Sections and paragraphs (*COBOL for AIX Language Reference*)

Example: FILE-CONTROL paragraph

The following example shows how the FILE-CONTROL paragraph associates each file in the COBOL program with a physical file known to your file system. This example shows a FILE-CONTROL paragraph for a VSAM indexed file.

```
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-STL-STATUS.
```

(1) The SELECT clause chooses a file in the COBOL program to be associated with a corresponding system file.

(2) The ASSIGN clause associates the program's name for the file with the name of the file as known to the system. COMMUTER may be the system file name or the name of the environment variable whose value (at run time) is used as the system file name with optional directory and path names.

(3) Use the ORGANIZATION clause to describe the file's organization. If omitted, the default is ORGANIZATION IS SEQUENTIAL.

(4) Use the ACCESS MODE clause to define the manner in which the records in the file will be made available for processing—sequential, random, or dynamic. If you omit this clause, ACCESS IS SEQUENTIAL is assumed.

(5) You might have additional statements in the FILE-CONTROL paragraph depending on the type of file and file system you use.

RELATED TASKS
"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"

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 collating sequence specified by the locale setting. The locale setting refers to the national language locale name in effect at compile time. It is usually set at installation.
- 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 ASCII sequence that you define in the SPECIAL-NAMES paragraph

You can also specify a collating sequence of your own definition.

Restriction: If the code page is DBCS, Extended Unix(R) Code (EUC), or UTF-8, you cannot use the ALPHABET-NAME clause.

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

RELATED TASKS
"Choosing alternate collating sequences" on page 153
"Controlling the collating sequence" on page 110
"Comparing national data items" on page 102

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 ASCII 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.


   Object-Computer.

      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 plus character (X'2B' in the ASCII alphabet), code:

```
SYMBOLIC CHARACTERS PLUS IS 44
```

You cannot use the SYMBOLIC CHARACTERS clause when the code page indicated by the locale is a multibyte-character code page.

RELATED TASKS

"Setting the locale" on page 106

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.

You cannot use the CLASS clause when the code page indicated by the locale is a multibyte-character code page.

Identifying files to the operating system

The ASSIGN clause associates the name of a file within a program with the name of the file as it is known to the operating system.

You can use either an environment variable, a system file-name, a literal, or a data-name in the ASSIGN clause. If you specify an environment variable as the assignment-name, the environment variable is evaluated at run time and the value is used as the system file-name with optional directory and path names.

If you plan to use a file system other than the default file system, you need to select the file system explicitly, for example, by specifying the file-system identifier before the system file-name. For example, if the file MYFILE is an STL file, and you use F1 as the name of the file in your program, the ASSIGN clause would be:

```
SELECT F1 ASSIGN TO STL-MYFILE
```

If MYFILE is not an environment variable, then the code above treats MYFILE as a system file-name. If MYFILE is an environment variable, then the value of the environment variable is used. For example, if MYFILE is set as MYFILE=VSAM-YOURFILE, the system file-name in the ASSIGN clause becomes YOURFILE at run time, and the file is treated as a VSAM file, overriding the file-system ID used in the ASSIGN clause.

Note though that if you enclose an assignment-name in quotation marks or single quotation marks (for example, "STL-MYFILE"), the value of the environment variable, if any, is ignored. The assignment-name is treated as a literal.

RELATED TASKS
"Varying the input or output file at run time"
"Identifying files" on page 119

RELATED REFERENCES
"FILESYS" on page 250
ASSIGN clause (*COBOL for AIX Language Reference*)

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 in your 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 *assignment-name* in your export command.

Environment variable values in effect at the time of the OPEN statement are used for associating COBOL file-names to the system file-names (including any path specifications).

"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 MASTERA
```

Suppose you want the program to access either the checking or savings file using the same MASTER file. To do so, set the MASTERA environment variable (before the program runs) by using one of the following two statements as appropriate, assuming the checking and savings files are in the /accounts directory:

```
export MASTERA=/accounts/checking
export MASTERA=/accounts/savings
```

You can use the same program to access either the checking or savings file by way of the COBOL MASTER file without having to change or recompile the source.

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 COBOL for AIX compiler limits the maximum size of DATA DIVISION elements.

RELATED CONCEPTS
"Comparison of WORKING-STORAGE and LOCAL-STORAGE" on page 13

RELATED TASKS
"Using data in input and output operations"
"Using data from another program" on page 14

RELATED REFERENCES
Compiler limits (*COBOL for AIX Language Reference*)

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 records and their fields in the file. The record-name established is the object of WRITE and REWRITE statements.

Programs in the same run unit can refer to the same COBOL file-names.

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.

You can share physical files without using external or global file definitions in COBOL source programs.

For example, you can specify that an application has two COBOL file-names, but these COBOL files are associated with one system file:

```
SELECT F1 ASSIGN TO MYFILE.
SELECT F2 ASSIGN TO MYFILE.
```

RELATED CONCEPTS
"Nested programs" on page 407

RELATED TASKS
"Sharing files between programs (external files)" on page 426

RELATED REFERENCES
"FILE SECTION entries"

FILE SECTION entries

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

Table 1. **FILE SECTION entries**

Clause	To define
FD	The *file-name* to be referred to in PROCEDURE DIVISION input-output statements (OPEN, CLOSE, READ, START, and DELETE). Must match *file-name* in the SELECT clause. *file-name* is associated with the system file through the *assignment-name*.
RECORD CONTAINS *n*	Size of logical records (fixed length)
RECORD IS VARYING	Size of logical records (variable length)
RECORD CONTAINS *n* TO *m*	Size of logical records (variable length)
VALUE OF	An item in the label records associated with file. Comments only.
DATA RECORDS	Names of records associated with file. Comments only.
RECORDING MODE	Record type for sequential files

Comparison of WORKING-STORAGE and LOCAL-STORAGE

When a program is invoked, the WORKING-STORAGE associated with the program is allocated. 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.

"Example: storage sections"

RELATED TASKS

"WORKING-STORAGE SECTION for defining class instance data" on page 348
Chapter 28, "Preparing COBOL programs for multithreading," on page 441
"Ending and reentering main programs or subprograms" on page 406

RELATED REFERENCES

Working-storage section (*COBOL for AIX Language Reference*)
Local-storage section (*COBOL for AIX Language Reference*)

Example: storage sections

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

```
CBL apost,pgmn(lu)
*********************************
* 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 13

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" on page 15
"Sharing data in nested programs" on page 15
"Sharing data in recursive or multithreaded programs" on page 15

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 417

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 407

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 441

RELATED TASKS

"Making recursive calls" on page 416

RELATED REFERENCES

SET statement (*COBOL for AIX Language Reference*)

"THREAD" on page 235

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 493

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 18
"Scope terminators" on page 18
"Imperative statements"
"Conditional statements"
"Declaratives" on page 20

RELATED REFERENCES
PROCEDURE DIVISION structure (*COBOL for AIX 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 18

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 17
"Scope terminators"

RELATED TASKS
"Selecting program actions" on page 67

RELATED REFERENCES
Conditional statements (*COBOL for AIX 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, control flow, or CALL interface convention.

RELATED REFERENCES
Chapter 14, "Compiler-directing statements," on page 243
Compiler-directing statements (*COBOL for AIX 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 17
"Imperative statements" on page 17

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 254

RELATED REFERENCES
Declaratives (*COBOL for AIX 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 TASKS
"Using variables, structures, literals, and constants"
"Assigning values to data items" on page 23
"Displaying values on a screen or in a file (DISPLAY)" on page 28
"Using intrinsic functions (built-in functions)" on page 28
"Using tables (arrays) and pointers" on page 30
"Processing character data in an international environment" on page 95

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`.

© Copyright IBM Corp. 1995, 2004

```
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.

Use the hexadecimal-notation format (X') to express control characters X'00' through X'1F' within an alphanumeric literal. Results are unpredictable if you specify these control characters in the basic format of alphanumeric literals.

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 TASKS

"Setting environment variables" on page 169

RELATED REFERENCES

Classes and categories of data (*COBOL for AIX Language Reference*)
PICTURE clause (*COBOL for AIX Language Reference*)
Literals (*COBOL for AIX Language Reference*)
Figurative constants (*COBOL for AIX 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 2. **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: • `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 24

RELATED TASKS

"Initializing a structure (INITIALIZE)" on page 25

"Assigning values to elementary or group data items (MOVE)" on page 26
"Joining data items (STRING)" on page 79
"Splitting data items (UNSTRING)" on page 81
"Assigning arithmetic results (MOVE or COMPUTE)" on page 26
"Tallying and replacing data items (INSPECT)" on page 87
"Assigning input from a screen or file (ACCEPT)" on page 27
"Processing character data in an international environment" on page 95

RELATED REFERENCES
COBOL for AIX 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	*bbbbb*[1]
99XX9	12AB3	*bbbbb*[1]
XXBX/XX	ABbC/DE	*bbbb/bb*[1]
**99.9CR	1234.5CR	**00.0*bb*[1]
A(5)	ABCDE	*bbbbb*[1]
+99.99E+99	+12.34E+02	+00.00E+00
1. The symbol *b* 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	*bbbbbbbb*[1]	*bbbb*ABCD[1]
1. The symbol *b* 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]	AB*b*C/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	*b*00000000000000000000000000[1]
2	R0013900004800000000000000000	*b*00000000000000000000000000[1]
3	S0014100001200000000000000000	*b*00000000000000000000000000[1]
4	C0013830000000000425000000000	*b*00000000000000000000000000[1]
5	C0020100000000000000100000000	*b*00000000000000000000000000[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:

```
. . .
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 97

RELATED REFERENCES

MOVE statement (*COBOL for AIX Language Reference*)

"Converting national data" on page 100

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)
```

RELATED REFERENCES
"DIAGTRUNC" on page 209
Intrinsic functions (*COBOL for AIX Language 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 either of the following changes:

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

  ```
  SYSIN is Names-Input
  ```

- Set the environment variable CONSOLE to a valid file specification by using the export command. For example:

  ```
  export CONSOLE=/myfiles/myinput.rpt
  ```

  The environment variable must be the same as the system device used. In the above example, the system device is Console, but the method of assigning an environment variable to the system device name is supported for all valid system devices. For example, if the system device is SYSIN, the environment variable that must be assigned a file specification is SYSIN also.

The ACCEPT statement assigns the input line to the data item. When the input line is shorter than the data item, the data item is padded with spaces. When you read from a screen and the input line is longer than the data item, the remaining characters are discarded. When you read from a file and the input line is longer than the data item, the remaining characters are retained as the next input line for the file.

When you assign a value to a national data item, the input data is converted from the code page associated with the current locale to UTF-16.

RELATED CONCEPTS
"Unicode and encoding of language characters" on page 97

RELATED TASKS
"Setting environment variables" on page 169

RELATED REFERENCES
SPECIAL-NAMES paragraph (*COBOL for AIX 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 screen:

```
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. For example, the following statement writes to the file specified in the SYSOUT environment variable if defined:

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

When you display the value of a national data item, the output data is converted to the code page associated with the current locale.

RELATED CONCEPTS
"Unicode and encoding of language characters" on page 97

RELATED TASKS
"Converting national data" on page 100

RELATED REFERENCES
DISPLAY statement (*COBOL for AIX Language Reference*)

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 65
"Converting data items (intrinsic functions)" on page 88
"Evaluating data items (intrinsic functions)" on page 91

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 51
"Using procedure and function pointers" on page 424

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 32
"Controlling how numeric data is stored" on page 33
"Checking for incompatible data (numeric class test)" on page 40
"Performing arithmetic" on page 41
"Using currency signs" on page 47

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

© Copyright IBM Corp. 1995, 2004

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 36

RELATED CONCEPTS

Appendix C, "Intermediate results and arithmetic precision," on page 513

RELATED TASKS

"Displaying numeric data"

"Controlling how numeric data is stored" on page 33
"Performing arithmetic" on page 41

RELATED REFERENCES

"Sign representation and processing" on page 39
"ARITH" on page 201

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  $zz,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 36

RELATED TASKS

"Controlling how numeric data is stored"
"Defining numeric data" on page 31
"Performing arithmetic" on page 41

RELATED REFERENCES

MOVE statement (*COBOL for AIX 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 36

RELATED CONCEPTS

"Formats for numeric data"
"Data format conversions" on page 38
Appendix C, "Intermediate results and arithmetic precision," on page 513

RELATED TASKS

"Defining numeric data" on page 31
"Displaying numeric data" on page 32
"Performing arithmetic" on page 41

RELATED REFERENCES

"Conversions and precision" on page 39
"Sign representation and processing" on page 39

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.

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 that originate 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 3. **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 *COBOL for AIX 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.

COMP-1 and COMP-2 data items are represented in IEEE format if the FLOAT(NATIVE) compiler option (the default) is in effect. If FLOAT(S390) (or its synonym, FLOAT(HEX)) is in effect, COMP-1 and COMP-2 data items are represented consistently with zSeries, that is, in hexadecimal floating-point format. For details, see the description of the FLOAT option referenced below.

RELATED CONCEPTS
Appendix C, “Intermediate results and arithmetic precision,” on page 513

RELATED REFERENCES
VALUE clause (*COBOL for AIX Language Reference*)
“TRUNC” on page 236
“FLOAT” on page 218

Examples: numeric data and internal representation

The following table shows the internal representation of numeric items for binary data types.

Table 4. **Internal representation of binary numeric items**

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

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.

The following table shows the internal representation of numeric items for native data types. Assume that the CHAR(NATIVE) and FLOAT(NATIVE) compiler options are in effect.

Table 5. **Internal representation of native numeric items**

Numeric type	PICTURE and USAGE and optional SIGN clause	Value	Internal representation
External decimal	PIC S9999 DISPLAY	+ 1234 - 1234 1234	31 32 33 34 31 32 33 74 31 32 33 34
	PIC 9999 DISPLAY	1234	31 32 33 34
	PIC S9999 DISPLAY SIGN LEADING	+ 1234 - 1234	31 32 33 34 71 32 33 34
	PIC S9999 DISPLAY SIGN LEADING SEPARATE PIC S9999 DISPLAY SIGN TRAILING SEPARATE	+ 1234 - 1234 + 1234 - 1234	2B 31 32 33 34 2D 31 32 33 34 31 32 33 34 2B 31 32 33 34 2D
Internal decimal	PIC S9999 PACKED-DECIMAL COMP-3	+ 1234 - 1234	01 23 4C 01 23 4D
	PIC 9999 PACKED-DECIMAL COMP-3	1234	01 23 4C
Internal floating point	COMP-1	+ 1234 - 1234	44 9A 40 00 C4 9A 40 00
Internal floating point	COMP-2	+ 1234 - 1234	40 93 48 00 00 00 00 00 C0 93 48 00 00 00 00 00
External floating point	PIC +9(2).9(2)E+99 DISPLAY	+ 1234	2B 31 32 2E 33 34 45 2B 30 32
		- 1234	2D 31 32 2E 33 34 45 2B 30 32

The following table shows the internal representation of numeric items for zSeries data types. Assume that the CHAR(EBCDIC) and FLOAT(HEX) compiler options are in effect.

Table 6. **Internal representation of numeric items when CHAR(EBCDIC) and FLOAT(HEX) are in effect**

Numeric type	PICTURE and USAGE and optional SIGN clause	Value	Internal representation
External decimal	PIC S9999 DISPLAY	+ 1234 - 1234 1234	F1 F2 F3 C4 F1 F2 F3 D4 F1 F2 F3 C4
	PIC 9999 DISPLAY	1234	F1 F2 F3 F4
	PIC S9999 DISPLAY SIGN LEADING	+ 1234 - 1234	C1 F2 F3 F4 D1 F2 F3 F4
	PIC S9999 DISPLAY SIGN LEADING SEPARATE PIC S9999 DISPLAY SIGN TRAILING SEPARATE	+ 1234 - 1234 + 1234 - 1234	4E F1 F2 F3 F4 60 F1 F2 F3 F4 F1 F2 F3 F4 4E F1 F2 F3 F4 60
Internal decimal	PIC S9999 PACKED-DECIMAL COMP-3	+ 1234 - 1234	01 23 4C 01 23 4D
	PIC 9999 PACKED-DECIMAL COMP-3	1234	01 23 4C
Internal floating point	COMP-1	+ 1234 - 1234	43 4D 20 00 C3 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

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, COMPUTE, or other arithmetic statement

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"

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 six digits, the fixed-point data item will receive only six 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 six 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 C, "Intermediate results and arithmetic precision," on page 513

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:
0, 1, 2, 3, 8, 9, A, and B

Negative:
4, 5, 6, 7, C, D, E, and F

When the CHAR(NATIVE) compiler option is in effect, signs generated internally are 3 for positive and unsigned, and 7 for negative.

When the CHAR(EBCDIC) compiler option is in effect, signs generated internally are C for positive, F for unsigned, and D for negative.

Given X'*ds*', where *d* represents the digit and *s* is the sign representation, the valid sign representations for internal decimal (USAGE PACKED-DECIMAL) COBOL data are:

Positive:
A, C, E, and F

Negative:
B and D

Signs generated internally are C for positive and unsigned, and D for negative.

Note that the sign representation of unsigned internal decimal numbers is different between COBOL for AIX and host COBOL. Host COBOL generates F internally as the sign of unsigned internal decimal numbers.

RELATED REFERENCES
Appendix A, "Summary of differences with host COBOL," on page 505

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.

Performing arithmetic

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

- "COMPUTE and other arithmetic statements"
- "Arithmetic expressions"
- "Numeric intrinsic functions" on page 42

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 45
Appendix C, "Intermediate results and arithmetic precision," on page 513

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 7. **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 45
Appendix C, "Intermediate results and arithmetic precision," on page 513

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.

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 8. **Numeric intrinsic functions**

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

"Examples: numeric intrinsic functions"

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 = 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 45
Appendix C, "Intermediate results and arithmetic precision," on page 513

RELATED REFERENCES

"ARITH" on page 201

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 521

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'80' used as the currency sign:

```
    Currency Sign X'80' 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 X'80' with code page 1252 (Latin 1).

"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 S99999V99.
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.
```

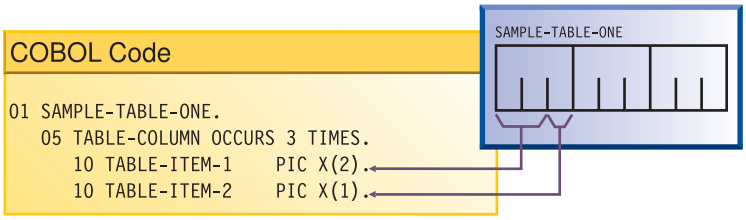
The above example produces the following display output:

```
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 53
"Putting values into a table" on page 56
"Nesting tables" on page 52
"Creating variable-length tables (DEPENDING ON)" on page 60
"Searching a table" on page 62
"Processing table items using intrinsic functions" on page 65
"Handling tables efficiently" on page 485

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.

© Copyright IBM Corp. 1995, 2004

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

RELATED TASKS

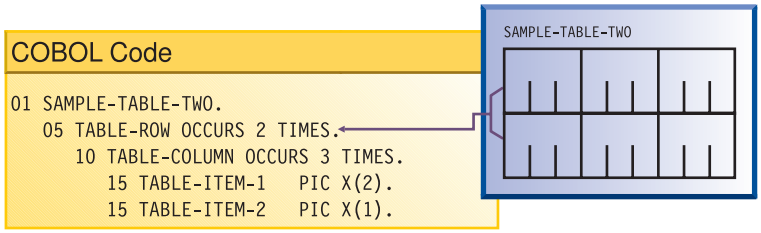
"Creating variable-length tables (DEPENDING ON)" on page 60
"Nesting tables"
"Putting values into a table" on page 56
"Referring to an item in a table" on page 53
"Searching a table" on page 62

RELATED REFERENCES

OCCURS clause (*COBOL for AIX Language Reference*)

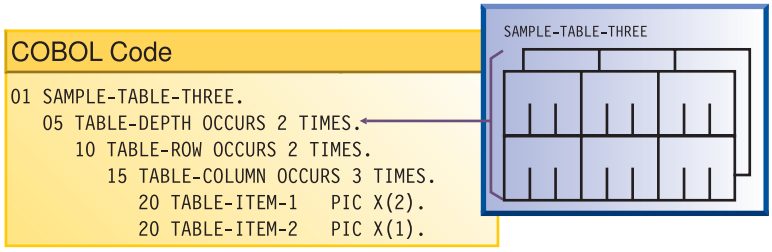
Nesting tables

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 51
"Referring to an item in a table"
"Putting values into a table" on page 56
"Creating variable-length tables (DEPENDING ON)" on page 60
"Searching a table" on page 62
"Processing table items using intrinsic functions" on page 65
"Handling tables efficiently" on page 485

RELATED REFERENCES

OCCURS clause (*COBOL for AIX 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 55
"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.

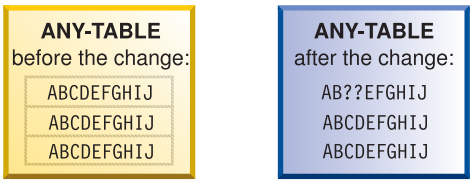
You can increment or decrement a literal or variable subscript by a specified integer amount. For example:

```
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 55

"Putting values into a table" on page 56
"Searching a table" on page 62
"Handling tables efficiently" on page 485

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 54

"Putting values into a table"
"Searching a table" on page 62
"Processing table items using intrinsic functions" on page 65
"Handling tables efficiently" on page 485

RELATED REFERENCES
INDEXED BY phrase (*COBOL for AIX Language Reference*)
INDEX phrase (*COBOL for AIX 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 61
"Initializing a table (INITIALIZE)"
"Assigning values when you define a table (VALUE)" on page 57
"Assigning values to a variable-length table" on page 62

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 58
"Example: PERFORM and indexing" on page 59

RELATED REFERENCES
PERFORM with VARYING phrase (*COBOL for AIX 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 (*COBOL for AIX 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-OBJ is then set to 3.

RELATED REFERENCES
REDEFINES clause (*COBOL for AIX Language Reference*)
PERFORM statement (*COBOL for AIX Language Reference*)
INITIALIZE statement (*COBOL for AIX Language Reference*)
OCCURS clause (*COBOL for AIX 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-On
           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.
 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 D, “Complex OCCURS DEPENDING ON,” on page 523

RELATED TASKS

“Assigning values to a variable-length table” on page 62
“Loading a variable-length table”

RELATED REFERENCES

OCCURS DEPENDING ON clause (*COBOL for AIX 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.
 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 "3ABCDE".
    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 REFERENCES
OCCURS DEPENDING ON clause (*COBOL for AIX 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 64

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 (*COBOL for AIX 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 "AAAAAAAA00" 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)
          = "A1234AAAAAAAA00"
        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 "A1234AAAAAAAA00"
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 (*COBOL for AIX 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 28

RELATED REFERENCES

Intrinsic functions (*COBOL for AIX 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 75

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 71

RELATED REFERENCES
IF statement (*COBOL for AIX Language Reference*)
EVALUATE statement (*COBOL for AIX 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:

© Copyright IBM Corp. 1995, 2004

```
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 70
"Example: EVALUATE using multiple WHEN statements" on page 70
"Example: EVALUATE testing several conditions" on page 70

RELATED TASKS

"Coding conditional expressions" on page 71
"Using the EVALUATE statement" on page 69
"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.

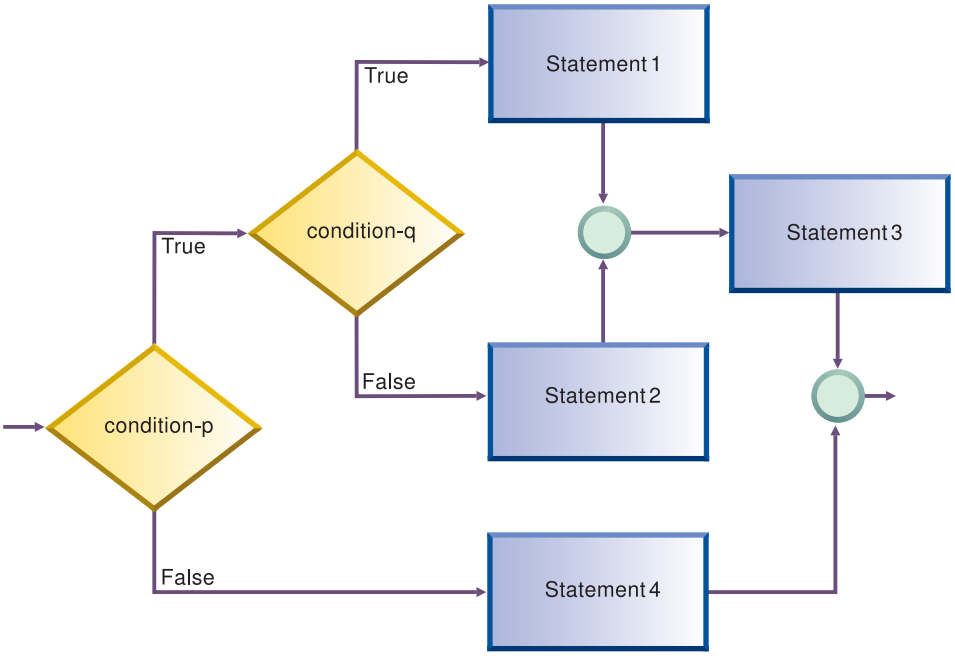
Use nested IF statements sparingly. The logic can be difficult to follow, although explicit scope terminators and proper indentation help.

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 67

RELATED REFERENCES

Explicit scope terminators (*COBOL for AIX 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 67

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.
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 73
"Checking for incompatible data (numeric class test)" on page 40
"Comparing national data items" on page 102

RELATED REFERENCES
Rules for condition-name values (*COBOL for AIX Language Reference*)
Switch-status condition (*COBOL for AIX Language Reference*)
Sign condition (*COBOL for AIX Language Reference*)
Comparing numeric and alphanumeric operands (*COBOL for AIX Language Reference*)
Combined conditions (*COBOL for AIX Language Reference*)
Class condition (*COBOL for AIX Language Reference*)
"UPSI" on page 252

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 73

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" "O" "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 76
"Coding a loop through a table" on page 77
"Executing multiple paragraphs or sections" on page 77

RELATED REFERENCES
PERFORM statement (*COBOL for AIX 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 76

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:

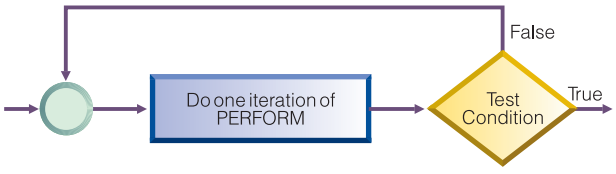
```
PERFORM 010-PROCESS-ONE-MONTH 12 TIMES
INSPECT . . .
```

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:

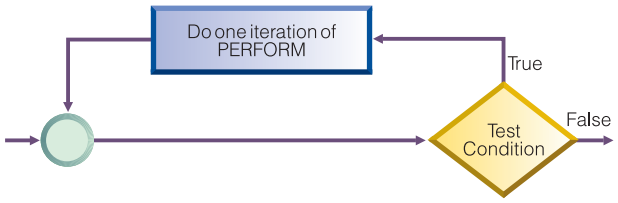


In the following example, the implicit WITH TEST BEFORE phrase provides a do-while structure:

```
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 65

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 81
"Manipulating null-terminated strings" on page 83
"Referring to substrings of data items" on page 84
"Tallying and replacing data items (INSPECT)" on page 87
"Converting data items (intrinsic functions)" on page 88
"Evaluating data items (intrinsic functions)" on page 91
"Processing character data in an international environment" on page 95

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"

RELATED TASKS
"Handling errors in joining and splitting strings" on page 157

RELATED REFERENCES
STRING statement (*COBOL for AIX 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.

© Copyright IBM Corp. 1995, 2004

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.bSMITHbbbbb
444bSPRINGbST.,bCHICAGO,bILL.bbbbbb
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
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 97

RELATED TASKS
"Handling errors in joining and splitting strings" on page 157

RELATED REFERENCES
UNSTRING statement (*COBOL for AIX 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
|        |         |         |         |         |         |
ZYFOUR-PENNY-NAILS     707890/BBA 475120 00122 000379.50
```

UNSTRING program results

When the UNSTRING statement is performed, the following steps take place:

1. 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.

2. 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. Positions 48 through 53 (000379) are placed in DISPLAY-DOLS. The period (.) delimiter character in DBY-1 is placed in DLTR-2, and the value 6 is placed in CTR-4.
8. 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	475120000122BBA
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 (*COBOL for AIX 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 EBCDIC 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"
"Unicode and encoding of language characters" on page 97

RELATED TASKS
"Referring to an item in a table" on page 53

RELATED REFERENCES
"SSRANGE" on page 233
Reference modification (*COBOL for AIX Language Reference*)
Function definitions (*COBOL for AIX 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 87

RELATED TASKS
"Referring to substrings of data items" on page 84
"Using national data (Unicode) in COBOL" on page 98

RELATED REFERENCES
Reference modification (*COBOL for AIX 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 (*COBOL for AIX Language Reference*)
INTEGER (*COBOL for AIX 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"

RELATED CONCEPTS
"Unicode and encoding of language characters" on page 97

RELATED REFERENCES
INSPECT statement (*COBOL for AIX 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 87

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 97

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.

The conversion uses the case mapping defined in the current locale. The length of the function might differ from the length of the argument.

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 JOHNSON*bbb*, the value after the statement is performed is *bbb*NOSNHOJ, 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 34

RELATED TASKS

"Assigning input from a screen or file (ACCEPT)" on page 27
"Displaying values on a screen or in a file (DISPLAY)" on page 28
"Converting national data" on page 100

RELATED REFERENCES
NUMVAL (*COBOL for AIX Language Reference*)
NUMVAL-C (*COBOL for AIX Language Reference*)
"ARITH" on page 201

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 97

RELATED TASKS
"Evaluating single characters for collating sequence"
"Finding the largest or smallest data item"
"Finding the length of data items" on page 93
"Finding the date of compilation" on page 94

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 *(COBOL for AIX Language Reference)*
ORD *(COBOL for AIX 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 VALLEJO*bbb* 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 THOMAS*bbbb* 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 '*f*bbbb' 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 '*g*bbbbbbbbb' 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 41
"Processing table items using intrinsic functions" on page 65

RELATED REFERENCES

ORD-MAX (*COBOL for AIX Language Reference*)
ORD-MIN (*COBOL for AIX 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 41
"Processing table items using intrinsic functions" on page 65

RELATED REFERENCES

LENGTH (*COBOL for AIX 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 (*COBOL for AIX Language Reference*)

Chapter 7. Enabling programs for international environments

COBOL for AIX provides facilities for you to adapt your applications to different languages and countries, thus providing a framework for internationalization of your applications. Internationalization continues to be an important market requirement for software applications.

You can write your applications to reflect the cultural conventions of the locale in effect when the applications are run. Cultural conventions include things like sort order, character classification, time and date format, number format, monetary format, postal address format, telephone number format, and national language. With COBOL for AIX, you can select the appropriate code pages and collating sequences and can use language elements and compiler options to handle both Unicode and double-byte character sets (DBCS).

RELATED TASKS
"Processing character data in an international environment"
"Coding for use of DBCS support" on page 104
"Setting the locale" on page 106

Processing character data in an international environment

COBOL for AIX 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 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:
  - `NSYMBOL` to control whether national or DBCS processing is used for the `N` symbol in literals and `PICTURE` clauses
  - `NCOLLSEQ` to specify the collating sequence for comparison of national operands

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 9. **COBOL statements and national data**

COBOL statement	Can be national	Comment	For more information
`ACCEPT`	*identifier-1*	Converted from the code page of the current locale	"Assigning input from a screen or file (ACCEPT)" on page 27

© Copyright IBM Corp. 1995, 2004

Table 9. **COBOL statements and national data** *(continued)*

COBOL statement	Can be national	Comment	For more information
CALL	*identifier-2*, *identifier-3*, *identifier-4*, *identifier-5*; *literal-2*, *literal-3*		"Passing data" on page 417
COPY . . . REPLACING	*operand-1*, *operand-2*		COPY statement (*COBOL for AIX Language Reference*)
DISPLAY	*identifier-1*	Converted to the code page of the current locale	"Displaying values on a screen or in a file (DISPLAY)" on page 28
INITIALIZE	REPLACING	If you specify REPLACING NATIONAL, *identifier-2* and *literal-1* must be of class national, and vice versa.	"Examples: initializing data items" on page 24
INSPECT	Identifiers and literals other than *identifier-3* (the TALLYING identifier)	If any of these is of class national, all must be.	"Tallying and replacing data items (INSPECT)" on page 87
INVOKE	method-name as *identifier-2* or *literal-1*; *identifier-3* or *literal-2* in the BY VALUE phrase		"Invoking methods (INVOKE)" on page 361
MERGE	Merge keys, if you specify NCOLLSEQ(BIN)	The COLLATING SEQUENCE phrase does not apply.	"Setting sort or merge criteria" on page 153
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 26
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 64
SORT	Sort keys, if you specify NCOLLSEQ(BIN)	The COLLATING SEQUENCE phrase does not apply.	"Setting sort or merge criteria" on page 153
STRING	Any identifiers and literals other than *identifier-4* (the POINTER identifier)	If any of these is of class national, all must be.	"Joining data items (STRING)" on page 79
UNSTRING	Delimiters (*identifier-2*, *identifier-3*), data receiving fields (*identifier-4*), delimiter receiving fields) *identifier-5*; *literal-3*, *literal-4*	If any of these is of class national, all must be.	"Splitting data items (UNSTRING)" on page 81

The use of national data affects these intrinsic functions:

Table 10. **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 93

Table 10. **Intrinsic functions and national data** *(continued)*

Intrinsic function	Argument type can be national?	Function type	For more information
LOWER-CASE, UPPER-CASE	Yes	National	"Converting to uppercase or lowercase (UPPER-CASE, LOWER-CASE)" on page 89
MAX, MIN	Yes	National	"Finding the largest or smallest data item" on page 91
ORD-MAX, ORD-MIN	Yes	Integer	"Finding the largest or smallest data item" on page 91
REVERSE	Yes	National	"Converting to reverse order (REVERSE)" on page 89

RELATED CONCEPTS
"Unicode and encoding of language characters"

RELATED TASKS
"Setting the locale" on page 106
"Using national data (Unicode) in COBOL" on page 98
"Converting national data" on page 100
"Processing UTF-8 data" on page 101
"Processing Chinese GB 18030 data" on page 102
"Comparing national data items" on page 102
"Processing alphanumeric data items that contain DBCS data" on page 106

RELATED REFERENCES
"NSYMBOL" on page 223

Unicode and encoding of language characters

Definitions: 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 associated with 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.)

COBOL for AIX provides basic run-time support for Unicode, which can handle tens of thousands of characters that cover all commonly used characters and symbols in the world.

There are several encoding schemes in Unicode, called Unicode Transformation Format (UTF), such as UTF-8, UTF-16, and UTF-32. COBOL for AIX 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'00*nn*' 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: On z/OS and AIX,Enterprise COBOL for z/OS and COBOL for AIX support UTF-16 in big-endian format in national data items. On Windows(R),COBOL for Windows supports UTF-16 in little-endian format (UTF-16LE) in national data items. If you are porting UTF-16 data with byte order marks or UTF-16LE data to COBOL for AIX from another platform, you must convert that data to UTF-16 big-endian format to process such data as national data. You can perform such conversions by using the `NATIONAL-OF` intrinsic function.

RELATED TASKS
"Processing character data in an international environment" on page 95

RELATED REFERENCES
"Locales and code pages supported" on page 112
Characters (*COBOL for AIX Language Reference*)
Character sets and code pages (*COBOL for AIX Language Reference*)

Using national data (Unicode) in COBOL

In COBOL for AIX, 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"41424344" to X
```

also results in moving Unicode AB (not the bit pattern 41424344) to X.

Use the SOSI compiler option to control how shift-out and shift-in characters within a national literal are handled.

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 11. **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]	ASCII	ASCII DBCS	UTF-16BE
Encoding units per character	1	1	1 or 2[2]
Bytes per character	1 byte	2 bytes	2 or 4 bytes

1. National literals in your source program are converted to UTF-16 for use at run time.
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:
   - COBOL characters A-Z, a-z, 0-9, space, + -*/= $,;.“()><:’
   - All characters that are converted from an EBCDIC, ASCII, or EUC code page

RELATED CONCEPTS

“Unicode and encoding of language characters” on page 97

RELATED TASKS

“Converting national data” on page 100
“Comparing national data items” on page 102
“Processing UTF-8 data” on page 101

RELATED REFERENCES
"NSYMBOL" on page 223
"SOSI" on page 230

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 for the data item.

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 for the data item.

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 code page in effect at run time. 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 in effect at run time, 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 run-time code page.

"Example: converting national data" on page 101

RELATED TASKS
"Setting the locale" on page 106

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.

```
* . . .
 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, "ISO8859-7")
         to Data-in-Unicode
* . . . process Data-in-Unicode here . . .
     Move function Display-of(Data-in-Unicode, "ISO8859-7")
         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 ISO8859-7 (Ascii 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
```

Assuming that the locale in effect is en_US.ISO8859-1, Data-in-Greek is converted to Unicode by this MOVE statement based on the code page ISO8859-1 to UTF-16BE conversion. This conversion would not produce the expected results because Data-in-Greek is actually encoded in ISO8859-7.

If you set the locale to el_GR.ISO8859-7 (that is, your program handles ASCII data in Greek), you can code the same example correctly as follows:

```
* . . .
 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 (unless the code page of the locale in effect is UTF-8, in which case the native alphanumeric data is already encoded in 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 100

Processing Chinese GB 18030 data

COBOL for AIX supports GB 18030 (a national-character standard specified by the government of the People's Republic of China). If the code page specified for the locale in effect is GB18030 (a code page that supports GB 18030), USAGE DISPLAY data items that contain GB 18030 characters encoded in GB18030 can be processed in a program. GB 18030 characters can take 1 to 4 bytes each, therefore the program logic must be sensitive to the multibyte nature of such data.

You can process GB 18030 characters using the national data support in these ways:

- You can use Unicode data to define and process GB 18030 characters that are represented in CCSID 01200.
- You can process data in any code page (including GB18030, which has CCSID 1392) 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 GB18030 or 1392 as the second argument of each function.

  The following example illustrates these conversions:

```
 01 Chinese-ASCII 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-ASCII, 1392) to UnicodeString
*  Process data in Unicode
     Move function Display-of(UnicodeString, 1392) to Chinese-GB18030-String
```

GB 18030 characters are encoded through the existing Chinese ASCII code page, CCSID 1392, 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 100

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

Use the NCOLLSEQ compiler option to determine which type of compare you want to perform.

NCOLLSEQ(BINARY)

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.

NCOLLSEQ(LOCALE)

When you use a locale-based comparison, the operands are compared by using the algorithm for collation order associated with the locale in effect. Trailing spaces are truncated from the operands except that an operand consisting of all spaces is truncated to a single space.

When you compare operands of unequal lengths, the shorter operand is not extended with spaces because such an extension could alter the expected results for the locale.

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 98
"Coding a choice of actions" on page 67
"Tallying and replacing data items (INSPECT)" on page 87
"Coding a loop" on page 76
"Doing a serial search (SEARCH)" on page 63
"Joining data items (STRING)" on page 79
"Splitting data items (UNSTRING)" on page 81

RELATED REFERENCES

Relation condition (*COBOL for AIX Language Reference*)
Comparison of numeric and alphanumeric operands (*COBOL for AIX Language Reference*)

Coding for use of DBCS support

IBM COBOL for AIX supports using applications in any of many national languages, including languages that use double-byte character sets (DBCS).

The following list summarizes the support for DBCS:

- DBCS characters in user-defined words (multibyte names)
- DBCS characters in comments
- DBCS data type (with `PICTURE N` or `G`)
- DBCS literals
- Collating sequence

RELATED TASKS

"Setting the locale" on page 106
"Declaring DBCS data"
"Specifying DBCS literals" on page 105
"Controlling the collating sequence" on page 110
"Testing for valid DBCS characters" on page 106

Declaring DBCS data

You define the DBCS class and category as shown in the following table:

Table 12. **DBCS classes and categories**

Level of item	Class	Category
Elementary	Alphabetic	Alphabetic
	Numeric	Numeric
	Alphanumeric	Numeric edited Alphanumeric edited Alphanumeric DBCS
Nonelementary (group)	Alphanumeric	Alphanumeric

Use the PICTURE clause and symbols G, G and B, or N to represent a DBCS data item. Each PICTURE symbol represents a DBCS character position. The number of bytes occupied by each double-byte character is assumed to be 2. Therefore, do not include single-byte characters in a DBCS data item.

You can specify a DBCS data item with USAGE DISPLAY-1. When you use PICTURE symbol G, you must specify USAGE DISPLAY-1. When you use PICTURE symbol N and omit the USAGE clause, USAGE DISPLAY-1 or USAGE NATIONAL is implied depending on the NSYMBOL compiler option in effect.

If you use a VALUE clause with the USAGE clause, you must specify a DBCS literal or the figurative constants SPACE or SPACES.

If a data item has USAGE DISPLAY-1 (either explicitly or implicitly), the selected locale must indicate a code page that includes DBCS characters. If the code page of the locale does not include DBCS characters, such data items are flagged as errors.

For the purpose of handling reference modifications, each character in a DBCS data item is considered to occupy the number of bytes that corresponds to the code-page width (that is, 2).

RELATED REFERENCES
"NSYMBOL" on page 223

Specifying DBCS literals

You can specify either of two literal types to represent double-byte character constants: N'*dbcs characters*' (provided that compiler option NSYMBOL(DBCS) is in effect) and G'*dbcs characters*'.

In addition, you can use the alphanumeric literal syntax to specify any character in one of the supported code pages. However, such a literal is treated as alphanumeric in COBOL language semantics (that is, semantics appropriate for single-byte characters).

The literal delimiters can be single or double quotation marks depending on the APOST or QUOTE compiler option setting.

You cannot continue an alphanumeric literal containing multibyte characters. The maximum length of an N or G literal is 28 double-byte characters. The length of an N or G literal is limited by the available space in Area B on a single source line.

Using ALL

The figurative constants {ALL} SPACE or {ALL} SPACES represent SBCS, DBCS, or national space characters, depending on context. (You can optionally code the word ALL for readability; it has no effect.)

ALL *literal* represents all or part of the string generated by successive concatenations of the single-byte characters or double-byte characters that comprise the literal. The literal must be an alphanumeric literal or a DBCS literal. The literal must not be a figurative constant.

Comparing literals

Comparisons of DBCS literals are based on the compile-time locale. Therefore, do not use DBCS literals in the source program within a statement with an implied relational condition between two DBCS literals (such as VALUE G *literal-1* THRU G *literal-2*) unless the intended run-time locale is the same as the compile-time locale.

RELATED REFERENCES
"NSYMBOL" on page 223

Testing for valid DBCS characters

Kanji and DBCS class test are defined to be consistent with their zSeries definitions. Both class tests are internally performed by converting the double-byte characters to the double-byte characters defined for z/OS. The converted double-byte characters are tested for DBCS and Japanese graphic characters.

Kanji class test results in testing for valid Japanese graphic characters. This testing includes Katakana, Hiragana, Roman, and Kanji character sets.

The Kanji class test is done by checking the converted characters for X'41' - X'7E' for the first byte and X'41' - X'FE' for the second byte plus the space character X'4040'.

DBCS class test results in testing for valid graphic characters for the code page.

The DBCS class test is done by checking the converted characters for X'41' - X'FE' for both the first and second byte of each character plus the space character X'4040'.

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 79
"Splitting data items (UNSTRING)" on page 81
"Referring to substrings of data items" on page 84
"Converting national data" on page 100

Setting the locale

A *locale* is a collection of data that encodes information about a cultural environment. You can establish a cultural environment for an application by selecting the active locale. Only one locale can be active at a time. The active locale affects the behavior of the locale-sensitive interfaces for the entire program.

Setting the locale affects the following aspects of an application:

- Code page
- Messages
- Collating sequence
- Date and time formats
- Character classification and case conversion

The locale setting does not affect the following items:

- Decimal point and numeric separator

- Currency sign

Instead, Standard COBOL 85 defines specific language elements for controlling these items.

Code page

You can use the characters that are represented in a supported code page in COBOL names, data definitions, literals, and comments.

The locale in effect determines the code page for compiling source programs (including alphanumeric literal values) and running them. That is, the code page that is used for compilation is based on the locale setting at compile time, and the code page that is used for running an application program is based on the locale setting at run time.

Thus, the evaluation of literal values in the source program is handled with the locale in effect at compile time. For example, the conversion of national literals from the source representation to UTF-16 for running the program is sensitive to the compile-time locale.

The code page that is in effect for a particular alphanumeric data item depends on the `USAGE` clause, the `CHAR` option, and locale in effect. The choice between ASCII and EBCDIC is made as follows:

- Data item that are defined with the `NATIVE` phrase on the `USAGE` clause are encoded in an ASCII code page.
- Data items described without the `NATIVE` phrase are encoded according to the `CHAR` option, as follows:
  - In ASCII with `CHAR(NATIVE)`
  - In EBCDIC with `CHAR(EBCDIC)`

The appropriate code page is determined as follows:

ASCII From the current run-time locale

EBCDIC
From the EBCDIC_CODEPAGE environment variable, if set. Otherwise, the default EBCDIC code page from the current locale setting.

The code page for national data items and national literals is UTF-16, CCSID 1200.

Messages

The following messages are NLS enabled, and appropriate message text and formats are used based on the locale setting:

- Compiler messages
- Run-time messages
- Compiler listing headers (including locale-sensitive date and time formats)
- Debugger user interface

Collating sequence

Locale sensitivity for the collating sequence for alphanumeric or DBCS items applies only when the `COLLSEQ(LOCALE)` compiler option is in effect. The locale has no effect on the collation order of such data items if `COLLSEQ(BIN)` or `COLLSEQ(EBCDIC)` is in effect.

The collating sequence for single-byte alphanumeric characters for the program collating sequence is based on the compile-time or run-time locale. If you specify the PROGRAMMING COLLATING SEQUENCE clause in the source program, the collating sequence is set at compile time and is used regardless of the run-time locale. If instead you set the collating sequence by using the COLLSEQ compiler option, the run-time locale takes precedence.

The compile-time locale is used for language elements with syntax or semantic rules that are affected by locale-sensitive collation order (when the COLLSEQ(LOCALE) or NCOLLSEQ(LOCALE) compiler option is in effect), such as the following elements:

- Condition-name VALUE clause with THRU phrase
- EVALUATE statement with literal value range (*literal-1* THRU *literal-2*)
- *literal-1* THRU *literal-2* phrase in an ALPHABET clause
- Ordinal positions of characters specified in SYMBOLIC CHARACTERS clause
- THRU phrase in CLASS clause

The collating sequence for alphanumeric or DBCS keys in SORT or MERGE statements is always based on the run-time locale when the COLLSEQ(LOCALE) compiler option is in effect.

Keys for a SORT or MERGE statement can be national only if the NCOLLSEQ(BIN) option is in effect.

The run-time locale-based collating sequence is always applicable to DBCS and EUC data, independent of the COBOL source-level collating-sequence specification (which applies to single-byte alphanumeric data), except for comparisons of literals.

RELATED TASKS
"How locale is determined"
"Specifying DBCS literals" on page 105
"Controlling the collating sequence" on page 110
"Accessing the locale and code-page values in effect" on page 115

RELATED REFERENCES
"Locales and code pages supported" on page 112
"Run-time environment variables" on page 172
"CHAR" on page 203
"COLLSEQ" on page 205
"NCOLLSEQ" on page 223
AIX General Programming Concepts: Writing and Debugging Programs

How locale is determined

The setting of the current locale is determined from a combination of the applicable environment variables and system settings. Environment variables are used first. If an applicable locale category is not defined by environment variables, it is determined from defaults and system settings.

To verify the locale that is in effect at compile time, check the compiler listing. You can see the locale in effect for the compilation in the last few lines of the listing.

To access the locale in effect at run time, call the library function _iwzGetLocaleCP. For details, see the related task about accessing the locale and code pages in effect.

Environment variables

The following environment variables are used as the source of the locale information for a COBOL program:

- LANG
- LC_ALL
- LC_CTYPE
- LC_COLLATE
- LC_TIME
- LC_MESSAGES

The following logic determines the setting for each locale category:

1. If LC_ALL is set, its value applies to all locale categories.
2. Otherwise, the values of individual locale environment variables (LC_*xxxx*) apply to the specific locale categories:

   LC_CTYPE
   Defines character classification, case conversion, and other character attributes. Use this category to define the code page in effect.

   LC_COLLATE
   Defines the collating sequence in effect. This variable affects only greater-than or less-than comparisons, such as in relational conditions or in the `SORT` and `MERGE` statements.

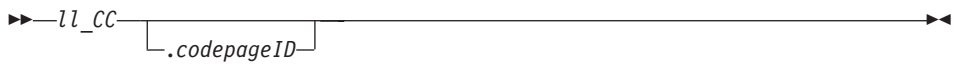
   LC_MESSAGES
   Defines the format for affirmative and negative responses and affects whether messages (error messages and listing headers for example) are in US English or Japanese. For any locale other than Japanese, US English is used.

   LC_TIME
   Lists rules and symbols for formatting time and date information. In COBOL for AIX, this variable affects only the date and time shown on the compiler listings. All other date and time values are controlled through COBOL language syntax.
3. Any locale category that is not set by the previous two steps is set from the value of the LANG environment variable.

Locale value format

COBOL for AIX uses the POSIX-defined locale conventions. Use the following format to set the locale environment variables (LC_*xxxx*):

Locale value syntax



ll A lowercase two-letter ISO language code

CC An uppercase two-letter ISO country code

codepageID
The code page to be used for native `DISPLAY` and `DISPLAY-1` data

You must code a valid value for the locale name (*ll_CC*) and a valid code page (*codepageID*) that corresponds to the locale name, as shown in the table of supported locales and code pages referenced below.

For example, to set the locale to Canadian French encoded in ISO8859-1, issue this command in the command window from which you compile and execute a COBOL application:

```
export LC_ALL=fr_CA.ISO8859-1
```

System settings

If the value of an applicable locale category is not determined from environment variables, the following default and system settings are used:

- When the language and country codes are determined from environment variables, but the code page is not, the default system code page for the language and country combination is used.
- Multiple code pages might apply to the language and country-code combination. If you do not want the AIX system to select a default code page, you must specify the code page explicitly.

UTF-8: UTF-8 encoding is supported for any language and country code combination.

RELATED TASKS

"Accessing the locale and code-page values in effect" on page 115
"Setting environment variables" on page 169

RELATED REFERENCES

"Locales and code pages supported" on page 112
"Run-time environment variables" on page 172

Controlling the collating sequence

Various operations, such as comparisons, sorting, and merging, are sensitive to the collating sequence that is in effect for the program and data items. How you control the collating sequence depends on the code page in effect for the category of the data: alphanumeric, DBCS, or national.

Alphanumeric collating sequence

You can specify the following clauses in the `SPECIAL-NAMES` paragraph only if the code page in effect is a single-byte ASCII code page:

- `ALPHABET` clause
- `SYMBOLIC CHARACTERS` clause
- `CLASS` clause

If you specify these clauses when the source code page in effect includes DBCS characters, the clauses will be diagnosed and treated as comments.

The rules of the COBOL user-defined alphabet-name and symbolic characters assume a character-by-character collating sequence (not a collating sequence that depends on a sequence of multiple characters). Therefore, locale-sensitive collating can be expressed by assigning a weight to each character in the code set.

Standard COBOL 85 rules for the `PROGRAM COLLATING SEQUENCE` clause and the `COLLATING SEQUENCE` phrase of `SORT` and `MERGE` apply to the collating sequence for alphanumeric data items.

If the collating sequence in effect is NATIVE (the default if you do not specify the COLLATING SEQUENCE clause or the PROGRAM COLLATING SEQUENCE clause), the collating sequence is based on the locale setting. This setting applies to SORT and MERGE statements and to the program collating sequence.

The collating sequence affects the processing of the following items:

- ALPHABET clause (for example, *literal-1* THRU *literal-2*)
- SYMBOLIC CHARACTERS specifications
- VALUE range specifications for level-88 items, relation conditions, and SORT and MERGE statements

DBCS collating sequence

You can use data items and literals of class DBCS in a relation condition with any relational operator. Each operand must be either of class DBCS, alphabetic, or alphanumeric (elementary or group). You can, for example, compare a DBCS item with an alphanumeric item. No conversion or editing is done. No distinction is made between items of category DBCS and items of category DBCS edited.

COBOL for AIX performs DBCS comparisons based on the rules for alphanumeric comparisons. The comparison is based on the locale setting for the collating sequence if the COLLSEQ(LOCALE) compiler option is in effect.

The PROGRAM COLLATING SEQUENCE clause has no effect on comparisons that involve data items of class DBCS or DBCS literals.

National collating sequence

You can use data items and literals of class national in a relation condition with any relational operator. The PROGRAM COLLATING SEQUENCE clause does not affect comparisons involving national operands.

Use the NCOLLSEQ(LOCALE) compiler option to have your comparisons based on the algorithm for collation order associated with the locale value in effect.

Intrinsic functions that are sensitive to collating sequence

The following intrinsic functions depend on the ordinal positions of characters. For an ASCII code page, these intrinsic functions are supported based on the collating sequence in effect. For an EUC code page or a code page that includes DBCS characters, the ordinal positions of single-byte characters are assumed to correspond to the hexadecimal representations of the single-byte characters. For example, the ordinal position for 'A' is 66 (X'41' + 1) and the ordinal position for '*' is 43 (X'2A' + 1).

Table 13. **Intrinsic functions that are sensitive to collating sequence**

Intrinsic function	Returns:	Comments
CHAR	Character of the ordinal position given	
MAX	Content of the argument that contains the maximum value	The arguments can be alphabetic, alphanumeric, national, or numeric.[1]
MIN	Content of the argument that contains the minimum value	The arguments can be alphabetic, alphanumeric, national, or numeric.[1]

Table 13. **Intrinsic functions that are sensitive to collating sequence** *(continued)*

Intrinsic function	Returns:	Comments
ORD	Ordinal position of the given character	
ORD-MAX	Integer ordinal position in the argument list of the argument that contains the maximum value	The arguments can be alphabetic, alphanumeric, national, or numeric.[1]
ORD-MIN	Integer ordinal position in the argument list of the argument that contains the minimum value	The arguments can be alphabetic, alphanumeric, national, or numeric.[1]

1. Code page and collating sequence are not applicable when the function has numeric arguments.

These intrinsic functions are not supported for the DBCS data type.

Comparisons that involve a group item are based on the rules for the comparison of alphanumeric operands.

RELATED TASKS
"Specifying the collating sequence" on page 8
"Comparing national data items" on page 102

RELATED REFERENCES
"COLLSEQ" on page 205
"NCOLLSEQ" on page 223
Comparison of numeric and alphanumeric operands (*COBOL for AIX Language Reference*)

Locales and code pages supported

The following table shows the locales that could be available on your system, and the code pages that are supported for each locale. COBOL for AIX supports the locales that are available on the system at compile time and at run time. The locales that are available on the system are normally located at /usr/lib/nls/loc.

The case of each character for a locale name is significant. See the footnote in the table below for more information.

The first column, Locale name, shows the valid combinations of ISO language code and ISO country code (*language_COUNTRY*) that are supported. The second column show the associated language, and the third column shows the associated country or area.

The fourth column, ASCII-based code pages, shows the ASCII code pages that are valid as the code-page ID for the locale with the corresponding *language_COUNTRY* value. These table entries are not definitive. For the current list of valid locales, consult your system documentation for the specific version and configuration of AIX that you are running. The locale that you select must be valid, that is, installed both where you develop and where you run the program.

The fifth column, EBCDIC code pages, shows the EBCDIC code pages that are valid as the code-page ID for the locale with the corresponding *language_COUNTRY* value. These code pages are valid as content for the

EBCDIC_CODEPAGE environment variable. If the EBCDIC_CODEPAGE environment variable is not set, the rightmost code-page entry in this column is selected by default as the EBCDIC code page for the corresponding locale.

Table 14. **Supported locales and code pages**

Locale name[1]	Language	Country or area	ASCII-based code pages	EBCDIC code pages	Language group
any			UTF-8	EBCDIC code pages that are applicable to the locale are based on the *language* and *COUNTRY* portions of the locale name regardless of the code-page value of the locale.	
ar_AA	Arabic	Arabic countries	ISO8859-6	IBM-16804, IBM-420	Arabic
be_BY	Byelorussian	Belarus	ISO8859-5	IBM-1025, IBM-1154	Latin 5
bg_BG	Bulgarian	Bulgaria	ISO8859-5	IBM-1025, IBM-1154	Latin 5
ca_ES	Catalan	Spain	ISO8859-1, IBM-850, 8859-15	IBM-285, IBM-1145	Latin 1
cs_CZ	Czech	Czech Republic	ISO8859-2	IBM-870, IBM-1153	Latin 2
da_DK	Danish	Denmark	ISO8859-1, IBM-850, 8859-15	IBM-277, IBM-1142	Latin 1
de_CH	German	Switzerland	ISO8859-1, IBM-850, 8859-15	IBM-500, IBM-1148	Latin 1
de_DE	German	Germany	ISO8859-1, IBM-850, 8859-15	IBM-273, IBM- 1141	Latin 1
el_GR	Greek	Greece	ISO8859-7	IBM-4971, IBM-875	Greek
en_AU	English	Australia	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
en_BE	English	Belgium	ISO8859-1, IBM-850, 8859-15	IBM-500, IBM-1148	Latin 1
en_GB	English	United Kingdom	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
en_JP	English	Japan	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
en_US	English	United States	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
en_ZA	English	South Africa	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
es_ES	Spanish	Spain	ISO8859-1, IBM-850, 8859-15	IBM-284, IBM-1145	Latin 1
fi_FI	Finnish	Finland	ISO8859-1, IBM-850, 8859-15	IBM-278, IBM-1143	Latin 1
fr_BE	French	Belgium	ISO8859-1, IBM-850, 8859-15	IBM-297, IBM-1148	Latin 1
fr_CA	French	Canada	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
fr_CH	French	Switzerland	ISO8859-1, IBM-850, 8859-15	IBM-500, IBM-1148	Latin 1
fr_FR	French	France	ISO8859-1, IBM-850, 8859-15	IBM-297, IBM-1148	Latin 1
hr_HR	Croatian	Croatia	ISO8859-2	IBM-870, IBM-1153	Latin 2
hu_HU	Hungarian	Hungary	ISO8859-2	IBM-870, IBM-1153	Latin 2
is_IS	Icelandic	Iceland	ISO8859-1, IBM-850, 8859-15	IBM-871, IBM-1149	Latin 1
it_CH	Italian	Switzerland	ISO8859-1, IBM-850, 8859-15	IBM-500, IBM-1148	Latin 1
it_IT	Italian	Italy	ISO8859-1, IBM-850, 8859-15	IBM-280, IBM-1144	Latin 1
iw_IL	Hebrew	Israel	ISO8859-8	IBM-12712, IBM-424	Hebrew
Iw_IL	Hebrew	Israel	IBM-856	IBM-12712, IBM-424	Hebrew

Table 14. **Supported locales and code pages** *(continued)*

Locale name[1]	Language	Country or area	ASCII-based code pages	EBCDIC code pages	Language group
ja_JP	Japanese	Japan	IBM-eucJP	IBM-930, IBM-939, IBM-1390, IBM-1399	Ideographic languages
Ja_JP	Japanese	Japan	IBM-943, IBM-932	IBM-930, IBM-939, IBM-1390, IBM-1399	Ideographic languages
ko_KR	Korean	Korea, Republic of	IBM-eucKR	IBM-933, IBM-1364	Ideographic languages
lt_LT	Lithuanian	Lithuania	IBM-1257	n/a	Lithuanian
lv_LV	Latvian	Latvia	IBM-1257	n/a	Latvian
mk_MK	Macedonian	Macedonia	ISO8859-5	IBM-1025, IBM-1154	Latin 5
nl_BE	Dutch	Belgium	ISO8859-1, IBM-850, 8859-15	IBM-500, IBM-1148	Latin 1
nl_NL	Dutch	Netherlands	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
no_NO	Norwegian	Norway	ISO8859-1, IBM-850, 8859-15	IBM-277, IBM-1142	Latin 1
pl_PL	Polish	Poland	ISO8859-2	IBM-870, IBM-1153	Latin 2
pt_BR	Portuguese	Brazil	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
pt_PT	Portuguese	Portugal	ISO8859-1, IBM-850, 8859-15	IBM-037, IBM-1140	Latin 1
ro_RO	Romanian	Romania	ISO8859-2	IBM-870, IBM-1153	Latin 2
ru_RU	Russian	Russian federation	ISO8859-5	IBM-1025, IBM-1154	Latin 5
sh_SP	Serbian (Latin)	Serbia	ISO8859-2	IBM-870, IBM-1153	Latin 2
sk_SK	Slovak	Slovakia	ISO8859-2	IBM-870, IBM-1153	Latin 2
sl_SI	Slovenian	Slovenia	ISO8859-2	IBM-870, IBM-1153	Latin 2
sq_AL	Albanian	Albania	ISO8859-1, IBM-850, 8859-15	IBM-500, IBM-1148	Latin 1
sv_SE	Swedish	Sweden	ISO8859-1, IBM-850, 8859-15	IBM-278, IBM-1143	Latin 1
th_TH	Thai	Thailand	TIS-620	IBM-9030	Thai
tr_TR	Turkish	Turkey	ISO8859-9	IBM-1026, IBM-1155	Turkish
uk_UA	Ukranian	Ukraine	ISO8859-5, IBM-1124	IBM-1123, IBM-1154	Latin 5
zh_CN	Chinese (simplified)	China	IBM-eucCN	IBM-1388	Ideographic languages
Zh_CN	Chinese	China	GB18030	IBM-1388	Ideographic languages
zh_TW	Chinese (traditional)	Taiwan	IBM-eucTW	IBM-1371, IBM-937	Ideographic languages

1. The case of each character in the locale name shown in the table is significant and might not reflect the casing of a locale name with a specific code page selected (or implied) for the locale. See the locale file name in the locale directory (normally at /usr/lib/nls/loc) for the proper casing of each character for the locale name selected. A locale name with the UTF-8 code page is in general entirely uppercase (for example, ZH_CN.UTF-8).

RELATED TASKS

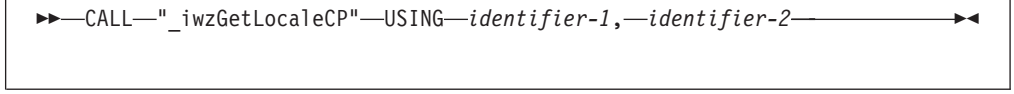
"How locale is determined" on page 108

Accessing the locale and code-page values in effect

For some of your applications, you might want to verify the locale and the EBCDIC code page that are in effect during the application execution and convert a code-page ID to the corresponding CCSID. You can use callable library routines to perform such queries and conversions.

The syntax for obtaining the locale and EBCDIC code-page values in effect is shown here:

CALL _iwzGetLocaleCP syntax



***identifier-1* (output)**
An alphanumeric item of 20 characters in length that represents the null-terminated locale value in the following format:

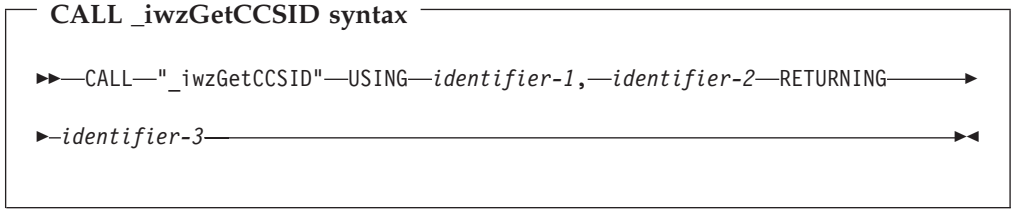
1. Two-character language code
2. An underscore
3. Two-character country code
4. A period
5. The code page value for the locale

For example, `en_US.IBM-1252` is the locale value of language code `en`, country code `US`, and code page `IBM-1252`.

***identifier-2* (output)**
An alphanumeric item of 10 characters in length that represents the null-terminated EBCDIC code-page ID in effect. For example, `IBM-1140`.

The syntax to convert a code-page ID to the corresponding CCSID is shown here:

CALL _iwzGetCCSID syntax



***identifier-1* (input)**
An alphanumeric item that represents a null-terminated code-page ID.

***identifier-2* (output)**
A signed 4-byte binary item, such as one defined as `PIC S9(5) COMP-5`. The CCSID that corresponds to the input code-page ID string is returned.

***identifier-3* (output)**
A signed 4-byte binary data item, which is set as follows:

0 Successful

1 The code-page ID is valid but does not have an associated CCSID; *identifier-2* is set to -1.

-1 The code-page ID is not a valid code page; *identifier-2* is set to -1.

To call these services, you must use the PGMNAME(MIXED) and NODYNAM compiler options.

"Example: get and convert a code-page ID"

RELATED TASKS
"Setting the locale" on page 106

RELATED REFERENCES
"DYNAM" on page 210
"PGMNAME" on page 226
Chapter 14, "Compiler-directing statements," on page 243

Example: get and convert a code-page ID

The following sample shows how you can use the callable services _iwzGetLocaleCP and _iwzGetCCSID to check the locale and the EBCDIC code page in effect and convert a code-page ID to the corresponding CCSID.

```
cbl pgmname(lm)
       Identification Division.
       Program-ID.  "Samp1".
       Data Division.
       Working-Storage Section.
       01 locale-in-effect.
          05 ll-cc             pic x(5).
          05 filler-period     pic x.
          05 ASCII-CP          Pic x(14).
       01 EBCDIC-CP            pic x(10).

       01 CCSID                pic s9(5) comp-5.
       01 RC                   pic s9(5) comp-5.

       01 n                    pic 99.

       Procedure Division.
       Get-locale-and-codepages section.
       Get-locale.
           Display "Start Samp1."
           Call "_iwzGetLocaleCP"
             using locale-in-effect, EBCDIC-CP
           Move 0 to n
           Inspect locale-in-effect
             tallying n for characters before initial x'00'
           Display "locale in effect: " locale-in-effect (1 : n)
           Move 0 to n
          Inspect EBCDIC-CP
             tallying n for characters before initial x'00'
          Display "EBCDIC code page in effect: "
            EBCDIC-CP (1 : n).

      Get-CCSID-for-EBCDIC-CP.
          Call "_iwzGetCCSID" using EBCDIC-CP, CCSID returning RC
          Evaluate RC
            When 0
              Display "CCSID for " EBCDIC-CP (1 : n) " is " CCSID
            When 1
              Display EBCDIC-CP (1 : n)
                      " does not have a CCSID value."
            When other
              Display EBCDIC-CP (1 : n) " is not a valid code page."
```

```
           End-Evaluate.

       Done.
           Goback.
```

If you set the locale to ja_JP.IBM-943 (`set LC_ALL=ja_JP.IBM-943`), the display output from the sample program is:

```
Start Samp1.
locale in effect: ja_JP.IBM-943
EBCDIC code page in effect: IBM-1399
CCSID for IBM-1399 is 0000001399
```

Chapter 8. Processing files

Reading data from files and writing data to files is an essential part of most COBOL programs. Your program can retrieve information, process it as you request, and then write the results. The major tasks you can perform in processing a file are first opening the file and then reading it, and (depending on the type of file organization and access) adding, replacing, or deleting records.

Before the actual processing, however, you need to identify the files and describe their physical structure, including whether they are organized as sequential, relative, indexed, or line sequential. Identifying them entails naming them and their file system. You might also want to set up a file status field that you can check later to make sure that the processing worked properly.

RELATED CONCEPTS
"File system" on page 121

RELATED TASKS
"Identifying files"
"Enabling COBOL applications to access SFS files" on page 126
"Protecting against errors when opening files" on page 131
"Specifying a file organization and access mode" on page 131
"Setting up a field for file status" on page 135
"Describing the structure of a file in detail" on page 135
"Coding input and output statements for files" on page 136

Identifying files

In the `FILE-CONTROL` clause of the `INPUT-OUTPUT SECTION` of the `ENVIRONMENT DIVISION`, you must specify a name for the file that you want to use and optionally specify a name for the file system:

```
SELECT file ASSIGN TO FileSystemID-Filename
```

file is the name that you use inside the program to refer to the file. It is not necessarily the actual name of the file as known by the system.

FileSystemID identifies the file system as one of the following:

VSAM
VSAM file system. You can abbreviate VSAM as `VSA`.

Specify the VSAM file system when you want to access VSAM files or Encina(R) SFS files.

STL STL file system

RSD Record sequential delimited file system

If you do not provide the file-system specification, the run-time option `FILESYS` is used to select the file system. The default for the `FILESYS` run-time option is `VSAM`.

Filename is the name of the physical file that you want to access. Alternatively, you can use an environment variable to specify the file-name at run time.

© Copyright IBM Corp. 1995, 2004

RELATED CONCEPTS
"File system" on page 121

RELATED TASKS
"Identifying VSAM files"
"Identifying Encina SFS files"
"Identifying STL files" on page 121
"Identifying RSD files" on page 121

RELATED REFERENCES
"VSAM file system" on page 122
"SFS file system" on page 122
"STL file system" on page 123
"RSD file system" on page 125
"Run-time environment variables" on page 172
"FILESYS" on page 250

Identifying VSAM files

To use the VSAM file system for VSAM files, identify a file as follows:

```
SELECT file1 ASSIGN USING 'VSA-MyFile'
```

If the run-time option `FILESYS(VSA)` is in effect, identify a file as follows:

```
SELECT file1 ASSIGN TO 'MyFile'
```

If you have defined the environment variable *MYFILE* (for example, `export MYFILE=VSA-MYFILE`), identify a file as follows:

```
SELECT file1 ASSIGN TO MYFILE
```

Identifying Encina SFS files

To use the VSAM file system for SFS files, identify a file as follows:

```
SELECT file1 ASSIGN TO Myfile
```

Myfile, the COBOL *assignment-name*, is a run-time environment variable. Use an `export` command of the following form to assign a value to the environment variable at run time:

```
export Myfile="/.:/myEnc/mySFS/mySFSfil(/.:/myEnc/mySFS/  \
  mySFSfil;myaltfil1,/.:/myEnc/mySFS/mySFSfil;myaltfil2)"
```

This command provides the following information:

- `/.:/myEnc/mySFS/` is the fully qualified DCE Cell Directory Service (CDS) name for the Encina server.
- *mySFSfil* is the base file.
- `/.:/myEnc/mySFS/mySFSfil` is the fully qualified DCE CDS base file-name.
- *myaltfil1* and *myaltfil2* are the alternate index files.

For an alternate index file, the file-name must be in the format of its fully qualified DCE CDS base file-name followed by a semicolon (`;`) and the alternate index file-name: `/.:/myEnc/mySFS/mySFSfil;myaltfil1`.

A comma is required between specifications of alternate index files in the `export` command.

RELATED REFERENCES
"SFS file system" on page 122

Identifying STL files

To use the STL file system, identify a file as follows:

```
SELECT file1 ASSIGN USING 'STL-MyFile'
```

If the run-time option FILESYS(STL) is in effect, identify a file as follows:

```
SELECT file1 ASSIGN TO 'MyFile'
```

If you have defined the environment variable *MYFILE* (for example, `export MYFILE=STL-MYFILE`), identify a file as follows:

```
SELECT file1 ASSIGN TO MYFILE
```

Identifying RSD files

To use the record sequential delimited file system, identify a file as follows:

```
SELECT file1 ASSIGN USING 'RSD-MyFile'
```

If the run-time option FILESYS(RSD) is in effect, identify a file as follows:

```
SELECT file1 ASSIGN TO 'MyFile'
```

If you have defined the environment variable *MYFILE* (for example, `export MYFILE=RSD-MYFILE`), identify a file as follows:

```
SELECT file1 ASSIGN TO MYFILE
```

File system

Record-oriented files that are organized as sequential, relative, or indexed are accessed through a *file system*. You can use file-system functions to create and manipulate the records in any of these types of files.

COBOL for AIX supports the following file systems:

- The VSAM file system, which lets you use access VSAM files or Encina SFS files. (Encina SFS is the file system used by CICS.) The VSAM file system is provided with COBOL for AIX, whereas Encina SFS is supplied as part of CICS or can be ordered independently of CICS.
- The STL file system, which provides the basic facilities for local files. It is provided with COBOL for AIX, and supports sequential, relative, and indexed files.
- The RSD (record sequential delimited) file system, which lets you share data with programs written in other languages. RSD files are sequential only and support all COBOL data types in records. Text data in records can be edited by most file editors.

Most programs will have the same behaviors on all file systems. However, files written using one file system cannot be read using a different file system.

You can select a file system by setting the assignment-name environment variable or by using the FILESYS run-time option. All the file systems let you use COBOL statements to read and write COBOL files.

RELATED TASKS
"Identifying files" on page 119

RELATED REFERENCES
"VSAM file system"
"SFS file system"
"STL file system" on page 123
"RSD file system" on page 125
zSeries host data type considerations ("File data" on page 512)
"FILESYS" on page 250

VSAM file system

The VSAM file system supports VSAM files and SFS files. It supports sequential, indexed, and relative files, and provides the basic file facilities that you need for file processing on AIX. It conforms to Standard COBOL 85.

The `LINE SEQUENTIAL` organization is the only file organization type not supported by the VSAM file system.

The file system is not safe for use with multiple threads.

You can share VSAM files with programs written in PL/I.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Identifying VSAM files" on page 120

RELATED REFERENCES
"SFS file system"
VSAM File System Reply Messages

SFS file system

The Encina SFS (Structured File Server) file system is a record-oriented file system that supports sequential, relative, and indexed COBOL files. It provides the basic facilities that you need for accessing files sequentially, randomly, or dynamically. You can process SFS files with the standard file operations such as read, insert, update, or delete.

To access SFS files, you specify the VSAM file system. See the related task about identifying files for details.

Each SFS file has one primary index, which defines the physical ordering of the records in the file, and can have any number of secondary indices, which provide alternate sequences in which the records can be accessed.

You specify the full name of an SFS file by the name of the SFS server on which it resides, followed by the name of the file itself. For example, if the server name is /.:/encina/sfs/*my_server* and the file-name is *myfile*, then the full file-name is /.:/encina/sfs/*my_server*/*myfile*. (The name in this form is referred to as a *fully qualified DCE Cell Directory Service (CDS)* file-name.)

The SFS file system is nonhierarchical. That is, you can specify only individual file names, not directory names, after the server name.

The SFS file system supports three types of file organization, known as entry-sequenced (that is, sequential), relative, and clustered (that is, indexed).

All data in SFS files is managed by an SFS server. SFS provides a system administration tool, `sfsadmin`, for performing administrative functions such as creating files and indices, determining what volumes are available on the SFS server, and so on, through a command-line interface. For details, see the related reference below.

COBOL access to SFS files is nontransactional; that is, each operation against an SFS file is performed either in its entirety or not at all (sometimes called *atomic*). In the event of an SFS system failure, the results of a file operation completed by a COBOL application might not be reflected in the SFS file.

With the SFS file system, you can easily read and write files to be shared with PL/I programs.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Identifying files" on page 119
"Identifying Encina SFS files" on page 120
"Enabling COBOL applications to access SFS files" on page 126
"Improving SFS performance" on page 129
"Compiling for SFS files" on page 180
Encina SFS Programming Guide

RELATED REFERENCES
Encina Administration Guide Volume 2: Server Administration

STL file system

The STL file system (Standard language file system) supports sequential, indexed, and relative files. It provides the basic file facilities that you need for accessing files. It conforms to Standard COBOL 85, and gives good performance and the ability to port easily between AIX and Windows-based systems.

The `LINE SEQUENTIAL` organization is the only file organization type not supported by the STL file system.

The file system is safe for use with threads. However, you must ensure that multiple threads do not access the level-01 records for the file at the same time. Multiple threads can perform operations on the same STL file, but you must use a `pthread_cond_wait` call or its equivalent to force all but one of the threads to wait for the file access to complete on the active thread.

With the STL file system, you can easily read and write files to be shared with PL/I programs.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Identifying STL files" on page 121

RELATED REFERENCES
"STL file system return codes" on page 124

STL file system return codes

In the FILE-CONTROL paragraph, you can code the following clause for an STL file:

```
FILE STATUS data-name-1 data-name-8
```

After an input-output operation on the file, *data-name-1* will contain a status code that is independent of the file system used, and *data-name-8* will contain one of the STL file system return codes shown in the tables below.

Table 15. **STL file system return codes**

Code	Meaning	Notes
0	Successful completion	The input-output operation completed successfully.
1	Invalid operation	This return code should not occur; it indicates an error in the file system.
2	I/O error	A call to an operating system I/O routine returned an error code.
3	File not open	Attempt to perform an operation (other than OPEN) on a file that is not open
4	Key value not found	Attempt to read a record using a key that is not in the file
5	Duplicate key value	Attempt to use a key a second time for a key that does not allow duplicates
6	Invalid key number	This return code should not occur; it indicates an error in the file system.
7	Different key number	This return code should not occur; it indicates an error in the file system.
8	Invalid flag for the operation	This return code should not occur; it indicates an error in the file system.
9	End of file	An end of file was detected. This is not an error.
10	I/O operation must be preceded by an I/O GET operation	The operation is looking for the current record, and the current record has not been defined.
11	Error return from get space routine	The operating system indicates that not enough memory is available.
12	Duplicate key accepted	The operation specified a key, and the key is a duplicate.
13	Sequential access and key sequence bad	Sequential access was specified, but the records are not in sequential order.
14	Record length < max key	The record length does not allow enough space for all of the keys.
15	Access to file denied	The operating system reported that it cannot access the file. Either the file does not exist or the user does not have the proper permission of the operating system to access the file.
16	File already exists	You attempted to open a new file, but the operating system reports that the file already exists.
17	(Reserved)	
18	File locked	Attempt to open a file that is already open in exclusive mode

Table 15. **STL file system return codes** *(continued)*

Code	Meaning	Notes
19	File table full	The operating system reports that its file table is full.
20	Handle table full	The operating system reports that it cannot allocate any more file handles.
21	Title does not say STL	Files opened for reading by the STL file system must contain a header record that contains "STL" at a certain offset in the file.
22	Bad indexcount arg for create	This return code should not occur; it indicates an error in the file system.
23	Index or rel record > 64 KB	Index and relative records are limited to a length of 64 KB.
24	Error found in file header or data in open of existing file	STL files begin with a header. The header or its associated data has inconsistent values.
25	Indexed open on seq file	Attempt to open a sequential file as an indexed or relative file

The following table shows return codes for errors detected in the adapter open routines.

Table 16. **STL file system adapter open routine return codes**

Code	Meaning	Notes
1000	Sequential open on indexed or relative file	Attempt to open an indexed or relative file as a sequential file
1001	Relative open of indexed file	Attempt to open a relative file as an indexed file
1002	Indexed open of sequential file	Attempt to open an indexed file as a sequential file
1003	File does not exist	The operating system reports that the file does not exist.
1004	Number of keys differ	Attempt to open a file with a different number of keys
1005	Record lengths differ	Attempt to open a file with a different record length
1006	Record types differ	Attempt to open a file with a different record type
1007	Key position or length differs	Attempt to open a file with a different key position or length

RELATED TASKS

"Using file status keys" on page 161

RELATED REFERENCES

"STL file system" on page 123

FILE STATUS clause (*COBOL for AIX Language Reference*)

RSD file system

The RSD (record sequential delimited) file system supports sequential files. You can process RSD files with the standard system file utility functions, such as browse, edit, copy, delete, and print.

RSD files conform to Standard COBOL 85 and give good performance. They give you the ability to port files easily between AIX and Windows-based systems and to share files between programs and applications written in different languages.

RSD files support all COBOL data types in records of fixed length. Each record written is followed by a new-line control character. For a read operation, the file record area is filled for the record length. If an end-of-file is encountered before the record area is filled, the record area is padded with space characters.

If you edit an RSD file with a text editor, you must ensure that the length of each record is maintained. For example, if you edit file *infile*, and want to ensure that each record has 80 characters, you can pad each record to column 80 with spaces and write the result to file *outfile* by issuing this command:

```
awk '{printf("\%-80s\n",$0)}' infile > outfile
```

Attempting a `WRITE` statement with the `AFTER ADVANCING` or `BEFORE ADVANCING` phrase to an RSD file causes the statement to fail with the file status key set to 30.

The RSD file system is safe for use with threads. However, you must ensure that multiple threads do not access the level-01 records for the file at the same time. Multiple threads can perform operations on the same RSD file, but you must use a `pthread_cond_wait` call or its equivalent to force all but one of the threads to wait for the file access to complete on the active thread.

RELATED CONCEPTS

"File organization and access mode" on page 131

RELATED TASKS

"Identifying RSD files" on page 121

Enabling COBOL applications to access SFS files

To access Encina SFS files from a COBOL application that runs under AIX, do these steps:

1. Compile and link the COBOL programs in the application by using the `cob2_r4` command.
2. Use the VSAM file system. (`FILESYS(VSA)` is the default for the `FILESYS` run-time option.)
3. Ensure that the Encina SFS server that your application will access is running.
4. Set the ENCINA_CDS_ROOT environment variable to the fully qualified name of the Encina SFS server. For example:

   ```
   export ENCINA_CDS_ROOT=/.:/cics/sfs/test1
   ```

5. (Optional) If your application creates one or more SFS files, and you want to allocate the files on an SFS data volume that has a name other than encinaSfsVol, you can specify either or both of the following names:
   - The name of the SFS data volume on which the SFS files are to be created. To do so, assign a value to the run-time environment variable ENCINA_SFS_DATA_VOLUME. The data volume must have been defined to the SFS server. If you do not know which data volumes are available to the SFS server, issue the command `sfsadmin list lvols`.

     By default, SFS files are created on the data volume that is named encinaSfsVol.

- The name of the SFS data volume on which alternate index files, if any, are to be created. To do so, assign a value to the run-time environment variable ENCINA_SFS_INDEX_VOLUME. The data volume must have been defined to the SFS server.

  By default, alternate index files are created on the same volume as the corresponding base files.

6. Identify each SFS file by using the fully qualified DCE Cell Directory Service (CDS) name:
   - The Encina SFS server name must precede the file-name.
   - The alternate index file-names must start with the base file-name, followed by a semicolon (`;`) and the alternate index name.

   For example, if /.:/cics/sfs/test1 is the Encina SFS server, and VSAM04A is an SFS file that has alternate index VSAM04A1, you could identify VSAM04A by issuing the following `export` command:

   ```
   export VSAM04A="/.:/cics/sfs/test1/VSAM04A(/.:/cics/sfs/test1/VSAM04A;VSAM04A1)"
   ```

   For more information about fully qualified names for SFS servers and files, see the related task about identifying Encina SFS files.

"Example: accessing SFS files"

RELATED TASKS
"Identifying Encina SFS files" on page 120
"Compiling for SFS files" on page 180
"Improving SFS performance" on page 129
Encina SFS Programming Guide

RELATED REFERENCES
"SFS file system" on page 122
"Run-time environment variables" on page 172
"FILESYS" on page 250
Encina Administration Guide Volume 2: Server Administration

Example: accessing SFS files

The following example shows the COBOL file descriptions that you could code and the `sfsadmin` and `export` commands that you could issue to create and access two SFS files:

- VSAM04: an indexed file that has no alternate index
- VSAM04A: an indexed file that has one alternate index, VSAM04A1

COBOL file descriptions

```
. . .
input-output section.
file-control.

    select VSAM04-file
        assign to VSAM04
        access dynamic
        organization is indexed
        record key is VSAM04-rec-num
        file status is VSAM04-status.

    select VSAM04A-file
        assign to VSAM04A
        access dynamic
        organization is indexed
        record key is VSAM04A-rec-num
```

```
        alternate record key is VSAM04A-date-time
        file status is VSAM04A-status.

data division.
file section.

FD  VSAM04-file
    data record is VSAM04-record.
  01 VSAM04-record.
     05 VSAM04-rec-num               pic x(10).
     05 VSAM04-rec-data              pic x(70).

FD  VSAM04A-file
    data record is VSAM04A-record.
  01 VSAM04A-record.
     05 VSAM04A-rec-num              pic x(10).
     05 VSAM04A-date-time.
        07 VSAM04A-date-yyyymmdd     pic 9(8).
        07 VSAM04A-time-hhmmsshh     pic 9(8).
        07 VSAM04A-date-time-counter pic 9(8).
     05 VSAM04A-rec-data             pic x(1000).
```

sfsadmin commands

Create each indexed file by issuing the `sfsadmin create clusteredfile` command, and add an alternate index by issuing the `sfsadmin add index` command, as in the following example:

```
sfsadmin create clusteredfile VSAM04 2 \
PrimaryKey byteArray 10 \
DATA byteArray 70 \
primaryIndex -unique 1 PrimaryKey sfs_SFS_SERV
#
sfsadmin create clusteredfile VSAM04A 3 \
PrimaryKey byteArray 10 \
AltKey1 byteArray 24 \
DATA byteArray 1000 \
primaryIndex -unique 1 PrimaryKey sfs_SFS_SERV
#
sfsadmin add index VSAM04A VSAM04A1 1 AltKey1
```

As shown in the first `sfsadmin create clusteredfile` command above, you must specify the following items:

- The name of the new indexed file (`VSAM04` in this example)
- The number of fields per record (`2`)
- The description of each field (`PrimaryKey` and `DATA`, each a byte array)
- The name of the primary index (`primaryIndex`)
- The number of fields in the primary index (`1`)
- The names of the fields in the primary index (`PrimaryKey`)
- The name of the data volume on which the file is to be stored (`sfs_SFS_SERV`)

By default, duplicate keys are allowed in the primary index of a clustered file. In the `sfsadmin create clusteredfile` commands above, the `-unique` option specifies that key values in the primary index must be unique within the file.

As shown in the `sfsadmin add index` command above, you must specify the following items:

- The name of the file to which an alternate index is to be added (`VSAM04A` in this example)
- The name of the new index (`VSAM04A1`)
- The number of fields to be used as keys in the new index (`1`)

- The names of the fields in the new index (`AltKey1`)

For details about the syntax of the commands `sfsadmin create clusteredfile` and `sfsadmin add index`, see the related references below.

export commands

Before you run the program that processes the SFS files, issue these `export` commands to specify the Encina SFS server (`/.:/cics/sfs/test1`) that will access the files, and the data volume (`sfs_SFS_SERV`) that will store the files:

```
# Set environment variables required by the VSAM file system
# for SFS files:
export ENCINA_CDS_ROOT=/.:/cics/sfs/test1
export ENCINA_SFS_DATA_VOLUME=sfs_SFS_SERV
export ENCINA_SFS_INDEX_VOLUME=sfs_SFS_SERV
# Set environment variable to access SFS file VSAM04:
export VSAM04=/.:/cics/sfs/test1/VSAM04
# Set environment variable to access SFS file VSAM04A and the
# alternate index VSAM04A1:
export VSAM04A="/.:/cics/sfs/test1/VSAM04A(/.:/cics/sfs/test1/VSAM04A;VSAM04A1)"
```

RELATED REFERENCES

Encina Administration Guide Volume 2: Server Administration

Improving SFS performance

You can improve the performance of applications that access SFS files in two ways:

- Use two types of caching on the client machine
- Reduce the frequency of saving changes that are made to SFS files

Enabling client-side caching

By default, records in SFS files are written to and read from the SFS server, and a remote procedure call (RPC) is needed whenever a record is accessed. When you enable *client-side caching*, however, records can instead be stored in local memory (a *cache*) on the client machine and sent (*flushed*) to the server in a single RPC. As a result, less time is needed to access records.

You can specify either or both of two types of caching: *read caching* and *insert caching*:

- If you enable read caching, the first sequential read of a file causes the current record and a number of neighboring records to be read from the server and placed in the read cache. Subsequent sequential reads, updates, and deletes are made in the read cache rather than on the server.
- If you enable insert caching, insert operations (but not reads, updates, or deletes) are done in the insert cache rather than on the server.

To enable client-side caching for all the SFS files in your application, set the ENCINA_VSAM_CACHE environment variable before you run the application. See the related reference below about run-time environment variables for a syntax diagram for the ENCINA_VSAM_CACHE environment variable.

You can code a single value for the cache size to indicate that the same number of pages is to be used for the read cache and for the insert cache, or you can code distinct values for the read and insert cache by separating the values by a colon (`:`). Express size units as numbers of pages. If you code zero as the size of the read cache, insert cache, or both, that type of caching is disabled.

For example, the following command sets the size of the read cache to 16 pages and the size of the insert cache to 64 pages for each SFS file in the application:

```
export ENCINA_VSAM_CACHE=16:64
```

You can also specify one or both of the following flags to make client-side caching more flexible:

- To allow uncommitted data (records that are new or modified but have not yet been sent to the server, known as *dirty* records) to be read, specify ALLOW_DIRTY_READS.

  This flag removes the restriction for read caching that the files being accessed must be locked.
- To allow any inserts to be cached, specify INSERTS_DESPITE_UNIQUE_INDICES.

  This flag removes the restriction for insert caching that all active indices for clustered files and active alternate indices for entry-sequenced and relative files must allow duplicates.

For example, the following command allows maximum flexibility:

```
export ENCINA_VSAM_CACHE=16:64:ALLOW_DIRTY_READS,INSERTS_DESPITE_UNIQUE_INDICES
```

To set client-side caching differently for certain files, code a putenv() call that sets ENCINA_VSAM_CACHE before the `OPEN` statement for each file for which you want to change the caching policy. During a program, the environment-variable settings that you make in a putenv() call take precedence over the environment-variable settings that you make in an `export` command.

"Example: setting and accessing environment variables" on page 178

Reducing the frequency of saving changes

Normally, an RPC occurs for each write or update operation on an SFS file that does not use client-side caching (that is, the *operational force* feature of SFS is enabled). All changes to the file that result from an input-output operation are committed to disk before control returns to the application.

You can change this behavior so that the result of input-output operations on SFS files might not be committed to disk until the files are closed (that is, a *lazy-write* strategy is used). If each change to an SFS file is not being immediately saved, the application can run faster.

To change the default commit behavior for all the SFS files in your application, set the ENCINA_VSAM_AUTO_FLUSH environment variable to `OFF` before you run the application:

```
export ENCINA_VSAM_AUTO_FLUSH=OFF
```

To set the flush value differently for certain files, code a putenv() call that sets ENCINA_VSAM_AUTO_FLUSH before the `OPEN` statement for each file for which you want to change the flush value. During a program, the environment-variable settings that you make in a putenv() call take precedence over the environment-variable settings that you make in an `export` command.

"Example: setting and accessing environment variables" on page 178

If client-side caching is in effect for an SFS file (that is, environment variable ENCINA_VSAM_CACHE is set to a valid nonzero value), the setting of ENCINA_VSAM_AUTO_FLUSH for the file is ignored. Operational force is disabled for that file.

RELATED TASKS
"Identifying Encina SFS files" on page 120
"Setting environment variables" on page 169
Encina SFS Programming Guide

RELATED REFERENCES
"SFS file system" on page 122
"Run-time environment variables" on page 172

Protecting against errors when opening files

If your program tries to open and read a file that does not exist, normally an error occurs. However, there might be times when opening a nonexistent file makes sense. For such cases, use the optional keyword `OPTIONAL` with `SELECT`:

```
SELECT OPTIONAL file ASSIGN TO filename
```

Specifying a file organization and access mode

In the `FILE-CONTROL` paragraph, you need to define the physical structure of a file and its access mode:

```
FILE-CONTROL.
    SELECT file ASSIGN TO FileSystemID-Filename
    ORGANIZATION IS org ACCESS MODE IS access.
```

For *org*, you can choose `SEQUENTIAL` (the default), `LINE SEQUENTIAL`, `INDEXED`, or `RELATIVE`.

For *access*, you can choose `SEQUENTIAL` (the default), `RANDOM`, or `DYNAMIC`.

Sequential and line-sequential files must be accessed sequentially, but for indexed or relative files, all three access modes are possible.

File organization and access mode

You can organize your files as sequential, line-sequential, indexed, or relative. You should decide on the file organization and access modes when you design your program. The access mode defines how COBOL reads and writes files, but not how files are organized.

Your file-management system handles the input and output requests and record retrieval from the input-output devices.

The following table summarizes file organization and access modes for COBOL files.

Table 17. **File organization and access mode**

File organization	Order of records	Records can be deleted or replaced?	Access mode
Sequential	Order in which they were written	A record cannot be deleted, but its space can be reused for a same-length record.	Sequential only
Line-sequential	Order in which they were written	No	Sequential only
Indexed	Collating sequence by key field	Yes	Sequential, random, or dynamic
Relative	Order of relative record numbers	Yes	Sequential, random, or dynamic

RELATED CONCEPTS
"Sequential file organization"
"Line-sequential file organization"
"Indexed file organization" on page 133
"Relative file organization" on page 133
"Sequential access" on page 133
"Random access" on page 134
"Dynamic access" on page 134

RELATED TASKS
"Specifying a file organization and access mode" on page 131

RELATED REFERENCES
"File input-output limitations" on page 134

Sequential file organization

A sequential file contains records organized by the order in which they were entered. The order of the records is fixed.

Records in sequential files can be read or written only sequentially.

After you have placed a record into a sequential file, you cannot shorten, lengthen, or delete the record. However, you can update (`REWRITE`) a record if the length does not change. New records are added at the end of the file.

If the order in which you keep records in a file is not important, sequential organization is a good choice whether there are many records or only a few. Sequential output is also useful for printing reports.

RELATED CONCEPTS
"Sequential access" on page 133

RELATED REFERENCES
"Valid COBOL statements for sequential files" on page 139

Line-sequential file organization

Line-sequential files are like sequential files, except that the records can contain only characters as data. Line-sequential files are supported by the native byte stream files of the operating system.

Line-sequential files that are created with WRITE statements with the ADVANCING phrase can be directed to a printer as well as to a disk.

RELATED CONCEPTS
"Sequential file organization" on page 132

RELATED REFERENCES
"Valid COBOL statements for line-sequential files" on page 139

Indexed file organization

An indexed file contains records ordered by a *record key*. Each record contains a field that contains the record key. The record key uniquely identifies the record and determines the sequence in which it is accessed with respect to other records. A record key for a record might be, for example, an employee number or an invoice number.

An indexed file can also use *alternate indexes*, that is, record keys that let you access the file using a different logical arrangement of the records. For example, you could access the file through employee department rather than through employee number.

The record transmission (access) modes allowed for indexed files are sequential, random, or dynamic. When indexed files are read or written sequentially, the sequence is that of the key values.

EBCDIC consideration: As with any change in the collating sequence, if your indexed file is a local EBCDIC file, the EBCDIC keys will not be recognized as such outside of your COBOL program. For example, an external sort program, unless it also has support for EBCDIC, will not sort records in the order that you might expect.

RELATED REFERENCES
"Valid COBOL statements for indexed and relative files" on page 140

Relative file organization

A relative record file contains records ordered by their *relative key*, that is, the record number that represents the record location relative to where the file begins. For example, 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 forth. The records can have fixed length or variable length.

The 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.

RELATED REFERENCES
"Valid COBOL statements for indexed and relative files" on page 140

Sequential access

Code ACCESS IS SEQUENTIAL in the FILE-CONTROL paragraph.

For indexed files, records are accessed in the order of the key field selected (either primary or alternate), beginning at the current position of the file position indicator.

For relative files, records are accessed in the order of the relative record numbers.

RELATED CONCEPTS
"Random access"
"Dynamic access"

RELATED REFERENCES
"File position indicator" on page 138

Random access

Code `ACCESS IS RANDOM` in the `FILE-CONTROL` paragraph.

For indexed files, records are accessed according to the value you place in a key field (primary, alternate, or relative). There can be one or more alternate indexes.

For relative files, records are accessed according to the value you place in the relative key.

RELATED CONCEPTS
"Sequential access" on page 133
"Dynamic access"

Dynamic access

Code `ACCESS IS DYNAMIC` in the `FILE-CONTROL` paragraph.

Dynamic access supports a mixture of sequential and random access in the same program. With dynamic access, you can use one COBOL file definition to perform both sequential and random processing, accessing some records in sequential order and others by their keys.

For example, suppose you have an indexed file of employee records, and the employee's hourly wage forms the record key. Also, suppose your program is interested in those employees who earn between $12.00 and $18.00 per hour and those who earn $25.00 per hour and above. To access this information, retrieve the first record randomly (with a random-retrieval `READ`) based on the key of 1200. Next, begin reading sequentially (using `READ NEXT`) until the salary field exceeds 1800. Then switch back to a random read, this time based on a key of 2500. After this random read, switch back to reading sequentially until you reach the end of the file.

RELATED CONCEPTS
"Sequential access" on page 133
"Random access"

File input-output limitations

- For line-sequential files:
  - Maximum record size: 64 KB
  - Maximum number of bytes allocated for a file: 64 GB
- For VSAM files:
  - Minimum record size: 1 byte
  - Maximum record size: 64,000 bytes
  - Maximum record key length: 255 bytes
  - Maximum relative key value: 2**32 -1
  - Maximum number of bytes allocated for a file: 2**31 -1
- For STL files:
  - Minimum record size: 1 byte

  - Maximum record size: 65,535 bytes
  - Maximum record key length: 255 bytes
  - Maximum number of alternate keys: 253 bytes
  - Maximum relative key value: 2**32 -1
  - Maximum number of bytes allocated for a file: 2**31 -1
- For RSD files:
  - Fixed-length records only
  - Minimum record size: 1 byte
  - Maximum record size: 65,535 bytes
  - Maximum number of bytes allocated for a file: 64 GB

Additional or more restrictive limits might be applicable depending on the platform where the target file is located.

RELATED REFERENCES
Encina Administration Guide Volume 2: Server Administration

Setting up a field for file status

Establish a FILE STATUS key by using the FILE STATUS clause in the FILE-CONTROL paragraph and data definitions in the DATA DIVISION:

```
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    . . .
    FILE STATUS IS file-status
```

file-status specifies the two-character COBOL file status key that you define in the WORKING-STORAGE SECTION:

```
WORKING-STORAGE SECTION.
01  file-status    PIC 99.
```

Restriction: The data item referenced in the FILE STATUS clause cannot be variably located (for example, it cannot follow a variable-length table).

RELATED TASKS
"Using file status keys" on page 161

RELATED REFERENCES
FILE STATUS clause (*COBOL for AIX Language Reference*)

Describing the structure of a file in detail

In the FILE SECTION of the DATA DIVISION, start a file description using the keyword FD and the same file-name you used in the corresponding SELECT statement in the FILE-CONTROL paragraph:

```
DATA DIVISION.
FILE SECTION.
FD  filename
01  recordname
    nn . . . fieldlength & type
    nn . . . fieldlength & type
    . . .
```

filename is also the file-name you use in the OPEN, READ, and CLOSE statements.

recordname is the name of the record used in WRITE and REWRITE statements. You can specify more than one record for a file.

fieldlength is the logical length of a field, and *type* specifies the format of a field. If you break the record description entry beyond level 01 in this manner, map each element accurately to the corresponding field in the record.

RELATED REFERENCES
Data relationships (*COBOL for AIX Language Reference*)
Level-numbers (*COBOL for AIX Language Reference*)
PICTURE clause (*COBOL for AIX Language Reference*)
USAGE clause (*COBOL for AIX Language Reference*)

Coding input and output statements for files

After you identify and describe the files in the ENVIRONMENT DIVISION and the DATA DIVISION, you can process the file records in the PROCEDURE DIVISION of your program.

Code your COBOL program according to the types of files that you use, whether sequential, line sequential, indexed, or relative. The general format for coding input and output (as shown in the example referenced below) involves opening the file, reading it, writing information into it, and then closing it.

"Example: COBOL coding for files"

RELATED TASKS
"Identifying files" on page 119
"Protecting against errors when opening files" on page 131
"Specifying a file organization and access mode" on page 131
"Setting up a field for file status" on page 135
"Describing the structure of a file in detail" on page 135
"Opening a file" on page 138
"Reading records from a file" on page 141
"Adding records to a file" on page 142
"Replacing records in a file" on page 143
"Deleting records from a file" on page 143

Example: COBOL coding for files

The general format of input-output coding is shown below. Explanations of user-supplied information (lowercase text in the example) 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    PIC 99.
    . . .
PROCEDURE DIVISION.
    . . .
    OPEN iomode filename    (9)
    . . .
    READ filename
    . . .
    WRITE recordname
    . . .
    CLOSE filename
    . . .
  STOP RUN.
```

(1) ***filename***

Any valid COBOL name. You must use the same file-name in the SELECT and FD statements, and in the OPEN, READ, START, DELETE, and CLOSE statements. This name is not necessarily the actual name of the file as known to the system. Each file requires its own SELECT, FD, and input-output statements. For WRITE and REWRITE, you specify a record defined for the file.

(2) ***assignment-name***

You can code ASSIGN TO *assignment-name* to specify the target file-system ID and the file-name as it is known to the system directly, or you can set a value indirectly by using an environment variable.

If you want to have the system file-name identified at OPEN time, specify ASSIGN USING *data-name*. The value of *data-name* at the time of the execution of the OPEN statement for that file is used. You can optionally precede the system file identification by the file-system type identification.

The following example illustrates how inventory-file is dynamically (by way of a MOVE statement) associated with the file /user/inventory/parts.

```
SELECT inventory-file ASSIGN USING a-file . . .
. . .
FD inventory-file . . .
. . .
77 a-file PIC X(25) VALUE SPACES.
. . .
    MOVE "/user/inventory/parts" TO a-file
    OPEN INPUT inventory-file
```

The following example illustrates how inventory-file is dynamically (by way of a MOVE statement) associated with the index file parts, and the alternate index files altpart1 and altpart2 are associated with the fully qualified DCE Cell-Relative name (/.:/Encina/sfs in this example) for the Encina server.

```
SELECT inventory-file ASSIGN USING a-file . . .
    ORGANIZATION IS INDEXED
    ACCESS MODE IS DYNAMIC
    RECORD KEY IS FILESYSFILE-KEY
    ALTERNATE RECORD KEY IS ALTKEY1
    ALTERNATE RECORD KEY IS ALTKEY2. . . .
. . .
FILE SECTION.
FD inventory-file . . .
. . .
WORKING-STORAGE SECTION.
01 a-file  PIC X(80) VALUE ' '. . . .
```

```
. . .
   MOVE "/.:/Encina/sfs/parts(/.:/Encina/sfs/parts;altpart1,/.:/
      Encina/sfs/parts;altpart2)" TO a-file
   OPEN INPUT inventory-file
```

(3) *org* Indicates the organization: `LINE SEQUENTIAL`, `SEQUENTIAL`, `INDEXED`, or `RELATIVE`. If you omit this clause, the default is `ORGANIZATION SEQUENTIAL`.

(4) *access*
Indicates the access mode, `SEQUENTIAL`, `RANDOM`, or `DYNAMIC`. If you omit this clause, the default is `ACCESS SEQUENTIAL`.

(5) *file-status*
The two-character COBOL `FILE STATUS` key.

(6) *recordname*
The name of the record used in the `WRITE` and `REWRITE` statements. You can specify more than one record for a file.

(7) *fieldlength*
The logical length of the field.

(8) *type*
Must match the record format of the file. If you break the record description entry beyond the level-01 description, map each element accurately against the record's fields.

(9) *iomode*
Specifies the open mode. If you are only reading from a file, code `INPUT`. If you are only writing to a file, code `OUTPUT` (to open a new file or write over an existing one) or `EXTEND` (to add records to the end of the file). If you are doing both, code `I-O`.

Restriction: `I-O` is not a valid parameter of `OPEN` for line-sequential files.

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`, `READ NEXT`, and `READ PREVIOUS` statements. Subsequent `READ`, `READ NEXT`, or `READ PREVIOUS` 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.

Opening a file

Before your program can use any `WRITE`, `START`, `READ`, `REWRITE`, or `DELETE` statement to process records in a file, the program must first open the file with an `OPEN` statement:

```
PROCEDURE DIVISION.
   . . .
   OPEN iomode filename
```

iomode specifies the open mode. If you are only reading from the file, code `INPUT` for the open mode. If you are only writing to the file, code `OUTPUT` (to open a new file or write over an existing one) or `EXTEND` (to add records to the end of the file) for the open mode.

To open a file that already contains records, use `OPEN INPUT`, `OPEN I-O` (not valid for line-sequential files), or `OPEN EXTEND`.

If you use `OPEN OUTPUT` for an SFS file that contains records, the COBOL run time deletes the file and then creates the file with attributes provided by COBOL. If you do not want an SFS file to be deleted, open the file by coding `OPEN I-O`.

If you open a sequential, line-sequential, or relative file as `EXTEND`, the added records are placed after the last existing record in the file. If you open an indexed file as `EXTEND`, each record that you add must have a record key that is higher than the highest record in the file.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Protecting against errors when opening files" on page 131

RELATED REFERENCES
"Valid COBOL statements for sequential files"
"Valid COBOL statements for line-sequential files"
"Valid COBOL statements for indexed and relative files" on page 140
OPEN statement (*COBOL for AIX Language Reference*)

Valid COBOL statements for sequential files

The following table shows the possible combinations of input-output statements for sequential files. The 'X' indicates that the statement can be used with the open mode shown at the top of the column.

Table 18. **Valid COBOL statements for 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

RELATED CONCEPTS
"Sequential file organization" on page 132
"Sequential access" on page 133

Valid COBOL statements for line-sequential files

The following table shows the possible combinations of input-output statements for line-sequential files. The 'X' indicates that the statement can be used with the open mode shown at the top of the column.

Table 19. **Valid COBOL statements for line-sequential files**

Access mode	COBOL statement	OPEN INPUT	OPEN OUTPUT	OPEN I-O	OPEN EXTEND
Sequential	OPEN	X	X		X
	WRITE		X		X
	START				
	READ	X			
	REWRITE				
	DELETE				
	CLOSE	X	X		X

RELATED CONCEPTS

"Line-sequential file organization" on page 132
"Sequential access" on page 133

Valid COBOL statements for indexed and relative files

The following table shows the possible combinations of input-output statements for indexed and relative files. The 'X' indicates that the statement can be used with the open mode shown at the top of the column.

Table 20. **Valid COBOL statements for indexed and relative 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
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	

RELATED CONCEPTS
“Indexed file organization” on page 133
“Relative file organization” on page 133
“Sequential access” on page 133
“Random access” on page 134
“Dynamic access” on page 134

Reading records from a file

Use the READ statement to retrieve (read) records from a file. To read a record, you must have opened the file with OPEN INPUT or OPEN I-O (OPEN I-O is not valid for line-sequential files). Check the file status key after each READ.

Records in sequential and line-sequential files can be retrieved only in the sequence in which they were written.

Records in indexed and relative record files can be retrieved sequentially (according to the ascending order of the key you are using for indexed files, or according to ascending relative record locations for relative files), randomly, or dynamically.

With dynamic access, you can switch between reading a specific record directly and reading records sequentially by using READ NEXT and READ PREVIOUS 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 or the READ PREVIOUS statements 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. When you code START followed by READ PREVIOUS, the previous record is read and the file position indicator is reset to the previous record. You can move the file position indicator randomly by using START, but all reading is done sequentially from that point.

You can continue to read records sequentially, or you can use the START statement to move the file position indicator. For example:

```
START file-name KEY IS EQUAL TO ALTERNATE-RECORD-KEY
```

When a direct READ is performed for an indexed file based on an alternate index for which duplicates exist, only the first record in the file (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 value of 02 is returned if there are more records with the same alternate key value to be read. A value of 00 is returned when the last record with that key value has been read.

RELATED CONCEPTS
“Sequential access” on page 133
“Random access” on page 134
“Dynamic access” on page 134
“File organization and access mode” on page 131

RELATED TASKS
“Opening a file” on page 138
“Using file status keys” on page 161

RELATED REFERENCES
"File position indicator" on page 138
FILE STATUS clause (*COBOL for AIX Language Reference*)

Statements used when writing records to a file

The following table shows the COBOL statements that you can use when creating or extending a file.

Table 21. **Statements used when writing records to a file**

Division	Sequential	Line sequential	Indexed	Relative
ENVIRONMENT	SELECT ASSIGN FILE STATUS ACCESS MODE	SELECT ASSIGN ORGANIZATION IS LINE SEQUENTIAL FILE STATUS ACCESS MODE	SELECT ASSIGN ORGANIZATION IS INDEXED RECORD KEY ALTERNATE RECORD KEY FILE STATUS ACCESS MODE	SELECT ASSIGN ORGANIZATION IS RELATIVE RELATIVE KEY FILE STATUS ACCESS MODE
DATA	FD entry	FD entry	FD entry	FD entry
PROCEDURE	OPEN OUTPUT OPEN EXTEND WRITE CLOSE	OPEN OUTPUT OPEN EXTEND WRITE CLOSE	OPEN OUTPUT OPEN EXTEND WRITE CLOSE	OPEN OUTPUT OPEN EXTEND WRITE CLOSE

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Specifying a file organization and access mode" on page 131
"Opening a file" on page 138
"Setting up a field for file status" on page 135
"Adding records to a file"

RELATED REFERENCES
"PROCEDURE DIVISION statements used to update files" on page 144

Adding records to a file

The COBOL WRITE statement adds a record to a file without replacing any existing records. The record to be added must not be larger than the maximum record size set when the file was defined. 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 file that has been opened with either OUTPUT or EXTEND.

Sequential and line-sequential files are always written sequentially.

For indexed files, new records must be written in ascending key sequence. If the file is opened EXTEND, the record keys of the records to be added must be higher than the highest primary record key in the file when the file was opened.

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 for which you have coded `ACCESS IS RANDOM` or `ACCESS IS DYNAMIC`, the records can be written in any order.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Specifying a file organization and access mode" on page 131
"Using file status keys" on page 161

RELATED REFERENCES
"Statements used when writing records to a file" on page 142
"PROCEDURE DIVISION statements used to update files" on page 144
FILE STATUS clause (*COBOL for AIX Language Reference*)

Replacing records in a file

To replace a record in a file, use `REWRITE` on a file that you opened as `I-O`. If you try to use `REWRITE` on a file that is not opened `I-O`, the record is not replaced and the status key is set to 49. Check the file status key after each `REWRITE` statement. Note the following about the length of the record:

- For sequential files, the length of the record you replace must be the same as the length of the original record.
- For indexed files, you can change the length of the record you replace.
- For variable-length relative files, you can change the length of the record you replace.

To replace a record randomly or dynamically, you do not have to first `READ` the record. Instead, locate the record you want to replace 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`.

You cannot open as `I-O` an extended-format data set that you allocate in the compressed format.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Opening a file" on page 138
"Using file status keys" on page 161

RELATED REFERENCES
FILE STATUS clause (*COBOL for AIX Language Reference*)

Deleting records from a file

To remove an existing record from an indexed or relative file, open the file `I-O` and use the `DELETE` statement. You cannot use `DELETE` on a sequential file or line-sequential file.

When `ACCESS IS SEQUENTIAL`, the record to be deleted must first be read by the COBOL program. The `DELETE` statement removes the record that was just read. If

the DELETE statement is not preceded by a successful READ, the record is not deleted, and the file status key value is set to 92.

When ACCESS IS RANDOM or ACCESS IS DYNAMIC, the record to be deleted need not be read by the COBOL program. To delete a record, move the key of the record to the RECORD KEY data item, and then issue the DELETE.

Check the file status key after each DELETE statement.

RELATED CONCEPTS
"File organization and access mode" on page 131

RELATED TASKS
"Opening a file" on page 138
"Reading records from a file" on page 141
"Using file status keys" on page 161

RELATED REFERENCES
FILE STATUS clause (*COBOL for AIX Language Reference*)

PROCEDURE DIVISION statements used to update files

The table below shows the statements that you can use in the PROCEDURE DIVISION for sequential, line-sequential, indexed, and relative files.

Table 22. **PROCEDURE DIVISION statements used to update files**

Access method	Sequential	Line sequential	Indexed	Relative
ACCESS IS SEQUENTIAL	OPEN EXTEND WRITE CLOSE or OPEN I-O READ REWRITE CLOSE	OPEN EXTEND WRITE CLOSE	OPEN EXTEND WRITE CLOSE or OPEN I-O READ REWRITE DELETE CLOSE	OPEN EXTEND WRITE CLOSE or OPEN I-O READ REWRITE DELETE CLOSE
ACCESS IS RANDOM	Not applicable	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	Not applicable	OPEN I-O READ NEXT READ PREVIOUS START CLOSE	OPEN I-O READ NEXT READ PREVIOUS START CLOSE
ACCESS IS DYNAMIC (random processing)	Not applicable	Not applicable	OPEN I-O READ WRITE REWRITE DELETE CLOSE	OPEN I-O READ WRITE REWRITE DELETE CLOSE

RELATED CONCEPTS

"File organization and access mode" on page 131

RELATED TASKS

"Opening a file" on page 138
"Reading records from a file" on page 141
"Adding records to a file" on page 142
"Replacing records in a file" on page 143
"Deleting records from a file" on page 143

RELATED REFERENCES

"Statements used when writing records to a file" on page 142

Chapter 9. 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.

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.

RELATED CONCEPTS
"Sort and merge process"

RELATED TASKS
"Describing the sort or merge file" on page 148
"Describing the input to sorting or merging" on page 148
"Describing the output from sorting or merging" on page 150
"Requesting the sort or merge" on page 152
"Determining whether the sort or merge was successful" on page 154
"Stopping a sort or merge operation prematurely" on page 156

RELATED REFERENCES
SORT statement (*COBOL for AIX Language Reference*)
MERGE statement (*COBOL for AIX 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.

© Copyright IBM Corp. 1995, 2004

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 (*COBOL for AIX Language Reference*)
MERGE statement (*COBOL for AIX 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.

RELATED REFERENCES
"FILE SECTION entries" on page 12

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
    RECORD CONTAINS 100 CHARACTERS.
01  Input-Record   PIC X(100).
```

RELATED TASKS

"Coding the input procedure" on page 150
"Requesting the sort or merge" on page 152

RELATED REFERENCES

"FILE SECTION entries" on page 12

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. SmplSort.
 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
     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 152

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

MOVE EXT-RECORD
  TO SORT-EXT-RECORD
PERFORM RELEASE-SORT-RECORD
. . .
RELEASE-SORT-RECORD.
  RELEASE SORT-RECORD
	PERFORM RELEASE-SORT-RECORD
	. . .
	RELEASE-SORT-RECORD.
	  RELEASE SORT-RECORD
	  FROM SORT-EXT-RECORD

RELATED REFERENCES
"Restrictions on input and output procedures" on page 151
RELEASE statement (*COBOL for AIX 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
    RECORD CONTAINS 100 CHARACTERS.
01  Output-Record   PIC X(100).
```

RELATED TASKS

"Coding the output procedure"

"Requesting the sort or merge" on page 152

RELATED REFERENCES

"FILE SECTION entries" on page 12

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.

RELATED REFERENCES

"Restrictions on input and output procedures"

RETURN statement (*COBOL for AIX Language Reference*)

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. However, the called program cannot issue a SORT or MERGE statement, and the called program must return to the caller.
- 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.

RELATED TASKS
"Coding the input procedure" on page 150
"Coding the output procedure" on page 151

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.
```

"Example: describing sort and input files for SORT" on page 149

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 154

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.

   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 if the compiler option NCOLLSEQ(BIN) is in effect. 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 D, "Complex OCCURS DEPENDING ON," on page 523

RELATED REFERENCES
"NCOLLSEQ" on page 223
SORT statement (*COBOL for AIX Language Reference*)
MERGE statement (*COBOL for AIX Language Reference*)

Choosing alternate collating sequences

You can sort or merge records in a collating sequence that you specify for single-byte character keys. The default collating sequence is the collating sequence specified by the locale setting in effect at compile time. To override the PROGRAM COLLATING SEQUENCE specified either explicitly (in the OBJECT-COMPUTER paragraph) or by default, 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.

The PROGRAM COLLATING SEQUENCE clause or the COLLATING SEQUENCE phrase applies only to keys of class alphabetic or alphanumeric.

RELATED TASKS
"Specifying the collating sequence" on page 8

RELATED REFERENCES
SORT statement (*COBOL for AIX Language Reference*)
Classes and categories of data (*COBOL for AIX 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 152

Determining whether the sort or merge was successful

The SORT or MERGE statement 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 and terminates the run unit (or the thread, in a multithreaded environment).

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.

RELATED REFERENCES
"Sort and merge error numbers"

Sort and merge error numbers

If you do not reference SORT-RETURN in your program, and the return code from a sort or merge operation is 16, COBOL for AIX issues a run-time diagnostic message that contains one of the error numbers shown in the table below.

Table 23. **Sort and merge error numbers**

Error number	Description
501	Invalid function
502	Invalid record type
503	Invalid record length
504	Type length error
505	Invalid type
506	Mismatched number of keys
507	Type is too long.
508	Invalid key offset
509	Invalid ascending or descending key
510	Invalid overlapping keys
511	No key was defined.
512	No input file was specified.
513	No output file was specified.
514	Mixed-type input files
515	Mixed-type output files

Table 23. **Sort and merge error numbers** *(continued)*

Error number	Description
516	Invalid input work buffer
517	Invalid output work buffer
518	COBOL input I/O error
519	COBOL output I/O error
520	Unsupported function
521	Invalid key
522	Invalid `USING` file
523	Invalid `GIVING` file
524	No work directory was supplied.
525	Work directory does not exist.
526	Sort common was not allocated
527	No storage for sort common
528	Binary buffer was not allocated.
529	Line-sequential file buffer was not allocated.
530	Work space allocation failed.
531	FCB allocation failed.

If you cannot determine the cause of an error, contact your IBM representative.

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 on exit from the declarative section.

Control then returns to the statement following the `SORT` or `MERGE` statement.

Chapter 10. 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:

- `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

RELATED TASKS
"Handling errors in joining and splitting strings"
"Handling errors in arithmetic operations" on page 158
"Handling errors in input and output operations" on page 159
"Handling errors when calling programs" on page 165

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)	EEEAA	EEEAA
Item-3	X(2)	EA	EA

© Copyright IBM Corp. 1995, 2004

Data item	PICTURE	Value before	Value after
Item-4	X(8)	*bbbbbbbb*[1]	*bbbbbbbb*[1]
String-ptr	9(2)	0	0
1. The symbol *b* 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

"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.

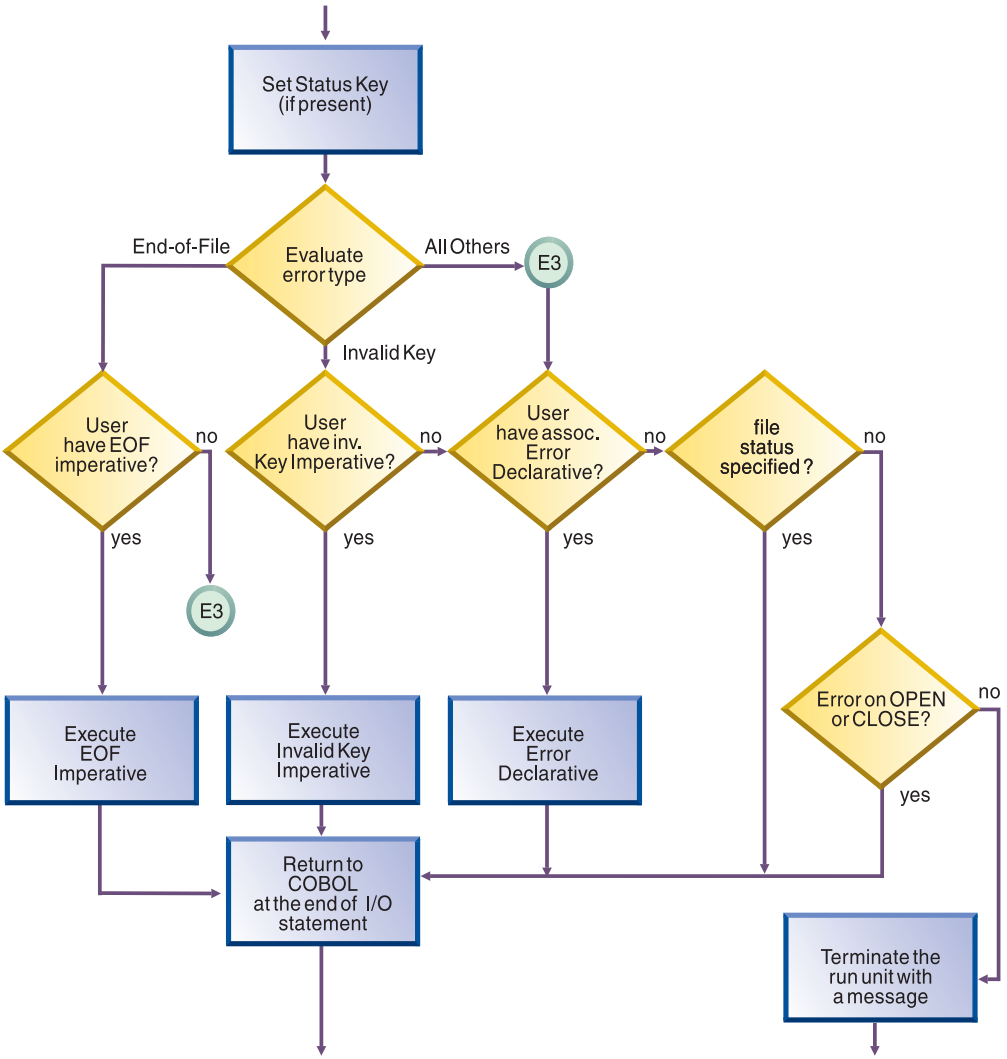
You can use any of the following techniques for intercepting and handling certain input or output errors:

- End-of-file condition (`AT END`)
- `ERROR` declarative
- File status key
- File system return code
- `INVALID KEY` phrase

To have your program continue, 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 COBOL run-time message is written and the run unit ends.

The following figure shows the flow of logic after a file-system input or output error occurs:



RELATED TASKS

"Using the end-of-file condition (AT END)"
"Coding ERROR declaratives" on page 161
"Using file status keys" on page 161
"Using file system return codes" on page 163
"Coding INVALID KEY phrases" on page 164

RELATED REFERENCES

Status key (Common processing facilities) (*COBOL for AIX 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 (*COBOL for AIX 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.

RELATED REFERENCES
EXCEPTION/ERROR declarative (*COBOL for AIX 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.

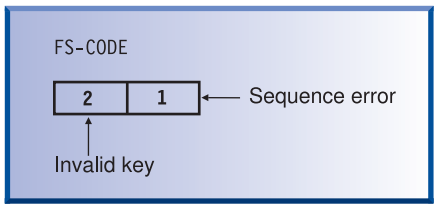
```
FILE STATUS IS data-name-1
```

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.

In addition to the file status key, you can code a second identifier in the FILE STATUS clause to get more detailed information about file system 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"
"Example: checking file system return codes" on page 163

RELATED TASKS
"Using file system return codes" on page 163

RELATED REFERENCES
File status key (Common processing facilities) (*COBOL for AIX 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 file system return codes

Often the two-character FILE STATUS code is too general to pinpoint the disposition of a request. You can get more detailed information about STL and VSAM file-system input and output requests by coding a second status area:

```
FILE STATUS IS data-name-1 data-name-2
```

The data item *data-name-1* specifies the two-character COBOL file status key. The data item *data-name-2* specifies a data item that contains the file-system return code when the COBOL file status key is not zero. *data-name-2* is at least 6 bytes long.

STL file system

If *data-name-2* is 6 bytes long, it contains the return code. If it is longer than 6 bytes, it also contains a message with further information. For example:

```
01  my-file-status-2.
    02 exception-return-value PIC 9(6).
    02 additional-info PIC X(100).
```

If you tried to open a file with a different definition than the one with which it was created, return code 39 would be returned in `exception-return-value`, and a message telling what keys you need to perform the open would be returned in `additional-info`.

VSAM file system

You must define *data-name-2* with `PICTURE X(n)` and `USAGE DISPLAY` attributes, where *n* is 6 or greater. The `PICTURE` string value represents the first *n* bytes of the VSAM reply message structure. If the size of the reply message structure, *m*, is less than *n*, only the first *m* bytes contain useful information.

"Example: checking file system return codes"

RELATED REFERENCES

"VSAM file system" on page 122
"STL file system" on page 123
VSAM File System Reply Messages

Example: checking file system return codes

This COBOL code does the following actions:

- 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 FILESYSFILE ASSIGN TO FILESYSFILE
    ORGANIZATION IS INDEXED
    ACCESS DYNAMIC
    RECORD KEY IS FILESYSFILE-KEY
    FILE STATUS IS FS-CODE, FILESYS-CODE.
DATA DIVISION.
FILE SECTION.
FD  FILESYSFILE
    RECORD  30.
01  FILESYSFILE-REC.
    10 FILESYSFILE-KEY            PIC X(6).
    10 FILLER                  PIC X(24).
WORKING-STORAGE SECTION.
01  RETURN-STATUS.
    05 FS-CODE                  PIC XX.
    05 FILESYS-CODE             PIC X(6).
PROCEDURE DIVISION.
    OPEN  INPUT FILESYSFILE.
    DISPLAY "OPEN INPUT FILESYSFILE FS-CODE: " FS-CODE.

    IF FS-CODE NOT = "00"
       PERFORM FILESYS-CODE-DISPLAY
       STOP RUN
    END-IF.

    MOVE "000005" TO FILESYSFILE-KEY.
    START FILESYSFILE KEY IS EQUAL TO FILESYSFILE-KEY.
    DISPLAY "START FILESYSFILE KEY="  FILESYSFILE-KEY
            " FS-CODE: "  FS-CODE.

    IF FS-CODE NOT = "00"
       PERFORM FILESYS-CODE-DISPLAY
    END-IF.

    IF FS-CODE = "00"
       PERFORM READ-NEXT UNTIL FS-CODE NOT = "00"
    END-IF.

    CLOSE FILESYSFILE.
    STOP RUN.

READ-NEXT.
    READ FILESYSFILE NEXT.
    DISPLAY "READ NEXT FILESYSFILE FS-CODE: " FS-CODE.
    IF FS-CODE NOT = "00"
       PERFORM FILESYS-CODE-DISPLAY
    END-IF.
    DISPLAY FILESYSFILE-REC.

FILESYS-CODE-DISPLAY.
    DISPLAY "FILESYS-CODE ==>", FILESYS-CODE.
```

Coding INVALID KEY phrases

You can include INVALID KEY phrases on READ, START, WRITE, REWRITE, and DELETE requests for 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.

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.

Part 2. Compiling, linking, running, and debugging your program

Chapter 11. Compiling, linking, and running programs 169
Setting environment variables 169
Setting environment variables in the command shell 169
Setting environment variables in a .profile file 170
Setting environment variables in a program . . 170
Precedence of environment variables 170
Compiler environment variables 170
Run-time environment variables 172
TZ environment parameter variables . . . 177
Example: setting and accessing environment variables 178
Compiling programs 178
Compiling from the command line 179
Examples: using cob2 for compiling 180
Compiling using shell scripts 180
Compiling for SFS files 180
Specifying compiler options with the PROCESS (CBL) statement 181
Modifying the default compiler configuration 182
Tailoring a configuration file 182
Stanzas in the configuration file 183
Correcting errors in your source program 184
Severity codes for compiler error messages . . 184
Generating a list of compiler error messages . . 185
Messages and listings for compiler-detected errors 185
Format of compiler error messages 186
cob2, cob2_j, cob2_r, and cob2_r4 options 186
Options that apply to compiling 186
Options that apply to linking 187
Options that apply to both compiling and linking 188
Linking programs 189
Passing options to the linker 189
Examples: using an invocation command for linking 190
Linker input and output files 191
Linker search rules 192
Linker file-name defaults 193
Correcting errors in linking. 193
Running programs 193
Redistributing COBOL for AIX library components 194

Chapter 12. Compiling, linking, and running OO applications 195
Compiling OO applications. 195
Preparing OO applications 196
Example: compiling and linking a COBOL class definition. 197
Running OO applications 197
Running OO applications that start with a main method 198
Running OO applications that start with a COBOL program 198

Chapter 13. Compiler options 199
ADATA 201
ARITH 201
BINARY 202
CALLINT 202
CHAR. 203
COLLSEQ 205
COMPILE 206
CURRENCY. 207
DATEPROC 208
DIAGTRUNC 209
DYNAM 210
ENTRYINT 210
EXIT 211
Character string formats. 212
User-exit work area 212
Parameter list for exit modules 212
Using INEXIT 213
Using LIBEXIT 214
Nested COPY statements 214
Using PRTEXIT. 215
Using ADEXIT 215
FLAG 216
FLAGSTD 217
FLOAT 218
LIB 219
LINECOUNT 220
LIST 220
LSTFILE 221
MAP 221
MAXMEM 222
NCOLLSEQ 223
NSYMBOL 223
NUMBER 224
OPTIMIZE 225
PGMNAME 226
PGMNAME(UPPER) 226
PGMNAME(MIXED) 227
PROFILE 227
QUOTE/APOST 227
SEPOBJ 228
Batch compilation 228
SEQUENCE 229
SIZE 230
SOSI 230
SOURCE 231
SPACE 232
SPILL 232
SQL 233
SSRANGE 233
TERMINAL 234

© Copyright IBM Corp. 1995, 2004

TEST 234
THREAD 235
TRUNC 236
TRUNC example 1 237
TRUNC example 2 238
VBREF 238
WSCLEAR 239
XREF 239
YEARWINDOW 240
ZWB 241

Chapter 14. Compiler-directing statements . . 243

Chapter 15. Run-time options 249
CHECK 249
DEBUG 250
ERRCOUNT 250
FILESYS 250
TRAP 251
UPSI 252

Chapter 16. Debugging 253
Debugging with source language 253
Tracing program logic 253
Finding and handling input-output errors . . . 254
Validating data 255
Finding uninitialized data 255
Generating information about procedures . . . 255
Debugging lines 255
Debugging statements 255
Example: USE FOR DEBUGGING 256
Debugging using compiler options 257
Finding coding errors 258
Checking syntax only. 258
Compiling conditionally 258
Finding line sequence problems 258
Checking for valid ranges 258
Selecting the level of error to be diagnosed . . 259
Example: embedded messages. 260
Finding program entity definitions and references 261
Listing data items 262
Using the debugger 262
Getting listings 263
Example: short listing 264
Example: SOURCE and NUMBER output . . . 266
Example: MAP output 266
Example: embedded map summary 267
Terms and symbols used in MAP output . . 268
Example: nested program map 269
Example: XREF output - data-name cross-references. 270
Example: XREF output - program-name cross-references. 271
Example: embedded cross-reference 271
Example: VBREF compiler output 272
Debugging with messages that have offset information 272
Debugging user exits 273
Debugging assembler routines. 273

Chapter 11. Compiling, linking, and running programs

The following sections explain how to:

- Set environment variables for the compiler and run time
- Compile programs
- Correct errors in your source program
- Link programs
- Correct errors in linking
- Run programs that have been compiled and linked
- Redistribute library components

The COBOL for AIX compiler and run-time environment support the high subset of Standard COBOL 85 functions, as do other IBM COBOL products. Although the IBM COBOL language is almost the same across platforms, some minor differences exist between Enterprise COBOL for z/OS and COBOL for AIX.

RELATED TASKS
"Setting environment variables"
"Compiling programs" on page 178
"Correcting errors in your source program" on page 184
"Linking programs" on page 189
"Correcting errors in linking" on page 193
"Running programs" on page 193
"Redistributing COBOL for AIX library components" on page 194

RELATED REFERENCES
Appendix A, "Summary of differences with host COBOL," on page 505

Setting environment variables

An *environment variable* defines some aspect of a user environment or a program environment that can vary. Environment variables are used by both the compiler and run-time library.

When you installed IBM COBOL for AIX, the installation process set environment variables to access the COBOL for AIX compiler and run-time libraries.

You use environment variables to set values that programs need. For example, you use the COBPATH environment variable to define the locations where the COBOL run time can find a program when another program dynamically calls it.

Specify the value of an environment variable by using the `export` command, as described below. If you do not set an environment variable, either a default value is applied or the variable is not defined.

Setting environment variables in the command shell

You can change the value of an environment variable by using the `export` command at the prompt in a command shell (for example, in an XTERM window). This environment variable definition applies to programs (processes or child

© Copyright IBM Corp. 1995, 2004

processes) that you run from that shell or from any of its descendants (that is, any shells called directly or indirectly from that shell).

For example, the following command sets the COBPATH environment variable (which defines the locations in which the COBOL run time locates dynamically accessed programs) to include two directories:

```
export COBPATH=/users/me/bin:/mytools/bin
```

Setting environment variables in a .profile file

You can add `export` commands to your .profile file in your home directory. If you define environment variables in the .profile file, the values of these variables are defined automatically whenever you begin an AIX session, and the values apply to all shell processes.

To compile and run a simple COBOL program, the only environment variables that need to be set are NLSPATH and LANG. These variables are usually set at installation.

Setting environment variables in a program

You can also set environment variables from within a COBOL program by using the putenv() POSIX function, and access the environment variables by using the getenv() POSIX function.

"Example: setting and accessing environment variables" on page 178

Precedence of environment variables

Some environment variables (such as COBPATH and NLSPATH) define directories in which to search for files. If multiple directory paths are listed, they are delimited by colons. Paths that are defined by environment variables are evaluated in order, from the first path to the last in the `export` statement. If multiple files that have the same name are defined in the paths of an environment variable, the *first* located copy of the file is used.

For example, directory `/abc/def` is searched before `/ghi` as a result of the following COBPATH definition:

```
export COBPATH=/abc/def:/ghi
```

RELATED TASKS

"Tailoring a configuration file" on page 182

RELATED REFERENCES

"Compiler environment variables"

"Run-time environment variables" on page 172

Compiler environment variables

The COBOL compiler uses the following environment variables.

Because COBOL words are defined to be case insensitive, all letters in COBOL words are treated as uppercase, including *library-name* and *text-name*. Thus environment variable names that correspond to such names must be uppercase. For example, the environment variable name that corresponds to `COPY MyCopy` is MYCOPY.

COBCPYEXT
Specifies the file suffixes to use in searches for copybooks when the `COPY` *name* statement does not indicate a file suffix. Specify one or more three-character file suffixes with or without leading periods. Separate multiple file suffixes with a space or comma.

If COBCPYEXT is not defined, the following suffixes are searched: CPY, CBL, COB, and the lowercase equivalents cpy, cbl, and cob.

COBLSTDIR
Specifies the directory into which the compiler listing file is written. Specify any valid path. To indicate an absolute path, specify a leading slash. Otherwise, the path is relative to the current directory. A trailing slash is optional.

If COBLSTDIR is not defined, the compiler listing is written into the current directory.

COBOPT
Specifies compiler options. To specify multiple compiler options, separate each option by a space or comma. Surround the list of options with quotation marks if the list contains blanks or characters that are significant to the AIX command shell. For example:

```
export COBOPT="TRUNC(OPT) TERMINAL"
```

Default values apply to individual compiler options.

DB2DBDFT
Specifies the database for compiling programs that have embedded SQL statements.

library-name
If you specify *library-name* as a user-defined word, the name is used as an environment variable, and the value of the environment variable is used as the path to locate the copybook.

If you do not specify a library-name, the compiler searches the library paths in the following order:

1. Current directory
2. Paths specified by the `-I`*xxx* option, if set
3. Paths specified by the SYSLIB environment variable

The search ends when the file is found.

For more details, see the documentation of the `COPY` statement in the related reference below about compiler-directing statements.

SYSLIB
Specifies paths to be used for COBOL `COPY` statements that have text-names that are unqualified by library-names. It also specifies paths to be used for `SQL INCLUDE` statements.

text-name
If you specify *text-name* as a user-defined word, the name is used as an environment variable, and the value of the environment variable is used as the file-name and possibly the path name of the copybook.

To specify multiple path names, delimit them with a colon (:) or a semicolon (;).

For more details, see the documentation of the `COPY` statement in the related reference below about compiler-directing statements.

RELATED CONCEPTS
"DB2 coprocessor" on page 277

RELATED TASKS
"Coding SQL statements" on page 278

RELATED REFERENCES
Chapter 14, "Compiler-directing statements," on page 243
Chapter 13, "Compiler options," on page 199
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186

Run-time environment variables

The COBOL run-time library uses the following environment variables:

assignment-name
Any COBOL file that you want to specify in an `ASSIGN` clause. This use of *assignment-name* follows the rules for a COBOL word. For example:

```
export OUTPUTFILE=january.car_results
```

If you make an assignment to a user-defined word that is not set as an environment variable, the assignment is made to a file that has the literal name of the user-defined word (`OUTPUTFILE` in the example below). If the assignment is valid, this file is written to the current directory.

After you set an assignment-name, you can use that environment variable as a COBOL user-defined word in an `ASSIGN` clause.

Based on the previous `export` statement, a COBOL source program could include the following `SELECT` and `ASSIGN` clause:

```
SELECT CARPOOL ASSIGN TO OUTPUTFILE
```

Because `OUTPUTFILE` is defined in an environment variable, this statement results in data being written to the file january.car_results.

You can use `ASSIGN` to specify a file stored in an alternate file system such as the Standard language file system (STL), record sequential delimited file system (RSD), or VSAM.

CLASSPATH
Specifies directory paths of Java(TM) .class files required for an OO application.

COBJVMINITOPTIONS
Specifies Java virtual machine (JVM) options used when COBOL initializes a JVM.

COBMSGS
Specifies the name of a file to which run-time error messages will be written.

To capture run-time error messages in a file, use the `export` command to set COBMSGS to a file-name. If your program has a run-time error that terminates the application, the file that COBMSGS is set to will contain an error message that indicates the reason for termination.

If COBMSGS is not set, error messages are written to the terminal.

COBPATH

Specifies the directory paths to be used by the COBOL run time to locate dynamically accessed programs such as shared libraries.

This variable must be set to run programs that require dynamic loading. For example:

```
export COBPATH=/pgmpath/pgmshlib
```

COBRTOPT

Specifies the COBOL run-time options.

Separate run-time options by a comma or a colon. Use parentheses or equal signs (=) as the delimiter for suboptions. Options are not case sensitive. For example, the following two commands are equivalent:

```
export COBRTOPT="check(ON),UPSI(00000000)"
export COBRTOPT='CHECK=on:UPSI=00000000"
```

The defaults for individual run-time options apply. For details, see the related reference below about run-time options.

EBCDIC_CODEPAGE

Specifies an EBCDIC code page applicable to the EBCDIC data processed by programs compiled with the `CHAR(EBCDIC)` or `CHAR(S390)` compiler option.

To set the EBCDIC code page, issue the following command, where *codepage* is the name of the code page to be used:

```
export EBCDIC_CODEPAGE=codepage
```

If EBCDIC_CODEPAGE is not set, the default EBCDIC code page is selected based on the current locale, as described in the related reference below about the locales and code pages supported. When the `CHAR(EBCDIC)` compiler option is in effect and multiple EBCDIC code pages are applicable to the locale in effect, you must set the EBCDIC_CODEPAGE environment variable unless the default EBCDIC code page for the locale is acceptable.

ENCINA_CDS_ROOT

Specifies the Encina SFS server name. For example:

```
export ENCINA_CDS_ROOT=/.:/cics/sfs/test1
```

ENCINA_SFS_DATA_VOLUME

Specifies the name of the SFS data volume on which SFS files are to be created. For example:

```
export ENCINA_SFS_DATA_VOLUME=sfs_SFS_SERV
```

This data volume must have been defined to the SFS server that your application accesses.

If this variable is not set, the default name encinaSfsVol is used.

ENCINA_SFS_INDEX_VOLUME

Specifies the name of the SFS data volume on which alternate index files are to be created. For example:

```
export ENCINA_SFS_INDEX_VOLUME=sfs_SFS_SERV
```

This data volume must have been defined to the SFS server that your application accesses.

If this variable is not set, alternate index files are created on the same data volume as the corresponding base index files.

ENCINA_VSAM_AUTO_FLUSH
Specifies whether all changes to Encina SFS files for each input-output operation are committed to disk before control is returned to the application (that is, whether the *operational force* feature of SFS is enabled). You can improve the performance of applications that use SFS files by specifying `OFF` for this environment variable. For example:

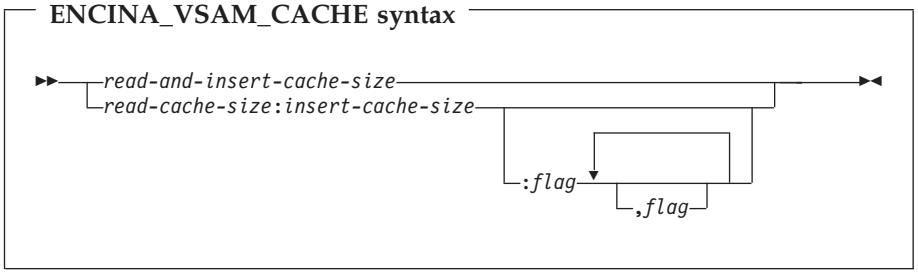
```
export ENCINA_VSAM_AUTO_FLUSH=OFF
```

When this environment variable is set to `OFF`, SFS uses a *lazy-write* strategy; that is, changes to SFS files might not be committed to disk until the files are closed.

If SFS client-side caching is in effect (that is, environment variable ENCINA_VSAM_CACHE is set to a valid nonzero value), the setting of ENCINA_VSAM_AUTO_FLUSH is ignored. Operational force is disabled.

If SFS client-side caching is not in effect, the value of ENCINA_VSAM_AUTO_FLUSH defaults to `ON`.

ENCINA_VSAM_CACHE
Specifies whether *client-side caching* is enabled for SFS files. You can improve the performance of applications that use SFS files by enabling client-side caching.



Size units are in numbers of pages. A size of zero indicates that caching is disabled. The possible flags are:

ALLOW_DIRTY_READS
Removes the restriction for read caching that the files being accessed must be locked.

INSERTS_DESPITE_UNIQUE_INDICES
Removes the restriction for insert caching that inserts are cached only if all active indices for clustered files and all active alternate indices for entry-sequenced and relative files allow duplicates.

For example, the following command sets the read-cache size to 16 pages and the insert-cache size to 64 pages. It also enables dirty reads and enables inserts despite unique indices:

```
export ENCINA_VSAM_CACHE=16:64:ALLOW_DIRTY_READS, \
    INSERTS_DESPITE_UNIQUE_INDICES
```

By default, client-side caching is not enabled.

LANG
Specifies the locale (as described in the related task about how locale is determined). LANG also influences the value of the NLSPATH environment variable as described below.

For example, the following command sets the language locale name to U.S. English:

```
export LANG=en_US
```

LC_ALL
Specifies the locale. A locale setting that uses LC_ALL overrides any setting that uses LANG or any other LC_*xx* environment variable (as discussed in the related task about how locale is determined).

LC_COLLATE
Specifies the collation behavior for the locale. This setting is overridden if LC_ALL if specified.

LC_CTYPE
Specifies the code page for the locale. This setting is overridden if LC_ALL if specified.

LC_MESSAGES
Specifies the language for messages for the locale. This setting is overridden if LC_ALL if specified.

LC_TIME
Determines the locale for date and time formatting information. This setting is overridden if LC_ALL if specified.

LIBPATH
Specifies the full path name for the COBOL run-time library. The default is set at installation.

LOCPATH
Specifies the search path where the locale information database exists. The path is a colon-separated list of directory names.

LOCPATH is used for any operations that are sensitive to the locale, including locale-sensitive comparisons of alphanumeric data items.

NLSPATH
Specifies the full path name of message catalogs and help files. NLSPATH must always be set, and is given an initial value of `usr/lib/nls/msg/%L/%N:/usr/lib/nls/msg/%L/%N.cat` during installation. `%L` is substituted by the value specified by the LANG environment variable. `%N` is substituted by the message catalog name used by COBOL.

COBOL for AIX installation puts the messages in usr/lib/nls/msg/*xx*, where *xx* is any language that COBOL for AIX supports. The default is en_US.

When you set NLSPATH, be sure to add to NLSPATH rather than replace it. Other programs might use this environment variable. For example:

```
DIR=xxxx
nlspath=$DIR/%L/%N:$NLSPATH
export NLSPATH
```

xxxx is the directory where COBOL was installed. The directory *xxxx* must contain a directory *xxxx*/en_US (in the case of a U.S. English language setup) that contains the COBOL message catalog.

Messages in the following languages are included with the product:

en_US English

ja_JP, Ja_JP
Japanese

You can specify the languages for the messages and for the locale setting differently. For example, you can set the environment variable LANG to `en_US` and set the environment variable LC_ALL to `ja_JP.IBM-eucJP`. In this example, any COBOL compiler or run-time messages will be in English, whereas native ASCII (`DISPLAY` or `DISPLAY-1`) data in the program is treated as encoded in code page IBM-eucJP (ASCII Japanese code page).

The compiler uses NLSPATH to access the message catalog. If NLSPATH is not set correctly, a terminating error message indicates that the message catalog was not found.

The run-time also library also uses NLSPATH to access the message catalog. If NLSPATH is not set correctly, run-time messages appear in an abbreviated form.

PATH
Specifies the directory paths of executable programs.

SYSIN, SYSIPT, SYSOUT, SYSLIST, SYSLST, CONSOLE, SYSPUNCH, SYSPCH
These COBOL environment names are used as the environment variable names that correspond to the mnemonic names used in `ACCEPT` and `DISPLAY` statements.

If the environment variable is not set, by default SYSIN and SYSIPT are directed to the logical input device (keyboard). SYSOUT, SYSLIST, SYSLST, and CONSOLE are directed to the system logical output device (screen). SYSPUNCH and SYSPCH are not assigned a default value and are not valid unless you explicitly define them.

For example, the following command defines `CONSOLE`:

```
export CONSOLE=/users/mypath/myfile
```

CONSOLE could then be used in conjunction with the following source code:

```
SPECIAL-NAMES.
    CONSOLE IS terminal
    . . .
    DISPLAY 'Hello World' UPON terminal
```

TMP Specifies the location of temporary work files (if needed) for `SORT` and `MERGE` functions. The defaults vary and are set by the sort utility installation program.

For example:

```
export TMP=/tmp
```

TZ Describes the time-zone information to be used by the locale. TZ has the following format:

```
export TZ=SSS[+|-]nDDD[,sm,sw,sd,st,em,ew,ed,et,shift]
```

When TZ is not present, the default is EST5EDT, the default locale value. When only the standard time zone is specified, the default value of *n* (difference in hours from GMT) is 0 instead of 5.

If you supply values for any of *sm*, *sw*, *sd*, *st*, *em*, *ew*, *ed*, *et*, or *shift*, you must supply values for all of them. If any of these values is not valid, the entire statement is considered invalid and the time-zone information is not changed.

For example, the following statement sets the standard time zone to CST, sets the daylight savings time to CDT, and sets a difference of six hours between CST and UTC. It does not set any values for the start and end of daylight savings time.

```
export TZ=CST6CDT
```

Other possible values are PST8PDT for Pacific United States and MST7MDT for Mountain United States.

RELATED TASKS

"How locale is determined" on page 108
"Identifying files" on page 119
"Enabling COBOL applications to access SFS files" on page 126
"Improving SFS performance" on page 129

RELATED REFERENCES

"Locales and code pages supported" on page 112
"TZ environment parameter variables"
"CHAR" on page 203
Chapter 15, "Run-time options," on page 249

TZ environment parameter variables

The values for the TZ variable are defined below.

Table 24. **TZ environment parameter variables**

Variable	Description	Default value
SSS	Standard time-zone identifier. This must be three characters, must begin with a letter, and can contain spaces.	EST
n	Difference (in hours) between the standard time zone and coordinated universal time (UTC), formerly called Greenwich mean time (GMT). A positive number denotes time zones west of the Greenwich meridian. A negative number denotes time zones east of the Greenwich meridian.	5
DDD	Daylight saving time (DST) zone identifier. This must be three characters, must begin with a letter, and can contain spaces.	EDT
sm	Starting month (1 to 12) of DST	4
sw	Starting week (-4 to 4) of DST	1
sd	Starting day of DST: 0 to 6 if *sw* is not zero; 1 to 31 if *sw* is zero	0
st	Starting time (in seconds) of DST	3600
em	Ending month (1 to 12) of DST	10
ew	Ending week (-4 to 4) of DST	-1
ed	Ending day of DST: 0 to 6 if *ew* is not zero; 1 to 31 if *ew* is zero	0
et	Ending time (in seconds) of DST	7200
shift	Amount of time change (in seconds)	3600

Example: setting and 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=ABCDEFG".
 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 ABCDEFG
     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.
```

Compiling programs

There are several ways to specify the options used to compile your programs:

- Set the COBOPT environment variable from the command line.
- Specify compiler options as options to the cob2, cob2_j, cob2_r, or cob2_r4 command. These commands can be used on the command line, in a shell script, or in a makefile.
- Use PROCESS (CBL) or *CONTROL statements.

An option that you specify by using PROCESS overrides every other option specification, except for nonoverridable options that are selected during product installation.

RELATED TASKS

"Compiling from the command line" on page 179
"Compiling using shell scripts" on page 180

"Compiling for SFS files" on page 180
"Specifying compiler options with the PROCESS (CBL) statement" on page 181
"Modifying the default compiler configuration" on page 182
Chapter 24, "Porting applications between platforms," on page 397

RELATED REFERENCES

"Compiler environment variables" on page 170
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
Chapter 13, "Compiler options," on page 199
Appendix A, "Summary of differences with host COBOL," on page 505

Compiling from the command line

To compile your COBOL program from the command line, issue one of the following commands depending on the type of program that you are compiling:

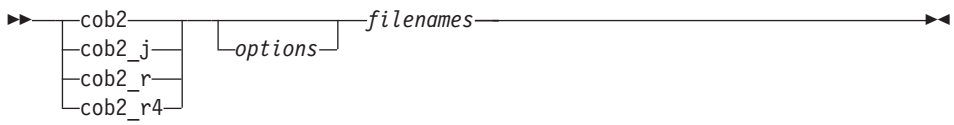
- `cob2_j` for object-oriented client programs and class definitions
- `cob2_r4` for applications that use the SFS file system
- `cob2_r` for:
  - Non-CICS applications that you compile with the `THREAD` compiler option.
  - CICS applications. Compile them with the `NOTHREAD` compiler option (the default).
- `cob2` otherwise

When you compile by using the `cob2_j` or `cob2_r4` command, the `THREAD` compiler option is automatically included as a default invocation option.

Each command also invokes the linker. The four commands accept compiler and linker options in any order on the command line. (For details about which libraries are linked when you use the four commands above, see the related task about linking programs.)

To compile multiple files, specify the file-names at any position in the command line, using spaces to separate options and file-names.

cob2 command syntax



For example, the following two commands are equivalent:

```
cob2 -g -qlib filea.cbl fileb.cbl -qflag(w)
cob2 filea.cbl -g -qflag(w) fileb.cbl -qlib
```

Any options that you specify apply to all files on the command line.

Only files with certain suffixes (such as .cbl) are passed to the compiler. All other files are passed to the linker.

The default location for compiler input and output is the current directory.

"Examples: using cob2 for compiling"

RELATED TASKS
"Modifying the default compiler configuration" on page 182
"Linking programs" on page 189

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
Chapter 13, "Compiler options," on page 199

Examples: using cob2 for compiling

The following examples show the output produced for specific cob2 specifications.

Table 25. **Output from the cob2 command**

To compile:	Enter:	These files are produced:
alpha.cbl	`cob2 -c alpha.cbl`	alpha.o
alpha.cbl and beta.cbl	`cob2 -c alpha.cbl beta.cbl`	alpha.o, beta.o
alpha.cbl with the LIST and ADATA options	`cob2 -qlist,adata alpha.cbl`	alpha.wlist, alpha.o[1], alpha.lst, alpha.adt, and a.out
1. If the linking is successful, this file is deleted.		

RELATED TASKS
"Compiling from the command line" on page 179

RELATED REFERENCES
"ADATA" on page 201
"LIST" on page 220

Compiling using shell scripts

You can use a shell script to automate your cob2, cob2_j, cob2_r, or cob2_r4 tasks. To prevent invalid syntax from being passed to the command, however, observe the following rules:

- Use an equal sign and colon rather than parentheses to delimit compiler suboptions.
- Use underscores rather than single quotation marks to delimit compiler suboptions.
- Do not use any blanks in the option string unless you enclose the string in quotation marks ("").

Table 26. **Examples of compiler-option syntax in a shell script**

Use in shell script	Use on command line
`-qFLOAT=NATIVE:,CHAR=NATIVE:`	`-qFLOAT(NATIVE),CHAR(NATIVE)`
`-qEXIT=INEXIT=_String_,MYMODULE::`	`-qEXIT(INEXIT('String',MYMODULE))`

Compiling for SFS files

When you use the SFS file system, compile your programs by using the cob2_r4 command, as in:

```
cob2_r4 alpha.cbl
```

When you compile by using the cob2_r4 command, the THREAD compiler option is automatically included as a default invocation option.

The cob2_r4 command also links the DCE threaded libraries that Encina needs. You can use the -# option to see which libraries are linked, as in:

```
cob2_r4 -# alpha.o
```

RELATED TASKS

"Enabling COBOL applications to access SFS files" on page 126

RELATED REFERENCES

"SFS file system" on page 122
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"THREAD" on page 235

Specifying compiler options with the PROCESS (CBL) statement

You can code compiler options in the PROCESS statement in your COBOL source programs.

CBL/PROCESS statement syntax



Code 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 by using 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.

RELATED REFERENCES

CBL (PROCESS) statement (*COBOL for AIX Language Reference*)

Modifying the default compiler configuration

The default options used by cob2 are obtained from the configuration file, which is by default /etc/cob2.cfg.

You can display the options used by the cob2 (or cob2_j, cob2_r, or cob2_r4) command by specifying the -# option on the command. If you are using the default configuration file, the command cob2 -# abc.cbl displays:

```
exec: /usr/lpp/cobol/bin/IGYCCOB2 abc.cbl
exec: /usr/bin/ld -bpT:0x10000000 -bpD:0x20000000 -bhalt:5 /lib/crt0.o abc.o
 -lcob2s -L/usr/lpp/cobol/lib -lsmrtlite -lC128 -lC -lc -lm
```

If you edit or display /etc/cob2.cfg (using the cat command), you see:

```
DEFLT: compiler1 = /usr/lpp/cobol/bin/IGYCCOB2
```

This is the line that specifies the COBOL compiler to use. Other lines in the file specify the linker and various options.

You can modify the cob2.cfg configuration file, for example to change the default options or the location of the compiler and libraries.

For example, the cob2_j stanza of cob2.cfg specifies the Java library-names. You might need to update the Java library-names to indicate the release level of Java that you are using.

Instead of modifying the default configuration file, you can tailor a copy of the file for your purposes.

RELATED TASKS
"Tailoring a configuration file"

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"Stanzas in the configuration file" on page 183

Tailoring a configuration file

You can tailor your compilation by:

1. Making a copy of the default compiler configuration file /etc/cob2.cfg
2. Changing your copy to support specific compilation requirements or other COBOL compilation environments
3. Using your copy instead of /etc/cob2.cfg

   To selectively use a tailored copy of the configuration file for a specific compilation, issue the cob2 (or cob2_j, cob2_r, or cob2_r4) command with the -F option. For example, to use /u/myhome/myconfig.cfg instead of /etc/cob2.cfg as the configuration file to compile myfile.cbl, issue the command:

   ```
   cob2 myfile.cbl -F/u/myhome/myconfig.cfg
   ```

If you tailor the configuration file, you can issue the cob2 command with the -# option to display the effect of your changes.

In /etc/cob2.cfg there are sections that begin cob2:, cob2_j:, cob2_r:, and cob2_r4:. These sections are called *stanzas*. You can list these stanzas by using the command ls /usr/bin/cob2*. When you do so, you see /usr/bin/cob2, /usr/bin/cob2_j, and so on. The files /usr/bin/cob2_j, /usr/bin/cob2_r, and

/usr/bin/cob2_r4 are linked to /usr/bin/cob2. Commands cob2 and cob2_j (and so on) execute the same module; however, cob2 uses the cob2 stanza and cob2_j uses the cob2_j stanza.

You can add your own stanza, for example mycob2, and use it by specifying it with the -F option:

```
cob2 myfile.cbl -F/u/myhome/myconfig.cfg:mycob2
```

Or you can define a mycob2 command:

```
ln -s /usr/bin/cob2 /u/myhome/mycob2
mycob2 myfile.cbl -F/u/myhome/myconfig
```

Or you can add mycob2 to /etc/cob2.cfg:

```
ln -s /usr/bin/cob2 mycob2
mycob2 myfile.cbl
```

Note that whatever directory you name in the ln command (such as /u/myhome above) must be in your PATH environment variable.

For a list of the attributes in each stanza, see the related reference below about stanzas. You can change any of the items. For example, to add a library to the list of libraries used by the linker, change the runlib2 attribute.

RELATED TASKS

"Setting environment variables" on page 169

RELATED REFERENCES

"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"Stanzas in the configuration file"

Stanzas in the configuration file

A stanza in the configuration file can contain any of the following attributes:

Table 27. **Stanza attributes**

Attribute	Description
compiler1	Path name of the COBOL compiler component. The default for cob2 is /usr/lpp/cobol/bin/IGYCCOB2.
crt	Path name of the object file passed as the first parameter to the linker. If you do not specify either the -p or -pg option, the value of crt is used. The default is /lib/crt0.o.
gcrt	Path name of the object file passed as the first parameter to the linker. If you specify the -pg option, the value of gcrt is used. The default is /lib/gcrt0.o.
ld	Path name to be used to link COBOL programs. The default is /usr/bin/ld.
ldflags	A string of option flags, separated by commas, to be passed to the linker.
mcrt	Path name of the object file passed as the first parameter to the linker, if you specified the -p option. The default is /lib/mcrt0.o.
proflibs	Profiling libraries used by the linker, separated by commas. The default is -l/lib/profiled, -l/usr/lib/profiled.
runlib1	A library option, followed by runlib2, that the compiler passes as a parameter to the linker to specify the COBOL main library for linking for both profiling and nonprofiling. The default is -lcob2s.

Table 27. **Stanza attributes** *(continued)*

Attribute	Description
runlib2	Libraries used by the linker, separated by commas; used for both profiling and nonprofiling. The default is -lsmrtlite, -lC128, -lC, -lc, lm.
use	Stanza from which attributes are taken, in addition to the local stanza. For single-valued attributes, values in the `use` stanza apply if no value is provided in the local, or default, stanza. For comma-separated lists, the values from the `use` stanza are added to the values from the local stanza.

RELATED TASKS
"Modifying the default compiler configuration" on page 182
"Tailoring a configuration file" on page 182

Correcting errors in your source program

Messages about source-code errors indicate where the error occurred (`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. You can leave a warning-level or informational-level message in a program without much risk, and you might decide that the recoding and compilation that are 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 or listing. If the message occurs for a program that has many S-level syntax errors, correct those errors and compile the program again. You can also resolve job set-up problems 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 setup is correct and you have corrected the S-level syntax errors, you need to contact IBM to investigate other U-level errors.

After correcting the errors in your source program, recompile the program. If this second compilation is successful, proceed 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 185
"Linking programs" on page 189

RELATED REFERENCES
"Messages and listings for compiler-detected errors" on page 185

Severity codes for compiler error messages

Errors the compiler can detect fall into the following five categories of severity:

Table 28. **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 runs correctly.
Warning (W) (return code=4)	To indicate a possible error. The program probably runs 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 run 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.

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.

RELATED REFERENCES
"Messages and listings for compiler-detected errors"
"Format of compiler error messages" on page 186

Messages and listings for compiler-detected errors

As the compiler processes your source program, it checks for COBOL language errors. For each error found, the compiler issues a message. These messages are collated in the compiler listing (subject to the `FLAG` option).

The compiler listing file has the same name as the compiler source file, but with the suffix .lst. For example, the compiler listing for myfile.cbl would be myfile.lst. The listing file is written to the directory from which the `cob2` (or `cob2_j`, `cob2_r`, or `cob2_r4`) command was issued.

Each message in the listing provides 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, and `BASIS`, `COPY`, or `REPLACE` statements are displayed near the top of the 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 the listing.

RELATED TASKS
"Correcting errors in your source program" on page 184
"Generating a list of compiler error messages" on page 185

RELATED REFERENCES
"Format of compiler error messages"
"Severity codes for compiler error messages" on page 184
"FLAG" on page 216

Format of compiler error messages

Each message issued by the compiler has the following form:

nnnnnn IGY*ppxxxx*-*l* *message-text*

nnnnnn
The number of the source statement of the last line that 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" on page 184
"FLAG" on page 216

cob2, cob2_j, cob2_r, and cob2_r4 options

The options listed below apply to all of the invocation commands: cob2, cob2_j, cob2_r, and cob2_r4.

Options that apply to compiling

-c Compiles programs but does not link them.

-comprc_ok=*n*

Controls the behavior upon return from the compiler. If the return code is less than or equal to *n*, the command continues to the link step, or in the compile-only case, exits with a zero return code. If the return code generated by the compiler is greater than *n*, the command exits with the same return code returned by the compiler.

The default is `-comprc_ok=4`.

-host Sets the compiler options for host COBOL data representations and language semantics:

- `CHAR(EBCDIC)`
- `COLLSEQ(EBCDIC)`
- `NCOLLSEQ(BIN)`
- `FLOAT(S390)`

The `-host` option changes the format of COBOL program command-line arguments from an array of pointers to an EBCDIC character string that has a halfword prefix that contains the string length. For additional information, see the related task below about using command-line arguments.

If you use the `-host` option and want a main routine in a C or PL/I object file to be the main entry point of your application, you must use the `-cmain` option as described below.

-I*xxx* Adds path *xxx* to the directories to be searched for copybooks if neither a library-name nor SYSLIB is specified. (This option is the uppercase letter *I*, not the lowercase letter *l*.)

Only a single path is allowed for each `-I` option. To add multiple paths, use multiple `-I` options. Do not insert spaces between `-I` and *xxx*.

If you use the `COPY` statement, you must ensure that the `LIB` compiler option is in effect.

-q*xxx* Passes options to the compiler, where *xxx* is any compiler option or set of compiler options. Do not insert spaces between `-q` and *xxx*.

If a parenthesis is part of the compiler option or suboption, or if a series of options is specified, include them in quotation marks.

To specify multiple options, delimit each option by a blank or comma. For example, the following two option strings are equivalent:

```
-qoptiona,optionb
-q"optiona optionb"
```

Options that apply to linking

-cmain

(Has an effect only if you also specify `-host`.) Makes a C or PL/I object file that contains a main routine the main entry point in the executable file. In C, a main routine is identified by the function name main(). In PL/I, a main routine is identified by the `PROC OPTIONS(MAIN)` statement.

If you link a C or PL/I object file that contains a main routine with one or more COBOL object files, you must use `-cmain` to designate the C or PL/I routine as the main entry point. A COBOL program cannot be the main

entry point in an executable file that contains a C or PL/I main routine. Unpredictable behavior occurs if this is attempted, and no diagnostics are issued.

-main:*xxx*
Makes *xxx* the first file in the list of files passed to the linker. The purpose of this option is to make the specified file the main program in the executable file. *xxx* must uniquely identify the object file or the archive library, and the suffix must be either .o or .a, respectively.

If `-main` is not specified, the first object, archive library, or source file specified in the command is the first file in the list of files passed to the linker.

If the syntax of `-main:`*xxx* is invalid, or if *xxx* is not the name of an object or source file processed by the command, the command terminates.

-o *xxx*
Names the object module *xxx*, where *xxx* is any name. If the `-o` option is not used, the name of the object module defaults to a.out.

-p Instructs the linker to set up the object file produced by the compiler for AIX profiling (command used to evaluate program performance) with minimum profiling information.

-pg Instructs the linker to set up the object file produced by the compiler for AIX graph profiling (command used to evaluate program performance) with maximum profiling information.

Options that apply to both compiling and linking

-F*xxx* Uses *xxx* as a configuration file or a stanza rather than the defaults specified in the /etc/cob2.cfg configuration file. *xxx* is one of the following:

- *configuration_file*:*stanza*
- *configuration_file*
- :*stanza*

-g Produces symbolic information used by the debugger.

-v Displays compile and link steps, and executes them.

-# Displays compile and link steps, but does not execute them.

-?, ? Displays help for the `cob2`, `cob2_j`, `cob2_r`, or `cob2_r4` command.

RELATED TASKS
"Compiling from the command line" on page 179
"Using command-line arguments" on page 429

RELATED REFERENCES
"Compiler environment variables" on page 170
"Run-time environment variables" on page 172

Linking programs

Use the linker to link specified object files and create an executable file or a shared object.

You have a choice of ways to start the linker:

- With one of the commands `cob2_j`, `cob2_r4`, `cob2_r`, or `cob2`:

  Each of these commands calls the linker unless you specify the `-c` option.

  For details about which command to use for which type of application, see the related task about compiling from the command line.

  `cob2_j`, `cob2_r4`, and `cob2_r` link with the COBOL multithreaded libraries. Additionally, `cob2_j` links with the Java Native Interface (JNI) run-time libraries, and `cob2_r4` links with the DCE threaded library. `cob2` links with the COBOL static run-time library.

  Linking with C: The linker accepts .o files, but does not accept .c files. If you want to link C and COBOL files together, first produce .o files for the C source files by using the `xlc -c` command.
- With the `ld` command:

  You can invoke the linker explicitly with the `ld` command. However, the compiler invocation commands pass several linker options and library-names to the linker automatically. In most cases, it is better to use one of the compiler invocation commands to link-edit your .o files.
- Through a makefile:

  You can write a makefile to organize the sequence of actions (such as compiling and linking) that are required to build your program. In the makefile you can use linker statements to specify the kind of output that you want.

You can specify linker options with any these methods.

"Examples: using an invocation command for linking" on page 190

RELATED TASKS

"Passing options to the linker"
"Compiling from the command line" on page 179
Chapter 27, "Building shared libraries," on page 433

RELATED REFERENCES

"Linker input and output files" on page 191
"Linker search rules" on page 192
make command (*AIX General Programming Concepts: Writing and Debugging Programs*)

Passing options to the linker

You can specify linker options by using any of these ways:

- One of the invocation commands `cob2`, `cob2_j`, `cob2_r`, or `cob2_r4`
- The `ld` command
- Makefile statements

Any options that you specify in an invocation command that are not recognized by the command are passed to the linker.

Several invocation command options influence the linking of your program. Consult the set of options for the command for these options. See the related reference below about the `ld` command for the full set of available linker options.

The table below shows the options that you are more likely to need for your COBOL programs. Precede each option with a hyphen (-) as shown.

Table 29. **Common linker options**

Option	Purpose

`-bdynamic`
`-bshared`
`-bstatic`
	Controls the processing of `-l` options and the way that shared objects are processed

`-bexpall`	Exports all global symbols, except imported symbols, unreferenced symbols defined in archive members, and symbols beginning with an underscore (_). When you use this option, you might be able to avoid using an export file.
`-bE:`*`foo`*`.exp`	Exports the symbols that are named in the export file *foo*.exp
`-bhalt:`*`error_level`*	Specifies the maximum error level allowed before the processing of linker commands halts
`-bI:`*`foo`*`.imp`, or `-bimport:`*`foo`*`.imp`	Imports the symbols from the import file *foo*.imp
`-bloadmap:`*`name`*	Requests that a log of linker actions and messages is saved in file *name*
`-bmap:`*`name`*	Writes an address map of the output object file to file *name*
`-bmaxdata:`*`bytes`* `-bmaxstack:`*`bytes`*	Specifies the maximum amount of space to reserve for the program data segment and stack segment for programs for which the size of these regions is a constraint
`-bM:SRE`	Makes the output module a shared reentrant object
`-bnoentry`	Indicates that this object does not have a main entry point
`-bnso`	Statically links a shared object as an ordinary object file
`-brtl` `-bnortl`	Determines which algorithm is used to find libraries that you specify with the `-l` option
`-L`*`dir`*	Specifies the directory to search for libraries specified by the `-l` option (default: /usr/lib)
`-l`*`name`*	Searches the specified library-file, where *name* selects the file lib*name*.a (default: libraries listed in cob2.cfg)

"Examples: using an invocation command for linking"

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"Linker input and output files" on page 191
"Linker search rules" on page 192
ld command (*AIX Commands Reference, Volume 3*)

Examples: using an invocation command for linking

You can use any of the COBOL invocation commands to both compile and link your programs. The following examples illustrate the use of `cob2`:

- To link two files together after they are compiled, do not use the `-c` option. For example, to compile and link alpha.cbl and beta.cbl and generate a.out, enter:

  ```
  cob2 alpha.cbl beta.cbl
  ```

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 a.out.

- To link a compiled file with a library, enter:

  ```
  cob2 foo.cbl -brtl -bshared -lmylib
  ```

  This command causes the linker to search for the library libmylib.so first, and then the library libmylib.a in each directory in the search path consecutively until either is encountered.

- To use options to limit the search for a library, enter:

  ```
  cob2 foo.cbl -bdynamic -llib1 -bstatic -llib2 -brtl
  ```

  In this case, to satisfy the first library specification, the linker searches for the library liblib1.so first and then the library liblib1.a in each directory (as described in the previous example). However, at the same time the linker only searches for liblib2.a in those same libraries.

- To use `-b` linker options on the invocation command line to create statically linked object files, enter:

  ```
  cob2 -bnso -bI:/usr/lib/syscalls.exp file1.cbl file2.cbl
  ```

- To compile and link in separate steps, enter commands such as these:

  ```
  cob2 -c file1.cbl               # Produce one object file
  cob2 -c file2.cbl file3.cbl     # Or multiple object files
  cob2 file1.o file2.o file3.o    # Link with appropriate libraries
  ```

- To combine beta.cbl and gamma.cbl into a shared library object called sh_bg, enter:

  ```
  cob2 -o sh_bg beta.cbl gamma.cbl -bexpall -bM:SRE -bnoentry
  ```

  "Example: creating a sample shared library" on page 434

Linker input and output files

The linker takes object files, links them with each other and with any library files that you specify, and produces an executable output file. The executable output can be either an executable program file or a shared object.

Linker inputs:

- Options
- Object files (*.o)
- Static library files (*.a)
- Dynamic library files (*.so)
- Import files (*.imp)

Linker outputs:

- Executable file (a.out by default)
- Shared object
- Return code

Import files: *Import files* are ASCII files that identify the external symbols to resolve at run time. An import file identifies the shared object that defines the imported symbols. The system loader finds and resolves those symbols at run time. If the first line of an import file begins with `#!` (pound sign, exclamation point), you can specify the file on the command line as an ordinary input file. Otherwise, you must use the `-bI` or `-bimport` option to specify the import file.

Export files: *Export files* are ASCII files that identify external symbols that are made available for another executable object file to import. The file format of an export file is the same as the file format of an import file.

Library files: *Libraries* are files that have suffix .a or .so. To designate a library, you can specify an absolute or relative path name or use the `-l` (lowercase letter L) option in the form `-l`*name*. The last form designates file lib*name*.a, or in dynamic mode, file lib*name*.so, to be searched for in several directories. These search directories include directories that you that specify by using `-L` options, and the standard library directories /usr/lib and /lib.

Note that the environment variable LIBPATH is not used to search for libraries that you specify on the command line either explicitly (for example, `libc.a`) or by using the `-l` option (for example, `-lc`). You must use `-L`*dir* options to indicate the directories to be searched for libraries that you specified with a `-l` option.

If you specify a shared object, or an archive file that contains a shared object, with an absolute or relative path name instead of with the `-l`*Name* option, the path name is included in the import file ID string in the loader section of the output file. You can override this behavior with the `-bnoipath` option.

You can create library files by combining one or more files into a single archive file by using the AIX `ar` command.

"Example: creating a sample shared library" on page 434

RELATED TASKS
"Passing options to the linker" on page 189

RELATED REFERENCES
"Linker search rules"
"Linker file-name defaults" on page 193
ar command (*AIX Commands Reference, Volume 1*)

Linker search rules

When searching for an object (.o), library (.a), or import file (.imp), the linker looks in the following locations:

1. The directory that you specify for the file.

   If you specify a path with the file, the linker searches only that path and stops linking if the file cannot be found there.
2. The current directory, if you did not specify a path.
3. If the environment variable LIBPATH is defined, its value is used as the default library path information.

The search for files depends on several `ld` options. If you specify `-brtl`, run-time linking is enabled. When used in conjunction with either `-bdynamic` or `-bshared`, the search for libraries that you specify with the `-l` option is satisfied by the suffix .so or .a. For each directory searched, a file with the suffix .so is looked for. If it is not found, a file with the suffix .a is looked for. If neither file is found, the search continues with the next directory.

If you use libraries other than the default ones in /usr/lib, you can specify one or more `-L` options that point to the locations of the other libraries. You can also set the LIBPATH environment variable, which lets you specify a search path for libraries at run time.

If the linker cannot locate a file, it generates an error message and stops linking.

RELATED TASKS
"Passing options to the linker" on page 189

RELATED REFERENCES
"Linker file-name defaults"
AIX General Programming Concepts: Writing and Debugging Programs

Linker file-name defaults

If you do not enter a file-name, the linker assumes the default names shown in the following table:

Table 30. **Default file-names assumed by the linker**

File	Default file-name	Default suffix
Object files	None. You must enter at least one object file name.	.o
Output file	a.out	None
Map file	The base name of the output file	map
Library files	The default libraries defined in the object files. Use compiler options to define the default libraries. Any additional libraries that you specify are searched before the default libraries.	.a or .so
Import files	None. You must explicitly enter the names of import files.	.imp
Export files	None. You must explicitly enter the names of export files.	.exp

Correcting errors in linking

When you use the `PGMNAME(UPPER)` compiler option, the names of subprograms referenced in `CALL` statements are translated to uppercase. For example, the compiler translates `Call "RexxStart"` to `Call "REXXSTART"`.

This change affects the linker, which recognizes case-sensitive names. If the real name of the called program is RexxStart, the linker will not find it, and will produce an error message saying that REXXSTART is an unresolved external reference.

This type of error typically occurs when you are calling API routines supplied by another software product. If the API routines have mixed-case names, you must take both of the following actions:

- Use the `PGMNAME(MIXED)` compiler option.
- Ensure that your `CALL` statements specify the correct names, with the correct mix of uppercase and lowercase, of the API routines.

Running programs

To run a COBOL program, do the following:

1. Make sure that any needed environment variables are set.

   For example, if your program uses an environment variable name to assign a value to a system file-name, set the environment variable.
2. Run the program:

At the command line, enter the name of the executable module or run a command file that invokes the module. For example, if the command `cob2 alpha.cbl beta.cbl -o gamma` is successful, you can run the program by entering `gamma`.

3. Correct run-time errors.

   Tip: If run-time messages are abbreviated or incomplete, the environment variables LANG or NLSPATH, or both, might be incorrectly set.

   You can use the debugger to examine the state of the program at the time of the errors.

RELATED TASKS

"Setting environment variables" on page 169
Using the debugger

RELATED REFERENCES

"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"Run-time environment variables" on page 172
Appendix I, "Run-time messages," on page 635

Redistributing COBOL for AIX library components

You can redistribute COBOL for AIX library components along with a developed application. You can install the components on any number of AIX systems that are used for production deployment, along with the application. You must install a licensed copy of the full COBOL for AIX product on the AIX system that is used to develop the application that is to be redistributed. You can redistribute the following COBOL for AIX file sets without any additional licenses:

- cobol.rte
- cobol.msg.Ja_JP
- cobol.msg.ja_JP
- cobol.msg.en_US
- SdU.vsam
- SdU.sfs

You can find these files on the product CD.

Chapter 12. Compiling, linking, and running OO applications

You can compile, link, and run object-oriented (OO) applications at the command line as discussed in the related tasks below.

RELATED TASKS
"Compiling OO applications"
"Preparing OO applications" on page 196
"Running OO applications" on page 197

Compiling OO applications

When you compile OO applications, use the following commands:

- `cob2_j` to compile COBOL client programs and class definitions
- `javac` to compile Java class definitions to produce *bytecode* (suffix .class)

When you compile using the `cob2_j` command, the `THREAD` compiler option is automatically included as a default invocation option, and the Java Native Interface (JNI) libraries are included in the list of libraries passed to the linker. (You might need to update the libraries, however, for the release level of Java that you are using. See the related task about modifying the default compiler configuration.)

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_j` command or by setting the SYSLIB environment variable.

RELATED TASKS
"Setting environment variables" on page 169
"Compiling programs" on page 178
"Modifying the default compiler configuration" on page 182
"Preparing OO applications" on page 196
"Running OO applications" on page 197
"Accessing JNI services" on page 383

RELATED REFERENCES
"Compiler environment variables" on page 170
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"THREAD" on page 235

© Copyright IBM Corp. 1995, 2004

Preparing OO applications

Use the cob2_j command to link OO COBOL applications. When you link using cob2_j, thread-enabled libraries are used for linking the application.

To prepare an OO COBOL client program for execution, link the object file to create a shared library.

To prepare a COBOL class definition for execution, process the following files:

1. Link the object file to create a shared library.

   You must name the resulting shared library 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 shared library 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 shared library 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 31. **Commands for compiling and linking a class definition**

Command	Input	Output
cob2_j -c *Classname*.cbl	*Classname*.cbl	*Classname*.o *Classname*.java
cob2_j -o lib*Classname*.so -bnoentry -bexpall -bM:SRE *Classname*.o	*Classname*.o	lib*Classname*.so
javac *Classname*.java	*Classname*.java	*Classname*.class

The cob2_j command also causes the library libjava.a to be linked with the object file.

After you issue the cob2_j and javac commands successfully, you have the executable components for the program: the shared library lib*Classname*.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" on page 197

RELATED TASKS

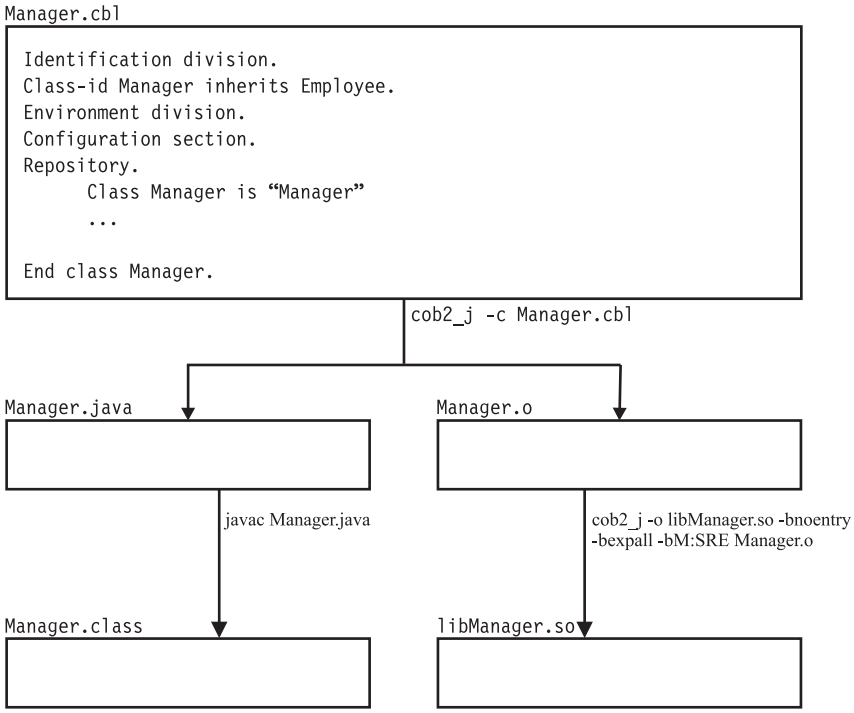
"Compiling programs" on page 178
"REPOSITORY paragraph for defining a class" on page 346
"Passing options to the linker" on page 189
Chapter 27, "Building shared libraries," on page 433

RELATED REFERENCES

"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186

Example: compiling and linking a COBOL class definition

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:



The class file Manager.class and the shared library libManager.so are the executable components of the application, and are generated in the current working directory.

RELATED TASKS

"Passing options to the linker" on page 189

Running OO applications

You can run object-oriented COBOL applications from the command line.

Specify the directory that contains the shared libraries 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.

The IBM AIX Developer Kit, Java Technology Edition, Version 1.3.1 or later is supported for running object-oriented COBOL applications.

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 32. **java command options for customizing the JVM**

Purpose	Option
To set a system property	`-D`*`name=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	`-Xms`*`value`*
To set the maximum Java heap size to *value* bytes	`-Xmx`*`value`*

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="-Xms10000000 -Xmx20000000 -verbose:gc"
```

Use blanks to separate options.

RELATED TASKS

"Running programs" on page 193
"Setting environment variables" on page 169
Chapter 22, "Writing object-oriented programs," on page 341
"Structuring OO applications" on page 379

RELATED REFERENCES

JVM options (*Persistent Reusable Java Virtual Machine User's Guide*)

Chapter 13. 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 33. **Compiler options**

Aspect of your program	Compiler option	Default	Abbreviations
Source language	"ARITH" on page 201	ARITH(COMPAT)	AR(C|E)
	"CURRENCY" on page 207	NOCURRENCY	CURR|NOCURR
	"LIB" on page 219	LIB	None
	"NSYMBOL" on page 223	NSYMBOL(NATIONAL)	NS(NAT|DBCS)
	"NUMBER" on page 224	NONUMBER	NUM|NONUM
	"QUOTE/APOST" on page 227	QUOTE	Q|APOST
	"SEQUENCE" on page 229	SEQUENCE	SEQ|NOSEQ
	"SOSI" on page 230	NOSOSI	None
	"SQL" on page 233	SQL("")	None
Date processing	"DATEPROC" on page 208	NODATEPROC, or DATEPROC(FLAG) if only DATEPROC is specified	DP|NODP
	"YEARWINDOW" on page 240	YEARWINDOW(1900)	YW
Maps and listings	"LINECOUNT" on page 220	LINECOUNT(60)	LC
	"LIST" on page 220	NOLIST	None
	"LSTFILE" on page 221	LSTFILE(LOCALE)	LST
	"MAP" on page 221	NOMAP	None
	"SOURCE" on page 231	SOURCE	S|NOS
	"SPACE" on page 232	SPACE(1)	None
	"TERMINAL" on page 234	TERMINAL	TERM|NOTERM
	"VBREF" on page 238	NOVBREF	None
	"XREF" on page 239	XREF(FULL)	X|NOX
Object module generation	"COMPILE" on page 206	NOCOMPILE(S)	C|NOC
	"OPTIMIZE" on page 225	NOOPTIMIZE	OPT|NOOPT
	"PGMNAME" on page 226	PGMNAME(UPPER)	PGMN(LU|LM)
	"SEPOBJ" on page 228	SEPOBJ	None

© Copyright IBM Corp. 1995, 2004

Table 33. **Compiler options** *(continued)*

Aspect of your program	Compiler option	Default	Abbreviations
Object code control	"BINARY" on page 202	BINARY(NATIVE)	None
	"CHAR" on page 203	CHAR(NATIVE)	None
	"COLLSEQ" on page 205	COLLSEQ(BIN)	None
	"DIAGTRUNC" on page 209	NODIAGTRUNC	DTR|NODTR
	"FLOAT" on page 218	FLOAT(NATIVE)	None
	"NCOLLSEQ" on page 223	NCOLLSEQ(BINARY)	NCS(L|BIN|B)
	"TRUNC" on page 236	TRUNC(STD)	None
	"ZWB" on page 241	ZWB	None
CALL statement behavior	"DYNAM" on page 210	NODYNAM	DYN|NODYN
Debugging and diagnostics	"FLAG" on page 216	FLAG(I,I)	F|NOF
	"FLAGSTD" on page 217	NOFLAGSTD	None
	"TEST" on page 234	NOTEST	None
	"SSRANGE" on page 233	NOSSRANGE	SSR|NOSSR
Other	"ADATA" on page 201	NOADATA	None
	"CALLINT" on page 202	CALLINT(SYSTEM,NODESC)	None
	"ENTRYINT" on page 210	ENTRYINT(SYSTEM)	None
	"EXIT" on page 211	NOEXIT	EX(INX,LIBX,PRTX, ADX)
	"MAXMEM" on page 222	MAXMEM(2000)	None
	"PROFILE" on page 227	PROFILE	None
	"SIZE" on page 230	8388608 bytes (approx. 8 MB)	SZ
	"SPILL" on page 232	SPILL(512)	None
	"THREAD" on page 235	NOTHREAD	None
	"WSCLEAR" on page 239	NOWSCLEAR	None

Installation defaults: The defaults listed with the options above are the defaults shipped with the product. They might have been changed by your installation. 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.

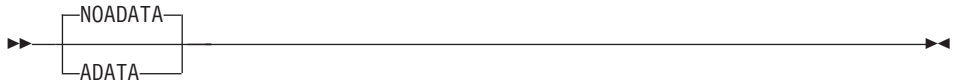
To find out the default compiler options in effect, run a test compilation without specifying any options; the output listing lists the default options specified by your installation. In some installations, certain compiler options are set up so that you cannot override them. If you have problems, see your system administrator.

Performance considerations: The CHAR, DYNAM, FLOAT, OPTIMIZE, SSRANGE, TEST, and TRUNC compiler options can all affect run-time performance.

RELATED REFERENCES
Chapter 14, "Compiler-directing statements," on page 243

ADATA

ADATA option syntax



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. This information is used by other tools, which will set ADATA ON for their use. 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
- As a command option
- As an installation default

RELATED REFERENCES
Appendix H, "COBOL SYSADATA file contents," on page 585

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 C, "Intermediate results and arithmetic precision," on page 513

BINARY

BINARY option syntax



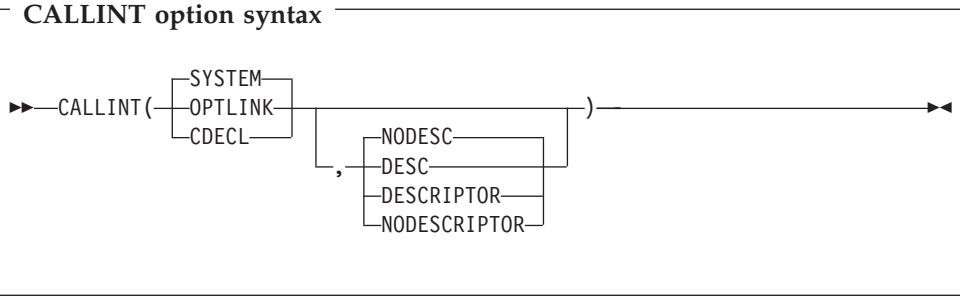
Default is: BINARY(NATIVE)

Abbreviations are: None

This option is treated as a comment.

CALLINT

CALLINT option syntax



Default is: CALLINT(SYSTEM,NODESC)

Abbreviations are: None

Use CALLINT to indicate the call interface convention applicable to calls made with the CALL statement, and to indicate whether argument descriptors are to be generated.

You can override this option for specific CALL statements by using the compiler directive >>CALLINT.

- Selecting a call interface convention:

  SYSTEM The SYSTEM suboption specifies that the call convention is that of the standard system linkage convention of the platform.

  SYSTEM is the only call interface convention supported on AIX.

  OPTLINK
  If you code the OPTLINK suboption, the compiler generates an I-level diagnostic, and the entire directive (not just the first keyword) is ignored.

  CDECL If you code the CDECL suboption, the compiler generates an I-level diagnostic, and the entire directive (not just the first keyword) is ignored.

- Specifying whether the argument descriptors are to be generated:

  DESC The DESC suboption specifies that an argument descriptor is passed for each argument on a CALL statement. For more information about argument descriptors, see the related references below.

  Attention: Do not specify the DESC suboption in object-oriented programs.

  DESCRIPTOR
  The DESCRIPTOR suboption is synonymous with the DESC suboption.

  NODESC The NODESC suboption specifies that no argument descriptors are passed for any arguments in a CALL statement.

  NODESCRIPTOR
  The NODESCRIPTOR suboption is synonymous with the NODESC suboption.

RELATED REFERENCES
Chapter 14, "Compiler-directing statements," on page 243

CHAR

CHAR option syntax



Default is: CHAR(NATIVE)

Abbreviations are: None

Specify CHAR(NATIVE) to use the native character representation (the native format) of the platform. For COBOL for AIX, the native format is defined by the code page indicated by the locale in effect at run time. The code page can be a single-byte ASCII code page or an ASCII-based multibyte code page (UTF-8, EUC, or ASCII DBCS).

CHAR(EBCDIC) and CHAR(S390) are synonymous and indicate that DISPLAY and DISPLAY-1 data items are in the character representation of zSeries, that is, in EBCDIC.

However, DISPLAY and DISPLAY-1 data items defined with the NATIVE phrase on the USAGE clause are not affected by the CHAR(EBCDIC) option. They are always stored in the native format of the platform.

The CHAR(EBCDIC) compiler option has the following effects on run-time processing:

- **USAGE DISPLAY and USAGE DISPLAY-1 items:** Characters in data items that are described with USAGE DISPLAY are treated as single-byte EBCDIC format. Characters in data items that are described with USAGE DISPLAY-1 are treated as EBCDIC DBCS format. (In the bullets that follow, the term *EBCDIC* refers to single-byte EBCDIC format for USAGE DISPLAY and to EBCDIC DBCS format for USAGE DISPLAY-1.)
  - Data that is encoded in the native format is converted to EBCDIC format on ACCEPT from the terminal.
  - EBCDIC data is converted to the native format on DISPLAY to the terminal.
  - The content of alphanumeric literals and DBCS literals is converted to EBCDIC format for assignment to data items that are encoded in EBCDIC. See the table in the related reference about the COLLSEQ option for the rules on the comparison of character data with the CHAR(EBCDIC) option in effect.
  - Editing is done with EBCDIC characters.
  - Padding is done with EBCDIC spaces. Group items that are used in alphanumeric operations (such as assignments and comparisons) are padded with single-byte EBCDIC spaces regardless of the definition of the elementary items within the group.
  - Figurative constant SPACE or SPACES used in a VALUE clause for an assignment to, or in a relation condition with, a USAGE DISPLAY item is treated as a single-byte EBCDIC space (that is, X'40').
  - Figurative constant SPACE or SPACES used in a VALUE clause for an assignment to, or in a relation condition with, a DISPLAY-1 item is treated as an EBCDIC DBCS space (that is, X'4040').
  - CLASS tests are performed based on EBCDIC value ranges.
- **USAGE DISPLAY items:**
  - The program-name in CALL *identifier*, CANCEL *identifier*, or in a format-6 SET statement is converted to the native format if the data item referenced by *identifier* is encoded in EBCDIC.
  - The file-name in the data item referenced by *data-name* in ASSIGN USING *data-name* is converted to the native format if the data item is encoded in EBCDIC.
  - The file-name in the SORT-CONTROL special register is converted to native format before being passed to a sort or merge function. (SORT-CONTROL has the implicit definition USAGE DISPLAY.)
  - Zoned decimal data (numeric PICTURE clause with USAGE DISPLAY) and external floating-point data are treated as EBCDIC format. For example, the value of PIC S9 value "1" is X'F1' instead of X'31'.
- **Group items:** Group items are treated similarly to USAGE DISPLAY items. (Note that a USAGE clause on a group item applies to the elementary items within the group and not to the group itself.)

Hexadecimal literals are assumed to represent EBCDIC characters if the literals are assigned to, or compared with, character data. For example, X'C1' compares equal to an alphanumeric item that has the value 'A'.

Figurative constants HIGH-VALUE, LOW-VALUE, SPACE or SPACES, ZERO or ZEROS, and QUOTE or QUOTES are treated logically as their EBCDIC character representations for assignments to or comparisons with data items that are encoded in EBCDIC.

In comparisons between nonnumeric DISPLAY items, the collating sequence used is the ordinal sequence of the characters based on their binary (hexadecimal) values (as modified by an alternate collating sequence for single-byte characters, if specified).

RELATED REFERENCES
Appendix B, "zSeries host data type considerations," on page 511
"COLLSEQ"

COLLSEQ

COLLSEQ option syntax



Default is: COLLSEQ(BIN)

Abbreviations are: CS(L), CS(E), CS(BIN), CS(B)

COLLSEQ specifies the collating sequence for comparison of alphanumeric operands:

- COLLSEQ(EBCDIC) uses the EBCDIC collating sequence rather than the ASCII collating sequence.
- COLLSEQ(LOCALE) uses locale-sensitive collation (consistent with the cultural conventions for collation for the locale).
- COLLSEQ(BIN) uses the hexadecimal values of the characters; the locale setting has no effect. This setting will give better run-time performance.

If you use the PROGRAM COLLATING SEQUENCE clause in your source with an alphabet-name of STANDARD-1, STANDARD-2, or EBCDIC, the COLLSEQ option is ignored. If you specify PROGRAM COLLATING SEQUENCE is NATIVE, the value of NATIVE is taken from the COLLSEQ option.

Otherwise, when the alphabet-name specified in the PROGRAM COLLATING SEQUENCE clause is defined with literals, the collating sequence used is that given by the COLLSEQ option, modified by the user-defined sequence given by the alphabet-name.

The former suboption NATIVE is deprecated. If you specify the NATIVE suboption, COLLSEQ(LOCALE) is assumed.

The following table summarizes the conversion and the collating sequence that are applicable, based on the types of data (ASCII or EBCDIC) used in a comparison

and the COLLSEQ option in effect when PROGRAM COLLATING SEQUENCE is not specified. If it is specified, the source specification has precedence over the compiler option specification. The CHAR option affects whether data is ASCII or EBCDIC.

Table 34. **Effect of comparand data type and collating sequence on comparisons**

Comparands	COLLSEQ(BIN)	COLLSEQ(LOCALE)	COLLSEQ(EBCDIC)
Both ASCII	No conversion is performed. The comparison is based on the binary value (ASCII).	No conversion is performed. The comparison is based on the current locale.	Both comparands are converted to EBCDIC. The comparison is based on the binary value (EBCDIC).
Mixed ASCII and EBCDIC	The EBCDIC comparand is converted to ASCII. The comparison is based on the binary value (ASCII).	The EBCDIC comparand is converted to ASCII. The comparison is based on the current locale.	The ASCII comparand is converted to EBCDIC. The comparison is based on the binary value (EBCDIC).
Both EBCDIC	No conversion is performed. The comparison is based on the binary value (EBCDIC).	The comparands are converted to ASCII. The comparison is based on the current locale.	No conversion is performed. The comparison is based on the binary value (EBCDIC).

RELATED REFERENCES
"CHAR" on page 203

COMPILE

COMPILE option syntax



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:

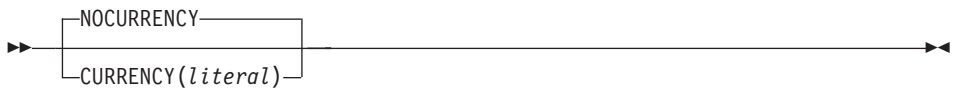
- LIST
- SSRANGE
- OPTIMIZE
- TEST

RELATED REFERENCES

"Messages and listings for compiler-detected errors" on page 185

CURRENCY

CURRENCY option syntax



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) that represents a single character. The character 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.

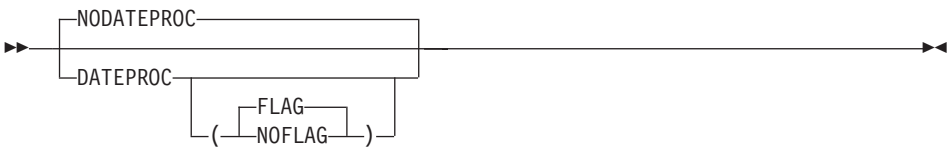
If you use both the CURRENCY option and the CURRENCY SIGN clause in a program, the CURRENCY option is ignored. Currency symbols specified in the CURRENCY SIGN clause or clauses can be used in PICTURE clauses.

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.

DATEPROC

DATEPROC option syntax



Default is: NODATEPROC, or DATEPROC(FLAG) 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.

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.

RELATED REFERENCES
"FLAG" on page 216

DIAGTRUNC

DIAGTRUNC option syntax



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.

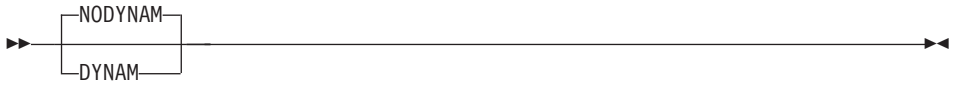
There is no diagnostic for COMP-5 receivers, nor for binary receivers when you specify the TRUNC(BIN) option.

RELATED CONCEPTS
"Formats for numeric data" on page 34
"Reference modifiers" on page 85

RELATED REFERENCES
"TRUNC" on page 236

DYNAM

DYNAM option syntax



Default is: NODYNAM

Abbreviations are: DYN|NODYN

Use DYNAM to cause nonnested, separately compiled programs invoked through the CALL *literal* statement to be loaded (for CALL) and deleted (for CANCEL) dynamically at run time. CALL *identifier* statements always result in a run-time load of the target program and are not affected by this option.

The condition for the ON EXCEPTION phrase can occur for a CALL statement that uses the literal name only when the DYNAM option is in effect.

Restriction: The DYNAM compiler option must not be used by programs that are translated by the CICS translator.

With NODYNAM, the target program name is resolved through the linker.

With the DYNAM option, this statement

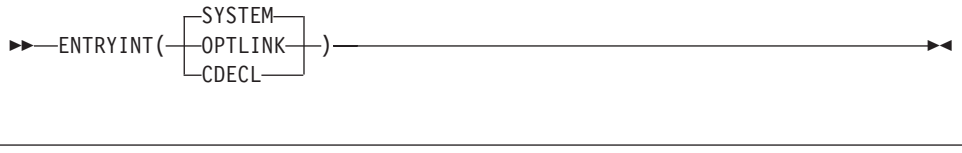
```
CALL "myprogram" . . .
```

has the identical behavior to these statements:

```
MOVE "myprogram" to id-1
CALL id-1 ...
```

ENTRYINT

ENTRYINT option syntax



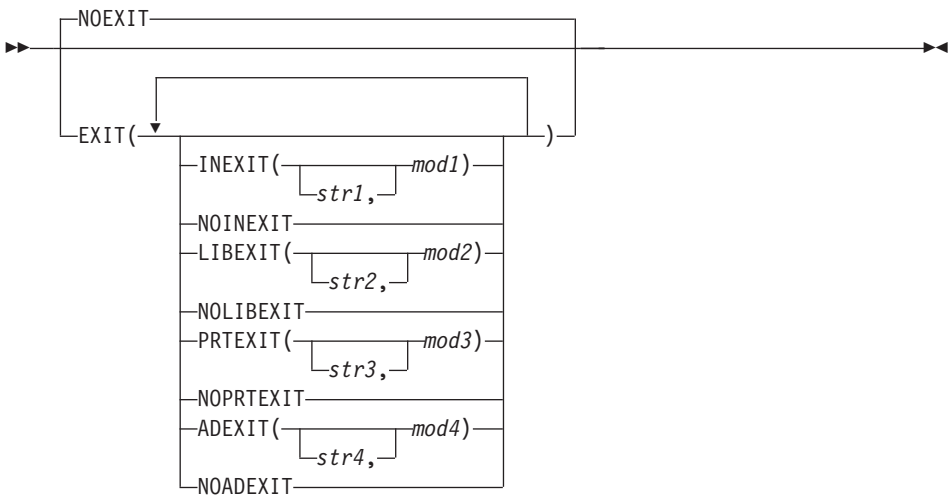
Default is: ENTRYINT(SYSTEM)

Abbreviations are: None

This option is treated as a comment.

EXIT

EXIT option syntax



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 (that is, you specify EXIT()), NOEXIT will be in effect. You can specify the suboptions in any order, separated by either commas or spaces. If you specify both the positive and negative form of a suboption (INEXIT|NOINEXT, LIBEXIT|NOLIBEXIT, PRTEXIT|NOPRTEXIT, or ADEXIT|NOADEXIT), the form specified last takes effect. If you specify the same suboption more than once, the suboption specified last takes effect.

Use the EXIT option to allow the compiler to accept user-supplied modules in place of SYSIN, SYSLIB (or copy library), and SYSPRINT. When creating your EXIT module, ensure that the module is linked as a shared library module before you run it with the COBOL compiler. EXIT modules are invoked with the system linkage convention of the platform.

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.

No PROCESS: The EXIT option cannot be specified in a PROCESS(CBL) statement. You can specify it only by using the environment variable COBOPT, as an option in the cob2 command, or at installation time.

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; if you use them, they can be up to 64 characters in length and must be enclosed in single quotation marks. Any character is allowed, but included single quotation marks must be doubled, and lowercase characters are folded to uppercase.

Character string formats

If *'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) that contains the length of the string. The table shows the location of the character string in the parameter list.

User-exit work area

When an exit is used, the compiler provides a user-exit work area that can be used to save the address of storage allocated by the exit module. This allows the module to be reentrant.

The user-exit work area is 4 fullwords, residing on a fullword boundary, that is initialized to binary zeroes 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. So, you will 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, and the PRTEXIT module uses the third word.

Parameter list for exit modules

The following table shows the format of the parameter list used by the compiler to communicate with the exit module.

Table 35. **Parameter list for exit modules**

Offset	Contains address of	Description of item
00	User-exit type	Halfword identifying which user exit is to perform the operation. 1=INEXIT; 2=LIBEXIT; 3=PRTEXIT; 4=ADEXIT

Table 35. **Parameter list for exit modules** *(continued)*

Offset	Contains address of	Description of item
02	Operation code	Halfword indicating the type of operation. 0=OPEN; 1=CLOSE; 2=GET; 4=FIND
04	Return code	Fullword, placed by the exit module, indicating status of the requested operation. 0=Successful; 4=End-of-data; 12=Failed
08	Data length	Fullword, placed by the exit module, specifying the length of the record being returned by the GET operation.
12	Data	Fullword, placed by the exit module, that contains the address of the record in a user-owned buffer, for the GET operation.
	or 'str2'	'str2' applies only to OPEN. The first halfword (on a halfword boundary) contains the length of the string; the string follows.
16	User-exit work area	4-fullword work area provided by the compiler for use by user-exit module.
32	Text-name	Fullword that contains the address of a null-terminated string that contains the fully qualified text-name. Applies only to FIND.
36	User exit parameter string	Fullword that contains the address of a four-element array, each element of which is a structure that contains a 2-byte length field followed by a 64-character string that contains the exit parameter string.

Only the second element of the parameter string array is used for `LIBEXIT`, to store the length of the `LIBEXIT` parameter string followed by the parameter string.

Using INEXIT

When `INEXIT` is specified, the compiler loads the exit module (*mod1*) during initialization, and invokes the module using the OPEN operation code (op code). This allows the module to prepare its source for processing and then pass the status of the OPEN request back to the compiler. Subsequently, each time the compiler requires a source statement, the exit module is invoked with the GET op code. The exit module then returns either the address and length of the next statement or the end-of-data indication (if no more source statements exist). When end-of-data is presented, the compiler invokes the exit module with the CLOSE op code so that the module can release any resources that are related to its input.

The compiler uses a parameter list to communicate with the exit module. The parameter list consists of 10 fullwords. 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 table shows the contents of the parameter list and a description of each item.

Using LIBEXIT

When LIBEXIT is specified, the compiler loads the exit module (*mod2*) during initialization. Calls are made to the module by the compiler to obtain copybooks whenever COPY or BASIS statements are encountered.

Use LIB: If LIBEXIT is specified, the LIB compiler option must be in effect.

The first call invokes the module with an OPEN op code. This allows the module to prepare the specified library-name for processing. The OPEN op code is also issued the first time a new library-name is specified. The exit module returns the status of the OPEN request to the compiler by passing a return code.

When the exit invoked with the OPEN op code returns, the exit module is then invoked with a FIND op code. The exit module establishes positioning at the requested text-name (or basis-name) in the specified library-name. This becomes the "active copybook." When positioning is complete, the exit module passes an appropriate return code to the compiler.

The compiler then invokes the exit module with a GET op code, and the exit module passes the compiler the length and address of the record to be copied from the active copybook. The GET operation is repeated until the end-of-data indicator is passed to the compiler.

When end-of-data is presented, the compiler will issue a CLOSE request so that the exit module can release any resources related to its input.

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.) When a valid nested COPY statement is encountered, the compiler issues a request based on the following:

- If the requested library-name from the nested COPY statement was not previously opened, the compiler invokes the exit module with an OPEN op code, followed by a FIND for the new text-name.
- If the requested library-name is already open, the compiler issues the FIND op code for the new requested text-name (an OPEN is not issued here).

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.

When the exit module receives the OPEN or FIND request, it should push its control information concerning the active copybook onto a stack and then complete the requested action (OPEN or FIND). The newly requested text-name (or basis-name) now becomes the active copybook.

Processing continues in the normal manner with a series of GET requests until the end-of-data indicator is passed to the compiler.

At end-of-data for the nested active copybook, the exit module should pop its control information from the stack. The next request from the compiler will be a FIND, so that the exit module can reestablish positioning at the previous active copybook.

The compiler now invokes the exit module with a GET request, and the exit module must pass the same record that was passed previously from this copybook. The compiler verifies that the same record was passed, and then the processing continues with GET requests until the end-of-data indicator is passed.

The table shows the contents of the parameter list used for `LIBEXIT` and a description of each item.

Using PRTEXIT

When `PRTEXIT` is specified, the compiler loads the exit module (*mod3*) during initialization. The exit module is used in place of the SYSPRINT data set.

The compiler invokes the module using the OPEN operation code (op code). This allows the module to prepare its output destination for processing and then pass the status of the OPEN request back to the compiler. Subsequently, each time the compiler has a line to be printed, the exit module is invoked with the PUT op code. The compiler supplies the address and length of the record that is to be printed, and the exit module returns 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.

Before the compilation is ended, the compiler invokes the exit module with the CLOSE op code so that the module can release any resources that are related to its output destination.

The table shows the contents of the parameter list used for `PRTEXIT` and a description of each item.

Using ADEXIT

When `ADEXIT` is specified, the compiler loads the exit module (*mod4*) during initialization. The exit module is called for each record written to the SYSADATA data set.

The compiler invokes the module using the OPEN operation code (op code). This allows the module to prepare for processing and then pass the status of the OPEN request back to the compiler. Subsequently, each time the compiler has written a SYSADATA record, the exit module is invoked with the PUT op code. The compiler supplies the address and length of the SYSADATA record, and the exit module returns the status of the PUT request to the compiler by a return code.

Before the compilation is ended, the compiler invokes the exit module with the CLOSE op code so that the module can release any resources.

The table shows the contents of the parameter list used for `ADEXIT` and a description of each item.

FLAG

FLAG option syntax



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 the embedding of the statement number in an arrow that points to the message code. The message code is 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.  . . .
```

When FLAG(*x*,*y*) is in effect, messages of severity *y* and above are embedded in the listing following the line that caused the message. (See the related reference below for information about messages for exceptions.)

Use NOFLAG to suppress error flagging. NOFLAG does not suppress error messages for compiler options.

Embedded messages

- Embedding level-U messages is not recommended. The specification of embedded level-U messages is accepted, but does not produce any messages in the source.
- The FLAG option does not affect diagnostic messages that are produced before the compiler options are processed.
- Diagnostic messages that are produced during processing of compiler options, CBL or PROCESS statements, or BASIS, COPY, or REPLACE statements are not embedded in the source listing. All such messages appear at the beginning of the compiler output.
- Messages that are produced during processing of the *CONTROL or *CBL statement are not embedded in the source listing.

RELATED REFERENCES
"Messages and listings for compiler-detected errors" on page 185

FLAGSTD

FLAGSTD option syntax



Default is: NOFLAGSTD

Abbreviations are: None

x specifies the level or subset of the COBOL 85 Standard to be regarded as conforming:

M Language elements that are *not* from the minimum subset are to be flagged as "nonconforming standard."

I Language elements that are *not* from the minimum or the intermediate subset are to be flagged as "nonconforming standard."

H The high subset is being used and elements will not be flagged by subset. And, elements in the IBM extension category will be flagged as "nonconforming Standard, IBM extension."

yy specifies, by a single character or combination of any two, the optional modules to be included in the subset:

D Elements from debug module level 1 are *not* flagged as "nonconforming standard."

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).

O 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")

This includes the language syntax for object-oriented COBOL and for improved interoperability, the PGMNAME(MIXED) compiler option, and the Millennium Language Extensions.

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
```

FLOAT

FLOAT option syntax



Default is: FLOAT(NATIVE)

Abbreviations are: None

Specify FLOAT(NATIVE) to use the native floating-point representation format of the platform. For COBOL for AIX, this is the IEEE format.

FLOAT(HEX) and FLOAT(S390) are synonymous and indicate that COMP-1 and COMP-2 data items are represented consistently with zSeries, that is, in hexadecimal floating-point format:

- Hexadecimal floating-point values are converted to IEEE format before any arithmetic operations (computations or comparisons).
- IEEE floating-point values are converted to hexadecimal format before being stored in floating-point data fields.
- Assignment to a floating-point item is done by converting the source floating-point data (for example, external floating point) to hexadecimal floating point as necessary.

However, COMP-1 and COMP-2 data items defined with the NATIVE keyword on the USAGE clause are not affected by the FLOAT(S390) option. They are always stored in the native format of the platform.

RELATED REFERENCES
Appendix B, "zSeries host data type considerations," on page 511

LIB

LIB option syntax



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:

- If the library-name is specified with a user-defined word (not a literal), you must set the corresponding environment variable to point to the desired directory and path for the copybook.
- If the library-name is omitted for a COPY statement, you can specify the path to be searched by using the -I*xxx* option of the cob2 or cob2_j, cob2_r, or cob2_r4 command.
- If the library-name is specified with a literal, the literal value is treated as the actual path name.

RELATED REFERENCES
Chapter 14, "Compiler-directing statements," on page 243

LINECOUNT

LINECOUNT option syntax



Default is: `LINECOUNT(60)`

Abbreviations are: `LC`

nnn must be an integer between 10 and 255, or 0.

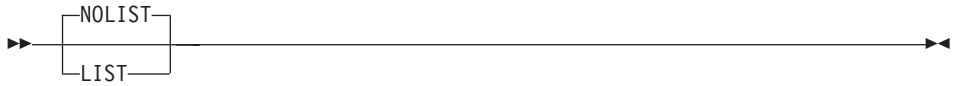
Use `LINECOUNT(`*nnn*`)` to specify the number of lines to be printed on each page of the compilation listing, or use `LINECOUNT(0)` to suppress pagination.

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



Default is: `NOLIST`

Abbreviations are: None

Use the `LIST` compiler option to produce a listing of the assembler-language expansion of your source code.

Any `*CONTROL` (or `*CBL`) `LIST` or `NOLIST` statements that you code in the `PROCEDURE DIVISION` have no effect. They are treated as comments.

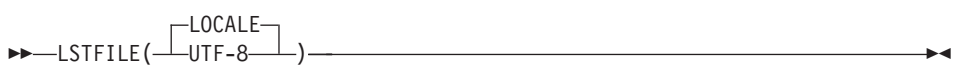
Assembler listing file: The assembler listing is written to a file that has the same name as the source program but has the suffix .wlist.

RELATED TASKS
"Getting listings" on page 263

RELATED REFERENCES
*CONTROL (*CBL) statement (*COBOL for AIX Language Reference*)

LSTFILE

LSTFILE option syntax



Default is: `LSTFILE(LOCALE)`

Abbreviations are: `LST`

Specify `LSTFILE(LOCALE)` to have your generated compiler listing encoded in the code page specified by the locale in effect.

Specify `LSTFILE(UTF-8)` to have your generated compiler listing encoded in UTF-8.

RELATED REFERENCES
"Setting the locale" on page 106

MAP

MAP option syntax



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`

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:

```
*CONTROL NOMAP           *CBL NOMAP
    01  A                    01  A
    02  B                    02  B
*CONTROL MAP             *CBL MAP
```

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 266

RELATED CONCEPTS
Chapter 16, "Debugging," on page 253

RELATED TASKS
"Getting listings" on page 263

RELATED REFERENCES
*CONTROL (*CBL) statement (*COBOL for AIX Language Reference*)

MAXMEM

MAXMEM option syntax



Default is: MAXMEM(2000)

Abbreviations are: None

Use MAXMEM in conjunction with OPTIMIZE to limit the amount of memory used by the compiler for local tables of specific, memory-intensive optimizations to *size* KB. If that memory is insufficient for a particular optimization, the scope of the optimization is reduced.

A value of -1 permits each optimization to take as much memory as it needs without checking for limits. Depending on the source file being compiled, the size of subprograms in the source, the machine configuration, and the workload on the system, this might exceed available system resources.

Usage notes

- The limit set by MAXMEM is the amount of memory for specific optimizations, not for the compiler as a whole. Tables required during the entire compilation process are not affected or included in this limit.
- Setting a large limit has no negative effect on the compilation of source files where the compiler needs less memory.
- Limiting the scope of optimization does not necessarily mean that the resulting program will be slower, only that the compiler may finish before finding all opportunities to increase performance.
- Increasing the limit does not necessarily mean that the resulting program will be faster, only that the compiler is better able to find opportunities to increase performance if they exist.

Depending on the source file being compiled, the size of the subprograms in the source, the machine configuration, and the workload on the system, setting the limit too high might lead to page space exhaustion. In particular, specifying MAXMEM(-1) allows the compiler to try to use an unlimited amount of storage, which in the worst case could exhaust the resources of the machine.

NCOLLSEQ

NCOLLSEQ option syntax



Default is: NCOLLSEQ(BINARY)

Abbreviations are: NCS(L), NCS(BIN), NCS(B)

NCOLLSEQ specifies the collating sequence for comparison of national operands:

- NCOLLSEQ(BIN) uses the hexadecimal values of the character pairs.
- NCOLLSEQ(LOCALE) uses the algorithm for collation order associated with the locale value in effect.

RELATED TASKS

"Comparing national data items" on page 102

NSYMBOL

NSYMBOL option syntax



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 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.

NUMBER

NUMBER option syntax



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.

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.

OPTIMIZE

OPTIMIZE option syntax



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. Optimizations performed include the propagation of constants, instruction scheduling, and the elimination of computations whose results are never used. 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.

Recommendation: Use OPTIMIZE(FULL) for database applications. It can make a huge performance improvement, because unused constants included by the associated COPY statements are eliminated. However, if your database application depends on unused data items, see the recommendations below.

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.

The OPTIMIZE and TEST options are mutually exclusive; if you use both, OPTIMIZE is ignored.

RELATED CONCEPTS
"Optimization" on page 488

PGMNAME

PGMNAME option syntax



Default is: PGMNAME(UPPER)

Abbreviations are: PGMN(LU|LM)

For compatibility with COBOL for OS/390(R) & VM, LONGMIXED and LONGUPPER are also supported.

LONGUPPER can be abbreviated as UPPER, LU, or U. LONGMIXED can be abbreviated as MIXED, LM, or M.

COMPAT: If you specify PGMNAME(COMPAT), PGMNAME(UPPER) will be set, and you will receive a warning message.

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:
  - CALL statements
  - CANCEL statements
  - SET *procedure-pointer* TO ENTRY statements
  - SET *function-pointer* TO ENTRY statements

PGMNAME(UPPER)

With PGMNAME(UPPER), 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-name or method-name 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 with alphabetic characters folded to uppercase.

PGMNAME(MIXED)

With PGMNAME(MIXED), program-names are processed as is, without truncation, translation, or folding to uppercase.

With PGMNAME(MIXED), all program-name definitions must be specified using the literal format of the program-name in the PROGRAM-ID paragraph or ENTRY statement.

PROFILE

PROFILE option syntax



Default is: PROFILE

Abbreviations are: None

PROFILE instructs the compiler to prepare the object file for AIX profiling (prof utility, used for performance analysis). Use this option with the -p option of the cob2 (or cob2_j, cob2_r, or cob2_r4) command.

RELATED TASKS
"Compiling from the command line" on page 179

QUOTE/APOST

QUOTE/APOST option syntax



Default is: QUOTE

Abbreviations are: Q|APOST

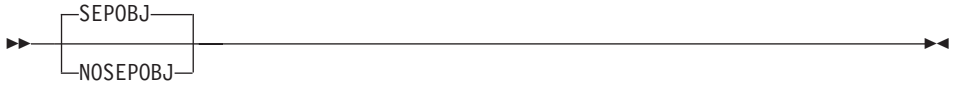
Use QUOTE if you want the figurative constant [ALL] QUOTE or [ALL] QUOTES to represent one or more quotation mark (") characters.

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.

SEPOBJ

SEPOBJ option syntax



Default is: SEPOBJ

Abbreviations are: None

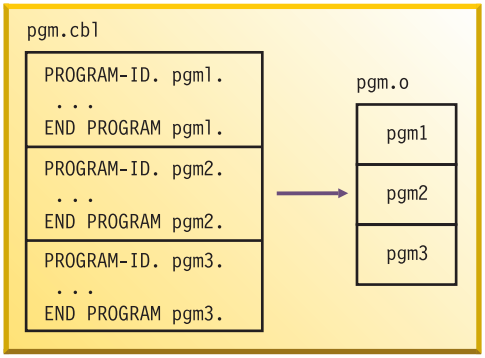
The option specifies whether each of the outermost COBOL programs in a batch compilation is to be generated as a separate object file rather than a single object file.

Batch compilation

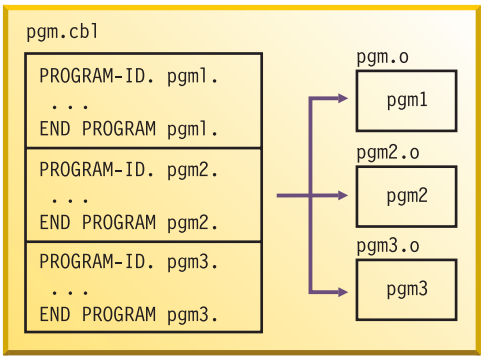
When multiple outermost programs (nonnested programs) are compiled with a single batch invocation of the compiler, the number of separate files produced for the object program output of the batch compilation depends on the compiler option SEPOBJ.

Assume that the COBOL source file pgm.cbl contains three outermost COBOL programs named pgm1, pgm2, and pgm3. The following figures illustrate whether the object program output is generated as one (with NOSEPOBJ) or three (with SEPOBJ) files.

Batch compilation with NOSEPOBJ



Batch compilation with SEPOBJ



Usage notes

- The SEPOBJ option is required to conform to Standard COBOL 85 where pgm2 or pgm3 in the above example is called using CALL *identifier* from another program.
- If the NOSEPOBJ option is in effect, the object module files are given the name of the source file but with suffix .o. If the SEPOBJ option is in effect, the names of the object files are based on the PROGRAM-ID name with suffix .o.
- The programs called using CALL *identifier* must be referred to by the names of the object files (rather than the PROGRAM-ID names) where PROGRAM-ID and the object file name do not match.

You must give the object file a valid file-name for the platform and the file system.

SEQUENCE

SEQUENCE option syntax



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.

Use NOSEQUENCE to suppress this checking and the diagnostic messages.

SIZE

SIZE option syntax



Default is: 8388608 bytes (approximately 8 MB)

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 800768.

*nnn*K specifies a decimal number in 1-KB increments, where 1 KB = 1024 bytes. The minimum acceptable value is 782K.

SOSI

SOSI option syntax



Default is: NOSOSI

Abbreviations are: None

NOSOSI With NOSOSI, character positions that have values X'1E' and X'1F' are treated as data characters.

NOSOSI conforms to the COBOL 85 Standard.

SOSI With SOSI, COBOL for AIX shift-out (SO) and shift-in (SI) control characters delimit ASCII DBCS character strings in COBOL source programs. The SO and SI characters have the encoded values of X'1E' and X'1F', respectively.

SO and SI characters have no effect on COBOL for AIX source code, except to act as placeholders for host DBCS SO and SI characters to ensure proper data handling when remote files are converted from EBCDIC to ASCII.

When the SOSI option is in effect, in addition to existing rules for COBOL for AIX, the following rules apply:

- All DBCS character strings (in user-defined words, DBCS literals, alphanumeric literals, national literals, and in comments) must be delimited by the SO and SI characters.
- User-defined words cannot contain both DBCS and SBCS characters.

- The maximum length of a DBCS user-defined word is 14 DBCS characters.
- Double-byte uppercase alphabetic letters are equivalent to the corresponding double-byte lowercase letters when used in user-defined words.
- A DBCS user-defined word must contain at least one letter that does not have its counterpart in a single-byte representation.
- Double-byte representations of single-byte characters for A-Z, a-z, 0-9, and the hyphen (-) cannot be included within a DBCS user-defined word. Rules applicable to these characters in single-byte representation apply to those in double-byte representation. For example, the hyphen (-) cannot appear as the first or the last character in a user-defined word.
- For alphanumeric literals that contain X'1E' or X'1F' values, the following rules apply when the SOSI compiler option is in effect:
  - Character positions with X'1E' and X'1F' are treated as SO and SI characters.
  - Character positions with X'1E' and X'1F' are included in the character string value of the literal unless it is part of a DBCS or alphanumeric literal that is not represented in hexadecimal notation.
  - The SO and SI characters must be paired (with each pair starting with the SO character) with zero or an even number of intervening bytes.
  - The pairs of SO and SI characters cannot be nested.
- If you embedded DBCS quotation marks within an N-literal delimited by quotation marks, use two consecutive DBCS quotation marks to represent a single DBCS quotation mark. Do not include a single DBCS quotation mark in an N-literal if the literal is delimited by quotation marks. The same rule applies to single quotation marks.
- The SHIFT-OUT and SHIFT-IN special registers are defined with X'0E' and X'0F' regardless of whether the SOSI option is in effect.

In general, host COBOL programs that are sensitive to the encoded values for the SO and SI characters will not have the same behavior on the AIX workstation.

SOURCE

SOURCE option syntax



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. Source statements that follow a *CONTROL NOSOURCE statement are not included in the listing until a subsequent *CONTROL SOURCE statement switches the output back to normal SOURCE format.

"Example: MAP output" on page 266

RELATED REFERENCES
*CONTROL (*CBL) statement (*COBOL for AIX Language Reference*)

SPACE

SPACE option syntax



Default is: SPACE(1)

Abbreviations are: None

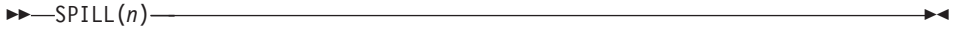
Use SPACE to select single-, double-, or triple-spacing in your source code listing.

SPACE has meaning only when the SOURCE compiler option is in effect.

RELATED REFERENCES
"SOURCE" on page 231

SPILL

SPILL option syntax



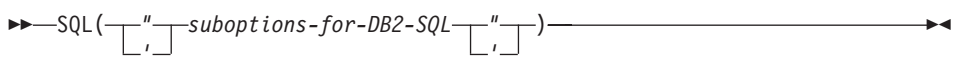
Default is: SPILL(512)

Abbreviations are: None

This option specifies the register spill area size. If the program being compiled is very complex or large, this option might be required. The spill size, *n*, is any integer between 96 and 32704 and designates the number of KB set aside for the register spill area.

SQL

SQL option syntax



Default is: `SQL("")`

Abbreviations are: None

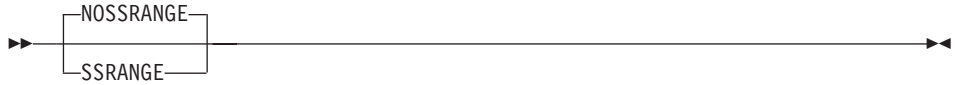
Use this option if you have SQL statements embedded in your COBOL source. It allows you to specify options to be used in handling the SQL statements in your program and is required if the suboption string, which specifies the SQL options, is to be specified explicitly to DB2.

The syntax shown can be used in either the `CBL` or `PROCESS` statements. If the `SQL` option is used in the `cob2` command, only the single quotation mark (') is allowed as the string delimiter: `-q"SQL('options')"`.

RELATED TASKS
Chapter 17, "Programming for a DB2 environment," on page 277

SSRANGE

SSRANGE option syntax



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 85

TERMINAL

TERMINAL option syntax



Default is: TERMINAL

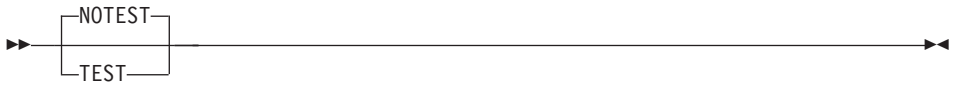
Abbreviations are: TERM|NOTERM

Use TERMINAL to send progress and diagnostic messages to the display.

Use NOTERMINAL if you do not want this additional output.

TEST

TEST option syntax



Default is: NOTEST

Abbreviations are: None

Use TEST to produce object code that contains symbol and statement information that enables the debugger to perform symbolic source-level debugging.

Use NOTEST if you do not want to generate object code with debugging information.

Programs compiled with NOTEST run with the debugger, but there is limited debugging support.

The TEST option will be turned off if you use the WITH DEBUGGING MODE clause. The TEST option will appear in the list of options, but a diagnostic message will be issued to advise you that because of the conflict, TEST will not be in effect.

THREAD

THREAD option syntax



Default is: NOTHREAD

Abbreviations are: None

THREAD indicates that the COBOL application is to be enabled for execution in a run unit that has multiple threads. All programs within a run unit must be compiled with the same option: either THREAD or NOTHREAD.

When the THREAD option is in effect, the following items are not supported. If encountered, they are diagnosed as errors:

- ALTER statement
- DEBUG-ITEM special register
- GO TO statement without procedure-name
- INITIAL phrase in PROGRAM-ID clause
- RERUN
- Segmentation module
- STOP *literal* statement
- STOP RUN
- USE FOR DEBUGGING statement

Usage notes

- RERUN is flagged as an error with THREAD, but is accepted as a comment with NOTHREAD.
- If you use the THREAD option, compile by using the command:
  - cob2_j for object-oriented (OO) clients and classes
  - cob2_r4 for programs that use the SFS file system
  - cob2_r for non-CICS programs

  cob2_j and cob2_r4 cause the THREAD option to automatically be included as a default invocation option when you compile COBOL programs.
- **CICS:** Compile CICS programs by using the cob2_r command and the NOTHREAD option.

Performance: When using the THREAD option, you can expect some run-time performance degradation due to the overhead of serialization logic that is automatically generated.

RELATED TASKS
"Compiling from the command line" on page 179
Chapter 28, "Preparing COBOL programs for multithreading," on page 441

TRUNC

TRUNC option syntax



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).

Tip: 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.

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 DB2, C/C++, 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 34

RELATED TASKS

RELATED REFERENCES
VALUE clause (*COBOL for AIX Language Reference*)

VBREF

VBREF option syntax



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.

WSCLEAR

WSCLEAR option syntax



Default is: NOWSCLEAR

Abbreviations are: None

Use WSCLEAR to clear your program's WORKING-STORAGE to binary zeros when the program is initialized. The storage is cleared before any VALUE clauses are applied.

Use NOWSCLEAR to bypass the storage clearing process.

If you use WSCLEAR and you are concerned about the size or performance of the object program, then you should also use OPTIMIZE(FULL). This instructs the compiler to eliminate all unreferenced data items from the DATA DIVISION, which will speed up the initialization process.

XREF

XREF option syntax



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 the XREF compiler option to get a sorted cross-reference listing. Names are listed in the order of the collating sequence indicated by the locale setting. This applies whether the names are in single-byte characters or contain multibyte characters (such as DBCS).

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 multibyte data-names and procedure-names as well as to single-byte names.

NOXREF suppresses this listing.

Usage notes

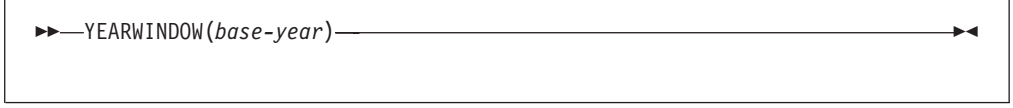
- Group names used in a MOVE CORRESPONDING statement are in the XREF listing. In addition, the elementary names in those groups are also listed.
- In the data-name XREF listing, line numbers preceded by the letter M indicate that the data item is explicitly modified by a statement on that line.
- XREF listings take additional storage.

RELATED CONCEPTS
Chapter 16, “Debugging,” on page 253

RELATED TASKS
“Getting listings” on page 263

YEARWINDOW

YEARWINDOW option syntax



Default is: YEARWINDOW(1900)

Abbreviations are: 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.

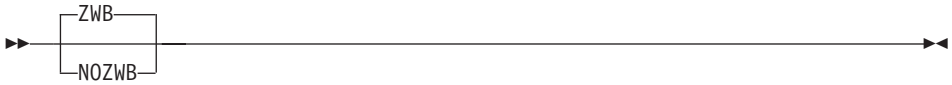
Usage notes

- 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

ZWB option syntax



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 14. Compiler-directing statements

Several compiler-directing statements and one compiler directive help you to direct the compilation of your program.

***CONTROL (*CBL) statement**
This compiler-directing statement selectively suppresses output or causes output to be produced. The keywords *CONTROL and *CBL are synonymous.

>>CALLINTERFACE directive
This compiler directive specifies the interface convention for calls, including whether argument descriptors are to be generated. The convention specified with >>CALLINTERFACE is in effect until another >>CALLINTERFACE specification is made. >>CALLINT is an abbreviation for >>CALLINTERFACE.

>>CALLINTERFACE can be used only in the PROCEDURE DIVISION.

The syntax and usage of the >>CALLINTERFACE directive are similar to that of the CALLINT compiler option. Exceptions are:

- The directive syntax does not include parentheses.
- The directive can be applied to selected calls as described below.
- The directive syntax includes the keyword DESCRIPTOR and its variants.

If you specify >>CALLINT with no suboptions, the call convention used is determined by the CALLINT compiler option.

DESCRIPTOR only: The >>CALLINT directive is treated as a comment except for these forms:

- >>CALLINT SYSTEM DESCRIPTOR, or equivalently >>CALLINT DESCRIPTOR
- >>CALLINT SYSTEM NODESCRIPTOR, or equivalently >>CALLINT NODESCRIPTOR

These directives turn DESCRIPTOR on or off; SYSTEM is ignored.

Note that if you code OPTLINK or CDECL (valid COBOL for Windows values) instead of SYSTEM, the compiler generates an I-level diagnostic, and the entire directive (not just the first keyword) is ignored.

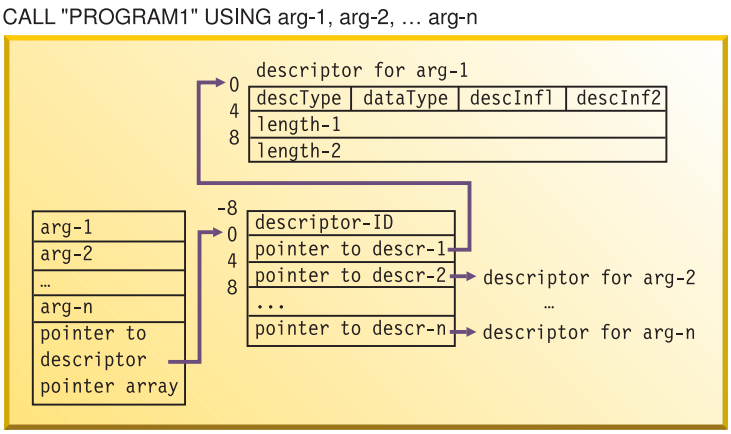
The >>CALLINT directive can be specified anywhere that a COBOL procedure statement can be specified. For example, the following is valid syntax:

```
MOVE 3 TO
>>CALLINTERFACE SYSTEM
RETURN-CODE.
```

The effect of >>CALLINT is limited to the current program. A nested program or a program compiled in the same batch inherits the calling convention specified with the CALLINT compiler option, but not a convention specified with the >>CALLINT compiler directive.

If you are writing a routine that is to be called with >>CALLINT SYSTEM DESCRIPTOR, this is the argument-passing mechanism:

© Copyright IBM Corp. 1995, 2004



pointer to descr-n
Points to the descriptor for the specific argument; 0 if no descriptor exists for the argument.

descriptor-ID
Set to `COBDESC0` to identify this version of the descriptor, allowing for a possible change to the descriptor entry format in the future.

descType
Set to X'02' (descElmt) for an elementary data item of `USAGE DISPLAY` with `PICTURE X(`*n*`)` or `USAGE DISPLAY-1` with `PICTURE G(`*n*`)` or `N(`*n*`)`. For all others (numeric fields, structures, tables), set to X'00'.

dataType
Set as follows:

- descType = X'00': dataType = X'00'
- descType = X'02' and the `USAGE` is `DISPLAY`: dataType = X'02' (typeChar)
- descType = X'02' and the `USAGE` is `DISPLAY-1`: dataType = X'09' (typeGChar)

descInf1
Always set to X'00'.

descInf2
Set as follows:

- If descType = X'00'; descInf2 = X'00'
- If descType = X'02':
  - If the `CHAR(EBCDIC)` option is in effect and the argument is not defined with the `NATIVE` option in the `USAGE` clause: descInf2 = X'40'
  - Else: descInf2 = X'00'

length-1
In the argument descriptor is the length of the argument for a fixed-length argument or the current length for a variable-length item.

length-2
The maximum length of the argument if the argument is a variable-length item. For a fixed-length argument, length-2 is equal to length-1.

COPY statement

This compiler-directing statement places prewritten text into a COBOL program. You must specify a *text-name* (the name of a copybook) that contains the prewritten text; for example, `COPY my-text`. You can qualify *text-name* with a *library-name*; for example, `COPY my-text of inventory-lib`. If *text-name* is not qualified, a *library-name* of `SYSLIB` is assumed. The following affects *library-name* and *text-name*:

library-name

If you specify *library-name* as a literal, the content of the literal is treated as the actual path. If you specify *library-name* as a user-defined word, the name is used as an environment variable and the value of the environment variable is used for the path to locate the copybook. To specify multiple path names, delimit them with a colon (:) or a semicolon (;).

If you do not specify *library-name*, the path used is as described under *text-name*.

text-name

If you specify *text-name* as a user-defined word, processing depends on whether the environment variable that corresponds to *text-name* is set. If the environment variable is set, the value of the environment variable is used as the file-name, and possibly the path name, for the copybook.

A *text-name* is treated as an absolute path if all three of these conditions are met:

- *library-name* is not used.
- *text-name* is a literal or an environment variable.
- The first character is '/'.

For example,

```
COPY "/mycpylib/mytext.cpy"
```

is treated as an absolute path.

If the environment variable that corresponds to *text-name* is not set, the search for the copybook uses the following names:

1. *text-name* with suffix .cpy
2. *text-name* with suffix .cbl
3. *text-name* with suffix .cob
4. *text-name* with no suffix

For example, `COPY MyCopy` searches in the following order:

1. MYCOPY.cpy (in all the specified paths, as described above)
2. MYCOPY.cbl (in all the specified paths, as described above)
3. MYCOPY.cob (in all the specified paths, as described above)
4. MYCOPY (in all the specified paths, as described above)

Note that COBOL defaults *library-name* and *text-name* to uppercase, unless the name is contained in a literal ("MyCopy"). In this example, `MyCopy` is not the same as `MYCOPY`. If your file-name is mixed case (as in MyCopy.cbl), define *text-name* as a literal in the `COPY` statement.

-I option

For other cases (when neither a *library-name* nor *text-name* indicates the path), the search path is dependent on the `-I` option.

To have `COPY A` be equivalent to `COPY A OF MYLIB`, specify `-I$MYLIB`.

Based on the above rules, `COPY "/X/Y"` will be searched in the root directory, and `COPY "X/Y"` will be searched in the current directory.

`COPY A OF SYSLIB` is equivalent to `COPY A`. The `-I` option does not affect `COPY` statements with explicit *library-name* qualifications besides those with the library name of `SYSLIB`.

If both *library-name* and *text-name* are specified, the compiler inserts a path separator (/) between the two values if *library-name* does not end in a /. For example, `COPY MYCOPY OF MYLIB` with the settings of

```
export MYCOPY=MYPDS(MYMEMBER)
export MYLIB=MYFILE
```

results in `MYFILE/MYPDS(MYMEMBER)`.

If you specify *text-name* as a user-defined word, you can access local files and also access PDS members on z/OS without changing your mainframe source. For example:

```
COPY mycopybook
```

In this example, when the environment variable *mycopybook* is set to `h/mypds(mycopy)`:

- `h` is assigned to the specific host.
- `mypds` is the z/OS PDS data set name.
- `mycopy` is the PDS member name.

You can access z/OS files from AIX using NFS (Network File System), which allows z/OS files to be accessed using an AIX path name. However, note that NFS converts the path separator to "." to follow z/OS naming conventions. Keep this in mind when assigning values to your environment variables to ensure proper name formation. For example, these settings:

```
export MYCOPY=(MYMEMBER)
export MYLIB=M/MYFILE/MYPDS
```

do not work because the resulting path is:

```
M/MYFILE/MYPDS/(MYMEMBER)
```

which becomes:

```
M.MYFILE.MYPDS.(MYMEMBER)
```

PROCESS (CBL) statement
This compiler-directing statement, which you can place before the `IDENTIFICATION DIVISION` header of an outermost program, specifies compiler options that are to be used during compilation of the program.

RELATED TASKS
"Changing the header of a source listing" on page 6
"Compiling from the command line" on page 179
"Specifying compiler options with the PROCESS (CBL) statement" on page 181

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186

CALLINTERFACE directive (*COBOL for AIX Language Reference*)
CBL (PROCESS) statement (*COBOL for AIX Language Reference*)
*CONTROL (*CBL) statement (*COBOL for AIX Language Reference*)
COPY statement (*COBOL for AIX Language Reference*)

Chapter 15. Run-time options

The following run-time options are supported:

Table 36. **Run-time options**

Option	Description	Default	Abbreviation
"CHECK"	Flags checking errors	CHECK(ON)	CH
"DEBUG" on page 250	Specifies whether the COBOL debugging sections specified by the USE FOR DEBUGGING declarative are active	NODEBUG	None
"ERRCOUNT" on page 250	Specifies how many conditions of severity 1 (W-level) can occur before the run unit terminates abnormally	ERRCOUNT(20)	None
"FILESYS" on page 250	Specifies the file system used for files for which no explicit file system selections are made, either through ASSIGN or an environment variable	FILESYS(VSA)	None
"TRAP" on page 251	Indicates whether COBOL intercepts exceptions	TRAP(ON)	None
"UPSI" on page 252	Sets the eight UPSI switches on or off for applications that use COBOL routines	UPSI(00000000)	None

CHECK

CHECK flags checking errors in an application. In COBOL, index, subscript, and reference modification ranges are checking errors.

CHECK option syntax



Default is: CHECK(ON).

Abbreviation is: CH

ON Specifies that run-time checking is performed.

OFF Specifies that run-time checking is not performed.

Usage note: CHECK(ON) has no effect if NOSSRANGE was in effect at compile time.

© Copyright IBM Corp. 1995, 2004

Performance consideration: If you compiled your COBOL program with SSRANGE and you are not testing or debugging an application, performance improves if you specify CHECK(OFF).

DEBUG

DEBUG specifies whether the COBOL debugging sections specified by the USE FOR DEBUGGING declarative are active.

DEBUG option syntax



Default is: NODEBUG.

DEBUG Activates the debugging sections.

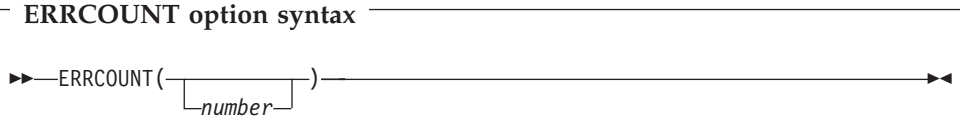
NODEBUG
Suppresses the debugging sections.

Performance consideration: To improve performance, use this option only while debugging.

ERRCOUNT

ERRCOUNT specifies how many conditions of severity 1 (W-level) can occur before the run unit terminates abnormally. Any severity-2 (E-level) or higher condition will result in termination of the run unit regardless of the ERRCOUNT option.

ERRCOUNT option syntax



Default: ERRCOUNT(20).

number
The number of severity-1 conditions that can occur while this run unit is running. If the number of conditions exceeds *number*, the run unit terminates abnormally.

FILESYS

FILESYS specifies the file system to be used for files for which no explicit file-system selection is made either through an ASSIGN statement or an environment variable. The option applies to sequential, relative, and indexed files.

FILESYS option syntax



Default is: `FILESYS(VSA)`.

VSA The file system is VSAM. Specify the VSAM file system when you want to use Encina SFS files.

STL The file system is STL.

RSD The file system is RSD.

Only the first three characters of the file-system identifier are used, and the identifier is case insensitive. For example, the following examples are all valid specifications for VSAM:

- `FILESYS(VSA)`
- `FILESYS(vSAM)`
- `FILESYS(vsa)`

RELATED TASKS

"Identifying files" on page 119

RELATED REFERENCES

"Run-time environment variables" on page 172

TRAP

`TRAP` indicates whether COBOL intercepts exceptions.

TRAP option syntax



Default is : `TRAP(ON)`.

If `TRAP(OFF)` is in effect and you do not supply your own trap handler to handle exceptional conditions, the conditions result in a default action by the operating system. For example, if your program attempts to store into an illegal location, the default system action is to issue a message and terminate the process.

ON Activates COBOL interception of exceptions.

OFF Deactivates COBOL interception of exceptions.

Usage notes

- Use `TRAP(OFF)` only when you need to analyze a program exception before COBOL handles it.

- When you specify TRAP(OFF) in a non-CICS environment, no exception handlers are established.
- Running with TRAP(OFF) (for exception diagnosis purposes) can cause many side effects because COBOL requires TRAP(ON). When you run with TRAP(OFF), you can get side effects even if you do not encounter a software-raised condition, program check, or abend. If you do encounter a program check or an abend with TRAP(OFF) in effect, the following side effects can occur:
  - Resources obtained by COBOL are not freed.
  - Files opened by COBOL are not closed, so records might be lost.
  - No messages or dump output are generated.

  The run unit terminates abnormally if such conditions are raised.

UPSI

UPSI sets the eight UPSI switches on or off for applications that use COBOL routines.

UPSI option syntax



Default is : UPSI(00000000).

nnnnnnnn

n represents one UPSI switch between 0 and 7, the leftmost *n* representing the first switch. Each *n* can either be 0 (off) or 1 (on).

Chapter 16. 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.

RELATED TASKS
"Debugging with source language"
"Debugging using compiler options" on page 257
"Using the debugger" on page 262
"Getting listings" on page 263
"Debugging with messages that have offset information" on page 272
"Debugging user exits" on page 273
"Debugging assembler routines" on page 273

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 254
"Validating data" on page 255
"Finding uninitialized data" on page 255
"Generating information about procedures" on page 255

RELATED REFERENCES
Source language debugging (*COBOL for AIX 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.

© Copyright IBM Corp. 1995, 2004

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 18

RELATED REFERENCES
DISPLAY statement (*COBOL for AIX 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 161

RELATED REFERENCES
Status key values and meanings (*COBOL for AIX Language Reference*)
Status key (*COBOL for AIX 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 (*COBOL for AIX 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 (*COBOL for AIX Language Reference*)
SET statement (*COBOL for AIX 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.

"Example: USE FOR DEBUGGING"

RELATED REFERENCES
Debugging line (*COBOL for AIX Language Reference*)
Coding debugging sections (*COBOL for AIX Language Reference*)
DEBUGGING declarative (*COBOL for AIX 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 file. 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 259
"Finding coding errors" on page 258
"Finding line sequence problems" on page 258
"Checking for valid ranges" on page 258
"Finding program entity definitions and references" on page 261
"Listing data items" on page 262
"Getting listings" on page 263
"Using the debugger" on page 262

RELATED REFERENCES

"COMPILE" on page 206
"SEQUENCE" on page 229
"SSRANGE" on page 233
"FLAG" on page 216
"XREF" on page 239
"MAP" on page 221
"VBREF" on page 238
"LIST" on page 220
"TEST" on page 234

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.

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: 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 206

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 229

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 233
"Performance-related compiler options" on page 490

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 to be 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 37. **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 185

RELATED REFERENCES
"FLAG" on page 216
"Messages and listings for compiler-detected errors" on page 185
"Severity codes for compiler error messages" on page 184

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.

```
DATA VALIDATION AND UPDATE PROGRAM               IGYTCARA   Date 05/14/2004  Time 12:26:53   Page    26
  LineID  PL SL  ----+-*A-1-B--+----2----+----3----+----4----+----5----+----6----+----7--+--8 Map and Cross Reference
.
.
.
  000977              /
  000978              ****************************************************************
  000979              ***         I N I T I A L I Z E   P A R A G R A P H          **
  000980              ***  Open files. Accept date, time and format header lines.    **
  000981         IA4690***   Load location-table.                                     **
  000982              ****************************************************************
  000983                 100-initialize-paragraph.
  000984                   move spaces to ws-transaction-record                                IMP 339
  000985                   move spaces to ws-commuter-record                                   IMP 315
  000986                   move zeroes to commuter-zipcode                                     IMP 326
  000987                   move zeroes to commuter-home-phone                                  IMP 327
  000988                   move zeroes to commuter-work-phone                                  IMP 328
  000989                   move zeroes to commuter-update-date                                 IMP 332
  000990                   open input update-transaction-file                                  203
  ==000990==> IGYPS2052-S An error was found in the definition of file "LOCATION-FILE".  The
                          reference to this file was discarded.
    000991                      location-file                                                    192
  000992                     i-o commuter-file                                                 180
  000993                     output print-file                                                 216
  000994                   if loccode-file-status not = "00" or                                248
  000995                      update-file-status not = "00" or                                 247
  000996                      updprint-file-status not = "00"                                  249
  000997      1               display "Open Error ..."
  000998      1               display "  Location File Status = " loccode-file-status         248
  000999      1               display "  Update   File Status = " update-file-status          247
  001000      1               display "  Print    File Status = " updprint-file-status        249
  001001      1             perform 900-abnormal-termination                                   1433
  001002                  end-if
  001003         IA4760     if commuter-file-status not = "00" and not = "97"                  240
  001004      1             display "100-OPEN"
  001005      1             move 100 to comp-code                                              230
  001006      1             perform 500-vsam-error                                             1387
  001007      1             display "Commuter File Status (OPEN) = "
  001008      1                      commuter-file-status                                      240
  001009      1             perform 900-abnormal-termination                                   1433
  001010         IA4790     end-if
  001011                    accept ws-date from date                                           UND
  ==001011==> IGYPS2121-S "WS-DATE" was not defined as a data-name.  The statement was discarded.
    001012         IA4810     move corr ws-date to header-date                                  UND 463
  ==001012==> IGYPS2121-S "WS-DATE" was not defined as a data-name.  The statement was discarded.
    001013                    accept ws-time from time                                          UND
  ==001013==> IGYPS2121-S "WS-TIME" was not defined as a data-name.  The statement was discarded.
    001014         IA4830     move corr ws-time to header-time                                  UND 457
  ==001014==> IGYPS2121-S "WS-TIME" was not defined as a data-name.  The statement was discarded.
    001015         IA4840     read location-file                                                192
.
.
.
DATA VALIDATION AND UPDATE PROGRAM               IGYTCARA   Date 05/14/2004  Time 12:26:53   Page    69
LineID  Message code  Message text
     192  IGYDS1050-E   File "LOCATION-FILE" contained no data record descriptions.
                        The file definition was discarded.
     899  IGYPS2052-S   An error was found in the definition of file "LOCATION-FILE".
                        The reference to this file was discarded.
                        Same message on line:    990
    1011  IGYPS2121-S   "WS-DATE" was not defined as a data-name.  The statement was discarded.
                        Same message on line:   1012
    1013  IGYPS2121-S   "WS-TIME" was not defined as a data-name.  The statement was discarded.
                        Same message on line:   1014
    1015  IGYPS2053-S   An error was found in the definition of file "LOCATION-FILE".
                        This input/output statement was discarded.
                        Same message on line:   1027
    1026  IGYPS2121-S   "LOC-CODE" was not defined as a data-name.  The statement was discarded.
    1209  IGYPS2121-S   "COMMUTER-SHIFT" was not defined as a data-name.  The statement was discarded.
                        Same message on line:   1230
    1210  IGYPS2121-S   "COMMUTER-HOME-CODE" was not defined as a data-name.  The statement was discarded.
                        Same message on line:   1231
    1212  IGYPS2121-S   "COMMUTER-NAME" was not defined as a data-name.  The statement was discarded.
                        Same message on line:   1233
    1213  IGYPS2121-S   "COMMUTER-INITIALS" was not defined as a data-name.  The statement was discarded.
                        Same message on line:   1234
    1223  IGYPS2121-S   "WS-NUMERIC-DATE" was not defined as a data-name.  The statement was discarded.
Messages    Total    Informational    Warning    Error    Severe    Terminating
Printed:       19                                  1        18
* Statistics for COBOL program IGYTCARA:
*    Source records = 1755
*    Data Division statements = 279
*    Procedure Division statements = 479
Locale = en_US.ISO8859-1                  (1)
End of compilation 1,  program IGYTCARA,  highest severity: Severe.
Return code 12
```

(1) The locale that the compiler used.

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.

User-defined words in your program are sorted using the locale that is active. Hence, the collating sequence determines the order for the cross-reference listing, including multibyte words.

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 270
"Example: XREF output - program-name cross-references" on page 271
"Example: embedded cross-reference" on page 271

RELATED TASKS
"Getting listings" on page 263

RELATED REFERENCES
"XREF" on page 239

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.

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 266

RELATED TASKS
"Getting listings" on page 263

RELATED REFERENCES
"MAP" on page 221

Using the debugger

Use the TEST option to prepare your executable COBOL program for use with the debugger.

The Distributed Debugger is a debugger that is provided with the COBOL for AIX compiler. To be able to use the Distributed Debugger to step through a run of your program, use the TEST compiler option. Alternatively, you can use the -g option of the cob2 (or cob2_j, cob2_r, or cob2_r4) command to prepare your program to use the debugger.

To invoke the debugger to examine an executable file, issue the command idebug *filename*, where *filename* is the name of your program. If the program was compiled with the -g option, the debugger will show symbolic and line-number information.

RELATED TASKS
"Compiling from the command line" on page 179

RELATED REFERENCES
"TEST" on page 234

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 38. **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 To check the locale in effect during compilation	Short listing	Diagnostic messages about the compilation"1" on page 264; list of options in effect for the program; statistics about the content of the program Locale line that shows the locale in effect	NOSOURCE, NOXREF, NOVBREF, NOMAP, 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 231
To find certain data items; 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 221"2" on page 264

Table 38. **Using compiler options to get listings** *(continued)*

Use	Listing	Contents	Compiler option
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 239[2] [3]
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]	Generated code	"LIST" on page 220[2] [4]
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 238

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. The assembler listing is written to the listing file (a file that has the same name as the source program but with the suffix .wlist).

"Example: short listing"
"Example: SOURCE and NUMBER output" on page 266
"Example: MAP output" on page 266
"Example: embedded map summary" on page 267
"Example: nested program map" on page 269
"Example: XREF output - data-name cross-references" on page 270
"Example: XREF output - program-name cross-references" on page 271
"Example: embedded cross-reference" on page 271
"Example: VBREF compiler output" on page 272

RELATED TASKS

"Generating a list of compiler error messages" on page 185

RELATED REFERENCES

"Messages and listings for compiler-detected errors" on page 185

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.

```
PP 5724-H44 IBM COBOL for AIX         2.0.0       Date 05/14/2004  Time 12:26:53   Page  1 (1)

PROCESS(CBL) statements:   (2)
CBL    NOSOURCE,NOXREF,NOVBREF,NOMAP,NOLIST    (3)        HCQ00010
Options in effect:    (4)
   NOADATA
     QUOTE
     ARITH(COMPAT)
     CALLINT(NODESCRIPTOR)
     CHAR(NATIVE)
     COLLSEQ(BINARY)
   NOCOMPILE(S)
   NOCURRENCY
   NODATEPROC
   NODIAGTRUNC
   NODYNAM
   NOEXIT
     FLAG(I,I)
   NOFLAGSTD
     FLOAT(NATIVE)
     LIB
     LINECOUNT(60)
   NOLIST
     LSTFILE(LOCALE)
   NOMAP
     MAXMEM(2048K)
     NCOLLSEQ(BINARY)
     NSYMBOL(NATIONAL)
   NONUMBER
   NOOPTIMIZE
     PGMNAME(LONGUPPER)
   NOPROFILE
     SEPOBJ
     SEQUENCE
     SIZE(8388608)
   NOSOSI
   NOSOURCE
     SPACE(1)
     SPILL(512)
     SQL
   NOSSRANGE
     TERM
   NOTEST
   NOTHREAD
     TRUNC(STD)
   NOVBREF
   NOWSCLEAR
   NOXREF
     YEARWINDOW(1900)
     ZWB
    DATA VALIDATION AND UPDATE PROGRAM (5)                        SLISTING  Date 05/14/2004  Time 12:26:53   Page    2
  LineID  Message code  Message text    (6)
          IGYDS0139-W   Diagnostic messages were issued during processing of compiler options.  These messages are
                       located at the beginning of the listing.
     193  IGYDS1050-E   File "LOCATION-FILE" contained no data record descriptions.  The file definition was discarded.
     889  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:   1009
    1008  IGYPS2121-S   "LOC-CODE" was not defined as a data-name.  The statement was discarded.
    1219  IGYPS2121-S   "COMMUTER-SHIFT" was not defined as a data-name.  The statement was discarded.
                         Same message on line:   1240
    1220  IGYPS2121-S   "COMMUTER-HOME-CODE" was not defined as a data-name.  The statement was discarded.
                         Same message on line:   1241
    1222  IGYPS2121-S   "COMMUTER-NAME" was not defined as a data-name.  The statement was discarded.
                         Same message on line:   1243
    1223  IGYPS2121-S   "COMMUTER-INITIALS" was not defined as a data-name.  The statement was discarded.
                         Same message on line:   1244
    1233  IGYPS2121-S   "WS-NUMERIC-DATE" was not defined as a data-name.  The statement was discarded.
    Messages    Total    Informational    Warning    Error   Severe   Terminating    (7)
  Printed:      21                         2          1       18
  * Statistics for COBOL program SLISTING:    (8)
  * Source records = 1765
  * Data Division statements = 277
  * Procedure Division statements = 513
  Locale = en_US.ISO8859-1                    (9)
  End of compilation 1,  program SLISTING,  highest severity: Severe.   (10)
  Return code 12
```

(1) COBOL default page header, including compiler level information from the LVLINFO installation-time compiler option.

(2) Message about options specified in a PROCESS (or CBL) statement. This message does not appear if no options were specified.

(3) Options coded in the PROCESS (or CBL) statement.

(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 the library phase

diagnostics, if there were any. Diagnostics for the library phase are always 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 SLISTING.

(9) The locale that the compiler used.

(10) Program statistics for the compilation unit. When you perform a batch compilation (multiple outermost COBOL programs in a single 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 01/31/2004  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*** EOE. Close files and stop run.                           **
                087500****************************************************************
                087600 procedure division.
                087700   000-do-main-logic.
                087800     display "PROGRAM SRCOUT - Beginning"
                087900     perform 050-create-vsam-master-file.
                088150     display "perform 050-create-vsam-master finished".
   088151**     088125     perform 100-initialize-paragraph
                088200     display "perform 100-initialize-paragraph finished"
                088300     read update-transaction-file into ws-transaction-record
                088400         at end
              1 088500       set transaction-eof to true
                088600     end-read
                088700     display "READ completed"
                088800     perform until transaction-eof
              1 088900       display "inside perform until loop"
              1 089000       perform 200-edit-update-transaction
              1 089100       display "After perform 200-edit   "
              1 089200       if no-errors
              2 089300         perform 300-update-commuter-record
              2 089400         display "After perform 300-update "
              1 089650       else
   089651**   2 089600         perform 400-print-transaction-errors
              2 089700         display "After perform 400-errors "
              1 089800       end-if
              1 089900       perform 410-re-initialize-fields
              1 090000       display "After perform 410-reinitialize"
              1 090100       read update-transaction-file into ws-transaction-record
              1 090200           at end
              2 090300         set transaction-eof to true
              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 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                          LSEQ= ORGANIZATION LINE SEQUENTIAL
    E = EXTERNAL                      O = Has OCCURS clause               SEQ= ORGANIZATION SEQUENTIAL
    VLO=Variably Located Origin       OG= Group has own length definition INDX= ORGANIZATION INDEXED
    VL= Variably Located              R = REDEFINES                       REL= ORGANIZATION RELATIVE

(2)      (3) (4)                                    (5)      (6)         (7)          (8)
Source   Hierarchy and                                                               Data Def
LineID   Data Name                                Length(Displacement) Data Type     Attributes
     4  PROGRAM-ID IGYTCARA----------------------------------------------------------------------*
   180   FD COMMUTER-FILE . . . . . . . . . . . .                      File           INDX
   182   1  COMMUTER-RECORD . . . . . . . . . . .        80           Group
   183     2  COMMUTER-KEY. . . . . . . . . . . .        16(0000000)  Display
   184     2  FILLER. . . . . . . . . . . . . . .        64(0000016)  Display
   186   FD COMMUTER-FILE-MST . . . . . . . . . .                      File           INDX
   188   1  COMMUTER-RECORD-MST . . . . . . . . .        80           Group
   189     2  COMMUTER-KEY-MST. . . . . . . . . .        16(0000000)  Display
   190     2  FILLER. . . . . . . . . . . . . . .        64(0000016)  Display
   192   FD LOCATION-FILE . . . . . . . . . . . .                      File           SEQ
   203   FD UPDATE-TRANSACTION-FILE . . . . . . .                      File           SEQ
   208   1  UPDATE-TRANSACTION-RECORD . . . . . .        80           Display
   216   FD PRINT-FILE. . . . . . . . . . . . . .                      File           SEQ
   221   1  PRINT-RECORD. . . . . . . . . . . . .       121           Display
   228   1  WORKING-STORAGE-FOR-IGYCARA . . . . . .       1           Display
```

(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) Length of data item. Base locator value.

(6) Hexadecimal displacement from the beginning of the containing structure.

(7) Data type and usage.

(8) Data definition attribute codes. The definitions are explained at the top of the DATA DIVISION map.

RELATED REFERENCES

"Terms and symbols used in MAP output" on page 268

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.    EMBMAP.
    . . .
000176                Data division.
000177                File section.
000178
000179
000180                FD  COMMUTER-FILE
000181                    record 80 characters.                                          (1)   (2)
000182                  01 commuter-record.                                               80
000183                    05 commuter-key               PIC x(16).                     16(0000000)
000184                    05 filler                     PIC x(64).                     64(0000016)
    . . .
000221         IA1620   01 print-record               pic x(121).                      121
    . . .
000227                Working-storage section.
000228                  01 Working-storage-for-EMBMAP  pic x.                             1
000229
000230                  77 comp-code                  pic S9999 comp.                    2
000231                  77 ws-type                    pic x(3)   value spaces.           3
000232
000233
000234                  01 i-f-status-area.                                              2
000235                    05 i-f-file-status           pic x(2).                        2(0000000)
000236                       88 i-o-successful        value zeroes.                IMP
000237
000238
000239                  01 status-area.                                                 8
000240                    05 commuter-file-status      pic x(2).                  (3)   2(0000000)
000241                       88 i-o-okay              value zeroes.                IMP
000242                    05 commuter-vsam-status.                                      6(0000002)
000243                      10 vsam-r15-return-code    pic 9(2) comp.                   2(0000002)
000244                      10 vsam-function-code      pic 9(1) comp.                   2(0000004)
000245                      10 vsam-feedback-code      pic 9(3) comp.                   2(0000006)
000246
000247                  77 update-file-status         pic xx.                          2
000248                  77 loccode-file-status        pic xx.                          2
000249                  77 updprint-file-status       pic xx.                          2
    . . .
000877                procedure division.
000878                  000-do-main-logic.
000879                    display "PROGRAM EMBMAP - Beginning".
000880                    perform 050-create-vsam-master-file.                      931
    . . .
```

(1) Decimal length of data item

(2) Hexadecimal displacement from the beginning of the base locator value

(3) Special definition symbols:

UND The user name is undefined.

DUP The user name is defined more than once.

IMP An implicitly defined name, such as special registers and figurative constants.

IFN An intrinsic function reference.

EXT An external reference.

***** The program name is unresolved because the NOCOMPILE option is in effect.

Terms and symbols used in MAP output

This table describes the terms used in the listings produced by the MAP option.

Table 39. **Terms and symbols used in MAP output**

Usage	Description
ALPHA-EDIT	Alphabetic-edited
ALPHABETIC	Alphabetic
AN-EDIT	Alphanumeric-edited
BINARY	Binary (computational)
COMP-1	Internal floating point (single precision)

Table 39. **Terms and symbols used in MAP output** *(continued)*

Usage	Description
COMP-2	Internal floating point (double precision)
DBCS	DBCS (display-1)
DBCS-EDIT	DBCS edited
DISP-NUM	External decimal
DISPLAY	Alphanumeric
File processing method	File (FD)
FUNCTION-POINTER	Pointer to an externally callable function
GROUP	Group fixed-length
GRP-VARLEN	Group variable-length
INDEX	Index
INDX-NAME	Index name
Level name	Condition (77)
Level name for condition-name	Condition (88)
Level name for RENAMES	Condition (66)
NUM-EDIT	Numeric-edited
OBJECT REFERENCE	Object reference
PACKED-DEC	Internal decimal (computational-3)
POINTER	Pointer
PROCEDURE-POINTER	Pointer to an externally callable program (or function)
Sort file definition	Sort definition (SD)

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

    (1)
Program Attribute codes (rightmost column) have the following meanings:
   C = COMMON
   I = INITIAL
   U = PROCEDURE DIVISION USING...

   (2)   (3)      (4)                                        (5)
Source Nesting                                             Program
LineID Level   Program Name from PROGRAM-ID paragraph     Attributes
     2         NESTED. . . . . . . . . . . . . . . . . .
    12     1     X1. . . . . . . . . . . . . . . . . . .
    20     2       X11 . . . . . . . . . . . . . . . . .
    27     2       X12 . . . . . . . . . . . . . . . . .
    35     1     X2. . . . . . . . . . . . . . . . . . .
```

(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

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)        (2)                            (3)
  Defined   Cross-reference of data names   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)        (6)                            (7)
  Defined   Cross-reference of procedures   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)        (2)                            (3)
Defined   Cross-reference of programs     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 and 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
  . . .
```

(1) Line number of the definition of the data-name or procedure-name in the program

(2) Special definition symbols:

UND The user name is undefined.

DUP The user name is defined more than once.

IMP Implicitly defined name, such as special registers and figurative constants.

IFN Intrinsic function reference.

EXT External reference.

***** The program name is unresolved because the NOCOMPILE option is in effect.

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  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  121  122  122  122  122  122  123  123
                             123  123  123  123  123  124  124  124  125  125  125  125  125  125  125  126
                             126  126  126  126  127  127  127  127  128  128  129  129  130  130  130  130
                             131  131  131  131  131  132  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  137  138  138  138  138  141  141  142  142  144  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  174  175  175
```

(1) Number of times the verb is used in the program

(2) Verb

(3) Line numbers where the verb is used

Debugging with messages that have offset information

Some IWZ messages include offset information that you can use to identify the particular line of a program that failed. To use this information:

1. Compile the program with the LIST option. This step produces an assembler listing file, which has a suffix of .wlist.
2. When you get a message that includes offset information, find the offset information for the COBOL program. In the following example, the program is IWZ903, and the corresponding hexadecimal offset is 0x14c (highlighted in bold):

```
IWZ903S  The system detected a data exception.
         Message routine called from offset 0x38 of routine iwzWriteERRmsg.
         iwzWriteERRmsg called from offset 0xa0 of routine _iwzcBCD_ADD_Pckd.
         _iwzcBCD_ADD_Pckd called from offset 0x14c of routine IWZ903.
IWZ901S  Program exits due to severe or critical error.
```

3. Look in the .wlist file for the hexadecimal offset, and to the left of the hexadecimal offset you will see the COBOL statement number. In this example, the statement number corresponding to 0x14c is 35 (highlighted in bold):

```
35| 000144 addi     39000004   1     LI       gr8=4
35| 000148 bl       4BFFFEB9   0     CALL     gr3=_iwzcBCD_ADD_Pckd
35| 00014C ori      60000000   1
35| 000150 fmr.     FC000091   0
```

4. Look in your program listing for the statement.

RELATED REFERENCES

"LIST" on page 220

Debugging user exits

To debug a user-exit routine, use the debugger on the main compiler module, not on cob2. The main compiler module is a separate process started by `cob2`, and the debugger can debug only one process.

1. Use `cob2` with the `-#` option to see how `cob2` calls the main compiler module and what options it passes. For example, the following command compiles *pgmname*.cbl with the IWZRMGUX user exit:

   ```
   cob2 -c -q"EXIT(ADEXIT(IWZRMGUX))" pgmname.cbl
   ```

   Modify this command as follows:

   ```
   cob2 -# -c -q"EXIT(ADEXIT(IWZRMGUX))" pgmname.cbl
   ```

   This is what you will see:

   ```
   IGYCCOB2 -q"EXIT(ADEXIT(IWZRMGUX))" pgmname.cbl
   ```

   This call to `IGYCCOB2` is what calls your user exit.

2. Debug the user exit as follows:

   ```
   idebug IGYCCOB2 -q"EXIT(ADEXIT(IWZRMGUX))" pgmname.cbl
   ```

The debugger automatically stops at the beginning of your user exit, assuming that you built the exit with debug information.

Debugging assembler routines

Use the Disassembly view to debug assembler routines. Because assembler routines have no debug information, the debugger automatically goes to this view.

Set a breakpoint at a disassembled statement in the Disassembly view by double-clicking in the prefix area. By default, during startup the debugger runs until it hits the first debuggable statement. To cause the debugger to stop at the very first instruction in the application (debuggable or not), you must use the `-i` option. For example:

```
idebug -i progname
```

Part 3. Accessing databases

Chapter 17. Programming for a DB2 environment 277
DB2 coprocessor 277
Coding SQL statements 278
Using SQL INCLUDE with the DB2 coprocessor 278
Using binary items 278
Using national items 279
Determining the success of SQL statements . . 279
Starting DB2 before compiling. 279
Compiling with the SQL option 279
Separating SQL suboptions 280
Using package and bind file-names 280
Ignored options 280

Chapter 18. Developing COBOL programs for CICS 281
Coding COBOL applications to run under CICS 281
Coding for ASCII-EBCDIC differences 282
Getting the system date under CICS. 282
Making dynamic calls under CICS 283
Shared library considerations 283
Accessing SFS data 284
Calling between COBOL and C/C++ under CICS 284
Compiling and running CICS programs 285
Selecting run-time options 285
Debugging CICS programs 285

Chapter 19. Open Database Connectivity (ODBC) 287
Comparison of ODBC and embedded SQL . . . 287
Background 288
Installing and configuring software for ODBC . . 288
Coding ODBC calls from COBOL: overview . . . 288
Using data types appropriate for ODBC . . . 288
Passing pointers as arguments in ODBC calls 289
Example: passing pointers as arguments in ODBC calls 290
Accessing function return values in ODBC calls 291
Testing bits in ODBC calls 291
Using COBOL copybooks for ODBC APIs 292
Example: sample program using ODBC copybooks 293
Example: copybook for ODBC procedures. . . 294
Example: copybook for ODBC data definitions 297
ODBC names truncated or abbreviated for COBOL 297
Compiling and linking programs that make ODBC calls 299

© Copyright IBM Corp. 1995, 2004

Chapter 17. 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.
- Start DB2 if it is not already started.
- Compile with the `SQL` compiler option.

RELATED CONCEPTS
"DB2 coprocessor"

RELATED TASKS
"Coding SQL statements" on page 278
"Starting DB2 before compiling" on page 279
"Compiling with the SQL option" on page 279
DB2 Application Development Guide: Programming Client Applications
DB2 Application Development Guide: Programming Server Applications

RELATED REFERENCES
DB2 Universal Database SQL Reference Volume 1
DB2 Universal Database SQL Reference Volume 2

DB2 coprocessor

When you use the DB2 coprocessor, the compiler handles your source program containing embedded SQL statements without your having to use a separate preprocessor. 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.

Certain restrictions on the use of COBOL language that applied when the preprocessor was used no longer apply:

- You can identify host variables used on SQL statements without using `EXEC SQL BEGIN DECLARE SECTION` and `EXEC SQL END DECLARE SECTION` statements.
- You can compile in batch a source file that contains multiple nonnested COBOL programs.
- The source program can contain nested programs.
- The source program can contain object-oriented COBOL language extensions.

You must specify the SQL compiler option when you compile programs that use the DB2 coprocessor.

RELATED TASKS
"Compiling with the SQL option" on page 279

© Copyright IBM Corp. 1995, 2004

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.

You can use SQL statements even for large objects (such as BLOB and CLOB) and compound SQL. The size of large objects is limited to 16 MB for a group or elementary data item.

Using SQL INCLUDE with the DB2 coprocessor

An SQL INCLUDE statement is treated identically to a native COBOL COPY statement, including the search path and the file suffixes used. 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.

COBOL does not use the DB2 environment variable DB2INCLUDE for SQL INCLUDE processing.

If you use the DB2INCLUDE environment variable for SQL INCLUDE processing, you can simply concatenate it with the setting of the COBOL SYSLIB environment variable in the .profile file in your home directory or at the prompt in an AIX command shell. For example:

```
export SYSLIB=$DB2INCLUDE:$SYSLIB
```

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 effect 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.

Using national items

DB2 treats all host variables as encoded in a specific code page, either Unicode (UTF-8 and UTF-16) or an ASCII/EUC code page. If you are using national items in SQL statements, the DB2 application code page must be set to UTF-8.

The DB2 application code page is determined from the value of the DB2CODEPAGE registry variable or, if DB2CODEPAGE is not set, from the code page of the locale in effect.

When the DB2 application code page in effect is UTF-8, alphanumeric (`USAGE DISPLAY`) host variables are interpreted as UTF-8 data, and DBCS or national (`USAGE DISPLAY-1` or `USAGE NATIONAL`) host variables are interpreted as UTF-16 data. Thus, character host variables that are used in SQL statements must be all Unicode (UTF-8 for variables described as `USAGE DISPLAY` and UTF-16 for variables described as `USAGE DISPLAY-1` or `NATIONAL`) or all ASCII/EUC.

RELATED TASKS
DB2 Universal Database Application Development Guide: Programming Client Applications

Determining the success of SQL statements

When DB2 finishes executing an SQL statement, DB2 sends a return code in the `SQLCODE` and `SQLSTATE` fields of SQLCA to indicate whether the operation succeeded or failed. Your program should test the return code and take any necessary action.

RELATED CONCEPTS
"Formats for numeric data" on page 34

Starting DB2 before compiling

Because the compiler works in conjunction with the DB2 coprocessor, you must start DB2 before you compile your program.

To connect to the target database for the compile, you can connect before you start the compile or have the compiler make the connection. To have the compiler connect, specify the database by either of these means:

- Use the `DATABASE` suboption in the `SQL` option.
- Name the database in the DB2DBDFT environment variable.

Compiling with the SQL option

The option string that you provide on the `SQL` compiler option is made available to the DB2 coprocessor. Only the DB2 coprocessor views the content of the string. The following `cob2` command passes the database name SAMPLE and the DB2 options `USER` and `USING` to the coprocessor:

```
cob2 -q"sql('database sample user myname using mypassword')" mysql.cbl. . .
```

The `SQL` options that you include in the suboption string are cumulative.

Separating SQL suboptions

Because of the concatenation of multiple SQL option specifications, you can separate SQL suboptions (which might not fit into a single CBL statement) into multiple CBL statements.

The SQL options specified from multiple sources are concatenated in the order of the specifications. For example, suppose that your mypgm.cbl source file has the following code:

```
cbl . . . SQL("string2") . . .
cbl . . . SQL("string3") . . .
```

When you issue the command cob2 mypgm.cbl -q:"SQL('string1')", the following SQL option string is passed to the DB2 coprocessor:

"*string1 string2 string3*"

The concatenated strings are delimited with single spaces. When multiple instances of the same SQL suboption are found, the last specification of the suboption in the concatenated string will be in effect. The compiler limits the length of the concatenated DB2 option string to 4 KB.

Using package and bind file-names

Two of the suboptions that you can specify with the SQL option are package name and bind file name. If you do not specify these names, default names are constructed based on the source file-name for a nonbatch compilation or on the first program for a batch compilation. For subsequent nonnested programs of a batch compilation, the names are based on the PROGRAM-ID of each program.

For the package name, the base name (the source file-name or the PROGRAM-ID) is modified as follows:

- Names longer than eight characters are truncated to eight characters.
- Lowercase letters are folded to uppercase.
- Any character other than A-Z, 0-9, or _ (underscore) is changed to 0.
- If the first character is not alphabetic, it is changed to A.

Thus if the base name is *9123aB-cd*, the package name is *A123AB0C*.

For the bind file-name, the suffix .bnd is added to the base name. Unless explicitly specified, the file-name is relative to the current directory.

Ignored options

The following options, which were meaningful to and used by the preprocessor, are ignored by the coprocessor:

- MESSAGES
- NOLINEMACRO
- OPTLEVEL
- OUTPUT
- SQLCA
- TARGET
- WCHARTYPE

RELATED REFERENCES

Precompile program (*DB2 Universal Database Command Reference*)

Chapter 18. Developing COBOL programs for CICS

You can write CICS applications in COBOL and run them on the AIX workstation using TXSeries.

After you have installed and configured CICS, you need to prepare COBOL applications to run under CICS. The steps are outlined here.

1. Initialize the CICS environment.

   The environment variables are set when you start the CICS region. To set environment variables that are unique to a particular region, set them in `\var\cics_regions\`*xxx*`\environment` (where *xxx* is the name of the region). Set the environment variables that are in effect for all CICS regions to access programs, mapsets, copybooks, and files.
2. Create the application by using an editor to do the following tasks:
   - Code your program using COBOL statements and CICS commands.
   - Create COBOL copybooks.
   - Create the CICS screen maps that your program uses.
3. Use the CICS command `cicsmap` to process the screen maps.
4. Use the CICS command `cicstcl` to translate the CICS commands to valid COBOL statements and to compile and link the program.
5. Define the resources for your application, such as transactions, application programs, and files to the CICS region to which you have access. CICS administrator authority is required to perform these actions.
6. Access CICS regions by logging on to DCE using `dce_logon` and `cicsterm`.
7. Select your CICS region where your resources are defined. Depending on how your system is configured, you might need to first log on to CICS by using the supplied CESN.
8. Run the application by entering the four-character transaction ID that is associated with the application.

RELATED TASKS
CICS Application Programming Guide

Coding COBOL applications to run under CICS

In general, the COBOL language is supported in a CICS environment. However, there are certain restrictions and considerations that you should be aware of when you code COBOL applications to run under CICS.

Object-oriented programming and interoperability with Java are not supported under CICS. COBOL class definitions and methods cannot be run in a CICS environment.

Do not use `EXEC`, `CICS`, `DLI`, or `END-EXEC` for variable names, and do not use user-specified parameters to the main program.

In addition, it is recommended that you not use:

- `FILE-CONTROL` entry in the `ENVIRONMENT DIVISION`
- `FILE SECTION` of the `DATA DIVISION`

© Copyright IBM Corp. 1995, 2004

- USE declaratives (except USE FOR DEBUGGING)

The following COBOL language statements are not recommended for use in a CICS environment:

- ACCEPT (format 1)
- CLOSE
- DELETE
- DISPLAY
- MERGE
- OPEN
- READ
- REWRITE
- SORT
- START
- STOP *literal*
- WRITE

Apart from some forms of the ACCEPT statement, mainframe CICS does not support any of the COBOL language elements in the preceding list. If you use any of these COBOL language elements, be aware that:

- The application is not completely portable to the mainframe CICS environment.
- In the case of a CICS failure, a backout (restoring the resources that are associated with the failed task) for resources that were updated by using the above statements will not be possible.

When you code nested programs, pass DFHEIBLK and DFHCOMMAREA as parameters to any nested programs that contain EXEC commands or references to the EIB. You must also pass the same parameters to any program that forms part of the control hierarchy between such a program and its top-level program.

Coding for ASCII-EBCDIC differences

If your CICS program is to run on an ASCII platform and it accesses EBCDIC data, be aware that neither the CICS run time nor the COBOL run time automatically converts the data to ASCII encoding.

If your program is designed to access mainframe data and you do not build with host data type options, you might need to add logic to your program to test whether the data is EBCDIC and, if necessary, explicitly convert the encoding.

Getting the system date under CICS

To retrieve the system date in a CICS program, you can use a format-2 ACCEPT statement with the four-digit year options:

```
ACCEPT identifier FROM DATE YYYYMMDD
ACCEPT identifier FROM DAY YYYYDDD
```

Alternatively, you can use the CURRENT-DATE intrinsic function.

You can use a format-2 ACCEPT statement to retrieve two-digit year dates:

```
ACCEPT identifier FROM DATE
ACCEPT identifier FROM DAY
```

These methods work in both CICS and non-CICS environments.

Do not use a format-1 ACCEPT statement in a CICS program.

RELATED TASKS
"Compiling and running CICS programs" on page 285
"Making dynamic calls under CICS"
"Accessing SFS data" on page 284
"Calling between COBOL and C/C++ under CICS" on page 284
"Debugging CICS programs" on page 285

Making dynamic calls under CICS

You can use dynamic calls in the CICS environment. However, you must set the COBPATH environment variable correctly. You also must make sure that the called module has the correct name. Consider the following example.

```
WORKING-STORAGE SECTION.
01  WS-COMMAREA     PIC 9 VALUE ZERO.
77   SUBPNAME       PIC X(8) VALUE SPACES
. . .
PROCEDURE DIVISION.
    MOVE 'alpha' TO SUBPNAME.
    CALL SUBPNAME USING DFHEIBLK, DFHCOMMAREA, WS-COMMAREA.
. . .
```

Because alpha is a COBOL program that contains CICS statements, CICS control blocks DFHEIBLK and DFHCOMMAREA must be passed (as shown) to alpha. The source for alpha is in the file alpha.ccp. The CICS command CICSTCL is used to translate, compile, and link alpha.ccp. COBOL defaults to uppercase names. Therefore, unless you change this default by using the PGMNAME(MIXED)option, you need to name the source file ALPHA.ccp (not alpha.cpp) to produce ALPHA.ibmcob and not alpha.ibmcob.

Suppose that the CICS region is called *green*. Then file ALPHA.ibmcob must be copied to /var/cics_regions/green/bin and the AIX SMIT tool must be used to define ALPHA as a CICS program.

To the file /var/cics_regions/green/environment your installation staff must add:

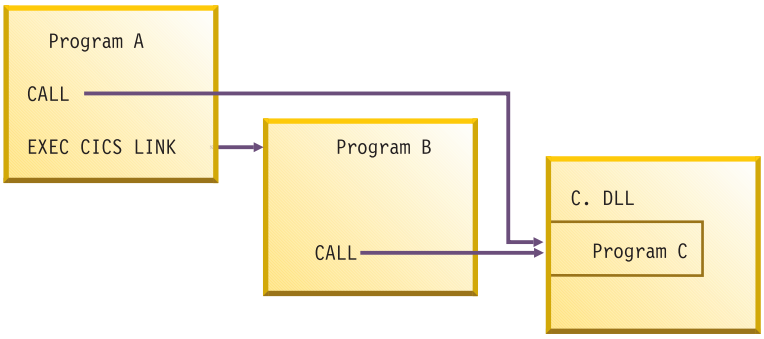
```
COBPATH=/var/cics_regions/green/bin
```

Then they must shut down the CICS green region and restart it. If you put dynamically called programs in some other directory, make sure that your installation staff adds the directory to COBPATH and that the CICS servers have permission to access the directory.

Shared library considerations

If you have a shared library that contains one or more COBOL programs, do not use it in more than one run unit within the same CICS transaction, or the results are unpredictable. The following figure shows a CICS transaction in which the same subprogram is called from two different run units:

- Program A calls Program C (in C.so).
- Program A links to Program B using an EXEC CICS LINK command. This combination becomes a new run unit within the same transaction.
- Program B calls Program C (in C.so).



Programs A and B share the same copy of Program C, and any changes to its state affect both.

In the CICS environment, programs in a shared library are initialized (both the `WSCLEAR` compiler option and `VALUE` clause initialization) only on the first call within a run unit. If a COBOL subprogram is called more than once, from either the same or different main programs, the subprogram will be initialized only on the first call.

If you need the subprogram initialized on the first call from each main program, you should statically link a separate copy of the subprogram with each calling program. If you need the subprogram initialized on every call, you should use one of the following methods:

- Put data to be reinitialized in the `LOCAL-STORAGE SECTION` of the subprogram rather than in `WORKING-STORAGE`. This placement affects initialization by the `VALUE` clause only, not by the `WSCLEAR` compiler option.
- Use `CANCEL` to cancel the subprogram after each use, so that the next call will be to the program in its initial state.
- Add the `INITIAL` attribute to the subprogram.

Accessing SFS data

You can access SFS (the default file system used by TXSeries) through the VSAM file system when not running under CICS.

RELATED TASKS

"Identifying Encina SFS files" on page 120

Calling between COBOL and C/C++ under CICS

The following rules govern calls between COBOL and C/C++ programs under CICS:

- COBOL programs that contain CICS commands can call C/C++ programs as long as the called C/C++ programs do not contain any CICS commands.
- C/C++ programs that contain CICS commands can call COBOL programs as long as the called COBOL programs do not contain any CICS commands.
- COBOL programs can issue an `EXEC CICS LINK` or `EXEC CICS XCTL` to a C/C++ program regardless of whether the C/C++ program contains CICS commands.

Therefore, if your COBOL program invokes a C/C++ program that contains CICS commands (or vice versa), use `EXEC CICS LINK` or `EXEC CICS XCTL` rather than the COBOL `CALL` statement.

Compiling and running CICS programs

COBOL for AIX CICS applications must use the thread-safe version of the COBOL run-time library. Compile such applications by using the `cob2_r` command and the `NOTHREAD` compiler option (the default).

`TRUNC(BIN)` is a recommended compiler option for a COBOL program that will run under CICS. However, if you are certain that the nontruncated values of `BINARY`, `COMP`, or `COMP-4` data items conform to `PICTURE` specifications, you might improve program performance by using `TRUNC(OPT)`.

You can use a `COMP-5` data item instead of a `BINARY`, `COMP`, or `COMP-4` data item as an `EXEC CICS` command argument. `COMP-5` data items are treated like `BINARY`, `COMP`, or `COMP-4` data items are when `TRUNC(BIN)` is in effect, regardless of whether you explicitly set that option.

You must use the `PGMNAME(MIXED)` compiler option for applications that use CICS Client.

You must not use `DYNAM` or `NOLIB` when you translate COBOL programs with the CICS translator. Avoid using `TRUNC(STD)`. All other COBOL compiler options (except `THREAD`) are supported.

Selecting run-time options

When no specific file system has been selected by means of an `ASSIGN` clause, use the `FILESYS` run-time option to specify the file system to use.

RELATED TASKS
"Compiling from the command line" on page 179
CICS Application Programming Guide

RELATED REFERENCES
Chapter 13, "Compiler options," on page 199
"THREAD" on page 235
"FILESYS" on page 250
Appendix B, "zSeries host data type considerations," on page 511

Debugging CICS programs

Before you debug your CICS programs, you need to translate them into COBOL. Then you can debug them the same way as you would debug any other COBOL program.

Alternatively, you can debug CICS programs by using the Distributed Debugger that is shipped with COBOL for AIX. Be sure to instruct the compiler to produce the symbolic information that is used by the debugger.

RELATED CONCEPTS
Chapter 16, "Debugging," on page 253

RELATED TASKS
CICS Application Programming Guide

Chapter 19. Open Database Connectivity (ODBC)

Open Database Connectivity (OBDC) is a specification for an application programming interface (API) that enables applications to access multiple database management systems using Structured Query Language (SQL). Using the ODBC interface in your COBOL applications, you can dynamically access databases and file systems that support the ODBC interface.

ODBC permits maximum interoperability: a single application can access many different database management systems. This interoperability enables you to develop, compile, and ship an application without targeting a specific type of data source. Users can then add the database drivers, which link the application to the database management systems of their choice.

When you use the ODBC interface, your application makes calls through a driver manager. The driver manager dynamically loads the necessary driver for the database server to which the application connects. The driver, in turn, accepts the call, sends the SQL to the specified data source (database), and returns any result.

Comparison of ODBC and embedded SQL

Your COBOL applications that use embedded SQL for database access must be processed by a preprocessor or coprocessor for a particular database and have to be recompiled if the target database changes. Because ODBC is a call interface, there is no compile-time designation of the target database as there is with embedded SQL. Not only can you avoid having multiple versions of your application for multiple databases, but your application can dynamically determine which database to target.

Some of the advantages of ODBC are:

- ODBC provides a consistent interface regardless of the kind of database server used.
- You can have more than one concurrent connection.
- Applications do not have to be bound to each database on which they will run. Although COBOL for AIX does this bind for you automatically, it binds automatically to only one database. If you want to choose which database to connect to dynamically at run time, you must take extra steps to bind to a different database.

Embedded SQL also has some advantages:

- Static SQL usually provides better performance than dynamic SQL. It does not have to be prepared at run time, thus reducing both processing and network traffic.
- With static SQL, database administrators have to grant users access to a package only rather than access to each table or view that will be used.

© Copyright IBM Corp. 1995, 2004

Background

The X/Open Company and the SQL Access Group jointly developed a specification for a callable SQL interface, referred to as the X/Open Call Level Interface. The goal of this interface is to increase portability of applications by enabling them to become independent of any one database vendor's programming interface.

ODBC was originally developed by Microsoft(R) for Microsoft operating systems based on a preliminary draft of X/Open CLI. Since then, other vendors have provided ODBC drivers that run on other platforms, such as UNIX systems.

Installing and configuring software for ODBC

To enable ODBC for data access in COBOL for AIX, you must:

1. Install an ODBC driver manager and drivers.
2. Add the ODBC database drivers necessary for your installation.
3. Install the RDBMS client (for example, DB2 UDB, Oracle 7 SQL*NET).

Coding ODBC calls from COBOL: overview

To access ODBC from COBOL programs, you need to consider data descriptions to fit what ODBC expects and how to pass arguments, access return values for functions, and test bits. IBM COBOL for AIX also provides copybooks to help you use ODBC calls.

RELATED TASKS
"Using data types appropriate for ODBC"
"Passing pointers as arguments in ODBC calls" on page 289
"Accessing function return values in ODBC calls" on page 291
"Testing bits in ODBC calls" on page 291
"Using COBOL copybooks for ODBC APIs" on page 292
"Compiling and linking programs that make ODBC calls" on page 299

Using data types appropriate for ODBC

The data types specified in ODBC APIs are defined in terms of ODBC C types in the API definitions. Use the COBOL data declarations corresponding to the indicated ODBC C types of the arguments as shown in the table below:

Table 40. **ODBC C types and corresponding COBOL declarations**

ODBC C type	COBOL form	Description
SQLSMALLINT	`COMP-5 PIC S9(4)`	Signed short integer (2-byte binary)
SQLUSMALLINT	`COMP-5 PIC 9(4)`	Unsigned short integer (2-byte binary)
SQLINTEGER	`COMP-5 PIC S9(9)`	Signed long integer (4-byte binary)
SQLUINTEGER	`COMP-5 PIC 9(9)`	Unsigned long integer (4-byte binary)
SQLREAL	`COMP-1`	Floating point (4 bytes)
SQLFLOAT	`COMP-2`	Floating point (8 bytes)
SQLDOUBLE	`COMP-2`	Floating point (8 bytes)
SQLCHAR	`POINTER`	Pointer to unsigned character
SQLHDBC	`POINTER`	Connection handle
SQLHENV	`POINTER`	Environment handle

Table 40. **ODBC C types and corresponding COBOL declarations** *(continued)*

ODBC C type	COBOL form	Description
SQLHSTMT	POINTER	Statement handle
SQLHWND	POINTER	Window handle

The pointer to an unsigned character is in COBOL a pointer to a null-terminated string. You define the target (of the pointer) item with PIC X(*n*), where *n* is large enough to represent the null-terminated field. Some ODBC APIs require you to pass null-terminated character strings as arguments.

Do not use z/OS host data type options. ODBC APIs expect their parameters to be in native format.

RELATED TASKS
"Passing pointers as arguments in ODBC calls"
"Accessing function return values in ODBC calls" on page 291

Passing pointers as arguments in ODBC calls

If you specify an argument as a pointer to one of the data types acceptable to ODBC, then you need to do one of these steps:

- Pass the target item of the pointer BY REFERENCE.
- Define a pointer data item that points to the target item and pass that BY VALUE.
- Pass the ADDRESS OF the target item BY VALUE.

To illustrate, assume the function is defined as

```
RETCODE SQLSomeFunction(PSomeArgument)
```

Here PSomeArgument is defined as an argument that points to SomeArgument.

You can pass the argument to SQLSomeFunction in one of the following ways:

- Pass SomeArgument BY REFERENCE:

  ```
  CALL "SQLSomeFunction" USING BY REFERENCE SomeArgument
  ```

  You can use USING BY CONTENT SomeArgument instead if SomeArgument is an input argument.
- Define a pointer data item PSomeArgument to point to SomeArgument:

  ```
  SET PSomeArgument TO ADDRESS OF SomeArgument
  CALL "SQLSomeFunction" USING BY VALUE PSomeArgument
  ```
- Pass ADDRESS OF SomeArgument BY VALUE:

  ```
  CALL "SQLSomeFunction" USING BY VALUE ADDRESS OF SomeArgument
  ```

You can use the last approach only if the target argument, SomeArgument, is a level 01 item in the LINKAGE SECTION. If so, you can set the addressability to SomeArgument in one of the following ways:

- Explicitly by using either a pointer or an identifier, as in the following examples:

  ```
  SET ADDRESS OF SomeArgument TO a-pointer-data-item
  ```

  ```
  SET ADDRESS OF SomeArgument to ADDRESS OF an-identifier
  ```
- Implicitly by having SomeArgument passed in as an argument to the program from which the ODBC function call is being made.

"Example: passing pointers as arguments in ODBC calls" on page 290

Example: passing pointers as arguments in ODBC calls

The following fragment of a sample program shows how to invoke the SQLAllocHandle function:

```
. . .
WORKING-STORAGE SECTION.
    COPY ODBC3.
    . . .
01  SQL-RC     COMP-5    PIC S9(4).
01  Henv       POINTER.
. . .
PROCEDURE DIVISION.
. . .
    CALL "SQLAllocHandle"
        USING
        By VALUE     sql=handle-env
                     sql-null-handle
        By REFERENCE Henv
        RETURNING      SQL-RC
    IF SQL-RC NOT = (SQL-SUCCESS or SQL-SUCCESS-WITH-INFO)
        THEN
            DISPLAY "SQLAllocHandle failed."
            . . .
        ELSE
        . . .
```

You can use any one of the following examples for calling the SQLConnect function:

Example 1:

```
. . .
CALL "SQLConnect" USING BY VALUE     ConnectionHandle
                        BY REFERENCE ServerName
                        BY VALUE     SQL-NTS
                        BY REFERENCE UserIdentifier
                        BY VALUE     SQL-NTS
                        BY REFERENCE AuthentificationString
                        BY VALUE     SQL-NTS
                  RETURNING          SQL-RC
. . .
```

Example 2:

```
. . .
SET Ptr-to-ServerName             TO ADDRESS OF ServerName
SET Ptr-to-UserIdentifier         TO ADDRESS OF UserIdentifier
SET Ptr-to-AuthentificationString TO ADDRESS OF AuthentificationString
CALL "SQLConnect" USING BY VALUE     ConnectionHandle
                                     Ptr-to-ServerName
                                     SQL-NTS
                                     Ptr-to-UserIdentifier
                                     SQL-NTS
                                     Ptr-to-AuthentificationString
                                     SQL-NTS
                  RETURNING          SQL-RC
. . .
```

Example 3:

```
. . .
CALL "SQLConnect" USING BY VALUE     ConnectionHandle
                                     ADDRESS OF ServerName
                                     SQL-NTS
                                     ADDRESS OF UserIdentifier
                                     SQL-NTS
```

```
                                    ADDRESS OF AuthentificationString
                                    SQL-NTS
                    RETURNING       SQL-RC
. . .
```

In **Example 3**, you must define `Servername`, `UserIdentifier`, and `AuthentificationString` as level-01 items in the `LINKAGE SECTION`.

The `BY REFERENCE` or `BY VALUE` phrase applies to all arguments until overridden by another `BY REFERENCE`, `BY VALUE`, or `BY CONTENT` phrase overrides it.

Accessing function return values in ODBC calls

Specify the function return values for an ODBC call by using the `RETURNING` phrase on the `CALL` statement:

```
CALL "SQLAllocEnv" USING BY VALUE Phenv RETURNING SQL-RC
    IF SQL-RC NOT = SQL-SUCCESS
        THEN
            DISPLAY "SQLAllocEnv failed."
            . . .
        ELSE
            . . .
    END-IF
    . . .
```

Testing bits in ODBC calls

For some of the ODBC APIs, you must set bit masks and query bits. You can use the callable library routine iwzODBCTestBits for querying bits.

Call this routine as follows:

```
CALL "iwzODBCTestBits" USING identifier-1, identifier-2 RETURNING identifier-3
```

identifier-1
: This is the field being tested. It must be a 2- or 4-byte binary number field, that is, `USAGE COMP-5 PIC 9(4)` or `PIC 9(9)`.

identifier-2
: This is the bit mask field to select the bits to be tested. It must be defined with the same `USAGE` and `PICTURE` as *identifier-1*.

identifier-3
: This is the return value for the test and has the following return values:

  0 None of the bits indicated by *identifier-2* is `ON` in *identifier-1*.

  1 All the bits selected by *identifier-2* are `ON` in *identifier-1*.

  -1 One or more bits are `ON` and one or more bits are `OFF` among the bits selected by *identifier-2* for *identifier-1*.

  -100 Invalid input argument found (such as an 8-byte binary number field is used as *identifier-1*).

  You must define it as `USAGE COMP-5` with `PICS9(4)`.

You can set multiple bits in a field using COBOL arithmetic expressions with the bit masks defined in the `ODBCCOB` copybook. For example, you can set the bits for `SQL-CVT-CHAR`, `SQL-CVT-NUMERIC`, and `SQL-CVT-DECIMAL` in the `InfoValue` field with this statement:

```
COMPUTE InfoValue = SQL-CVT-CHAR + SQL-CVT-NUMERIC + SQL-CVT-DECIMAL
```

After you set InfoValue, you can pass it to the iwzTestBits function as the second argument.

The operands of the arithmetic expression above represent disjoint bits from each other as defined for each of such bit mask symbols in ODBCCOB copybook. You should be careful not to repeat the same bit in an arithmetic expression for this purpose (since the operations are arithmetic additions, not logical ORs). For example, the following code results in InfoValue not having the SQL-CVT-CHAR bit on:

```
COMPUTE InfoValue = SQL-CVT-CHAR + SQL-CVT-NUMERIC + SQL-CVT-DECIMAL + SQL-CVT-CHAR
```

Using COBOL copybooks for ODBC APIs

Included with IBM COBOL for AIX are copybooks that make it easier for you to access databases with ODBC drivers by using ODBC calls from your COBOL programs. You can use these copybooks with or without modifications.

The copybooks described here are for ODBC Version 3.0. However, Version 2.x copybooks are also supplied, and you can substitute them for the Version 3.0 copybooks if you need to develop applications for ODBC Version 2.x.

Table 41. **ODBC copybooks**

Copybook for Version 3.0 of ODBC	Copybook for Version 2.x of ODBC	Description	Location
ODBC3.CPY	ODBC2.CPY	Symbols and constants	INCLUDE folder for COBOL
ODBC3D.CPY	ODBC2D.CPY	DATA DIVISION definitions	ODBC folder in the SAMPLES folder for COBOL
ODBC3P.CPY	ODBC2P.CPY	PROCEDURE DIVISION statements	ODBC folder in the SAMPLES folder for COBOL

Including the paths for the INCLUDE and ODBC folders in your SYSLIB environment variable will ensure that the copybooks are available to the compiler.

The copybook ODBC3.CPY defines the symbols for constant values described for ODBC APIs. It maps constants used in calls to ODBC APIs to symbols specified in ODBC guides. You can use this copybook to specify and test arguments (input and output) and function return values.

The copybook ODBC3P.CPY lets you use prepared COBOL statements for commonly used functions for initializing ODBC, handling errors, and cleaning up (SQLAllocEnv, SQLAllocConnect, iwzODBCLicInfo, SQLAllocStmt, SQLFreeStmt, SQLDisconnect, SQLFreeConnect, and SQLFreeEnv). The copybook ODBC3D.CPY contains data declarations used by ODBC3.CPY in the WORKING-STORAGE SECTION (or LOCAL-STORAGE SECTION).

Some COBOL-specific adaptations have been made in these copybooks:

- Underscores (_) are replaced with hyphens (-). For example, SQL_SUCCESS is specified as SQL-SUCCESS.
- Names longer than 30 characters.

To include the copybook ODBC3.CPY, specify a COPY statement in the DATA DIVISION as follows:

- For a program, specify the COPY statement in the WORKING-STORAGE SECTION (in the outer-most program if programs are nested).
- For each method that makes ODBC calls, specify the COPY statement in the WORKING-STORAGE SECTION of the method (not the WORKING-STORAGE SECTION of the CLASS definition).

"Example: sample program using ODBC copybooks"
"Example: copybook for ODBC data definitions" on page 297
"Example: copybook for ODBC procedures" on page 294

RELATED REFERENCES

"ODBC names truncated or abbreviated for COBOL" on page 297

Example: sample program using ODBC copybooks

The following sample illustrates the use of three copybooks.

```
cbl  pgmname(mixed)
*****************************************************************
* ODBC3EG.CBL                                                   *
*---------------------------------------------------------------*
* Sample program using ODBC3, ODBC3D and ODBC3P copybooks       *
*****************************************************************
 IDENTIFICATION DIVISION.
 PROGRAM-ID. "ODBC3EG".
 DATA DIVISION.

 WORKING-STORAGE SECTION.
*  copy ODBC API constant definitions
     COPY "odbc3.cpy" SUPPRESS.
*  copy additional definitions used by ODBC3P procedures
     COPY "odbc3d.cpy".
*  arguments used for SQLConnect
 01  ServerName                    PIC X(10) VALUE Z"Oracle7".
 01  ServerNameLength       COMP-5 PIC S9(4) VALUE 10.
 01  UserId                        PIC X(10) VALUE Z"TEST123".
 01  UserIdLength           COMP-5 PIC S9(4) VALUE 10.
 01  Authentification              PIC X(10) VALUE Z"TEST123".
 01  AuthentificationLength COMP-5 PIC S9(4) VALUE 10.
 PROCEDURE DIVISION.
 Do-ODBC SECTION.
  Start-ODBC.
     DISPLAY "Sample ODBC 3.0 program starts"
*  allocate henv & hdbc
     PERFORM ODBC-Initialization
*  connect to data source
     CALL "SQLConnect" USING BY VALUE     Hdbc
                             BY REFERENCE ServerName
                             BY VALUE     ServerNameLength
                             BY REFERENCE UserId
                             BY VALUE     UserIdLength
                             BY REFERENCE Authentification
                             BY VALUE     AuthentificationLength
                       RETURNING SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
       MOVE "SQLConnect" to SQL-stmt
       MOVE SQL-HANDLE-DBC to DiagHandleType
       SET DiagHandle to Hdbc
       PERFORM SQLDiag-Function
     END-IF

*  allocate hstmt
```

```
     PERFORM Allocate-Statement-Handle
****************************************
*  add application specific logic here  *
****************************************
*  clean-up environment
     PERFORM ODBC-Clean-Up.
*  End of sample program execution
     DISPLAY "Sample COBOL ODBC program ended"
     GOBACK.
*  copy predefined COBOL ODBC calls which are performed
     COPY "odbc3p.cpy".
******************************************************
* End of ODBC3EG.CBL:  Sample program for ODBC 3.0 *
******************************************************
```

Example: copybook for ODBC procedures

This sample has procedures for initializing ODBC, cleaning up, and handling errors.

```
*****************************************************************
* ODBC3P.CPY                                                    *
*---------------------------------------------------------------*
*  Sample ODBC initialization, clean-up and error handling      *
*    procedures    (ODBC Ver 3.0)                               *
*****************************************************************
*** Initialization functions SECTION ****************************
 ODBC-Initialization SECTION.
*
  Allocate-Environment-Handle.
     CALL "SQLAllocHandle" USING
                             BY VALUE     SQL-HANDLE-ENV
                             BY VALUE     SQL-NULL-HANDLE
                             BY REFERENCE Henv
                           RETURNING      SQL-RC
      IF SQL-RC NOT = SQL-SUCCESS
       MOVE "SQLAllocHandle for Env" TO SQL-stmt
       MOVE SQL-HANDLE-ENV to DiagHandleType
       SET DiagHandle to Henv
       PERFORM SQLDiag-Function
     END-IF.
*
  Set-Env-Attr-to-Ver30-Behavior.
     CALL "SQLSetEnvAttr" USING
                              BY VALUE      Henv
                              BY VALUE      SQL-ATTR-ODBC-VERSION
                              BY VALUE      SQL-OV-ODBC3
*                                        or SQL-OV-ODBC2         *
*                                           for Ver 2.x behavior *
                              BY VALUE      SQL-IS-UINTEGER
                            RETURNING       SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
       MOVE "SQLSetEnvAttr" TO SQL-stmt
       MOVE SQL-HANDLE-ENV to DiagHandleType
       SET DiagHandle to Henv
       PERFORM SQLDiag-Function
     END-IF.
*
  Allocate-Connection-Handle.
     CALL "SQLAllocHandle" USING
                             By VALUE     SQL-HANDLE-DBC
                             BY VALUE     Henv
                             BY REFERENCE Hdbc
                           RETURNING      SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
         MOVE "SQLAllocHandle for Connection" to SQL-stmt
         MOVE SQL-HANDLE-ENV to DiagHandleType
```

```
         SET DiagHandle to Henv
         PERFORM SQLDiag-Function
     END-IF.

*** SQLAllocHandle for statement function SECTION ***************
 Allocate-Statement-Handle SECTION.
  Allocate-Stmt-Handle.
     CALL "SQLAllocHandle" USING
                             By VALUE     SQL-HANDLE-STMT
                             BY VALUE     Hdbc
                             BY REFERENCE Hstmt
                           RETURNING      SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
         MOVE "SQLAllocHandle for Stmt" TO SQL-stmt
         MOVE SQL-HANDLE-DBC to DiagHandleType
         SET DiagHandle to Hdbc
         PERFORM SQLDiag-Function
     END-IF.
*** Cleanup Functions SECTION ***********************************
 ODBC-Clean-Up SECTION.
*
  Free-Statement-Handle.
     CALL "SQLFreeHandle" USING
                              BY VALUE SQL-HANDLE-STMT
                              BY VALUE Hstmt
                            RETURNING  SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
         MOVE "SQLFreeHandle for Stmt" TO SQL-stmt
         MOVE SQL-HANDLE-STMT to DiagHandleType
         SET DiagHandle to Hstmt
         PERFORM SQLDiag-Function
     END-IF.
*
  SQLDisconnect-Function.
     CALL "SQLDisconnect" USING
                              BY VALUE Hdbc
                            RETURNING  SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
         MOVE "SQLDisconnect" TO SQL-stmt
         MOVE SQL-HANDLE-DBC to DiagHandleType
         SET DiagHandle to Hdbc
         PERFORM SQLDiag-Function
     END-IF.
*
  Free-Connection-Handle.
     CALL "SQLFreeHandle" USING
                              BY VALUE SQL-HANDLE-DBC
                              BY VALUE Hdbc
                            RETURNING  SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
        MOVE "SQLFreeHandle for DBC" TO SQL-stmt
         MOVE SQL-HANDLE-DBC to DiagHandleType
         SET DiagHandle to Hdbc
         PERFORM SQLDiag-Function
      END-IF.
*        Free-Environment-Handle.
     CALL "SQLFreeHandle" USING
                              BY VALUE SQL-HANDLE-ENV
                              BY VALUE Henv
                            RETURNING  SQL-RC
     IF SQL-RC NOT = SQL-SUCCESS
         MOVE "SQLFreeHandle for Env" TO SQL-stmt
         MOVE SQL-HANDLE-ENV to DiagHandleType
         SET DiagHandle to Henv
         PERFORM SQLDiag-Function
     END-IF.
*** SQLDiag function SECTION ************************************
```

```
 SQLDiag-Function SECTION.
  SQLDiag.
     MOVE SQL-RC TO SAVED-SQL-RC
     DISPLAY "Return Value = " SQL-RC
       IF SQL-RC = SQL-SUCCESS-WITH-INFO
         THEN
            DISPLAY SQL-stmt " successful with information"
         ELSE
            DISPLAY SQL-stmt " failed"
       END-IF
*    - get number of diagnostic records - *
     CALL "SQLGetDiagField"
             USING
               BY VALUE     DiagHandleType
                            DiagHandle
                            0
                            SQL-DIAG-NUMBER
               BY REFERENCE DiagRecNumber
               BY VALUE     SQL-IS-SMALLINT
               BY REFERENCE OMITTED
             RETURNING      SQL-RC
     IF SQL-RC = SQL-SUCCESS or SQL-SUCCESS-WITH-INFO
       THEN
*        - get each diagnostic record - *
         PERFORM WITH TEST AFTER
           VARYING DiagRecNumber-Index FROM 1 BY 1
             UNTIL DiagRecNumber-Index > DiagRecNumber
              or   SQL-RC NOT =
                     (SQL-SUCCESS or SQL-SUCCESS-WITH-INFO)
*          - get a diagnostic record - *
           CALL "SQLGetDiagRec"
                   USING
                     BY VALUE     DiagHandleType
                                  DiagHandle
                                  DiagRecNumber-Index
                     BY REFERENCE DiagSQLState
                                  DiagNativeError
                                  DiagMessageText
                     BY VALUE     DiagMessageBufferLength
                     BY REFERENCE DiagMessageTextLength
                   RETURNING          SQL-RC
           IF SQL-RC = SQL-SUCCESS OR SQL-SUCCESS-WITH-INFO
             THEN
               DISPLAY "Information from diagnostic record number"
                       " " DiagRecNumber-Index " for "
                       SQL-stmt ":"
               DISPLAY "  SQL-State = " DiagSQLState-Chars
               DISPLAY "  Native error code = " DiagNativeError
               DISPLAY "  Diagnostic message = "
                        DiagMessageText(1:DiagMessageTextLength)
             ELSE
               DISPLAY "SQLGetDiagRec request for " SQL-stmt
                       " failed with return code of: " SQL-RC
                       " from SQLError"
               PERFORM Termination
           END-IF
         END-PERFORM
       ELSE
*        - indicate SQLGetDiagField failed - *
         DISPLAY "SQLGetDiagField failed with return code of: "
                 SQL-RC
     END-IF
     MOVE Saved-SQL-RC to SQL-RC
     IF Saved-SQL-RC NOT = SQL-SUCCESS-WITH-INFO
       PERFORM Termination
     END-IF.
*** Termination Section****************************************
```

```
 Termination Section.
  Termination-Function.
     DISPLAY "Application being terminated with rollback"
     CALL "SQLTransact" USING BY VALUE henv
                                       hdbc
                                       SQL-ROLLBACK
                         RETURNING     SQL-RC
     IF SQL-RC = SQL-SUCCESS
       THEN
         DISPLAY "Rollback successful"
       ELSE
         DISPLAY "Rollback failed with return code of: "
                 SQL-RC
     END-IF
     STOP RUN.
*************************
* End of ODBC3P.CPY     *
*************************
```

Example: copybook for ODBC data definitions

This sample has data definitions for items such as message text and return codes.

```
*****************************************************************
* ODBC3D.CPY                (ODBC Ver 3.0)                      *
*---------------------------------------------------------------*
* Data definitions to be used with sample ODBC function calls   *
*  and included in Working-Storage or Local-Storage Section     *
*****************************************************************
* ODBC Handles
 01  Henv                       POINTER            VALUE NULL.
 01  Hdbc                       POINTER            VALUE NULL.
 01  Hstmt                      POINTER            VALUE NULL.
* Arguments used for GetDiagRec calls
 01  DiagHandleType             COMP-5  PIC 9(4).
 01  DiagHandle                 POINTER.
 01  DiagRecNumber              COMP-5  PIC 9(4).
 01  DiagRecNumber-Index        COMP-5  PIC 9(4).
 01  DiagSQLState.
     02 DiagSQLState-Chars              PIC X(5).
     02 DiagSQLState-Null               PIC X.
 01  DiagNativeError            COMP-5  PIC S9(9).
 01  DiagMessageText                    PIC X(511) VALUE SPACES.
 01  DiagMessageBufferLength    COMP-5  PIC S9(4)  VALUE 511.
 01  DiagMessageTextLength      COMP-5  PIC S9(4).
* Misc declarations used in sample function calls
 01  SQL-RC                     COMP-5  PIC S9(4)  VALUE 0.
 01  Saved-SQL-RC               COMP-5  PIC S9(4)  VALUE 0.
 01  SQL-stmt                           PIC X(30).
*************************
* End of ODBC3D.CPY     *
*************************
```

ODBC names truncated or abbreviated for COBOL

The following table shows ODBC names that are longer than 30 characters and shows their corresponding COBOL names.

Table 42. **ODBC names truncated or abbreviated for COBOL**

ODBC C #define symbol > 30 characters long	Corresponding COBOL name
SQL_AD_ADD_CONSTRAINT_DEFERRABLE	SQL-AD-ADD-CONSTRAINT-DEFER
SQL_AD_ADD_CONSTRAINT_INITIALLY_DEFERRED	SQL-AD-ADD-CONSTRAINT-INIT-DEF
SQL_AD_ADD_CONSTRAINT_INITIALLY_IMMEDIATE	SQL-AD-ADD-CONSTRAINT-INIT-IMM
SQL_AD_ADD_CONSTRAINT_NON_DEFERRABLE	SQL-AD-ADD-CONSTRAINT-NON-DEFE

Table 42. **ODBC names truncated or abbreviated for COBOL** *(continued)*

ODBC C #define symbol > 30 characters long	Corresponding COBOL name
SQL_AD_CONSTRAINT_NAME_DEFINITION	SQL-AD-CONSTRAINT-NAME-DEFINIT
SQL_AT_CONSTRAINT_INITIALLY_DEFERRED	SQL-AT-CONSTRAINT-INITIALLY-DE
SQL_AT_CONSTRAINT_INITIALLY_IMMEDIATE	SQL-AT-CONSTRAINT-INITIALLY-IM
SQL_AT_CONSTRAINT_NAME_DEFINITION	SQL-AT-CONSTRAINT-NAME-DEFINIT
SQL_AT_CONSTRAINT_NON_DEFERRABLE	SQL-AT-CONSTRAINT-NON-DEFERRAB
SQL_AT_DROP_TABLE_CONSTRAINT_CASCADE	SQL-AT-DROP-TABLE-CONSTRAINT-C
SQL_AT_DROP_TABLE_CONSTRAINT_RESTRICT	SQL-AT-DROP-TABLE-CONSTRAINT-R
SQL_C_INTERVAL_MINUTE_TO_SECOND	SQL-C-INTERVAL-MINUTE-TO-SECON
SQL_CA_CONSTRAINT_INITIALLY_DEFERRED	SQL-CA-CONSTRAINT-INIT-DEFER
SQL_CA_CONSTRAINT_INITIALLY_IMMEDIATE	SQL-CA-CONSTRAINT-INIT-IMMED
SQL_CA_CONSTRAINT_NON_DEFERRABLE	SQL-CA-CONSTRAINT-NON-DEFERRAB
SQL_CA1_BULK_DELETE_BY_BOOKMARK	SQL-CA1-BULK-DELETE-BY-BOOKMAR
SQL_CA1_BULK_UPDATE_BY_BOOKMARK	SQL-CA1-BULK-UPDATE-BY-BOOKMAR
SQL_CDO_CONSTRAINT_NAME_DEFINITION	SQL-CDO-CONSTRAINT-NAME-DEFINI
SQL_CDO_CONSTRAINT_INITIALLY_DEFERRED	SQL-CDO-CONSTRAINT-INITIALLY-D
SQL_CDO_CONSTRAINT_INITIALLY_IMMEDIATE	SQL-CDO-CONSTRAINT-INITIALLY-I
SQL_CDO_CONSTRAINT_NON_DEFERRABLE	SQL-CDO-CONSTRAINT-NON-DEFERRA
SQL_CONVERT_INTERVAL_YEAR_MONTH	SQL-CONVERT-INTERVAL-YEAR-MONT
SQL_CT_CONSTRAINT_INITIALLY_DEFERRED	SQL-CT-CONSTRAINT-INITIALLY-DE
SQL_CT_CONSTRAINT_INITIALLY_IMMEDIATE	SQL-CT-CONSTRAINT-INITIALLY-IM
SQL_CT_CONSTRAINT_NON_DEFERRABLE	SQL-CT-CONSTRAINT-NON-DEFERRAB
SQL_CT_CONSTRAINT_NAME_DEFINITION	SQL-CT-CONSTRAINT-NAME-DEFINIT
SQL_DESC_DATETIME_INTERVAL_CODE	SQL-DESC-DATETIME-INTERVAL-COD
SQL_DESC_DATETIME_INTERVAL_PRECISION	SQL-DESC-DATETIME-INTERVAL-PRE
SQL_DL_SQL92_INTERVAL_DAY_TO_HOUR	SQL-DL-SQL92-INTERVAL-DAY-TO-H
SQL_DL_SQL92_INTERVAL_DAY_TO_MINUTE	SQL-DL-SQL92-INTERVAL-DAY-TO-M
SQL_DL_SQL92_INTERVAL_DAY_TO_SECOND	SQL-DL-SQL92-INTERVAL-DAY-TO-S
SQL_DL_SQL92_INTERVAL_HOUR_TO_MINUTE	SQL-DL-SQL92-INTERVAL-HR-TO-M
SQL_DL_SQL92_INTERVAL_HOUR_TO_SECOND	SQL-DL-SQL92-INTERVAL-HR-TO-S
SQL_DL_SQL92_INTERVAL_MINUTE_TO_SECOND	SQL-DL-SQL92-INTERVAL-MIN-TO-S
SQL_DL_SQL92_INTERVAL_YEAR_TO_MONTH	SQL-DL-SQL92-INTERVAL-YR-TO-MO
SQL_FORWARD_ONLY_CURSOR_ATTRIBUTES1	SQL-FORWARD-ONLY-CURSOR-ATTR1
SQL_FORWARD_ONLY_CURSOR_ATTRIBUTES2	SQL-FORWARD-ONLY-CURSOR-ATTR2
SQL_GB_GROUP_BY_CONTAINS_SELECT	SQL-GB-GROUP-BY-CONTAINS-SELEC
SQL_ISV_CONSTRAINT_COLUMN_USAGE	SQL-ISV-CONSTRAINT-COLUMN-USAG
SQL_ISV_REFERENTIAL_CONSTRAINTS	SQL-ISV-REFERENTIAL-CONSTRAINT
SQL_MAXIMUM_CATALOG_NAME_LENGTH	SQL-MAXIMUM-CATALOG-NAME-LENGT
SQL_MAXIMUM_COLUMN_IN_GROUP_BY	SQL-MAXIMUM-COLUMN-IN-GROUP-B
SQL_MAXIMUM_COLUMN_IN_ORDER_BY	SQL-MAXIMUM-COLUMN-IN-ORDER-B
SQL_MAXIMUM_CONCURRENT_ACTIVITIES	SQL-MAXIMUM-CONCURRENT-ACTIVIT

Table 42. **ODBC names truncated or abbreviated for COBOL** *(continued)*

ODBC C `#define` symbol > 30 characters long	Corresponding COBOL name
SQL_MAXIMUM_CONCURRENT_STATEMENTS	SQL-MAXIMUM-CONCURRENT-STAT
SQL_SQL92_FOREIGN_KEY_DELETE_RULE	SQL-SQL92-FOREIGN-KEY-DELETE-R
SQL_SQL92_FOREIGN_KEY_UPDATE_RULE	SQL-SQL92-FOREIGN-KEY-UPDATE-R
SQL_SQL92_NUMERIC_VALUE_FUNCTIONS	SQL-SQL92-NUMERIC-VALUE-FUNCTI
SQL_SQL92_RELATIONAL_JOIN_OPERATORS	SQL-SQL92-RELATIONAL-JOIN-OPER
SQL_SQL92_ROW_VALUE_CONSTRUCTOR	SQL-SQL92-ROW-VALUE-CONSTRUCTO
SQL_TRANSACTION_ISOLATION_OPTION	SQL-TRANSACTION-ISOLATION-OPTI

Compiling and linking programs that make ODBC calls

Programs that make ODBC calls must be compiled with the PGMNAME(MIXED) compiler option. The ODBC entry points are case sensitive.

Part 4. Using XML and COBOL together

Chapter 20. Processing XML input 303
XML parser in COBOL 303
Accessing XML documents 304
Parsing XML documents 305
Processing XML events 306
Writing procedures to process XML 312
Understanding the content of XML-CODE 312
Using XML-TEXT and XML-NTEXT 314
Transforming XML text to COBOL data items 315
Restriction on processing procedures . . . 315
Ending processing procedures 315
Example: parsing XML 316
Understanding the encoding of XML documents 318
Coded character sets for XML documents . . . 319
Specifying the code page 320
Handling errors in parsing XML documents . . . 321
Unhandled exceptions 323
Handling exceptions 323
Terminating XML parsing 323
Code-page conflict exception 324

Chapter 21. Producing XML output 327
Generating XML output 327
Example: generating XML 329
Program XGFX 329
Program Pretty 331
Output from program XGFX 332
Enhancing XML output 332
Example: enhancing XML output 333
Controlling the encoding of generated XML output 336
Handling errors in generating XML output . . . 336

© Copyright IBM Corp. 1995, 2004

Chapter 20. 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 304
"Parsing XML documents" on page 305
"Processing XML events" on page 306
"Handling errors in parsing XML documents" on page 321
"Understanding the encoding of XML documents" on page 318

RELATED REFERENCES
Appendix F, "XML reference material," on page 569
XML specification

XML parser in COBOL

COBOL for AIX 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.

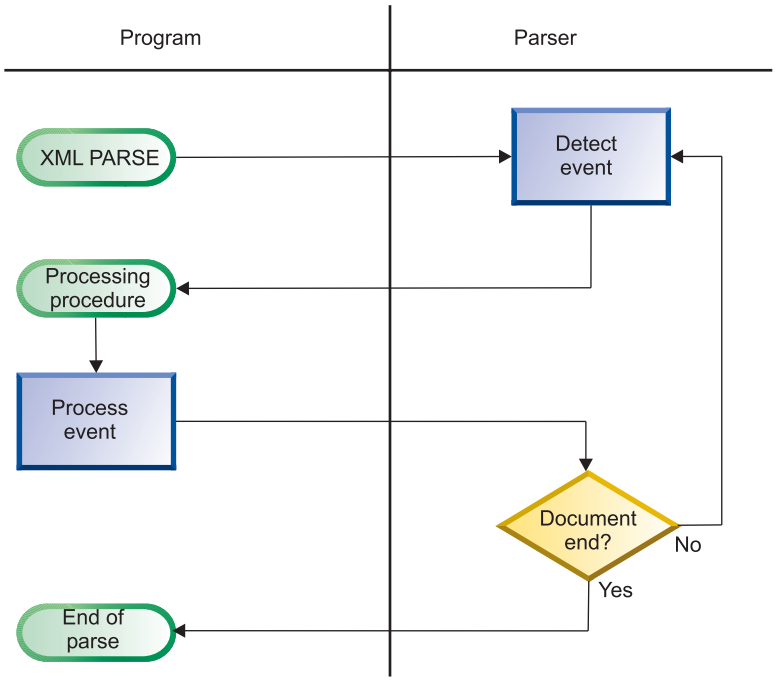
You start this exchange with the parser by using the XML PARSE statement, in which you designate your processing procedure. Execution of this XML PARSE statement begins the parsing and establishes your processing procedure with the parser. Each execution of your procedure causes the XML parser to continue analyzing the XML document and report the next event, passing back to your procedure the fragment

© Copyright IBM Corp. 1995, 2004

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"
"Parsing XML documents" on page 305
"Writing procedures to process XML" on page 312
"Handling errors in parsing XML documents" on page 321
"Understanding the encoding of XML documents" on page 318

RELATED REFERENCES
XML specification
"XML conformance" on page 575

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 from a parameter to your program or from a file.

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

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 EBCDIC or ASCII character sets. (See the related reference below about coded characters sets for more details.)

If the CHAR(EBCDIC) compiler option is in effect, do not specify the NATIVE keyword on the data description entry for the identifier if the entry describes an elementary item of USAGE DISPLAY. If the CHAR(EBCDIC) option is in effect and the identifier is alphanumeric, the content of the identifier must be encoded in EBCDIC.

ASCII XML documents that do not contain an encoding declaration are parsed with the code page indicated by the current run-time locale. EBCDIC XML documents that do not contain an encoding declaration are parsed with the code page specified in the EBCDIC_CODEPAGE environment variable. If the EBCDIC_CODEPAGE environment variable is not set, they are parsed with the default EBCDIC code page selected for the current run-time locale.

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 318

RELATED REFERENCES

"Locales and code pages supported" on page 112
"Coded character sets for XML documents" on page 319
XML PARSE statement (*COBOL for AIX 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;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.) 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.

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 '&', ''', '>', '<', and '"'. 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*..;' 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.

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, '<?', 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.

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.

Sample XML text

```
<<<![CDATA[>>
```

END-OF-CDATA-SECTION

Description

Occurs when the parser recognizes the end of a CDATA section.

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
XML-EVENT (*COBOL for AIX 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 43. **Special registers used by the XML parser**

Special register	Content	Implicit definition and usage
XML-EVENT[1 3]	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 3]	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
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

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.
3. The content of this special register is encoded according to the setting of the CHAR compiler option (EBCDIC, NATIVE, or S390).

When used in nested programs, these special registers are implicitly defined as GLOBAL in the outermost program.

Understanding the content of XML-CODE

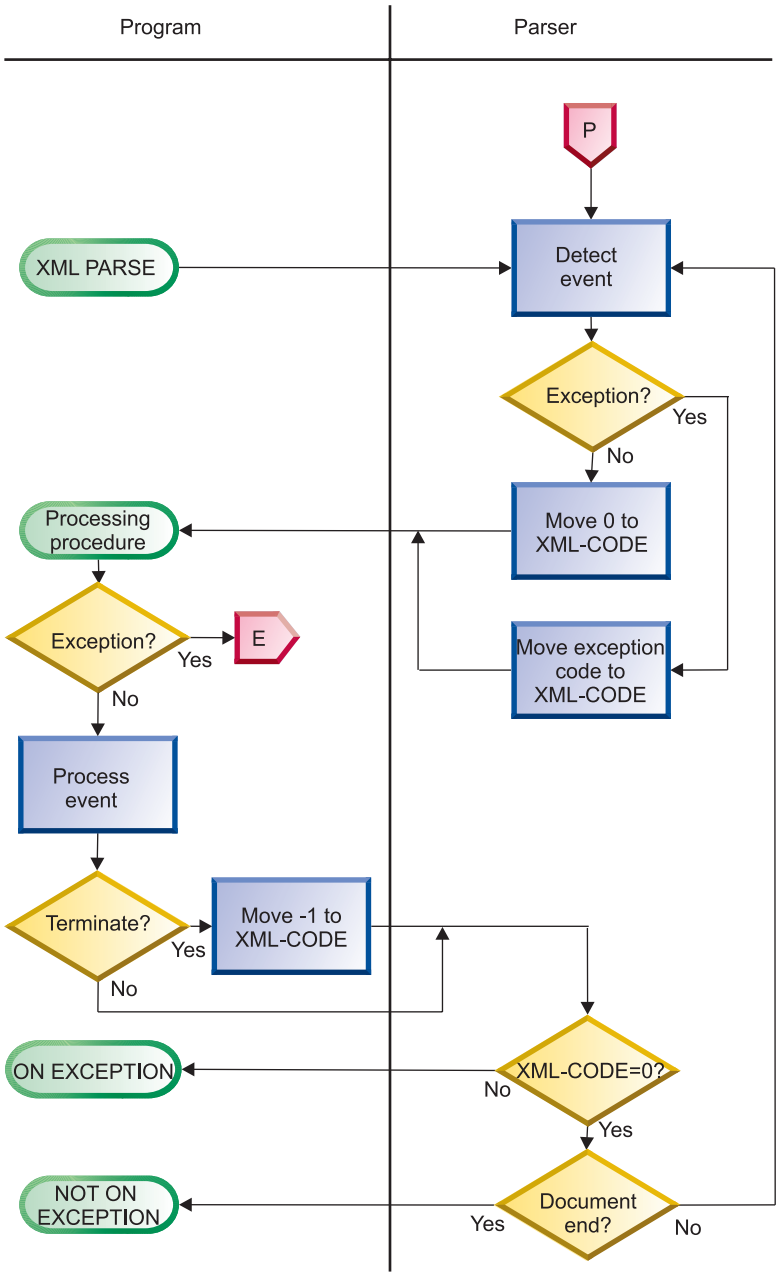
When the parser returns control to your XML PARSE statement, special register XML-CODE contains the most recent value set by the parser or by your processing procedure.

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, P) connect the multiple charts in this information. In particular, E in the following figure connects to the chart "Control flow for XML exceptions" on page 322, and P connects from "XML CCSID exception flow control" on page 324.

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 316

RELATED TASKS

"Using national data (Unicode) in COBOL" on page 98

RELATED REFERENCES

"XML PARSE exceptions that allow continuation" on page 569
"XML PARSE exceptions that do not allow continuation" on page 573
XML-CODE (*COBOL for AIX Language Reference*)
XML-EVENT (*COBOL for AIX Language Reference*)
XML-NTEXT (*COBOL for AIX Language Reference*)
XML-TEXT (*COBOL for AIX 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. xmlsampl.

 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 &amp; 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 xmlsampl.
```

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
- Native alphanumeric data items whose contents are encoded using one of the supported single-byte ASCII code pages
- Host alphanumeric data items whose contents are encoded using one of the supported single-byte EBCDIC code pages

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 pages.

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* for ASCII XML documents (the *external ASCII code page*) is the code page indicated by the current run-time locale. The external code page for EBCDIC XML documents (the *external EBCDIC code page*) is either:

- The code page that you specify in the EBCDIC_CODEPAGE environment variable
- The default EBCDIC code page selected for the current run-time locale if you do not set the EBCDIC_CODEPAGE environment variable

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 320

RELATED REFERENCES

"Locales and code pages supported" on page 112
"Coded character sets for XML documents"
"XML PARSE exceptions that allow continuation" on page 569
"XML PARSE exceptions that do not allow continuation" on page 573

Coded character sets for XML documents

Documents in national data items must be encoded with Unicode UTF-16, CCSID 1200.

XML documents in alphanumeric data items must be encoded using one of the single-byte ASCII or EBCDIC code pages shown in the table of locales and code pages referenced below. Documents in native alphanumeric data items must be encoded with an ASCII code page. Documents in host alphanumeric data items must be encoded with an EBCDIC code page. The single-byte code pages are those for which the "Language group" column (the rightmost column of the table) does not specify ideographic languages and is not blank.

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 100
"Specifying the code page"

RELATED REFERENCES
"Locales and code pages supported" on page 112

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 an ASCII or EBCDIC XML document that does not contain an encoding declaration is the run-time ASCII or EBCDIC code page.

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 44. **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
813	iso-8859-7, iso_8859-7
819	iso-8859-1, iso_8859-1
920	iso-8859-9, iso_8859-9
1200	UTF-16

RELATED TASKS

"Understanding the encoding of XML documents" on page 318

RELATED REFERENCES

"Locales and code pages supported" on page 112

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:

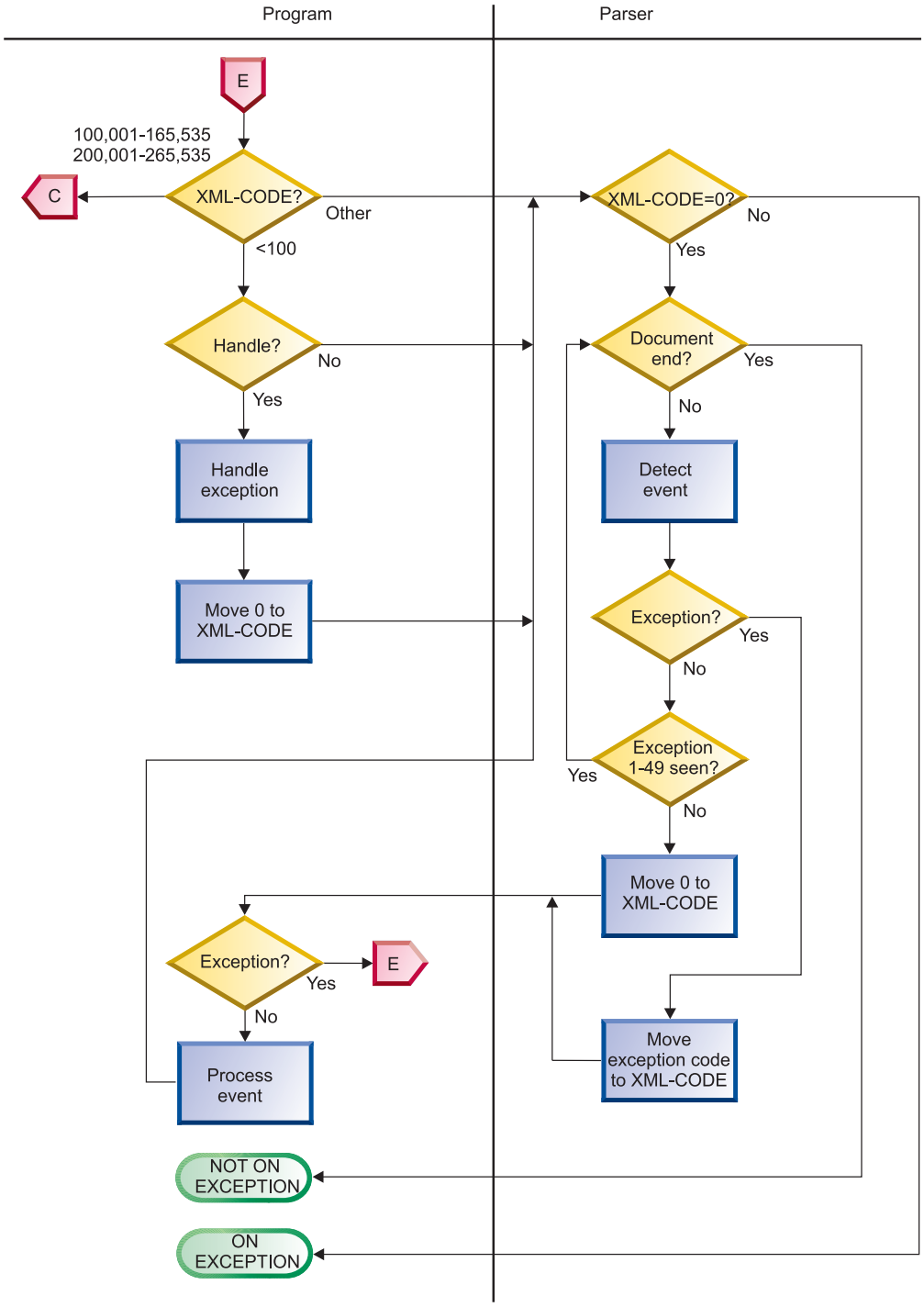
- 1-99
- 100,001-165,535
- 200,001-265,535

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, P) connect the multiple charts in this information. In particular, C connects to the chart "XML CCSID exception flow control" on page 324. Within this figure, E and E 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
- 200,001-265,535

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 or 200,001 through 265,535. These exception codes indicate that the code page of the document (as specified by its encoding declaration) conflicts with the external code-page information.

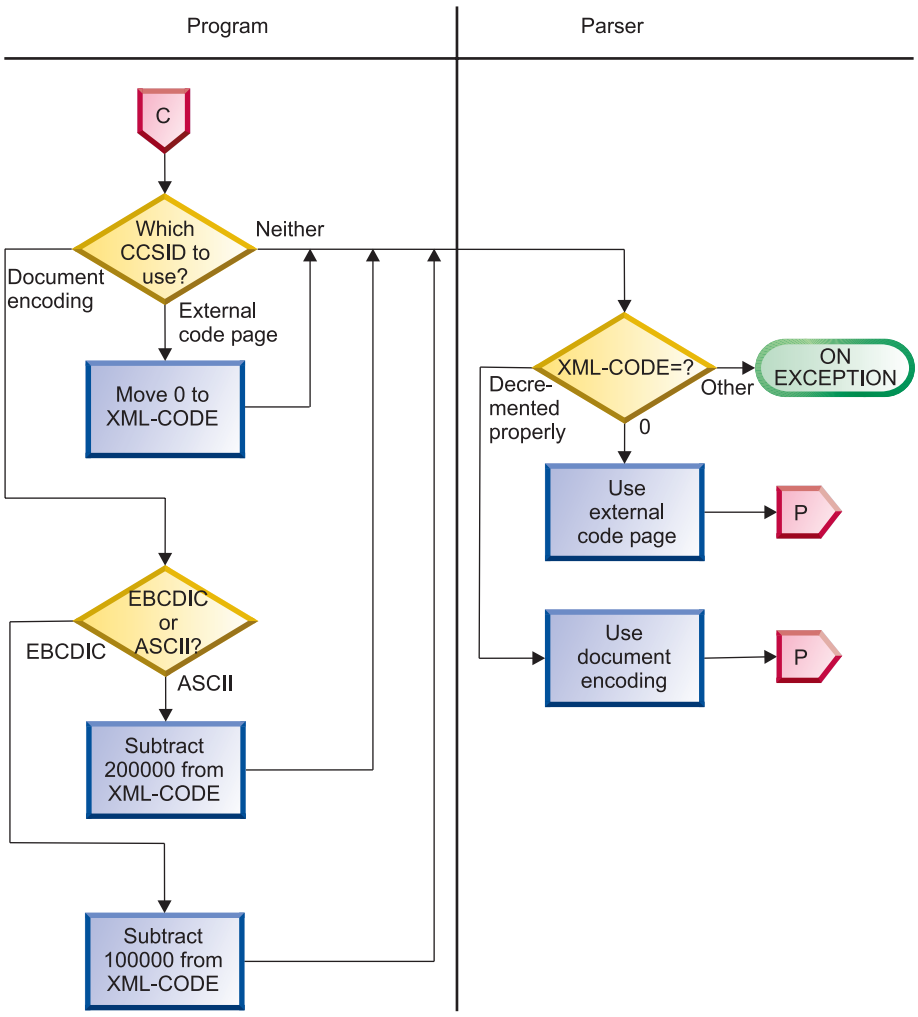
In this case, you can choose to parse with the code page of the document by subtracting 100,000 or 200,000 from the value in XML-CODE (depending on whether it is an EBCDIC code page or ASCII code page, respectively). For instance, if XML-CODE contains 101,140, the code page of the document is 1140. Alternatively, 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 ASCII code page or external EBCDIC code page, depending on whether the document data item is a native alphanumeric or host alphanumeric item, respectively.
- If you set XML-CODE to the code page of the document (that is, the original XML-CODE value minus 100,000 or 200,000, as appropriate), 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” on page 313, and connects from “Control flow for XML exceptions” on page 322.

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 318

RELATED REFERENCES

"XML PARSE exceptions that allow continuation" on page 569
"XML PARSE exceptions that do not allow continuation" on page 573
XML-CODE (*COBOL for AIX Language Reference*)

Chapter 21. 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, writing it to a file, or passing it as a parameter to another program.

RELATED TASKS
"Generating XML output"
"Enhancing XML output" on page 332
"Controlling the encoding of generated XML output" on page 336
"Handling errors in generating XML output" on page 336

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 external code pages are multibyte code pages, the locale in effect specifies a UTF-8 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 multibyte name (that is, is a data item whose name contains multibyte characters)
- Is an alphanumeric data item that contains multibyte characters

© Copyright IBM Corp. 1995, 2004

If *identifier-1* is alphanumeric, the code pages indicated by the compile-time locale and the run-time locale must be identical.

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 multibyte 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 336
"Handling errors in generating XML output" on page 336

RELATED REFERENCES
"Locales and code pages supported" on page 112
XML GENERATE statement (*COBOL for AIX Language Reference*)
Operation of XML GENERATE (*COBOL for AIX Language Reference*)
XML specification

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 xmlPO 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 20, “Processing XML input,” on page 303

RELATED REFERENCES

Operation of XML GENERATE (*COBOL for AIX 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 (*COBOL for AIX 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 329), 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 (*COBOL for AIX Language Reference*)
REPLACE statement (*COBOL for AIX 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 45. **Encoding of generated XML output**

If you define the receiving XML identifier as:	The generated XML output is encoded in:
Native alphanumeric	The code page indicated by the locale in effect
Host alphanumeric	The EBCDIC code page in effect[2]
National	UTF-16 big-endian (UTF-16BE, CCSID 1200)[1]

1. A *byte order mark* is not generated.
2. You can set the code page by using the EBCDIC_CODEPAGE environment variable. If the environment variable is not set, the encoding is in the default EBCDIC code page associated with the current locale.

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 TASKS
"Setting the locale" on page 106
"Setting environment variables" on page 169

RELATED REFERENCES
"CHAR" on page 203
Operation of XML GENERATE (*COBOL for AIX 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 84

RELATED REFERENCES

"XML GENERATE exceptions" on page 578

Part 5. Developing object-oriented programs

Chapter 22. Writing object-oriented programs 341
Example: accounts 342
Subclasses 343
Defining a class 344
CLASS-ID paragraph for defining a class . . . 346
REPOSITORY paragraph for defining a class 346
Example: external class-names and Java packages 347
WORKING-STORAGE SECTION for defining class instance data 348
Example: defining a class 349
Defining a class instance method 349
METHOD-ID paragraph for defining a class instance method 350
INPUT-OUTPUT SECTION for defining a class instance method 351
DATA DIVISION for defining a class instance method 351
PROCEDURE DIVISION for defining a class instance method 352
USING phrase for obtaining passed arguments 352
RETURNING phrase for returning a value 353
Overriding an instance method 353
Overloading an instance method 354
Coding attribute (get and set) methods 355
Example: coding a get method 355
Example: defining a method 356
Account class 356
Check class 357
Defining a client 357
REPOSITORY paragraph for defining a client 358
DATA DIVISION for defining a client 359
Choosing LOCAL-STORAGE or WORKING-STORAGE 360
Comparing and setting object references . . . 360
Invoking methods (INVOKE) 361
USING phrase for passing arguments . . . 362
RETURNING phrase for obtaining a returned value 362
Invoking overridden superclass methods . . 363
Creating and initializing instances of classes . . 364
Instantiating Java classes 364
Instantiating COBOL classes 364
Freeing instances of classes 365
Example: defining a client 365
Defining a subclass 366
CLASS-ID paragraph for defining a subclass 367
REPOSITORY paragraph for defining a subclass 367
WORKING-STORAGE SECTION for defining subclass instance data 368
Defining a subclass instance method 368
Example: defining a subclass (with methods) 369
CheckingAccount class (subclass of Account) 369
Defining a factory section 370
WORKING-STORAGE SECTION for defining factory data 371
Defining a factory method 371
Hiding a factory or static method 372
Invoking factory or static methods 373
Example: defining a factory (with methods) . . 374
Account class 374
CheckingAccount class (subclass of Account) 376
Check class 377
TestAccounts client program 378
Output produced by the TestAccounts client program 378
Wrapping procedure-oriented COBOL programs 379
Structuring OO applications 379
Examples: COBOL applications that you can run using the java command 380
Displaying a message: 380
Echoing the input strings: 380

Chapter 23. Communicating with Java methods 383
Accessing JNI services 383
Handling Java exceptions 385
Throwing an exception from your COBOL program 385
Catching a Java exception 385
Example: handling Java exceptions 385
Managing local and global references 386
Deleting, saving, and freeing local references 386
JNI services 387
Java access controls 387
Sharing data with Java 387
Coding interoperable data types in COBOL and Java 388
Declaring arrays and strings for Java 389
Manipulating Java arrays 390
Example: processing a Java int array . . . 392
Manipulating Java strings 392
Services for Unicode 392
Services for UTF-8. 393

© Copyright IBM Corp. 1995, 2004

Chapter 22. 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 COBOL for AIX, 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 COBOL for AIX 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 COBOL for AIX 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.

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 342

RELATED TASKS

"Defining a class" on page 344
"Defining a class instance method" on page 349
"Defining a client" on page 357
"Defining a subclass" on page 366
"Defining a factory section" on page 370
Chapter 12, "Compiling, linking, and running OO applications," on page 195

© Copyright IBM Corp. 1995, 2004

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.

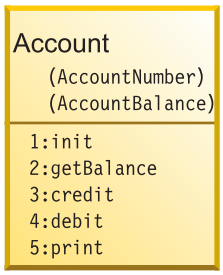
print Display account number and account balance.

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

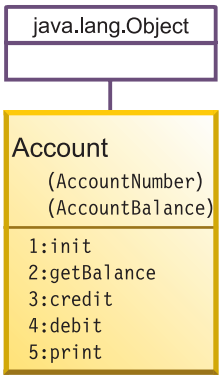
To keep the example simple, however, it is assumed that the account number and account balance are the only instance data that the Account class needs.

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

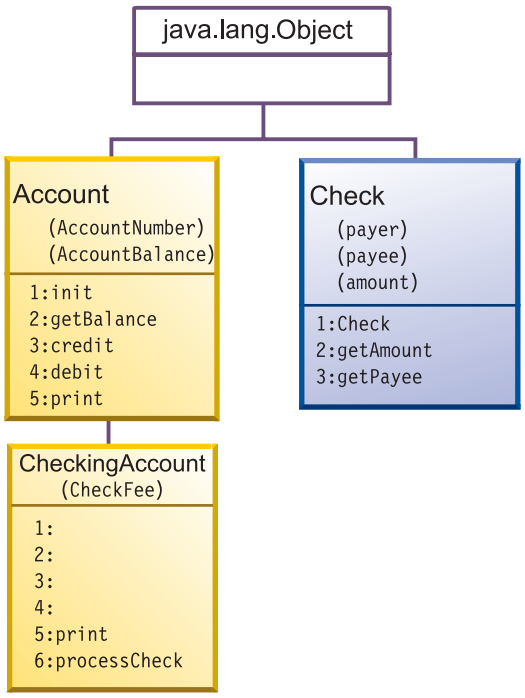
In the account example, Account is a general-purpose class. However, a bank could have many different types of accounts: checking accounts, savings accounts, mortgage loans, and so forth, all of which have all the general characteristics of accounts but could have additional characteristics not shared 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 356

RELATED TASKS

"Defining a class"

"Defining a class instance method" on page 349
"Defining a subclass" on page 366

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 46. **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 346 (required) `AUTHOR` paragraph (optional) `INSTALLATION` paragraph (optional) `DATE-WRITTEN` paragraph (optional) `DATE-COMPILED` paragraph (optional)

Table 46. **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 346 (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 349

RELATED TASKS

"WORKING-STORAGE SECTION for defining class instance data" on page 348
"Defining a class instance method" on page 349
"Defining a subclass" on page 366
"Defining a factory section" on page 370
"Describing the computing environment" on page 7
Chapter 12, "Compiling, linking, and running OO applications," on page 195

RELATED REFERENCES

COBOL class definition structure (*COBOL for AIX 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 (*COBOL for AIX Language Reference*)
User-defined words (*COBOL for AIX 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 389

RELATED REFERENCES

REPOSITORY paragraph (*COBOL for AIX 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 346

RELATED REFERENCES
REPOSITORY paragraph (*COBOL for AIX 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 364
"Freeing instances of classes" on page 365
"Defining a factory method" on page 371
"Coding attribute (get and set) methods" on page 355

Example: defining a class

This example shows a first attempt at the definition of the Account class, excluding method definitions.

```
 cbl 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 12, "Compiling, linking, and running OO applications," on page 195
"Defining a client" on page 357

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 47. **Structure of instance method definitions**

Division	Purpose	Syntax
IDENTIFICATION (required)	Name a method.	"METHOD-ID paragraph for defining a class instance method" on page 350 (required) AUTHOR paragraph (optional) INSTALLATION paragraph (optional) DATE-WRITTEN paragraph (optional) DATE-COMPILED paragraph (optional)

Table 47. **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 351 (optional)
DATA (optional)	Define external files. Allocate a copy of the data.	"DATA DIVISION for defining a class instance method" on page 351 (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 352 (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 356

RELATED TASKS
"PROCEDURE DIVISION for defining a class instance method" on page 352
"Overloading an instance method" on page 354
"Overriding an instance method" on page 353
"Invoking methods (INVOKE)" on page 361
"Defining a subclass instance method" on page 368
"Defining a factory method" on page 371

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 361
"Using national data (Unicode) in COBOL" on page 98

RELATED REFERENCES
Meaning of method names (*The Java Language Specification*)
Identifiers (*The Java Language Specification*)
METHOD-ID paragraph (*COBOL for AIX 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 (*COBOL for AIX 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 11
"Sharing data by using the EXTERNAL clause" on page 425

RELATED REFERENCES
DATA DIVISION overview (*COBOL for AIX 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

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 388
"Overriding an instance method"
"Overloading an instance method" on page 354
"Comparing and setting object references" on page 360
"Invoking methods (INVOKE)" on page 361
Chapter 12, "Compiling, linking, and running OO applications," on page 195

RELATED REFERENCES

"THREAD" on page 235
The procedure division header (*COBOL for AIX 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 356

RELATED TASKS
"PROCEDURE DIVISION for defining a class instance method" on page 352
"Coding interoperable data types in COBOL and Java" on page 388
"Invoking methods (INVOKE)" on page 361
"Invoking overridden superclass methods" on page 363
"Defining a subclass" on page 366
"Hiding a factory or static method" on page 372

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 361
"Defining a factory method" on page 371

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 348
"Processing the data" on page 15

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 349) the instance method definitions of the Account class, and shows the definition of the Java Check class.

Account class

```
 cbl 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 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.
```

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 12, “Compiling, linking, and running OO applications,” on page 195

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 48. **Structure of COBOL clients**

Division	Purpose	Syntax
IDENTIFICATION (required)	Name a client.	Code as usual, except that a client program must be: • 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" (required)
DATA (optional)	Describe the data that the client needs.	"DATA DIVISION for defining a client" on page 359 (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.

"Example: defining a client" on page 365

RELATED TASKS
Chapter 12, "Compiling, linking, and running OO applications," on page 195
Chapter 28, "Preparing COBOL programs for multithreading," on page 441
Chapter 23, "Communicating with Java methods," on page 383
"Coding interoperable data types in COBOL and Java" on page 388
"Creating and initializing instances of classes" on page 364
"Comparing and setting object references" on page 360
"Invoking methods (INVOKE)" on page 361
"Invoking factory or static methods" on page 373

RELATED REFERENCES
"THREAD" on page 235

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.
  Object-Computer.
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 346

RELATED REFERENCES
REPOSITORY paragraph (*COBOL for AIX 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 28, “Preparing COBOL programs for multithreading,” on page 441
“Coding interoperable data types in COBOL and Java” on page 388
“Invoking methods (INVOKE)” on page 361
“REPOSITORY paragraph for defining a client” on page 358

RELATED REFERENCES

RETURNING phrase (*COBOL for AIX 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 388
"Accessing JNI services" on page 383

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 severe error 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 354
"Coding interoperable data types in COBOL and Java" on page 388
"PROCEDURE DIVISION for defining a class instance method" on page 352
"Invoking overridden superclass methods"
"Invoking factory or static methods" on page 373
"Using national data (Unicode) in COBOL" on page 98

RELATED REFERENCES
INVOKE statement (*COBOL for AIX 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 342

RELATED TASKS
"Overriding an instance method" on page 353

RELATED REFERENCES
INVOKE statement (*COBOL for AIX 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 more 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 374

RELATED TASKS
"Accessing JNI services" on page 383
"Managing local and global references" on page 386
"DATA DIVISION for defining a client" on page 359
"Invoking methods (INVOKE)" on page 361
"Defining a factory section" on page 370
"Coding interoperable data types in COBOL and Java" on page 388

RELATED REFERENCES
VALUE clause (*COBOL for AIX Language Reference*)
INVOKE statement (*COBOL for AIX 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 386

Example: defining a client

This example shows a small client program of the Account class (as seen in "Example: defining a method" on page 356). 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

```
cbl thread,pgmname(longmixed)
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 374

RELATED TASKS

"Defining a factory method" on page 371
"Invoking factory or static methods" on page 373
Chapter 12, "Compiling, linking, and running OO applications," on page 195

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 342
"Example: defining a subclass (with methods)" on page 369

RELATED TASKS

"Defining a class" on page 344
"Overriding an instance method" on page 353
"Coding attribute (get and set) methods" on page 355
"Defining a subclass instance method" on page 368
"Defining a factory section" on page 370

RELATED REFERENCES

Inheritance, overriding, and hiding (*The Java Language Specification*)
COBOL class definition structure (*COBOL for AIX 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 346
"Coding attribute (get and set) methods" on page 355
"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 346

RELATED REFERENCES
REPOSITORY paragraph (*COBOL for AIX 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 348

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)" on page 369

RELATED TASKS

"Defining a class instance method" on page 349
"Overriding an instance method" on page 353
"Overloading an instance method" on page 354

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 356):

- 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 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 12, "Compiling, linking, and running OO applications," on page 195
"Invoking methods (INVOKE)" on page 361
"Overriding an instance method" on page 353
"Invoking overridden superclass methods" on page 363

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 49. **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" on page 371 (optional)
PROCEDURE (optional)	Define factory methods.	Factory method definitions: "Defining a factory method" on page 371

"Example: defining a factory (with methods)" on page 374

RELATED TASKS

"Defining a class" on page 344

"Creating and initializing instances of classes" on page 364
"Wrapping procedure-oriented COBOL programs" on page 379
"Structuring OO applications" on page 379

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 355
"Creating and initializing instances of classes" on page 364

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 50. **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 374

RELATED TASKS

"Structuring OO applications" on page 379
"Wrapping procedure-oriented COBOL programs" on page 379
"Creating and initializing instances of classes" on page 364
"Defining a class instance method" on page 349
"Coding attribute (get and set) methods" on page 355
"Overloading an instance method" on page 354
"Hiding a factory or static method"
"Invoking factory or static methods" on page 373

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 374

RELATED TASKS

"Coding interoperable data types in COBOL and Java" on page 388
"Overriding an instance method" on page 353
"Invoking methods (INVOKE)" on page 361

RELATED REFERENCES

Inheritance, overriding, and hiding (*The Java Language Specification*)
The procedure division header (*COBOL for AIX 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 severe error 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)" on page 374

RELATED TASKS

"Invoking methods (INVOKE)" on page 361
"Using national data (Unicode) in COBOL" on page 98
"Coding interoperable data types in COBOL and Java" on page 388

RELATED REFERENCES
INVOKE statement (*COBOL for AIX Language Reference*)

Example: defining a factory (with methods)

This example updates the previous examples ("Example: defining a method" on page 356, "Example: defining a client" on page 365, and "Example: defining a subclass (with methods)" on page 369):

- 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 `samples` subdirectory of the COBOL install directory, typically /usr/lpp/cobol/samples/oo. You can use the makefile there to compile and link the code.

Account class

```
 cbl 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 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 JNINativeInterface 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 JNINativeInterface 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 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 364
"Defining a factory method" on page 371
"Invoking factory or static methods" on page 373
Chapter 12, "Compiling, linking, and running OO applications," on page 195

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 344
"Defining a factory section" on page 370
"Defining a factory method" on page 371

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.

  You can run the program by specifying the name of the executable module at the command prompt.
- 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.

– Follow standard Java programming practice.

"Examples: COBOL applications that you can run using the java command"

RELATED TASKS

Chapter 12, "Compiling, linking, and running OO applications," on page 195
"Running programs" on page 193
"Defining a factory method" on page 371
"Declaring arrays and strings for Java" on page 389

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:

```
 cbl thread
 Identification Division.
 Class-id. CBLmain inherits Base.
 Environment Division.
 Configuration section.
 Repository.
     Class Base is "java.lang.Object"
     Class stringArray is "jobjectArray: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 thread,lib,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 P            pointer.
  Linkage section.
  01 SA           object reference stringArray.
  01 Sbuffer      pic N(65535).
  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 GetStringLength
        using by value JNIEnvPtr SAelement
        returning SAelementlen
      Call GetStringChars
         using by value JNIEnvPtr SAelement 0
         returning P
      Set address of Sbuffer to P
      Display function display-of(Sbuffer(1:SAelementlen))
      Call ReleaseStringChars
        using by value JNIEnvPtr SAelement P
    End-perform
    .
  End method "main".
End factory.
End class Echo.
```

RELATED TASKS

Chapter 12, “Compiling, linking, and running OO applications,” on page 195
“Defining a factory method” on page 371
Chapter 23, “Communicating with Java methods,” on page 383

Chapter 23. 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.

RELATED TASKS
"Using national data (Unicode) in COBOL" on page 98
"Accessing JNI services"
"Sharing data with Java" on page 387
Chapter 22, "Writing object-oriented programs," on page 341
Chapter 12, "Compiling, linking, and running OO applications," on page 195
Chapter 28, "Preparing COBOL programs for multithreading," on page 441

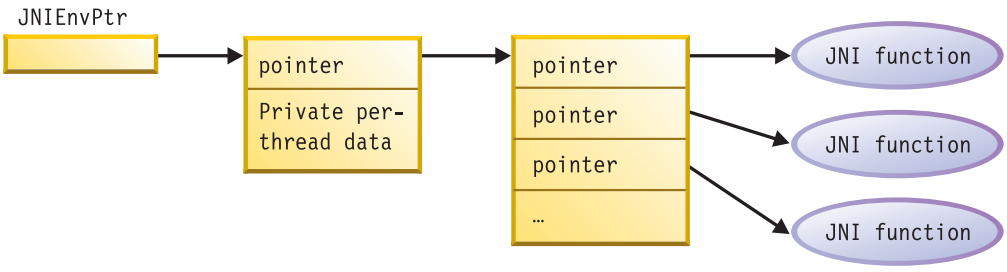
RELATED REFERENCES
The Java 2 Enterprise Edition Developer's Guide

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 these definitions:

- COBOL data definitions that correspond to the Java JNI types
- JNINativeInterface, the JNI environment structure that 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:



© Copyright IBM Corp. 1995, 2004

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. To be interoperable, the arguments must be in native format (for example, by being declared with the NATIVE clause on the data description entry).

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 386
"Handling Java exceptions" on page 385
"Coding interoperable data types in COBOL and Java" on page 388
"Defining a client" on page 357

RELATED REFERENCES

Appendix G, "JNI.cpy," on page 579
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 do these steps:

1. Test whether an exception occurred.
2. If an exception occurred, process the exception.
3. Clear the exception, if clearing is appropriate.

Use the following JNI services:

- 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 the java.lang.Throwable class.

"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. Automatic freeing of the local references occurs 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. Convert local references to global references if you want to save references with a `SET` statement in one of these data items:

- An object instance variable
- A factory variable
- A data item in the `WORKING-STORAGE SECTION` of a method

Otherwise, an error occurs. These storage areas persist when a method returns; therefore a 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. Free the large object if you do not need it for the additional computations. 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. Freeing the local references avoids 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 51. **JNI services for local and global references**

Service	Input arguments	Return value	Purpose
NewGlobalRef	• 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	• 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	• 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 is not 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 share the COBOL data types that have Java equivalents in these ways:

- Pass them as arguments in the `USING` phrase of an `INVOKE` statement.
- Receive them from a Java method as parameters in the `USING` phrase.
- Receive them as the `RETURNING` value in an `INVOKE` statement.
- 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"
"Declaring arrays and strings for Java" on page 389
"Manipulating Java arrays" on page 390
"Manipulating Java strings" on page 392
"Invoking methods (INVOKE)" on page 361
Chapter 26, "Sharing data," on page 417

Coding interoperable data types in COBOL and Java

Use only the COBOL data types in this table when you communicate with Java:

Table 52. **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:
	`level-number data-name PIC X.`
	`88 data-name-false value X'00'.`
	`88 data-name-true 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(n)`, where 1<=*n*<=4
int	`USAGE BINARY`, `COMP`, `COMP-4`, or `COMP-5`, with `PICTURE` clause of the form `S9(n)`, where 5<=*n*<=9
long	`USAGE BINARY`, `COMP`, `COMP-4`, or `COMP-5`, with `PICTURE` clause of the form `S9(n)`, where 10<=*n*<=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` *class-name*

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. A single-byte alphanumeric item can contain either EBCDIC or native content.
2. Java floating-point data is represented in IEEE floating point. Floating-point data items that you pass as arguments in an `INVOKE` statement or receive as parameters from a Java method must be in the native format. Therefore for example if you compile using the `-host` option of the `cob2_j` command or using the `FLOAT(S390)` option, each floating-point data item that you pass to or receive from a Java method must be declared with the `NATIVE` phrase in its data description entry.

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"CHAR" on page 203
"FLOAT" on page 218

Declaring arrays and strings for Java

When you communicate with Java, declare arrays with the special array classes, and declare strings with jstring. Code the COBOL data types shown in this table:

Table 53. **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`
String	`object reference jstring`

To use one of these classes for interoperability with Java, you must code an entry in the `REPOSITORY` paragraph. For example:

```
Configuration section.
Repository.
    Class jbooleanArray is "jbooleanArray".
```

The `REPOSITORY` paragraph entry for an object array type must specify an external class-name in one of these forms:

```
"jobjectArray"
"jobjectArray:external-classname-2"
```

In the first case, the `REPOSITORY` entry specifies an array class in which the elements of the array are objects of type java.lang.Object.

In the second case, the `REPOSITORY` entry specifies an array class in which the elements of the array are objects of type *external-classname-2*. Code a colon as the separator between the specification of the jobjectArray type and the external class-name of the array elements.

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 380

The following Java array types are currently not supported for interoperation with COBOL programs:

Table 54. **Noninteroperable array types in COBOL and Java**

Java data type	Corresponding COBOL data type
float[ ]	`object reference jfloatArray`
double[ ]	`object reference jdoubleArray`

RELATED TASKS

"REPOSITORY paragraph for defining a class" on page 346

Manipulating Java arrays

To represent the array in a COBOL program, code a group data item that contains a single elementary item. Code the elementary item as 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  longArray.
    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 55. **JNI array services**

Service	Input arguments	Return value	Purpose
GetArrayLength	• 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	• 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	• 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 Release*xxx*ArrayElements 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`.

Table 55. **JNI array services** *(continued)*

Service	Input arguments	Return value	Purpose
ReleaseBooleanArrayElements ReleaseByteArrayElements ReleaseCharArrayElements ReleaseShortArrayElements ReleaseIntArrayElements ReleaseLongArrayElements	• 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
NewObjectArray	• 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	• 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	• 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

1. NewObjectArray throws an exception if the system runs out of memory.
2. GetObjectArrayElement throws an exception if the index is not valid.
3. 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 380
"Example: processing a Java int array" on page 392

RELATED TASKS

"Coding interoperable data types in COBOL and Java" on page 388
"Declaring arrays and strings for Java" on page 389
"Accessing JNI services" on page 383

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
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

COBOL represents Java String data 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 national (Unicode) or UTF-8 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)`). Use these services for applications that you intend to be portable between the workstation and the mainframe.

Table 56. **Services that convert between jstring references and national data**

Service	Input arguments	Return value
NewString[1]	• 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	• The JNI environment pointer • A jstring object reference	The number of Unicode characters in the jstring object reference; binary fullword
GetStringChars[1]	• The JNI environment pointer • A jstring object reference • A pointer to a boolean data item, or NULL	• 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 ReleaseStringChars. • 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.
ReleaseStringChars	• 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 JNINativeInterface environment structure.

Services for UTF-8

You can use the following services, an extension of the JNI, to convert between jstring object references and UTF-8 strings. Use these services in programs that do not need to be portable to the mainframe.

Table 57. **Services that convert between jstring references and UTF-8 data**

Service	Input arguments	Return value
NewStringUTF[1]	• The JNI environment pointer • A pointer to a null-terminated UTF-8 string	jstring object reference, or NULL if the string cannot be constructed
GetStringUTFLength	• The JNI environment pointer • A jstring object reference	The number of bytes needed to represent the string in UTF-8 format; binary fullword
GetStringUTFChars[1]	• The JNI environment pointer • A jstring object reference • A pointer to a boolean data item, or NULL	• Pointer to an array of UTF-8 characters extracted from the jstring object, or NULL if the operation fails. The pointer is valid until it is released with ReleaseStringUTFChars. • 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 57. **Services that convert between jstring references and UTF-8 data** *(continued)*

Service	Input arguments	Return value
ReleaseStringUTFChars	• The JNI environment pointer • A jstring object reference • A pointer to the UTF-8 string that was derived from the jstring argument by using GetStringUTFChars	None; the storage for the UTF-8 string 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.

RELATED TASKS

"Accessing JNI services" on page 383
"Coding interoperable data types in COBOL and Java" on page 388
"Declaring arrays and strings for Java" on page 389
"Using national data (Unicode) in COBOL" on page 98
Chapter 12, "Compiling, linking, and running OO applications," on page 195

Part 6. Working with more complex applications

Chapter 24. Porting applications between platforms 397
Getting mainframe applications to compile . . . 397
Choosing the right compiler options. 397
Allowing for language features of mainframe COBOL 397
Using the COPY statement to help port programs. 398
Getting mainframe applications to run: overview 399
Fixing differences caused by data representations 399
Single-byte ASCII contrasted with single-byte EBCDIC 399
IEEE contrasted with hexadecimal 400
EBCDIC DBCS contrasted with ASCII-based multibyte strings 400
Fixing environment differences that affect portability 401
File-names 401
Control codes 401
Device-dependent control codes 401
Fixing differences caused by language elements 402
Writing code to run on the mainframe 402
Language features not supported by mainframe compilers. 402
Compiler options not supported by the mainframe compilers 402
Names not supported on other platforms . . . 403
Differences with THREAD 403
Writing applications that are portable between the AIX and Windows-based workstations 403

Chapter 25. Using subprograms 405
Main programs, subprograms, and calls 405
Ending and reentering main programs or subprograms 406
Calling nested COBOL programs 406
Nested programs 407
Example: structure of nested programs 408
Scope of names. 409
Local names. 409
Global names 409
Searching for name declarations 409
Calling nonnested COBOL programs 410
CALL identifier and CALL literal. 410
Calling between COBOL and C/C++ programs . . 411
Initializing environments 411
Passing data. 411
Collapsing stack frames and terminating run units or processes 411
Handling exceptions 412
COBOL and C/C++ data types 412
Example: COBOL program calling C/C++ functions 413
Example: C/C++ programs that are called by and call COBOL programs 414
Example: COBOL program called by a C/C++ program 415
Example: results of compiling and running examples 415
Making recursive calls 416
Passing return codes 416
RETURN-CODE values with nonthreaded support 416
RETURN-CODE values with threaded support 416

Chapter 26. Sharing data 417
Passing data. 417
Describing arguments in the calling program 418
Describing parameters in the called program 418
Testing for OMITTED arguments 419
Coding the LINKAGE SECTION 419
Coding the PROCEDURE DIVISION for passing arguments 420
Grouping data to be passed 420
Handling null-terminated strings 421
Using pointers to process a chained list . . . 421
Example: using pointers to process a chained list 422
Using procedure and function pointers 424
Passing return code information 425
Understanding the RETURN-CODE special register 425
Using PROCEDURE DIVISION RETURNING 425
Specifying CALL . . . RETURNING 425
Sharing data by using the EXTERNAL clause. . . 425
Sharing files between programs (external files) . . 426
Example: using external files 426
Using command-line arguments 429
Example: command-line arguments without -host option 430
Example: command-line arguments with -host option 430

Chapter 27. Building shared libraries 433
Static linking and shared libraries 433
How the linker resolves references to shared libraries 434
Example: creating a sample shared library. . . 434
Example 1: alpha.cbl 435
Example 2: beta.cbl 435
Example 3: gamma.cbl 435
Procedure 435
Example: creating a makefile for the sample shared library 437
Example: calling shared libraries using CALL identifier 437
Example 1: dl1.cbl. 438
Example 2: dlla.cbl 438
Procedure 438

© Copyright IBM Corp. 1995, 2004

Example: COBOL program calling COBOL and C shared libraries 439
Example 1: d16.cbl 439
Example 2: d16a.c 440
Example 3: d16b.cbl 440
Procedure 440

Chapter 28. Preparing COBOL programs for multithreading 441
Multithreading 441
Working with language elements with multithreading 442
Working with elements that have run-unit scope 443
Working with elements that have program invocation instance scope 443
Scope of COBOL language elements with multithreading 443
Choosing THREAD to support multithreading . . 444
Transferring control with multithreading 445
Using cancel with threaded programs 445
Ending a program 445
Preinitializing the COBOL environment . . . 445
Handling COBOL limitations with multithreading 446
Example: using COBOL in a multithreaded environment. 446
Source code for thrcob.c 446
Source code for subd.cbl. 447
Source code for sube.cbl 448

Chapter 29. Preinitializing the COBOL run-time environment 449
Initializing persistent COBOL environment . . . 449
Terminating preinitialized COBOL environment 450
Example: preinitializing the COBOL environment 451

Chapter 30. Processing two-digit-year dates 455
Millennium language extensions (MLE) 456
Principles and objectives of these extensions . . 456
Resolving date-related logic problems 457
Using a century window 458
Example: century window 459
Using internal bridging 459
Example: internal bridging 460
Moving to full field expansion. 460
Example: converting files to expanded date form 461
Using year-first, year-only, and year-last date fields 462
Compatible dates 463
Example: comparing year-first date fields . . . 464
Using other date formats 464
Example: isolating the year 464
Manipulating literals as dates 465
Assumed century window 466
Treatment of nondates 467
Setting triggers and limits 467
Example: using limits 468
Using sign conditions 469
Sorting and merging by date 469
Example: sorting by date and time 470
Performing arithmetic on date fields. 471
Allowing for overflow from windowed date fields 471
Specifying the order of evaluation 472
Controlling date processing explicitly 473
Using DATEVAL 473
Using UNDATE 473
Example: DATEVAL 474
Example: UNDATE 474
Analyzing and avoiding date-related diagnostic messages 474
Avoiding problems in processing dates 476
Avoiding problems with packed-decimal fields 476
Moving from expanded to windowed date fields 476

Chapter 24. Porting applications between platforms

Your AIX workstation has a different hardware and operating system architecture than IBM mainframes or Windows-based workstations. Because of fundamental platform differences, some problems can arise as you move COBOL programs between the AIX workstation, Windows-based workstation, and mainframe environments.

The sections below describe some of the differences between development platforms, and provide instructions to help you minimize portability problems.

RELATED TASKS
"Getting mainframe applications to compile"
"Getting mainframe applications to run: overview" on page 399
"Writing code to run on the mainframe" on page 402
"Writing applications that are portable between the AIX and Windows-based workstations" on page 403

RELATED REFERENCES
Appendix A, "Summary of differences with host COBOL," on page 505

Getting mainframe applications to compile

As you move programs to the AIX workstation from the mainframe, one of your first goals is to get the applications you have already been using to compile in the new environment without errors.

Choosing the right compiler options

One mainframe COBOL compiler option is not applicable under COBOL for AIX, and is treated as a comment. It might yield unpredictable results, and the COBOL for AIX compiler flags it with a W-level message:

NOADV Programs that require the use of `NOADV` are sensitive to device control characters and almost certainly are not portable. If your program relies on `NOADV`, revise it such that language specification does not assume a printer control character as the first character of the `01` record for the file.

Allowing for language features of mainframe COBOL

The following language features are valid under mainframe COBOL but can create errors or unpredictable results in your COBOL for AIX compilation. Where possible, the following table provides a solution to the potential problem:

Table 58. **Language features that differ from mainframe COBOL**

Language feature on mainframe	COBOL for AIX behavior	Solution or restriction
`ACCEPT` and `DISPLAY` statements	Determines the targets of `DISPLAY` or `ACCEPT` statements by checking COBOL environment variables	If your mainframe program expects host ddnames as the targets of `ACCEPT` or `DISPLAY` statements, define these targets by using equivalent environment variables with values set to appropriate file names.

© Copyright IBM Corp. 1995, 2004

Table 58. **Language features that differ from mainframe COBOL** *(continued)*

Language feature on mainframe	COBOL for AIX behavior	Solution or restriction
ASSIGN clause	Uses a different syntax and mapping to the system file name based on *assignment-name*	See ASSIGN clause (*COBOL for AIX Language Reference*).
CALL statement	Does not support file name as a CALL argument	
CLOSE statement	Treats phrases FOR REMOVAL, WITH NO REWIND, and UNIT/REEL as comments	Avoid use of these phrases in portable programs.
LABEL RECORD clause	Treats phrases LABEL RECORD IS *data-name*, USE. . .AFTER. . .LABEL PROCEDURE, and GO TO MORE-LABELS as errors	You cannot port programs that depend on the user-label processing that z/OS QSAM supports.
PROCEDURE-POINTER data items	Is 4 bytes in length. Is defined as 8 bytes on the mainframe.	
RERUN clause	Treats RERUN clause as a comment	
SHIFT-IN, SHIFT-OUT special registers	Puts out an E-level message when encountering these registers unless the CHAR(EBCDIC) compiler option is in effect	Use the CHAR(EBCDIC) compiler option.
SORT-CONTROL special register	Follows the file-naming conventions for the system file name identified by this register	Be aware of differences in naming conventions between AIX and the mainframe.
STOP RUN	Not supported in a multithreaded program	Replace STOP RUN with a call to the C exit() function
WRITE statement	Ignores ADVANCING phrase if you specify WRITE. . .ADVANCING with the environment names C01-C12 or S01-S05	

Using the COPY statement to help port programs

In many cases, you can avoid potential portability problems by using the COPY statement to isolate platform-specific code. For example, you can include platform-specific code in a compilation for a given platform and exclude it from compilation for a different platform. You can also use the COPY REPLACING phrase to globally change nonportable source code elements, such as file names.

RELATED REFERENCES

COPY statement (*COBOL for AIX Language Reference*)

"Run-time environment variables" on page 172

Appendix A, "Summary of differences with host COBOL," on page 505

Getting mainframe applications to run: overview

After you have downloaded your source program from the mainframe and compiled it on the AIX workstation without errors, the next step is to run the program. In many cases, you can get the same results from the AIX run as from the mainframe COBOL run without greatly modifying the source.

To assess whether to modify your source, you need to know how to fix the elements and behavior of the COBOL language that vary due to the underlying hardware or software architecture as referenced below.

RELATED TASKS
"Fixing differences caused by data representations"
"Fixing environment differences that affect portability" on page 401
"Fixing differences caused by language elements" on page 402

Fixing differences caused by data representations

COBOL stores signed packed-decimal and binary data in the same manner on both the mainframe and the workstation, but external-decimal, floating-point, and unsigned packed-decimal data are by default represented differently. Character data might be represented differently, depending on the USAGE clause that describes the data item and the locale that is in effect at run time.

Most programs act the same on the workstation as on the mainframe regardless of the data representation. To ensure the same behavior for your programs, you should understand the differences in the following ways of representing data, and take appropriate action:

- Single-byte ASCII and single-byte EBCDIC
- IEEE floating point and hexadecimal floating point
- EBCDIC DBCS and ASCII-based multibyte strings

Single-byte ASCII contrasted with single-byte EBCDIC

The AIX workstation uses the ASCII character set, and the mainframe uses the EBCDIC character set. Therefore, most characters have a different hexadecimal value. Also, code that depends on the EBCDIC hexadecimal values of character data probably fails when run using ASCII, as shown in the following table:

Table 59. **ASCII contrasted with EBCDIC**

Character	**Hexadecimal value if ASCII**	**Hexadecimal value if EBCDIC**
'0' through '9'	X'30' through X'39'	X'F0' through X'F9'
'a'	X'61'	X'81'
'A'	X'41'	X'C1'
blank	X'20'	X'40
Comparison	**Evaluation if ASCII**	**Evaluation if EBCDIC**
'a' < 'A'	False	True
'A' < '1'	False	True
x >= '0'	If true, does not indicate whether *x* is a digit	If true, *x* is probably a digit
x = X'40'	Does not test whether *x* is a blank	Tests whether *x* is a blank

Because of these differences, the results of sorting character strings are different with EBCDIC and ASCII. For many programs, these differences have no effect, but you should be aware of potential logic errors if your program depends on the exact sequence in which some character strings are sorted. If your program depends on the EBCDIC collating sequence and you are porting it to the workstation, you can obtain the EBCDIC collating sequence by using `PROGRAM COLLATING SEQUENCE IS EBCDIC` or the `COLLSEQ(EBCDIC)` compiler option.

To avoid problems with the different data representation between ASCII and EBCDIC characters, use the `CHAR(EBCDIC)` compiler option.

IEEE contrasted with hexadecimal

The AIX workstation represents floating-point data using the IEEE format. The mainframe uses the zSeries hexadecimal format.

The following table summarizes the differences between normalized floating-point IEEE and normalized hexadecimal for `USAGE COMP-1` data and `USAGE COMP-2` data.

Table 60. **IEEE contrasted with hexadecimal**

Specification	IEEE for `COMP-1` data	Hexadecimal for `COMP-1` data	IEEE for `COMP-2` data	Hexadecimal for `COMP-2` data
Range	*1.17E-38 to *3.37E+38	*5.4E-79 to *7.2E+75	*2.23E-308 to *1.67E+308	*5.4E-79 to *7.2E+75
Exponent representation	8 bits	7 bits	11 bits	7 bits
Mantissa representation	23 bits	24 bits	53 bits	56 bits
Digits of accuracy	6 digits	6 digits	15 digits	16 digits
* Indicates that the value can be positive or negative.				

For most programs, these differences should create no problems. However, use caution when porting if your program depends on hexadecimal representation of data.

To avoid most problems with the different representation between IEEE and hexadecimal floating-point data, use the `FLOAT(S390)` compiler option.

Performance consideration: In general, zSeries floating-point representation makes a program run more slowly because the software must simulate the semantics of zSeries hardware instructions. This is especially true if the `FLOAT(S390)` compiler option is in effect and a large number of floating-point calculations are performed in a program.

EBCDIC DBCS contrasted with ASCII-based multibyte strings

In alphanumeric data items, mainframe double-byte character strings (containing EBCDIC DBCS characters) are enclosed in shift codes, and AIX workstation multibyte character strings (containing ASCII DBCS, UTF-8, or EUC characters) are not enclosed in shift codes. The hexadecimal values used to represent the same characters are also different. To obtain mainframe behavior for alphanumeric data items that contain DBCS characters, use the `CHAR(EBCDIC)` compiler option and the `SOSI` compiler option.

In DBCS data items, mainframe double-byte character strings are not enclosed in shift codes, but the hexadecimal values used to represent characters are different from the hexadecimal values used to represent the same characters in workstation multibyte strings. To avoid problems with the different data representation between ASCII DBCS and EBCDIC DBCS characters, use the `CHAR(EBCDIC)` compiler option.

For most programs, these differences should not make porting difficult. However, if your program depends on the hexadecimal value of a multibyte string, or expects that an alphanumeric character string contains a mixture of single-byte characters and multibyte characters, use caution in your coding practices.

"Examples: numeric data and internal representation" on page 36

RELATED REFERENCES
"CHAR" on page 203
"BINARY" on page 202
"FLOAT" on page 218
"SOSI" on page 230
Appendix A, "Summary of differences with host COBOL," on page 505

Fixing environment differences that affect portability

Differences in file-names and control codes between the AIX workstation and mainframe platforms can also affect the portability of your programs.

File-names

File naming conventions on the AIX workstation are very different from those on the mainframe. The following file-name, for example, is valid on the AIX workstation but not on the mainframe (except perhaps in the HFS):

```
/users/joesmith/programs/cobol/myfile.cbl
```

This difference can affect portability if you use file-names in your COBOL source programs.

Case sensitivity: Unlike the mainframe, AIX is case sensitive. Names used in source programs (such as uppercase file-names) should be named appropriately in AIX file directories.

Control codes

Some characters that have no particular meaning on the mainframe are interpreted as control characters by AIX. This difference can lead to incorrect processing of ASCII text files. Files should not contain any of the following characters:

- X'0A' (LF: line feed)
- X'0D' (CR: carriage return)
- X'1A' (EOF: end of file)

Device-dependent control codes

If you use device-dependent (platform-specific) control codes in your programs or files, these control codes can cause problems when you try to port the programs or files to platforms that do not support the control codes.

As with all other platform-specific code, it is best to isolate such code as much as possible so that you can replace it easily when you move the application to another platform.

Fixing differences caused by language elements

In general, you can expect your portable COBOL programs to behave the same way on the AIX workstation that they do on the mainframe. However, be aware of the differences in FILE STATUS values used for I/O processing of input and output.

If your program is written to respond to status key data items, you should be concerned with two issues, depending on whether the program is written to respond to the first status key or the second status key:

- If your program is written to respond to the first file status data item (*data-name-1*), be aware that values returned in the 9X range depend on the platform. If your program relies on the interpretation of a particular 9X value (for example, 97), do not expect the value to have the same meaning on the workstation that it does on the mainframe. Instead, revise your program so that it responds to any 9X value as a generic I/O failure.
- If your program is written to respond to the second file status data item (*data-name-8*), be aware that the values returned depend on both the platform and file system. For example, STL returns values with a different record structure on the workstation than a VSAM file on the mainframe. If your program relies on the interpretation of the second file status data item, it is probably not portable.

RELATED REFERENCES
FILE STATUS clause (*COBOL for AIX Language Reference*)

Writing code to run on the mainframe

You can use IBM COBOL for AIX to write new applications, taking advantage of the productivity gains and increased flexibility of using your AIX workstation. You need to be aware of how to avoid using COBOL for AIX features that are not supported by IBM mainframe COBOL.

Language features not supported by mainframe compilers

IBM COBOL for AIX supports several language features not supported by the IBM mainframe COBOL compilers. As you write code on your AIX workstation that is intended to run on the mainframe, avoid using these features:

- Code-page names as arguments to DISPLAY-OF or NATIONAL-OF intrinsic functions
- READ statement using PREVIOUS phrase
- START statement using <, <=, or NOT > in the KEY PHRASE
- >>CALLINTERFACE compiler directive

Compiler options not supported by the mainframe compilers

A number of compiler options are not available with the mainframe compilers. Do not use any of the following options in your source code if you intend to port the code to the mainframe:

- BINARY(NATIVE) (treated as a comment)
- CALLINT (treated as a comment)
- CHAR(NATIVE)
- ENTRYINT (treated as a comment)
- FLOAT(NATIVE)
- PROFILE

Names not supported on other platforms

Be aware of the difference in file-naming conventions between AIX and other file systems. Avoid hard-coding the names of files in your source programs. Instead, use mnemonic names (in turn mapped to mainframe ddnames or environment variables) that you define on each platform. You can then compile your program to accommodate the changes in file-names without having to change the source code.

Specifically, consider how you refer to files in the following language elements:

- `ACCEPT` or `DISPLAY` target names
- `ASSIGN` clause
- `COPY` statement (*text-name* and *library-name*)

Differences with THREAD

Multithreaded programs on the mainframe must be recursive. Therefore, avoid coding nested programs if you intend to port your programs to the mainframe and enable them for execution in a multithreaded environment.

Writing applications that are portable between the AIX and Windows-based workstations

The Windows-based and AIX environments are similar and their language support is almost identical. However, there are differences between these platforms that you should keep in mind when developing applications to be portable between the Windows-based and the AIX workstations:

- Hard-coded file names in your source programs can lead to problems. Instead of hard-coding the names, use mnemonic names so that you can compile your program without having to change the source code. In particular, consider how you refer to files in the following language elements:
  - `ACCEPT` or `DISPLAY` statement
  - `ASSIGN` clause
  - `COPY` statement (*text-name* and *library-name*)
- Windows represents integers in *little-endian* format. AIX maintains integers in *big-endian* format. Therefore, if your Windows COBOL program depends on the internal representation of an integer, the program is probably not portable to AIX. Avoid writing programs that rely on such internal representation.
- Windows represents national characters in little-endian format. AIX represents national characters in big-endian format. Therefore, if your COBOL program depends on the internal representation of data items described with `USAGE NATIONAL`, the program is probably not portable between COBOL for Windows and COBOL for AIX. Avoid writing programs that depend on such internal representation.

  If your program does not depend on the internal representation of a national character, your program is probably portable between COBOL for Windows and COBOL for AIX, but you must convert file data to the representation of the target platform.

RELATED REFERENCES

NATIONAL phrase (*COBOL for AIX Language Reference*)

Chapter 25. Using subprograms

Many applications consist of several separately compiled programs linked together.

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 need to transfer control and usually need to have access to common data.

COBOL programs that are nested within each other can also communicate. All the required subprograms for an application can be contained in one program and thereby require only one compilation.

RELATED CONCEPTS
"Main programs, subprograms, and calls"

RELATED TASKS
"Calling nested COBOL programs" on page 406
"Calling nonnested COBOL programs" on page 410
"Calling between COBOL and C/C++ programs" on page 411

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" on page 406
"Calling nested COBOL programs" on page 406
"Calling nonnested COBOL programs" on page 410
"Calling between COBOL and C/C++ programs" on page 411
"Making recursive calls" on page 416

© Copyright IBM Corp. 1995, 2004

Ending and reentering main programs or subprograms

To end execution in the main program, you must code a STOP RUN or GOBACK statement in the main program. STOP RUN terminates the run unit and closes all files opened by the main program and its called subprograms. Control is returned to the caller of the main program, which is often the operating system. GOBACK has the same effect in the main program. An EXIT PROGRAM performed in a main program has no effect.

You can end a subprogram with an EXIT PROGRAM, a GOBACK, or a STOP RUN statement. If you use an EXIT PROGRAM or a GOBACK statement, control returns to the immediate caller of the subprogram without the run unit ending. An implicit EXIT PROGRAM statement is generated if there is no next executable statement in a called program. If you end the subprogram with a STOP RUN statement, the effect is the same as it is in a main program: all COBOL programs in the run unit are terminated, and control returns to the caller of the main program.

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 13

RELATED TASKS
"Calling nested COBOL programs"
"Making recursive calls" on page 416

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 nested program only from its directly containing program, unless you identify the nested program as COMMON in its PROGRAM-ID clause. In that case, you can call the *common program* from any program that is nested (directly or indirectly) in the same program as the common program. Only nested programs can be identified as COMMON. Recursive calls are not allowed.

Follow these guidelines when using nested program structures:

- Code an the IDENTIFICATION DIVISION in each program. All other divisions are optional.
- Make the name of a nested 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. Nested programs cannot have a CONFIGURATION SECTION.
- Include each nested program in the containing program immediately before its END PROGRAM marker.
- Use an END PROGRAM marker to terminate nested and containing programs.

RELATED CONCEPTS
"Nested programs"

RELATED REFERENCES
"Scope of names" on page 409
CALL statement (*COBOL for AIX Language Reference*)

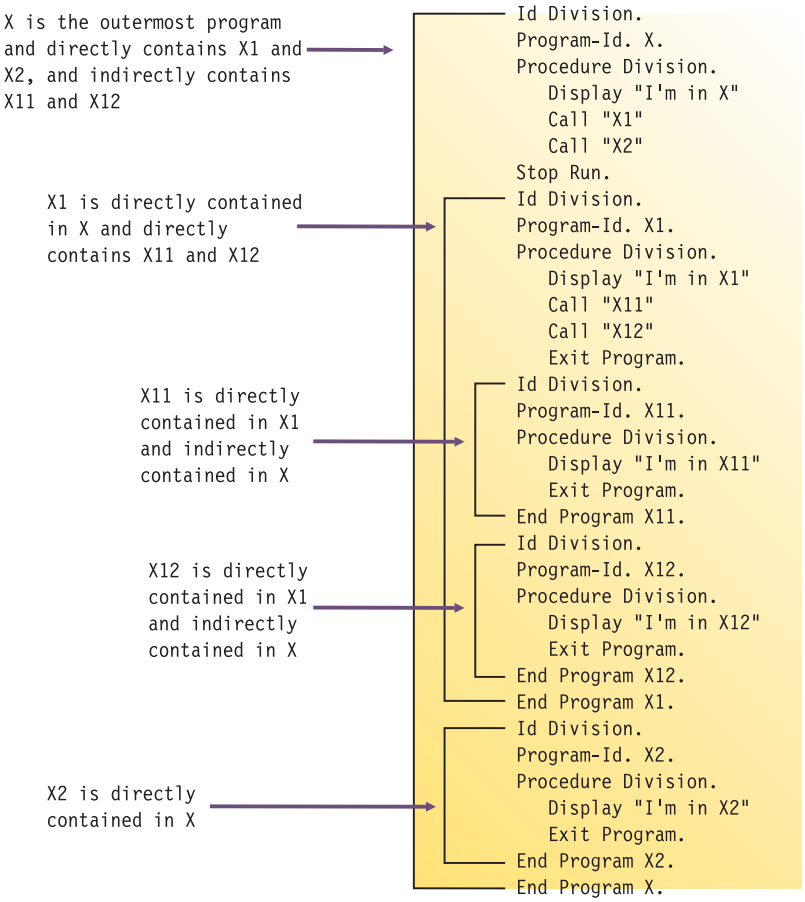
Nested programs

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 406

RELATED REFERENCES

"Scope of names" on page 409

Example: structure of nested programs

The following example shows a nested structure with some nested 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 A13.
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.

Calling nonnested COBOL programs

Your COBOL programs can call a subprogram that is linked into the same executable module as the caller (*static linking*) or that is provided in a shared library (*dynamic linking*). COBOL for AIX also provides for run-time resolution of the target subprogram from a shared library.

If you link the target program statically, it is part of the executable module of the caller and is loaded with the caller. If you link it dynamically or resolve the call at run time, it is provided in a library and is loaded either when the caller is loaded or when it is called.

Static linking and dynamic linking are done for COBOL `CALL` *literal* subprograms only. Run-time resolution is always done for COBOL `CALL` *identifier* and is done for `CALL` *literal* when the `DYNAM` option is in effect.

CALL identifier and CALL literal

`CALL` *identifier*, where *identifier* is a data item that contains the name of a nonnested subprogram when the program is run, always results in the target subprogram being loaded when it is called. Also, the name of the shared library must match the name of the target entry point.

`CALL` *literal*, where *literal* is the explicit name of a nonnested subprogram being called, can be resolved statically or dynamically. If the `NODYNAM` compiler option is in effect, either static or dynamic linking can be done. If `DYNAM` is in effect, `CALL` *literal* is resolved in the same way as `CALL` *identifier*: the target subprogram is loaded when it is called, and the name of the shared library must match the name of the target entry point.

These call definitions apply only in the case of a COBOL program calling a nonnested program. When a COBOL program calls a nested program, the `CALL` is resolved by the compiler without any system intervention.

Limitation: Two or more executables in an application cannot statically link to the same nonnested subprogram.

RELATED REFERENCES
"DYNAM" on page 210
CALL statement (*COBOL for AIX Language Reference*)

Calling between COBOL and C/C++ programs

You can call functions written in C/C++ from your COBOL programs and vice versa. The following rules and guidelines for applications that involve COBOL and C/C++ programs describe how to perform such interlanguage calls.

Note that unqualified references in this section to "C/C++" are to IBM C/C++.

Initializing environments

If your main program is written in C/C++ and makes multiple calls to a COBOL program, use one of the following approaches:

- Preinitialize the COBOL environment in your C/C++ program before it calls any COBOL programs. This approach is recommended because it provides the best performance.
- Put your COBOL program in an executable that is not part of the C/C++ routine that calls COBOL. Then every time that you want to call the main COBOL program, perform the following sequence in your C/C++ program:
  1. Load the program.
  2. Call the program.
  3. Unload the program.

Passing data

Some COBOL data types have C/C++ equivalents, but others do not. When you pass data between COBOL and C/C++ functions, be sure to restrict data exchange to appropriate data types.

The COBOL default is that arguments are passed `BY REFERENCE`. If an argument is passed `BY REFERENCE`, C/C++ gets a pointer to the argument. If you pass an argument `BY VALUE` in the `CALL` statement, COBOL passes the actual argument. `BY VALUE` can be used only for the following data types:

- An alphanumeric character
- A national character
- `BINARY`
- `COMP`
- `COMP-1`
- `COMP-2`
- `COMP-4`
- `COMP-5`
- `FUNCTION-POINTER`
- `OBJECT REFERENCE`
- `POINTER`
- `PROCEDURE-POINTER`

Collapsing stack frames and terminating run units or processes

Do not invoke functions in one language that collapse program stack frames of other languages. This guideline includes these situations:

- Collapsing some active stack frames from one language with active stack frames written in another language in the to-be-collapsed stack frames (C/C++ longjmp()).

- Terminating a run unit or process from one language while stack frames written in another language are active, such as issuing a COBOL `STOP RUN` or a C/C++ exit() or _exit(). Instead, structure the application in such a way that an invoked program terminates by returning to its invoker.

You can use C/C++ longjmp() or COBOL `STOP RUN` and C/C++ exit() or _exit() calls if the function does not collapse active stack frames of a language other than the language that initiates the function.

For the languages that do not initiate the collapsing and the termination, these adverse effects might occur:

- Normal cleanup or exit functions of the language might not be performed, such as the closing of files by COBOL during run-unit termination, or the cleanup of dynamically acquired resources by the involuntarily terminated language.
- User-specified exits or functions might not be invoked for the exit or termination, such as destructors and the C/C++ atexit() function.

Handling exceptions

In general, exceptions incurred during the execution of a stack frame are handled according to the rules of the language that incurs the exception.

IBM COBOL for AIX saves the exception environment at initialization of the COBOL run-time environment and restores it on termination of the COBOL environment. COBOL expects interfacing languages and tools to follow the same convention.

Because the COBOL implementation does not depend on the interception of exceptions through system services for the support of COBOL language semantics, you can specify the `TRAP(OFF)` run-time option to enable the exception-handling semantics of the non-COBOL language.

RELATED CONCEPTS
Chapter 29, “Preinitializing the COBOL run-time environment,” on page 449

RELATED TASKS
Chapter 26, “Sharing data,” on page 417

RELATED REFERENCES
“COBOL and C/C++ data types”
“Example: C/C++ programs that are called by and call COBOL programs” on page 414
“Example: COBOL program calling C/C++ functions” on page 413
“TRAP” on page 251

COBOL and C/C++ data types

The following table shows the correspondence between the data types that are available in COBOL and C/C++.

Table 61. **COBOL and C/C++ data types**

C/C++ data types	COBOL data types
wchar_t	`USAGE NATIONAL (PICTURE N)`
char	`PIC X`
signed char	No appropriate COBOL equivalent

Table 61. **COBOL and C/C++ data types** *(continued)*

C/C++ data types	COBOL data types
unsigned char	No appropriate COBOL equivalent
short signed int	PIC S9-S9(4) COMP-5. Can be COMP, COMP-4, or BINARY if you use the TRUNC(BIN) compiler option.
short unsigned int	PIC 9-9(4) COMP-5. Can be COMP, COMP-4, or BINARY if you use the TRUNC(BIN) compiler option.
long int	PIC 9(5)-9(9) COMP-5. Can be COMP, COMP-4, or BINARY if you use the TRUNC(BIN) compiler option.
long long int	PIC 9(10)-9(18) COMP-5. Can be COMP, COMP-4, or BINARY if you use the TRUNC(BIN) compiler option.
float	COMP-1
double	COMP-2
enumeration	Equivalent to level 88, but not identical
char(n)	PICTURE X(n)
array pointer (*) to type	No appropriate COBOL equivalent
pointer(*) to function	PROCEDURE-POINTER or FUNCTION-POINTER

RELATED REFERENCES
"TRUNC" on page 236

Example: COBOL program calling C/C++ functions

The following sample COBOL program calls C/C++ functions and illustrates the following concepts:

- C/C++ programs are called using the COBOL CALL statement. The CALL statement does not indicate if the called program is written in COBOL or C/C++.
- COBOL supports calling programs with mixed-case names.
- Arguments can be passed to C/C++ programs in different ways (for example, CALL BY REFERENCE, CALL BY VALUE).
- You must declare a function return value on the CALL statement that calls a C/C++ function.
- You must map COBOL data types to appropriate C/C++ data types.

```
 CBL PGMNAME(MIXED)
* This compiler option allows for
* case-sensitive names for called programs.
*
 IDENTIFICATION DIVISION.
 PROGRAM-ID. "COBCALLC".
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
*
 01 N4                  PIC 9(4)  COMP-5.
 01 NS4                 PIC S9(4) COMP-5.
 01 N9                  PIC 9(9)  COMP-5.
 01 NS9                 PIC S9(9) COMP-5.
 01 NS18                USAGE COMP-2.
 01 D1                  USAGE COMP-2.
 01 D2                  USAGE COMP-2.
 01 R1.
     02 NR1                  PIC 9(8) COMP-5.
     02 NR2                  PIC 9(8) COMP-5.
```

```
     02 NR3                   PIC 9(8) COMP-5.
 PROCEDURE DIVISION.
     MOVE 123 TO N4
     MOVE -567 TO NS4
     MOVE 98765432 TO N9
     MOVE -13579456 TO NS9
     MOVE 222.22 TO NS18
     DISPLAY "Call MyFun with n4=" N4 " ns4=" NS4 " N9=" n9
     DISPLAY "                 ns9="  NS9" ns18="  NS18
*
* The following CALL illustrates several ways to pass
* arguments.
*
     CALL "MyFun" USING N4 BY VALUE NS4 BY REFERENCE N9 NS9 NS18
     MOVE 1024 TO N4
*
* The following CALL returns the C function return value.
*
     CALL "MyFunR" USING BY VALUE N4 RETURNING NS9
     DISPLAY "n4=" N4 " and ns9= n4 times n4= " NS9
     MOVE -357925680.25 TO D1
     CALL "MyFunD" USING BY VALUE D1 RETURNING D2
     DISPLAY "d1=" D1 " and d2= 2.0 times d2= " D2
     MOVE 11111 TO NR1
     MOVE 22222 TO NR2
     MOVE 33333 TO NR3
     CALL "MyFunV" USING R1
     STOP RUN.
```

RELATED REFERENCES
CALL statement (*COBOL for AIX Language Reference*)

Example: C/C++ programs that are called by and call COBOL programs

The following sample program illustrates that a called C/C++ function receives arguments in the order in which they were passed in the COBOL `CALL` statement.

The file MyFun.c contains the following source code, which calls the COBOL program tprog1.cbl.

```
#include <stdio.h>
extern void TPROG1(double *);
void
MyFun(short *ps1, short s2, long *k1, long *k2, double *m)
{
    double x;
    x = 2.0*(*m);
    printf("MyFun got s1=%d s2=%d k1=%d k2=%d x=%f\n",
             *ps1, s2, *k1,*k2, x);
}

long
MyFunR(short s1)
{
    return(s1 * s1);
}

double
MyFunD(double d1)
{
    double z;
    /* calling COBOL */
    z = 1122.3344;
    (void) TPROG1(&z);
    /* returning a value to COBOL */
```

```
    return(2.0 * d1);
}

void
MyFunV(long *pn)
{
    printf("MyFunV got %d %d %d\n", *pn, *(pn+1), *(pn+2));
}
```

MyFun.c consists of the following functions:

MyFun
Illustrates passing a variety of arguments.

MyFunR
Illustrates how to pass and return a long variable.

MyFunD
Illustrates C/C++ calling a COBOL program and it also illustrates how to pass and return a double variable.

MyFunV
Illustrates passing a pointer to a record and accessing the items of the record in a C/C++ program.

Example: COBOL program called by a C/C++ program

The following example shows how to write COBOL programs that are called by C/C++ programs.

The file tprog1.cbl is called by the C/C++ function MyFunD in the program MyFun.c. The called COBOL program contains the following source code:

```
*
 IDENTIFICATION DIVISION.
 PROGRAM-ID. TPROG1.
*
 DATA DIVISION.
 LINKAGE SECTION.
*
 01 X                USAGE COMP-2.
*
 PROCEDURE DIVISION USING X.
     DISPLAY "TPROG1 got x= " X
     GOBACK.
```

Example: results of compiling and running examples

Compile and link the COBOL programs cobcallc.cbl and tprog.cbl and the program MyFun.c by using the following commands:

1. `xlc -c MyFun.c`
2. `cob2 cobcallc MyFun.o tprog1.cbl -o cobcallc`

Run program cobcallc by issuing the command `cobcallc`.

The results are as follows:

```
call MyFun with n4=00123 ns4=-00567 n9=0098765432
            ns9=-0013579456 ns18=.22222000000000000E 03
MyFun got s1=123 s2=-567 k1=98765432 k2=-13579456 x=444.440000
n4=01024 and ns9= n4 times n4= 0001048576
TPROG1 got x=  .11223344000000000E+04
d1=-.35792568025000000E+09 and d2= 2.0 times d2= -.71585136050000000E+09
MyFunV got 11111 22222 33333
```

RELATED REFERENCES
"Example: COBOL program calling C/C++ functions" on page 413
"Example: C/C++ programs that are called by and call COBOL programs" on page 414
"Example: COBOL program called by a C/C++ program" on page 415

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 either code the `RECURSIVE` clause on the `PROGRAM-ID` paragraph of the recursively called program or specify the `THREAD` compiler option. If you try to recursively call a COBOL program that does not either specify the `THREAD` compiler option or have the `RECURSIVE` clause coded on its `PROGRAM-ID` paragraph, the run unit will end abnormally.

RELATED TASKS
"Identifying a program as recursive" on page 6

RELATED REFERENCES
RECURSIVE attribute (*COBOL for AIX Language Reference*)
"THREAD" on page 235

Passing return codes

You can use the `RETURN-CODE` special register to pass information between separately compiled programs. You can set `RETURN-CODE` in a called program before returning to the caller, and then test this returned value in the calling program. This technique is typically used to indicate the level of success of the called program. For example, a `RETURN-CODE` of zero can be used to indicate that the called program executed successfully.

RETURN-CODE values with nonthreaded support

When a main program with nonthreaded support ends normally, the value of `RETURN-CODE` is passed to the operating system as a user return code. However, AIX restricts user return code values to 0 through 255. Therefore, if for example `RETURN-CODE` contains 258 when the program ends, AIX wraps the value within the supported range, resulting in a user return code of 2.

When a program with nonthreaded support encounters an unrecoverable exception, the run unit is terminated, and the user return code is set to 128 plus the signal number.

RETURN-CODE values with threaded support

With threaded support, the value of `RETURN-CODE` is never passed to the operating system. This situation occurs:

- When a main program ends normally
- When a program encounters an unrecoverable exception (in this case, the thread, not the run unit, in which the program is executing is terminated)

RELATED REFERENCES
RETURN-CODE special register (*COBOL for AIX Language Reference*)

Chapter 26. 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 419
"Coding the PROCEDURE DIVISION for passing arguments" on page 420
"Using procedure and function pointers" on page 424
"Passing return code information" on page 425
"Specifying CALL . . . RETURNING" on page 425
"Sharing data by using the EXTERNAL clause" on page 425
"Sharing files between programs (external files)" on page 426
"Using command-line arguments" on page 429

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.

Determine which of these data-passing methods to use based on what you want your program to do with the data.

Table 62. **Methods for passing data in the CALL statement**

Code	Purpose	Comments
`CALL . . . BY REFERENCE` *identifier*	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.

© Copyright IBM Corp. 1995, 2004

Table 62. **Methods for passing data in the CALL statement** *(continued)*

Code	Purpose	Comments
`CALL . . . BY CONTENT ADDRESS OF` *identifier*	To pass the address of *identifier* to a called program	Any changes to the copy of the address will not affect the address of *identifier*, but changes to *identifier* using the copy of the address will cause changes to *identifier*.
`CALL . . . BY CONTENT` *identifier*	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` *literal*	To pass a copy of a literal value to a called program	
`CALL . . . BY CONTENT LENGTH OF` *identifier*	To pass a copy of the length of a data item	The calling program passes the length of the *identifier* 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` *identifier*	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` *literal*	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.
`CALL . . . BY VALUE ADDRESS OF` *identifier*	To pass the address of *identifier* 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 *identifier*, but changes to *identifier* using the copy of the address will cause changes to *identifier*.
`CALL . . . RETURNING`	To call a C/C++ function with a function return value	

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.

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 TASKS

"Specifying CALL . . . RETURNING" on page 425
"Sharing data by using the EXTERNAL clause" on page 425
"Sharing files between programs (external files)" on page 426

RELATED REFERENCES

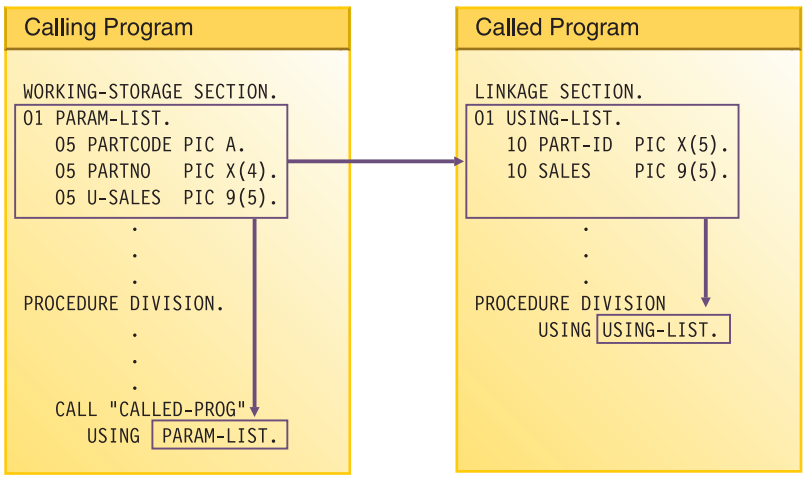
CALL statement (*COBOL for AIX Language Reference*)
INVOKE statement (*COBOL for AIX Language Reference*)

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 (*COBOL for AIX 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 419

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 83

RELATED REFERENCES
Null-terminated alphanumeric literals (*COBOL for AIX 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

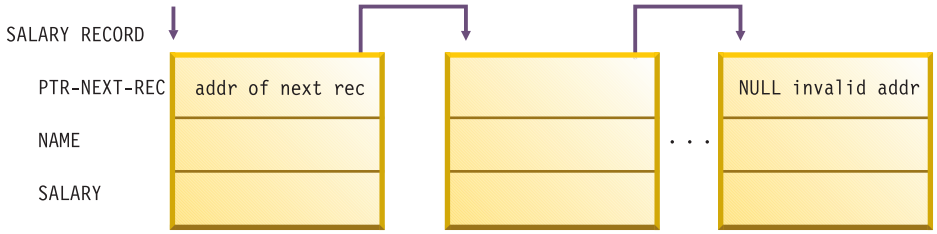
"Coding the LINKAGE SECTION" on page 419
"Coding the PROCEDURE DIVISION for passing arguments" on page 420

RELATED REFERENCES

SET statement (*COBOL for AIX 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 421

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.
- 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 returns a pointer that you can 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 a pointer data item only by using the SET statement. For example:

```
CALL 'MyCFunc' RETURNING ptr.
SET proc-ptr TO ptr.
CALL proc-ptr USING dataname.
```

Suppose that you set your pointer item to an entry address in a load module called with CALL *identifier* and your program later cancels that called module. Your pointer item becomes undefined, and reference to it thereafter is not reliable.

RELATED REFERENCES

PROCEDURE-POINTER phrase (*COBOL for AIX Language Reference*)
SET statement (*COBOL for AIX Language Reference*)

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 set according to the value of the RETURN-CODE of the program returning to the caller.

Setting of the RETURN-CODE by the called program is limited to calls between COBOL programs. Therefore, if your COBOL program calls a C program, you cannot expect the RETURN-CODE of the COBOL program to be set.

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
```

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 (*COBOL for AIX 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

Name	Function
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 "ef1openo"
     Call "ef1write"
     Call "ef1close"
     Call "ef1openi"
     Call "ef1read"
     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 "ef1close"
     Goback.
 End Program ef1.
```

```
 Identification Division.
 Program-Id.
     ef1openo.
*
* 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 ef1openo.
 Identification Division.
 Program-Id.
     ef1write.
*
* 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 ef1write.
 Identification Division.
 Program-Id.
     ef1openi.
*
* 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 ef1openi.
 Identification Division.
 Program-Id.
     ef1read.
*
* 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 ef1read.
 Identification Division.
 Program-Id.
     ef1close.
*
* 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 ef1
     If efs1 Not = 0
       Display "file status " efs1 " on close"
       Stop Run
     End-If
     Goback.
 End Program ef1close.
```

Using command-line arguments

You can pass arguments to a main program on the command line. The operating system calls main programs with a string that contains the arguments. How the arguments are treated depends on whether you use the `-host` option of the `cob2` (or `cob2_j`, `cob2_r`, or `cob2_r4`) command.

If you specify the `-host` option, AIX calls all main programs with an EBCDIC character string that has a halfword prefix that contains the string length. You must enter the command-line arguments as a single string enclosed in quotation marks ("). To pass a quotation-mark character in the string, precede the quotation mark with the backslash (\) escape character.

If you do not specify the -host option, AIX calls all main programs with the following arguments:

- Number of command-line arguments plus one
- Pointer to the name of the program
- Pointer to the first argument
- Pointer to the second argument
- . . .
- Pointer to the *n*th argument

"Example: command-line arguments without -host option"
"Example: command-line arguments with -host option"

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186

Example: command-line arguments without -host option

This example shows how to read the command-line arguments.

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. "targaix".
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
*
 linkage section.
 01  PARM-LEN PIC S9(9) COMP.
 01  OS-PARM.
     02 PARMPTR-TABLE OCCURS 1 TO 100 TIMES DEPENDING ON PARM-LEN.
        03 PARMPTR  POINTER.
 01 PARM-STRING PIC XX.
*
 PROCEDURE DIVISION USING BY VALUE PARM-LEN BY REFERENCE OS-PARM.
     display "parm-len=" parm-len
     SET ADDRESS OF PARM-STRING TO PARMPTR(2).
     DISPLAY "parm-string= '" PARM-STRING "'";
     EVALUATE PARM-STRING
         when "01"  display "case one"
         when "02"  display "case two"
         when "95"  display "case ninety five"
         when other display "case unknown"
     end-evaluate
     GOBACK.
```

Suppose you compile and run the following program:

```
cob2 targaix.cbl
a.out 95
```

The result is:

```
parm-len=000000002
parm-string= '95'
case ninety five
```

Example: command-line arguments with -host option

This example shows how to read the command-line arguments.

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. "testarg".
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
*
 linkage section.
 01  os-parm.
     05 parm-len         pic s999 comp.
     05 parm-string.
         10 parm-char    pic x occurs 0 to 100 times
                         depending on parm-len.
*
 PROCEDURE DIVISION using os-parm.
     display "parm-len=" parm-len
     display "parm-string='" parm-string "'"
     evaluate parm-string
       when "01"  display "case one"
       when "02"  display "case two"
       when "95"  display "case ninety five"
       when other display "case unknown"
     end-evaluate
     GOBACK.
```

Suppose you compile and run the following program:

```
cob2 -host testarg.cbl
a.out "95"
```

The result is:

```
parm-len=002
parm-string='95'
case ninety five
```

Chapter 27. Building shared libraries

By using linking, you can have a program call another program that is not contained in the source code of the calling program. Before or during execution, the object module of the calling program is linked with the object module of the called program.

You can use a shared library as a library of frequently used functions. Even if the shared library holds only one function, the shared library can provide that function to calling programs as needed.

In COBOL, a *shared library* is a collection of outermost programs. Although these outermost programs can contain nested programs, programs external to the shared library can call only the outermost programs (known as *entry points*). Just as you can compile and link several COBOL programs as a single executable file, you link one or more compiled outermost COBOL programs to create a shared library.

Because outermost programs in a shared library are part of a library of programs, each program is referred to as a *subprogram* in the shared library. Even if a shared library provides only one program, that program is considered a subprogram of the shared library.

You can call shared COBOL libraries and call a mix of COBOL and C shared libraries.

"Example: creating a sample shared library" on page 434
"Example: calling shared libraries using CALL identifier" on page 437
"Example: COBOL program calling COBOL and C shared libraries" on page 439

RELATED CONCEPTS
"Static linking and shared libraries"
"How the linker resolves references to shared libraries" on page 434

Static linking and shared libraries

Static linking occurs when a calling program is linked to a called program module, in a single executable module. The result of statically linking programs is an executable file or subprogram in a shared library that contains the executable code for multiple programs. This file includes both the calling program and the called program. When the program is loaded, the operating system places into memory a single file that contains the executable code and data.

The primary advantage of static linking is that you can create self-contained, independent programs. In other words, the executable program consists of one part (the executable file) that you need to keep track of. Static linking has these disadvantages:

- Because linked external programs are built into the executable files, these files become larger.
- You cannot change the behavior of executable files without relinking them.
- External called programs cannot be shared. Therefore, if more than one calling program needs to access the called programs, duplicate copies of the called programs must be loaded in memory.

© Copyright IBM Corp. 1995, 2004

To overcome these disadvantages, use shared libraries.

With shared libraries, several programs can use a single copy of an executable module. The executable module is completely separate from the programs that use it. You can build several subprograms into a shared library, and calling programs can use these subprograms as if they were part of the executable code of the calling program. You can change the shared library subprograms without recompiling or relinking the calling program.

Shared libraries typically provide common functions that can be used by a number of programs. For example, you can use shared libraries to implement subprogram packages, subsystems, and interfaces in other programs or to create object-oriented class libraries.

You can dynamically link with the supplied run-time shared libraries as well as with your own COBOL shared libraries.

"Example: creating a sample shared library"

RELATED CONCEPTS
"How the linker resolves references to shared libraries"

How the linker resolves references to shared libraries

When you compile a program, the compiler generates an object module for the code in the program. If you use any subprograms (*functions* in C, *subroutines* in other languages) that are in an external object module, the compiler adds an external program reference to your program's object module.

The linker resolves these external references. If it finds a reference to external subprograms in an import library or in a module definition file of a shared library, the code for the external subprogram is in a shared library. To resolve an external reference to a shared library, the linker adds information to the executable file that tells the loader where to find the shared library code when the executable file is loaded.

The linker does not resolve all references to shared libraries by COBOL `CALL` statements. With the `DYNAM` compiler option in effect, COBOL resolves `CALL` *identifier* and `CALL` *literal* statements when these calls are executed.

"Example: creating a sample shared library"

RELATED CONCEPTS
"Static linking and shared libraries" on page 433

RELATED REFERENCES
"Linker input and output files" on page 191

Example: creating a sample shared library

Each of the following three example files (alpha.cbl, beta.cbl, and gamma.cbl) contains a COBOL program. You can create a sample shared library by using the example programs and the procedure that follows.

Example 1: alpha.cbl

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. alpha.
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01 hello1   pic x(30)  value is "message from alpha to beta".
 01 hello2   pic x(30)  value is "message from alpha to gamma".
*
*
 PROCEDURE DIVISION.
     display "alpha begins"
     call "beta" using hello1
     display "alpha after beta"
     call "gamma" using hello2
     display "alpha after gamma"
     goback.
```

Example 2: beta.cbl

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. beta.
*
 ENVIRONMENT DIVISION.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
*
 Linkage section.
 01 msg   pic x(30).
*
 PROCEDURE DIVISION using msg.
     DISPLAY "beta gets msg=" msg.
     goback.
```

Example 3: gamma.cbl

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID. gamma.
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
*
 Linkage section.
 01 msg            pic x(30).
*
PROCEDURE DIVISION using msg.
    DISPLAY "gamma gets msg=" msg.
    goback.
```

Procedure

The simplest method of running these programs is to compile them into a single module by using the following command:

```
cob2 -o m_abg alpha.cbl beta.cbl gamma.cbl
```

You can then run the program by issuing the command `m_abg`.

The resulting output is:

```
alpha begins
beta gets msg=message from alpha to beta
alpha after beta
gamma gets msg=message from alpha to gamma
alpha after gamma
```

Instead of compiling the programs into a single module, you can put beta and gamma in a shared library (such as sh_bg), and put alpha.cbl in a module that uses that library. In this case, do the following steps:

1. (Optional) Create an export file (such as bg.exp) in which you define the symbols that the shared library exports. The contents of bg.exp are as follows:

   ```
   #!
   * symbols exported by shared library sh_bg (or archive libbg.a)
   BETA
   GAMMA
   ```

   The symbol names in the file are uppercase because the COBOL default is to use uppercase names for external symbols. If you need mixed-case names, use the `PGMNAME(MIXED)` compiler option.

   If you use an export file called bg.exp, you must use the `-bE:bg.exp` option when you create the shared library, as shown in the next step.
2. Combine beta and gamma into a shared library object called sh_bg by using the following command:

   ```
   cob2 -o sh_bg  beta.cbl gamma.cbl {-bE:bg.exp | -bexpall} -bM:SRE -bnoentry
   ```

   This command provides the following information to the compiler and linker:

   - `-o sh_bg beta.cbl gamma.cbl` names the output module sh_bg, and compiles and links beta.cbl and gamma.cbl.
   - `-bE:bg.exp` tells the linker to export the symbols that are named in export file bg.exp. Use this option only if you created an export file as shown in step 1 above.
   - `-bexpall` tells the linker to export most global symbols. Use this option if you are not using an export file.
   - `-bM:SRE` tells the linker to make the output module a shared reentrant object.
   - `-bnoentry` tells the linker that this object does not have a main entry point (it will be entered at BETA and GAMMA).
3. You can use sh_bg immediately or, if you have several shared objects, you might want to put them in an archive library for convenience. To make an archive library, use the following command:

   ```
   ar qv libbg.a sh_bg
   ```
4. Recompile alpha.cbl, this time using the archive library, by issuing *one* of the following commands:

   ```
   cob2 -o m_alpha alpha.cbl -L. libbg.a
   cob2 -o m_alpha alpha.cbl -L. -lbg
   ```

   `-l`*xx* is a standard AIX convention for `lib`*xx*`.a`. The `-L.` option tells the linker that libbg.a is in the current directory (`.`). Specifying the full directory is safer, as in:

   ```
   cob2 -o m_alpha alpha.cbl -L/usr/jane/libraries -lbg
   ```

   The `-L.` form works only if m_alpha and libbg.a are in the current directory.

As an alternative to the last three steps, you can create a makefile that combines these commands.

For more information about the use of shared libraries, read the relevant parts of the AIX documents referenced below.

"Example: creating a makefile for the sample shared library"

RELATED TASKS
"Passing options to the linker" on page 189

RELATED REFERENCES
"cob2, cob2_j, cob2_r, and cob2_r4 options" on page 186
"Linker input and output files" on page 191
AIX General Programming Concepts: Writing and Debugging Programs
AIX Commands Reference

Example: creating a makefile for the sample shared library

You can create a makefile for the sample shared library by using the following program. (The makefile assumes that the export file bg.exp defines the symbols that the shared library exports.)

```
#
#
all:     m_abg libbg.a m_alpha

#  Create m_abg containing alpha, beta, and gamma

m_abg:   alpha.cbl beta.cbl gamma.cbl
    cob2 -o m_abg alpha.cbl beta.cbl gamma.cbl

#  Create libbg.a containing beta and gamma
#  sh_bg.o is a shared object that exports the symbols defined in bg.exp
#  libbg.a is a shared library that contains one shared object
#  More objects can be added to the library

libbg.a: beta.cbl gamma.cbl bg.exp
    rm -rf libbg.a
    cob2 -o sh_bg  beta.cbl gamma.cbl -bE:bg.exp -bM:SRE -bnoentry
    ar qv libbg.a sh_bg
    rm -f sh_bg

#  Create m_alpha containing alpha and using library libbg.a
m_alpha: alpha.cbl
    cob2 -o m_alpha alpha.cbl -L. libbg.a

clean:
    rm -f m_abg m_alpha sh_bg libbg.a *.lst
```

At the end of the program is the `rm` command to remove sh_bg and the old copy of libbg.a.

Executing the command `m_abg` or the command `m_alpha` provides the same output.

Shared libraries are widely used in AIX. The COBOL run time is in several shared libraries, as is the C run time. Shared libraries provide a convenient and efficient way of packaging applications.

Example: calling shared libraries using CALL identifier

You can create and run executable modules that use `CALL` *identifier* to call shared libraries. The first example program, dl1.cbl, is a COBOL program that uses `CALL` *identifier* to call the second example program, dl1a.cbl.

Example 1: dl1.cbl

```
* Simple dynamic call to dl1a

 Identification Division.
 Program-id.    dl1.
*
 Environment Division.
 Configuration Section.
 Input-Output Section.
 File-control.
*
 Data Division.
 File Section.
 Working-storage Section.
 01 var pic x(10).
 Linkage Section.
*
 Procedure Division.
     move "Dl1A" to var.
     display "Calling " var.
     call var.
     move "dl1a     " to var.
     display "Calling " var.
     call var.
     stop run.
 End program dl1.
```

Example 2: dlla.cbl

```
* Called by dl1.cbl by call identifier.

 IDENTIFICATION DIVISION.
 PROGRAM-ID. dl1a.
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
 OBJECT-COMPUTER. ANY-THING.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 77 num pic 9(4) binary value is zero.
*
 PROCEDURE DIVISION.
 LA-START.
     display "COBOL DL1A function." upon console.
     add 11 to num.
     display "num = " num
     goback.
```

Procedure

To create and run the example, do these steps:

1. Enter `cob2 dl1.cbl -o dl1` to generate the executable module `dl1`.
2. Enter `cob2 dl1a.cbl -o DL1A` to generate the executable module `DL1A`.
3. Enter the command `export COBPATH=.` to set the directories to be searched for a dynamic call. In this case, the current directory will be searched.
4. Enter `dl1` to run the program.

Note that `DL1A` is in uppercase characters. Unless you use the `PGMNAME(MIXED)` compiler option, the program name is changed to uppercase characters.

Restrictions on run-time loading: When you make a call to a shared library using `CALL` *identifier* or `CALL` *literal* with the `DYNAM` option, you are restricted as follows:

- You can export only one name.

- The exported name must be the same as the name of the shared library.
- If the shared library is a COBOL shared library, you must link with the same COBOL library as was the shared library: `libcob2s.a` or `libcob2_r.a`.

The default library is determined by the `-lcob2s` and `-lcob2_r` command flags. Flag `-lcob2s` tells the linker to use `libcob2s.a`; `-lcob2_r` tells the linker to use `libcob2_r.a`.

Because the target file name of a `CALL` *identifier* must match the name of the program, you must generate the executable module in the above example as `DL1A`, not as `dl1a`.

Example: COBOL program calling COBOL and C shared libraries

You can have a main COBOL program dynamically call both a COBOL program and a C function. This example consists of three programs:

- dl6.cbl: A COBOL main program that uses `CALL` *identifier* to call dl6a and dl6b
- dl6a.c: A C function that dl6 calls
- dl6b.cbl: A COBOL program that dl6 calls

Example 1: d16.cbl

```
 cbl pgmname(longmixed)
* dl6:
* - call C function - dl6a executable
* - call "dl6b" with pgmname(mixed)
 Identification Division.
 Program-id.    dl6.
*
 Environment Division.
 Configuration Section.
 Input-Output Section.
 File-control.
*
 Data Division.
 File Section.
 Working-storage Section.
 01 var pic x(10).
 Linkage Section.
*
 Procedure Division.
     move "dl6a" to var.
     display "Calling " var.
     call var.
     move "dl6a" to var.
     display "Calling " var.
     call var.
     move "dl6b" to var.
     display "Calling " var.
     call var.
     move "dl6b" to var.
     display "Calling " var.
     call var.
     stop run.
 End program dl6.
```

Example 2: d16a.c

```
void dl6a() {
  static int n = 123;
  printf("C dl6a function.\n");
  n = n * 10;
  printf("n = %d\n", n);
}
```

Example 3: d16b.cbl

```
cbl pgmname(longmixed)
 IDENTIFICATION DIVISION.
 PROGRAM-ID. "dl6b".
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
 OBJECT-COMPUTER. ANY-THING.
*
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 77 num pic 9(4) binary value is zero.
*
 PROCEDURE DIVISION.
 LA-START.
     display "COBOL dl6b function." upon console.
     add 111 to num.
     display "num = " num
     goback.
```

Procedure

To create and run the example, do the following steps:

1. Enter `cob2 dl6.cbl -o dl6` to generate the executable module dl6.
2. Enter `cob2 dl6b.cbl -o dl6b` to generate the executable module dl6b.
3. Enter `xlc -o dl6a -edl6a dl6a.c` to generate the executable module dl6a with an entry point dl6a.
4. Enter the command `export COBPATH=.` to set the directories to be searched for a dynamic call. In this case, the current directory is searched.
5. Enter `dl6` to run the program.

Chapter 28. Preparing COBOL programs for multithreading

Although you cannot initiate or manage program threads in a COBOL program, you can prepare your COBOL program to run in a multithreaded environment. You can run your COBOL programs in multiple threads within a process. There is no explicit COBOL language to use for multithreaded execution; rather, you compile with the THREAD compiler option.

After you compile COBOL programs using the THREAD compiler option, other applications can call these COBOL programs in such a way that the programs run in multiple threads within a process or as multiple program invocation instances within a thread. Therefore, COBOL programs can run in multithreaded environments such as the Distributed Computing Environment (DCE).

"Example: using COBOL in a multithreaded environment" on page 446

RELATED CONCEPTS
"Multithreading"

RELATED TASKS
"Working with language elements with multithreading" on page 442
"Choosing THREAD to support multithreading" on page 444
"Transferring control with multithreading" on page 445
"Handling COBOL limitations with multithreading" on page 446

RELATED REFERENCES
"THREAD" on page 235
PROGRAM-ID paragraph (*COBOL for AIX 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.

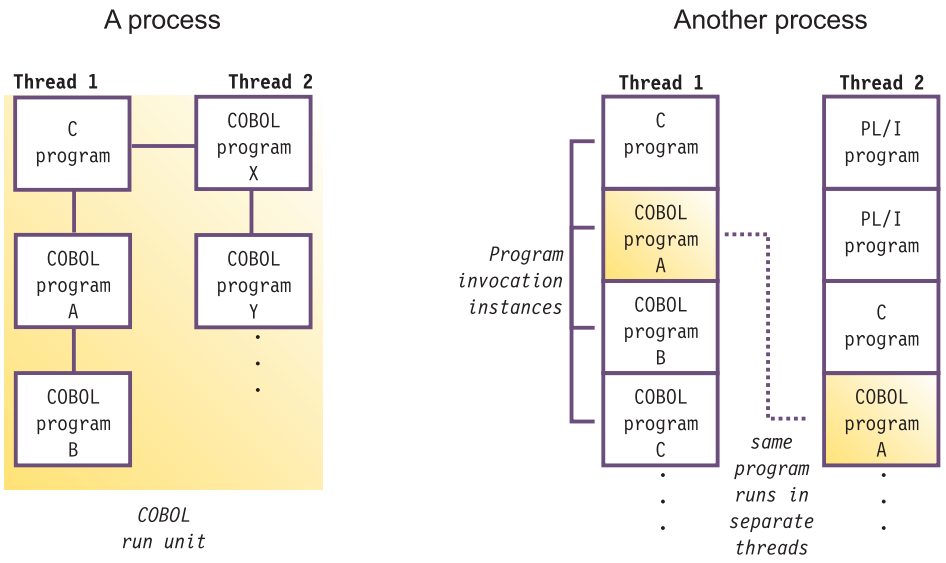
Within a process, an application can initiate one or more *threads*, each of which is a stream of computer instructions that controls that thread. A multithreaded process begins with one stream of instructions (one thread) and can later create other instruction streams to perform tasks. These multiple 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 that have 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 GOBACK statement and returns control to a C program. Within the run unit, COBOL programs can call non-COBOL programs, and vice versa.

© Copyright IBM Corp. 1995, 2004

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.



Do not confuse multiprocessing or multithreading with *multitasking*, a term that is generally used to describe the external behavior of applications. In multitasking, the operating system appears to be running more than one application simultaneously. Multitasking is not related to multithreading as implemented in COBOL.

"Example: using COBOL in a multithreaded environment" on page 446

RELATED TASKS

"Working with language elements with multithreading"
"Choosing THREAD to support multithreading" on page 444
"Transferring control with multithreading" on page 445
"Handling COBOL limitations with multithreading" on page 446

RELATED REFERENCES

"THREAD" on page 235

Working with language elements with multithreading

Because your COBOL programs can run as separate threads within a process, be aware that language elements can be interpreted in two different scopes:

Run-unit scope
: While the COBOL run unit runs, the language element persists and is available to other programs within the thread.

Program invocation instance scope
: The language element persists only within a particular instance of a program invocation.

These two types of scope are important in determining where an item can be referenced from and how long the item persists in storage. An item can be referenced from the scope in which it was declared or from its containing scope. For example, if a data item has run-unit scope, any instance of a program invocation in the run unit can reference the data item. An item persists in storage only as long as the item in which it is declared persists. For example, if a data item has program invocation instance scope, it will remain in storage only while that instance is running.

Working with elements that have run-unit scope

If you have resources that have run-unit scope (such as GLOBAL data declared in WORKING-STORAGE), you must synchronize access to that data from multiple threads by using logic in the application. You can take one or both of the following actions:

- Structure the application so that you do not access simultaneously from multiple threads resources that have run-unit scope.
- If you are going to access resources simultaneously from separate threads, synchronize access by using facilities provided by C or by platform functions.

If you have resources that have run-unit scope and you want them to be isolated within an individual program invocation instance (for example, programs with individual copies of data), define the data in the LOCAL-STORAGE SECTION. The data will then have the scope of the program invocation instance.

Working with elements that have program invocation instance scope

With these language elements, storage is allocated for each instance of a program invocation. Therefore, even if a program is called multiple times among multiple threads, each time it is called it will be allocated separate storage. For example, if program X is called in two or more threads, each instance of X that is called gets its own set of resources, such as storage.

Because the storage associated with these language elements has the scope of a program invocation instance, data is protected from access across threads. You do not have to concern yourself with synchronizing access to data. However, this data cannot be shared between invocations of programs unless it is explicitly passed.

RELATED REFERENCES
"Scope of COBOL language elements with multithreading"

Scope of COBOL language elements with multithreading

The following table summarizes the scope of various COBOL language elements.

Table 63. **Scope of COBOL language elements with multithreading**

Language element	Can be referenced from:	Lifetime same as:
ADDRESS-OF special register	Same as associated record	Program invocation instance
Files	Run unit	Run unit
Index data	Program	Program invocation instance
LENGTH of special register	Same as associated identifier	Same as associated identifier

Table 63. **Scope of COBOL language elements with multithreading** *(continued)*

Language element	Can be referenced from:	Lifetime same as:
LINAGE-COUNTER special register	Run unit	Run unit
LINKAGE-SECTION data	Run unit	Based on scope of underlying data
LOCAL-STORAGE data	Within the thread	Program invocation instance
RETURN-CODE	Run unit	Program invocation instance
SORT-CONTROL, SORT-CORE-SIZE, SORT-RETURN, TALLY special registers	Run unit	Program invocation instance
WHEN-COMPILED special register	Run unit	Run unit
WORKING-STORAGE data	Run unit	Run unit

Choosing THREAD to support multithreading

Use the THREAD compiler option for multithreading support. Use THREAD if your program will be called in more than one thread in a single process by an application (such as DCE server applications). Compiling with THREAD prepares the COBOL program for threading support. However, compiling with THREAD might adversely affect 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 compiler option. You cannot mix programs compiled with THREAD and compiled with NOTHREAD in the same run unit.

Compile object-oriented (OO) clients and classes by using the cob2_j command. Compile programs that use the SFS file system by using the cob2_r4 command. These commands cause the THREAD option to automatically be included as a default invocation option.

Language restrictions: When you use the THREAD option, you cannot use certain language elements. For details, see the related reference below.

Recursion: When you compile a program with the THREAD compiler option, you can call the program recursively in a threaded or nonthreaded environment. This recursive capability is available regardless of whether you specified the RECURSIVE phrase in the PROGRAM-ID paragraph.

RELATED TASKS

"Sharing data in recursive or multithreaded programs" on page 15
"Compiling OO applications" on page 195
"Compiling for SFS files" on page 180

RELATED REFERENCES

"THREAD" on page 235

Transferring control with multithreading

When you write COBOL programs for a multithreaded environment, choose appropriate program linkage and ending statements.

In general, it is recommended that the programs that initiate and manage multiple threads use the COBOL preinitialization interface.

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.

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.

Use `EXIT PROGRAM` as you would `GOBACK`, except from a main program where it has no effect.

When the COBOL environment is not preinitialized, and the COBOL run time can determine that there are no other COBOL programs active in the run unit, the COBOL process for terminating a run unit (including closing all open COBOL files) is performed on the `GOBACK` from the first program of this thread. This determination can be made if all COBOL programs that are called within the run unit have returned to their callers through `GOBACK` or `EXIT PROGRAM`.

This determination cannot be made when, for example:

- A thread that has one or more active COBOL programs was terminated (for example, because of an exception or by means of `pthread_exit`).
- A longjmp was executed and resulted in collapsing active COBOL programs in the invocation stack.

There is no COBOL function that effectively does a `STOP RUN` in a threaded environment. If you need this behavior, consider calling the C exit function from your COBOL program and using `_iwzCOBOLTerm` after the run-time termination exit.

Preinitializing the COBOL environment

If your program initiates multiple COBOL threads, for example your C program calls COBOL programs to carry out the input and output of data, do not assume that the COBOL programs will clean up their environment, such as releasing storage no longer needed. In particular, do not assume that files will be automatically closed. You should preinitialize the COBOL environment so that your application can control the COBOL cleanup.

RELATED CONCEPTS

Chapter 29, “Preinitializing the COBOL run-time environment,” on page 449

RELATED TASKS

“Ending and reentering main programs or subprograms” on page 406

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; all synchronization is provided for these by the run-time environment.

DB2: You can run a DB2 application in multiple threads. However, you must provide any needed synchronization for accessing DB2 data.

`SORT` and `MERGE`, and VSAM file I/O: `SORT` and `MERGE` should be active in only one thread at a time. Similarly, input and output for VSAM files should be active from only one thread at a time. However, the COBOL run-time environment does not enforce either of these restrictions. The application must therefore do so.

RELATED TASKS
"Making recursive calls" on page 416

Example: using COBOL in a multithreaded environment

This example consists of a C main program and two COBOL programs:

thrcob.c
A C main program that creates two COBOL threads, waits for them to finish, then exits

subd.cbl
A COBOL program that is run by the thread created by thrcob.c

sube.cbl
A second COBOL program that is run by the thread created by thrcob.c

To create and run the multithreading example, enter the following commands at an AIX shell prompt.:

- To compile thrcob.c: `xlc_r -c thrcob.c`
- To compile subd.cbl: `cob2_r -c subd.cbl`.
- To compile sube.cbl: `cob2_r -c sube.cbl`.
- To generate the executable thrcob: `cob2_r -o thrcob thrcob.o subd.o sube.o`.
- To run the program thrcob: `thrcob`.

Source code for thrcob.c

```
/* Creates COBOL threads, SUBD and SUBE.
   Threads must be created with undetached state for join to work. */
typedef int (*PFN)();
#include  <pthread.h>
#include  <stdio.h>
#include  <setjmp.h>

extern int errno;
extern void *SUBD(void *);
extern void *SUBE(void *);

extern void _iwzCOBOLInit(int fcode, PFN StopFun, int *err_code, void *StopArg);
extern void _iwzCOBOLTerm(int fcode, int *err_code);
```

```
jmp_buf Jmpbuf;

int StopFun(long *stoparg)
{
        printf("inside StopFun. Got stoparg = %d\n", *stoparg);
        *stoparg = 123;
        longjmp(Jmpbuf,1);
}

long StopArg = 0;

void testrc(int rc, const char *s)
{
        if (rc != 0){
                printf("%s: Fatal error rc=%d\n",s,rc);
                exit(-1);
  }
}

void pgmy()
{
        pthread_t t1, t2;
        int rc;
        long i;
        long j;
        void *r1, *r2;
        pthread_attr_t attr;

        _iwzCOBOLInit(1, StopFun, &rc, &StopArg);
        printf( "_iwzCOBOLinit got %d\n",rc);
        pthread_attr_init(&attr);
        pthread_attr_setdetachstate(&attr,PTHREAD_CREATE_UNDETACHED);

        i = 2000;
        rc = pthread_create( &t1, &attr, &SUBD, &1);
        testrc(rc,"create 1");
        j = 1000;
        rc = pthread_create( &t2, &attr, &SUBE, &j);
        testrc(rc,"create 2");
        printf("threads are %x and %x\n",t1, t2);

        rc = pthread_join(t1, &rl);
        printf("join %x got %d\n",t1,rc);
        rc = pthread_join(t2, &r2);
        printf("join %x got %d\n",t2,rc);

        _iwzCOBOLTerm(1, &rc);
        printf( "_iwzCOBOLTerm expects rc=0, got rc=%d\n",rc);
}

main()
{
        if (setjmp(Jmpbuf) ==0) (
                pgmy();
        }
)
```

Source code for subd.cbl

```
PROCESS PGMNAME(MIXED)
       IDENTIFICATION DIVISION
       PROGRAM-ID. "SUBD".
       ENVIRONMENT DIVISION.
       CONFIGURATION SECTION.
       SPECIAL NAMES.
           DECIMAL-POINT IS COMMA.
```

```
       INPUT-OUTPUT SECTION.
       DATA DIVISION.
       FILE SECTION.
       Working-Storage SECTION.

       Local-Storage Section.
       01 n2 pic 9(8) comp-5 value 0.

       Linkage Section.
       01 n1 pic 9(8) comp-5.

       PROCEDURE DIVISION using by Reference n1.
           Display "In SUBD "

           perform n1 times
              compute n2 = n2 + 1
              Display "From Thread 1: " n2
              CALL "Sleep" Using by value 1000
           end-perform

           GOBACK.
```

Source code for sube.cbl

```
      PROCESS PGMNAME(MIXED)
              IDENTIFICATION DIVISION.
              PROGRAM-ID. "SUBE".
              ENVIRONMENT DIVISION.
              CONFIGURATION SECTION.
              SPECIAL-NAMES.
                  DECIMAL-POINT IS COMMA.
              INPUT-OUTPUT SECTION.
              DATA DIVISION.
              FILE SECTION.
              Working-Storage SECTION.

              Local-Storage Section.
              01 n2 pic 9(8) comp-5 value 0.

              Linkage Section.
              01 n1 pic 9(8) comp-5.

              PROCEDURE DIVISION using by reference n1.

                  perform n1 times
                     compute n2 = n2 + 1
                     Display "From Thread 2: " n2
             *Go to sleep for 3/4 sec.
                     CALL "Sleep" Using by value 750
                  end-perform

                  GOBACK.
```

Chapter 29. Preinitializing the COBOL run-time environment

Preinitialization allows an application to initialize the COBOL run-time environment once, perform multiple executions using the environment, and then explicitly terminate the environment. You can use preinitialization to invoke COBOL programs multiple times from a non-COBOL environment, such as C/C++.

Restriction: Preinitialization is not supported under CICS.

Preinitialization has two primary benefits:

- The COBOL environment stays ready for program calls.

  Because the COBOL run unit is not terminated on return from the first COBOL program in the run unit, the COBOL programs that are invoked from a non-COBOL environment can be invoked in their last-used state.
- Performance is faster.

  Creating and taking down the COBOL run-time environment repeatedly involves overhead and can slow down your application.

Use preinitialization services for multilanguage applications where non-COBOL programs need to use a COBOL program in its last-used state. For example, a file can be opened on the first call to a COBOL program, and the invoking program expects subsequent calls to the program to find the file open.

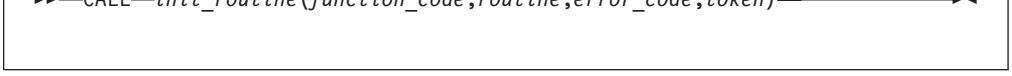
Use the interfaces described below to initialize and terminate a persistent COBOL run-time environment. Any shared library that contains a COBOL program used in a preinitialized environment cannot be deleted until the preinitialized environment is terminated.

"Example: preinitializing the COBOL environment" on page 451

RELATED TASKS
"Initializing persistent COBOL environment"
"Terminating preinitialized COBOL environment" on page 450

Initializing persistent COBOL environment

CALL init_routine syntax



CALL Invocation of *init_routine*, using language elements appropriate to the language from which the call is being made

init_routine
The name of the initialization routine: `_iwzCOBOLInit` or `IWZCOBOLINIT`

***function_code* (input)**
A 4-byte binary number, passed by value. *function_code* can be:

© Copyright IBM Corp. 1995, 2004

1 The first COBOL program invoked following this function invocation is treated as a subprogram.

***routine* (input)**
Address of the routine to be invoked if the run unit terminates. The token argument passed to this function is passed to the run-unit termination exit routine. This routine, when invoked upon run-unit termination, must not return to the invoker of the routine but rather call longjmp() or exit().

If you do not provide an exit routine address, an *error_code* is generated that indicates that preinitialization failed.

***error_code* (output)**
A 4-byte binary number. *error_code* can be:

0 Preinitialization was successful.

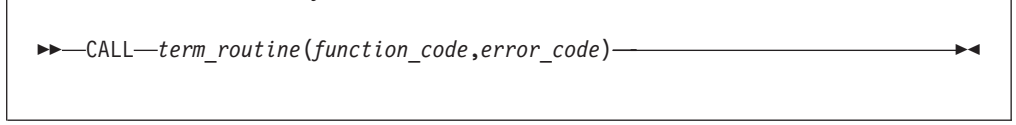
1 Preinitialization failed.

***token* (input)**
A 4-byte token to be passed to the exit routine specified in the earlier argument when that routine is invoked upon run-unit termination.

RELATED TASKS
"Terminating preinitialized COBOL environment"

Terminating preinitialized COBOL environment

CALL term_routine syntax



CALL Invocation of *term_routine*, using language elements appropriate to the language from which the call is being made.

term_routine
The name of the termination routine: `_iwzCOBOLTerm` or `IWZCOBOLTERM`.

***function_code* (input)**
A 4-byte binary number, passed by value. *function_code* can be:

1 Clean up the preinitialized COBOL run-time environment as if a COBOL `STOP RUN` statement had been performed; for example, all COBOL files are closed. However, the control returns to the caller of this service.

***error_code* (output)**
A 4-byte binary number. *error_code* can be:

0 Termination was successful.

1 Termination failed.

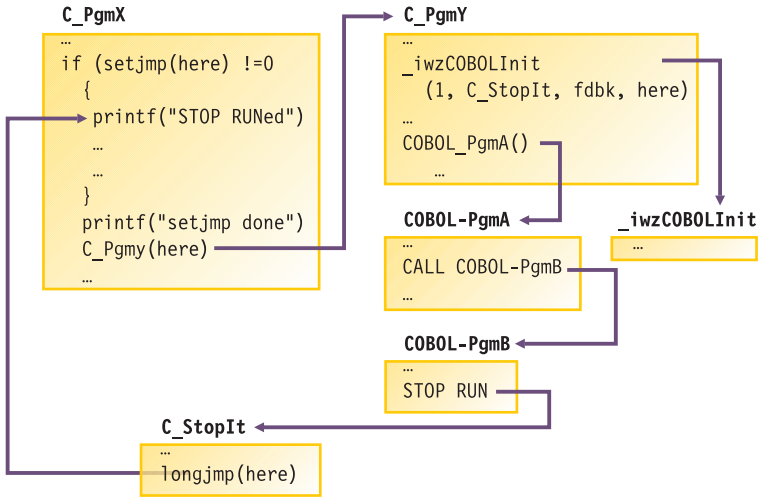
The first COBOL program called following the invocation of the preinitialization routine is treated as a subprogram. Thus, a GOBACK from this (initial) program *does not* trigger run-unit termination semantics (such as the closing of files). Run-unit termination (such as with STOP RUN) *does* free the preinitialized COBOL environment prior to the invocation of the run-unit exit routine.

If not active: If your program invokes the termination routine and the COBOL environment is not already active, the termination routine invocation has no effect on the execution, and control is returned to the invoker with an error code of 0.

"Example: preinitializing the COBOL environment"

Example: preinitializing the COBOL environment

The following figure illustrates how the preinitialized COBOL environment works. The example shows a C program initializing the COBOL environment, calling COBOL programs, then terminating the COBOL environment.



The following example shows the use of COBOL preinitialization. A C main program calls the COBOL program XIO several times. The first call to XIO opens the file, the second call writes one record, and so on. The final call closes the file. The C program then uses C-stream I/O to open and read the file.

To test and run the program, enter the following commands from a command shell:

```
xlc -c testinit.c
cob2 testinit.o xio.cbl
a.out
```

The result is:

```
_iwzCOBOLinit got 0
xio entered with x=0000000000
xio entered with x=0000000001
xio entered with x=0000000002
xio entered with x=0000000003
xio entered with x=0000000004
xio entered with x=0000000099
StopArg=0
_iwzCOBOLTerm expects rc=0 and got rc=0
FILE1 contains ----
```

```
11111
22222
33333
---- end of FILE1
```

Note that in this example, the run unit was not terminated by a COBOL STOP RUN; it was terminated when the main program called _iwzCOBOLTerm.

The following C program is in the file testinit.c:

```
#ifdef _AIX
typedef int (*PFN)();
#define LINKAGE
#else
#include <windows.h>
#define LINKAGE _System
#endif

#include   <stdio.h>
#include   <setjmp.h>

extern void _iwzCOBOLInit(int fcode, PFN StopFun, int *err_code, void *StopArg);
extern void _iwzCOBOLTerm(int fcode, int *err_code);
extern void LINKAGE XIO(long *k);

jmp_buf Jmpbuf;
long StopArg = 0;

int LINKAGE
StopFun(long *stoparg)
{
        printf("inside StopFun\n");
        *stoparg = 123;
        longjmp(Jmpbuf,1);
}

main()
{
        int rc;
        long k;
        FILE *s;
        int c;

        if (setjmp(Jmpbuf) ==0) {
                _iwzCOBOLInit(1, StopFun, &rc, &StopArg);
                printf( "_iwzCOBOLinit got %d\n",rc);
                for (k=0; k <= 4; k++) XIO(&k);
                k = 99; XIO(&k);
        }
        else printf("return after STOP RUN\n");
        printf("StopArg=%d\n", StopArg);
        _iwzCOBOLTerm(1, &rc);
        printf("_iwzCOBOLTerm expects rc=0 and got rc=%d\n",rc);
        printf("FILE1 contains ---- \n");
        s = fopen("FILE1", "r");
        if (s) {
                while (  (c = fgetc(s) ) != EOF ) putchar(c);
        }
        printf("---- end of FILE1\n");
}
```

The following COBOL program is in the file xio.cbl:

```
 IDENTIFICATION DIVISION.
 PROGRAM-ID.     xio.
*****************************************************************
 ENVIRONMENT    DIVISION.
```

```
 CONFIGURATION   SECTION.
 INPUT-OUTPUT    SECTION.
 FILE-CONTROL.
     SELECT file1 ASSIGN TO FILE1
       ORGANIZATION IS LINE SEQUENTIAL
       FILE STATUS IS file1-status.
 . . .
 DATA           DIVISION.
 FILE SECTION.
 FD FILE1.
 01 file1-id pic x(5).
 . . .
 WORKING-STORAGE SECTION.
 01 file1-status  pic xx    value is zero.
 . . .
 LINKAGE SECTION.
*
 01 x               PIC S9(8) COMP-5.
 . . .
 PROCEDURE DIVISION using x.
 . . .
     display "xio entered with x=" x
     if x = 0 then
       OPEN output FILE1
     end-if
     if x = 1  then
        MOVE ALL "1" to file1-id
        WRITE file1-id
     end-if
     if x = 2 then
        MOVE ALL "2" to file1-id
        WRITE file1-id
     end-if
     if x = 3 then
        MOVE ALL "3" to file1-id
        WRITE file1-id
     end-if
     if x = 99 then
       CLOSE file1
     end-if
     GOBACK.
```

Chapter 30. 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 456

RELATED TASKS

"Resolving date-related logic problems" on page 457
"Using year-first, year-only, and year-last date fields" on page 462
"Manipulating literals as dates" on page 465
"Setting triggers and limits" on page 467
"Sorting and merging by date" on page 469
"Performing arithmetic on date fields" on page 471
"Controlling date processing explicitly" on page 473
"Analyzing and avoiding date-related diagnostic messages" on page 474
"Avoiding problems in processing dates" on page 476

RELATED REFERENCES

DATE FORMAT clause (*COBOL for AIX Language Reference*)
"DATEPROC" on page 208
"YEARWINDOW" on page 240

© Copyright IBM Corp. 1995, 2004

Millennium language extensions (MLE)

The term *millennium language extensions* refers to the features of COBOL for AIX 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-INTEGER
  DATE-TO-YYYYMMDD
  DAY-OF-INTEGER
  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 208
"YEARWINDOW" on page 240

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 64. **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 459
"Example: internal bridging" on page 460
"Example: converting files to expanded date form" on page 461

RELATED TASKS
"Using a century window"
"Using internal bridging" on page 459
"Moving to full field expansion" on page 460

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 458
"Performing arithmetic on date fields" on page 471
"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 INFILE
                  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(TM) (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 464

RELATED CONCEPTS
"Compatible dates"

RELATED TASKS
"Sorting and merging by date" on page 469
"Using other date formats" on page 464

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 XXXXYY to another XXXXYY date field, but not to a date field with a format of XXXXYYYY.

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 "YYXXXX")
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 467

RELATED TASKS
"Controlling date processing explicitly" on page 473

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 473

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 469

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 yyxxx.
. . .
    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 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 467

RELATED TASKS

"Setting triggers and limits" on page 467
"Controlling date processing explicitly" on page 473

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 208
"YEARWINDOW" on page 240

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 459

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 474

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 (*COBOL for AIX 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 (*COBOL for AIX 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 473
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 7. Improving performance and productivity

Chapter 31. Tuning your program 481
Using an optimal programming style 481
Using structured programming 482
Factoring expressions. 482
Using symbolic constants 482
Grouping constant computations 482
Grouping duplicate computations 483
Choosing efficient data types 483
Computational data items 483
Consistent data types. 484
Arithmetic expressions 484
Exponentiations 484
Handling tables efficiently 485
Optimization of table references 486
Optimization of constant and variable items 487
Optimization of duplicate items 487
Optimization of variable-length items . . . 487
Comparison of direct and relative indexing 487
Optimizing your code 488
Optimization 488
Contained program procedure integration 489
Choosing compiler features to enhance performance. 489
Performance-related compiler options 490
Evaluating performance 491

Chapter 32. Simplifying coding. 493
Eliminating repetitive coding 493
Example: using the COPY statement. 494
Manipulating dates and times 495
Getting feedback 495
Handling conditions 495
Example: manipulating dates 496
Example: formatting dates for output 496
Feedback token. 497
Picture character terms and strings 498
Example: date-and-time picture strings 500
Century window 501
Example: querying and changing the century window 501

© Copyright IBM Corp. 1995, 2004

Chapter 31. 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 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. Convert instances of `EXEC CICS LINK` to `CALL` to improve transaction response time.

RELATED CONCEPTS
"Optimization" on page 488

RELATED TASKS
"Using an optimal programming style"
"Choosing efficient data types" on page 483
"Handling tables efficiently" on page 485
"Optimizing your code" on page 488
"Choosing compiler features to enhance performance" on page 489
"Improving SFS performance" on page 129

RELATED REFERENCES
"Performance-related compiler options" on page 490
Chapter 15, "Run-time options," on page 249

Using an optimal programming style

The coding style you use can, in certain circumstances, affect how the optimizer handles your code.

© Copyright IBM Corp. 1995, 2004

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	Less efficient
`V1 * V2 * V3 * (C1 * C2 * C3)`	`V1 * V2 * V3 * C1 * C2 * C3`
`C1 + C2 + C3 + V1 + V2 + V3`	`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.

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

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 34

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 53
"Choosing efficient data types" on page 483

RELATED REFERENCES
"SSRANGE" on page 233

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:

```
comp_v1 * d1 + comp_c1 * d2 + comp_c2 * d3 + 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:

```
comp_c1 * d1 + comp_c2 * d2 + comp_v1 * d3 + 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:

```
comp_c1 * d1 + comp_c2 * d2 + comp_c3 * d3 + 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:

```
comp_v1 * d1 + comp_v3 * d2 + comp_v4 * d3 + base_address
comp_v2 * d1 + comp_v3 * d2 + comp_v4 * d3 + base_address
```

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:

```
comp_v1 * d1 + comp_v2 * d2 + comp_v3 * d3 + base_address
comp_v1 * d1 + comp_v2 * d2 + comp_v4 * d3 + base_address
```

In the two references ELEMENT(V1 V2 V3) and ELEMENT(V1 V2 V3), the expressions are the same:

```
comp_v1 * d1 + comp_v2 * d2 + comp_v3 * d3 + base_address
comp_v1 * d1 + comp_v2 * d2 + comp_v3 * d3 + base_address
```

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 485

Optimizing your code

When your program is ready for final test, specify the `OPTIMIZE` compiler option 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 220
"OPTIMIZE" on page 225

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 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.
- 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.

RELATED CONCEPTS

"Optimization of table references" on page 486

RELATED REFERENCES

"OPTIMIZE" on page 225

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.

RELATED CONCEPTS
"Optimization" on page 488

RELATED TASKS
"Optimizing your code" on page 488
"Getting listings" on page 263

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 65. **Performance-related compiler options**

Compiler option	Purpose	Performance advantages	Performance disadvantages	Usage notes
"DYNAM" on page 210	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 library routine.	To free virtual storage that is no longer needed, issue the CANCEL statement.
OPTIMIZE(STD) (see "OPTIMIZE" on page 225)	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 symbolic debugging. For production runs, OPTIMIZE is recommended.
OPTIMIZE(FULL) (see "OPTIMIZE" on page 225)	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.
NOSSRANGE (see "SSRANGE" on page 233)	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.

Table 65. **Performance-related compiler options** *(continued)*

Compiler option	Purpose	Performance advantages	Performance disadvantages	Usage notes
NOTEST (see "TEST" on page 234)	To avoid the additional object code that would be produced to take full advantage of the Distributed Debugger.	TEST significantly enlarges the object file because it adds debugging information. When linking the program, you can direct the linker to exclude the debugging information, resulting in approximately the same size executable as would be created if the modules were compiled with NOTEST. If the debugging information is included in the executable, a slight performance degradation might occur because the larger executable will take longer to load and might increase paging.	None	TEST forces the NOOPTIMIZE compiler option into effect. For production runs, using NOTEST is recommended.
TRUNC(OPT) (see "TRUNC" on page 236)	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 488

RELATED TASKS
"Generating a list of compiler error messages" on page 185
"Choosing compiler features to enhance performance" on page 489
"Handling tables efficiently" on page 485

RELATED REFERENCES
"Sign representation and processing" on page 39

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 66. **Performance-tuning worksheet**

Compiler option	Consideration	Yes?
DYNAM	Do you use NODYNAM? Consider the performance tradeoffs.	
OPTIMIZE	Do you use OPTIMIZE for production runs? Can you use OPTIMIZE(FULL)?	
SSRANGE	Do you use NOSSRANGE for production runs?	
TEST	Do you use NOTEST for production runs?	
TRUNC	Do you use TRUNC(OPT) when possible?	

RELATED TASKS

"Choosing compiler features to enhance performance" on page 489

RELATED REFERENCES

"Performance-related compiler options" on page 490

Chapter 32. Simplifying coding

This material provides techniques for improving your productivity. By using the COPY statement, COBOL intrinsic functions, and 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 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 42

RELATED TASKS
"Eliminating repetitive coding"
"Converting data items (intrinsic functions)" on page 88
"Evaluating data items (intrinsic functions)" on page 91
"Manipulating dates and times" on page 495

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, either set the environment variable SYSLIB to multiple path names separated by a semicolon (;) or define your own environment variables and include the following phrase on the COPY statement:

```
IN/OF library-name
```

For example:

```
COPY MEMBER1 OF COPYLIB
```

If you omit this qualifying phrase, the default is SYSLIB.

Use a command such as the following example to set an environment variable that defines COPYLIB at compile time:

```
SET COPYLIB=D:\CPYFILES\COBCOPY
```

© Copyright IBM Corp. 1995, 2004

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 14, "Compiler-directing statements," on page 243

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 493

RELATED REFERENCES
Chapter 14, "Compiler-directing statements," on page 243

Manipulating dates and times

To invoke a date and time callable service, use a CALL statement with the correct parameters for the service. (For a list of the date and time callable services and more details about them, see the related references below.)

For example:

```
CALL "CEEDATE" using argument, format, result, feedback-code.
```

You define the data items in the CALL statement in the DATA DIVISION of your program with the data definitions required by the service that you are calling:

```
77  argument            pic  s9(9)  comp.
01  format.
    05 format-length     pic  s9(4)  comp.
    05 format-string     pic  x(80).
77  result              pic  x(80).
77  feedback-code        pic  x(12)  display.
```

In this example, the date and time callable service CEEDATE converts a number that represents a Lilian date in the data item argument to a date in character format, which is written to the data item result. The picture string contained in the data item format controls the format of the conversion. Information about the success or failure of the call is returned in the data item feedback-code.

In the CALL statements that you use to invoke the date and time callable services, you must use a literal for the program name rather than an identifier.

A program calls the date and time callable services by using the standard system linkage convention.

Getting feedback

You can specify a feedback code parameter (which is optional) in any date and time callable service. Specify OMITTED for this parameter if you do not want the date and time callable service to return information about the success or failure of the call. However, if you do not specify this parameter and the callable service does not complete successfully, the program will abend.

When you call a date and time callable service and specify OMITTED for the feedback code, the RETURN-CODE special register is set to 0 if the service is successful, but it is not altered if the service is unsuccessful. If the feedback code is not OMITTED, the RETURN-CODE special register is always set to 0 regardless of whether the service completed successfully.

Handling conditions

Condition handling by COBOL for AIX is significantly different from that by IBM Language Environment(R) on the host. COBOL for AIX adheres to the native COBOL condition handling scheme and does not provide the level of support that is in Language Environment.

If a feedback token is passed as an argument, it will simply be returned after the appropriate information has been filled in. You can then code logic in the calling routine to examine the contents and perform any actions if necessary. The condition will not be signaled.

"Example: manipulating dates"
"Example: formatting dates for output"

RELATED REFERENCES
Appendix E, "Date and time callable services," on page 529
"Feedback token" on page 497
"Picture character terms and strings" on page 498
"CALLINT" on page 202
Chapter 14, "Compiler-directing statements," on page 243
CALL statement (*COBOL for AIX Language Reference*)

Example: manipulating dates

This example shows how to use date and time callable services to convert a date to a different format and do a simple calculation on the formatted date.

```
CALL CEEDAYS USING dateof_hire, 'YYMMDD', doh_lilian, fc.
CALL CEELOCT USING todayLilian, today_seconds, today_Gregorian, fc.
COMPUTE servicedays = today_Lilian - doh_Lilian.
COMPUTE serviceyears = service_days / 365.25.
```

This example uses the original date of hire in the format YYMMDD to calculate the number of years of service for an employee. The calculation is as follows:

- The CEEDAYS (Convert Date to Lilian Format) service converts the dates to a Lilian format.
- The CEELOCT (Get Current Local Time) service gets the current local time.
- Subtract `doh_Lilian` from `today_Lilian` (the number of days from the beginning of the Gregorian calendar to the current local time) to calculate the employee's total number of days of employment.
- Divide that number by 365.25 to get the number of service years.

Example: formatting dates for output

This sample COBOL program uses date and time callable services to format and display a date from the results of a COBOL `ACCEPT` statement.

Many callable services offer you function that would require extensive coding using previous versions of COBOL. Two such services are CEEDAYS and CEEDATE, which you can use effectively when you want to format dates for output.

```
CBL QUOTE
       ID DIVISION.
       PROGRAM-ID. HOHOHO.
      ************************************************************
      * FUNCTION:  DISPLAY TODAY'S DATE IN THE FOLLOWING FORMAT: *
      *            WWWWWWWWW, MMMMMMMM DD, YYYY                  *
      *                                                          *
      *            For example:  MONDAY, MARCH 10, 1997          *
      *                                                          *
      ************************************************************
       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  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 " WWWWWWWWWZ, MMMMMMMMMZ 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.
```

Feedback token

A feedback token contains feedback information in the form of a condition token. The condition token set by the callable service will be returned to the calling routine, indicating whether the service completed successfully or not. COBOL for AIX uses the same feedback token as Language Environment, which is defined as follows:

```
01  FC.
    02  Condition-Token-Value.
    COPY  CEEIGZCT.
        03  Case-1-Condition-ID.
            04  Severity    PIC S9(4) COMP.
            04  Msg-No      PIC S9(4) COMP.
        03  Case-2-Condition-ID
                  REDEFINES Case-1-Condition-ID.
            04  Class-Code  PIC S9(4) COMP.
            04  Cause-Code  PIC S9(4) COMP.
        03  Case-Sev-Ctl    PIC X.
        03  Facility-ID     PIC XXX.
    02  I-S-Info            PIC S9(9) COMP.
```

The following describes the contents of each field and identifies differences from IBM Language Environment on the host:

Severity

This is the severity number with the following possible values:

0 Information only (or, if the entire token is zero, no information).

1 Warning - service completed, probably correctly.

2 Error detected - correction was attempted; service completed, perhaps incorrectly.

3 Severe error - service did not complete.

4 Critical error - service did not complete.

Msg-No This is the associated message number.

Case-Sev-Ctl
This field always contains the value 1.

Facility-ID
This field always contains the characters CEE.

I-S-Info
This field always contains the value 0.

The sample copybook CEEIGZCT.CPY defines the condition tokens. The condition tokens in the file are equivalent to those provided by Language Environment, except that character representations are in ASCII instead of EBCDIC. You must take these differences into account if you compare the condition tokens with those provided by Language Environment.

The descriptions of the individual callable services include a listing of the symbolic feedback codes that might be returned in the feedback code output field specified on invocation of the service. In addition to these, the symbolic feedback code CEE0PD might be returned for any callable service. See message IWZ0813S for details.

All date and time callable services are based on the Gregorian calendar. Date variables associated with this calendar have architectural limits. These limits are:

Starting Lilian date
The beginning of the Lilian date range is Friday 15 October 1582, the date of adoption of the Gregorian calendar. Lilian dates before this date are undefined. Therefore:

- Day zero is 00:00:00 14 October 1582.
- Day one is 00:00:00 15 October 1582.

All valid input dates must be after 00:00:00 15 October 1582.

End Lilian date
The end Lilian date range is set to 31 December 9999. Lilian dates after this date are undefined. The reason for this limit is a four-digit year.

RELATED REFERENCES
Appendix I, "Run-time messages," on page 635

Picture character terms and strings

You use picture character terms and strings to define the format of a date or time field that several of the date and time callable services use. A picture string is a template that indicates the format of the input of the data or the desired format of the output.

This table defines the supported picture character terms and string values.

Table 67. **Picture character terms and strings**

Picture terms	Explanations	Valid values	Notes
Y	One-digit year	0-9	Y valid for output only.
YY	Two-digit year	00-99	YY assumes range set by CEESCEN.
YYY	Three-digit year	000-999	YYY/ZYY used with <JJJJ>, <CCCC>, and <CCCCCCCC>.
ZYY	Three-digit year within era	1-999	
YYYY	Four-digit year	1582-9999	

Table 67. **Picture character terms and strings** *(continued)*

Picture terms	Explanations	Valid values	Notes
<JJJJ>	Japanese Era name in Kanji characters with UTF-16 hexadecimal encoding	*Heisei* (NX'5E736210') *Showa* (NX'662D548C') *Taisho* (NX'59276B63') *Meiji* (NX'660E6CBB')	Affects YY field: if <JJJJ> is specified, YY means the year within Japanese Era. For example, 1988 equals Showa 63.
MM ZM	Two-digit month One- or two-digit month	01-12 1-12	 For output, leading zero suppressed. For input, ZM treated as MM.
RRRR RRRZ	Roman numeral month	I*bbb*-XII*b* (left justified)	For input, source string is folded to uppercase. For output, uppercase only. I=Jan, II=Feb, ..., XII=Dec.
MMM Mmm MMMM...M Mmmm...m MMMMMMMMMZ Mmmmmmmmmz	Three-char month, uppercase Three-char month, mixed case Three-20 char mo., uppercase Three-20 char mo., mixed case Trailing blanks suppressed Trailing blanks suppressed	JAN-DEC Jan-Dec JANUARY*bb*-DECEMBER*b* January*bb*-December*b* JANUARY-DECEMBER January-December	For input, source string always folded to uppercase. For output, M generates uppercase and m generates lowercase. Output is padded with blanks (*b*) (unless Z specified) or truncated to match the number of Ms, up to 20.
DD ZD DDD	Two-digit day of month One- or two-digit day of mo. Day of year (Julian day)	01-31 1-31 001-366	For output, leading zero is always suppressed. For input, ZD treated as DD.
HH ZH	Two-digit hour One- or two-digit hour	00-23 0-23	For output, leading zero suppressed. For input, ZH treated as HH. If AP specified, valid values are 01-12.
MI	Minute	00-59	
SS	Second	00-59	
9 99 999	Tenths of a second Hundredths of a second Thousandths of a second	0-9 00-99 000-999	No rounding
AP ap A.P. a.p.	AM/PM indicator	AM or PM am or pm A.M. or P.M. a.m. or p.m.	AP affects HH/ZH field. For input, source string always folded to uppercase. For output, AP generates uppercase and ap generates lowercase.
W WWW Www WWW...W Www...w WWWWWWWWWZ Wwwwwwwwwz	One-char day-of-week Three-char day, uppercase Three-char day, mixed case Three-20 char day, uppercase Three-20 char day, mixed case Trailing blanks suppressed Trailing blanks suppressed	S, M, T, W, T, F, S SUN-SAT Sun-Sat SUNDAY*bbb*-SATURDAY*b* Sunday*bbb*-Saturday*b* SUNDAY-SATURDAY Sunday-Saturday	For input, Ws are ignored. For output, W generates uppercase and w generates lowercase. Output padded with blanks (unless Z specified) or truncated to match the number of Ws, up to 20.
All others	Delimiters	X'01'-X'FF' (X'00' is reserved for "internal" use by the date and time callable services)	For input, treated as delimiters between the month, day, year, hour, minute, second, and fraction of a second. For output, copied exactly as is to the target string.
Note: Blank characters are indicated by the symbol *b*.			

This table defines Japanese Eras used by date and time services when <JJJJ> is specified.

Table 68. **Japanese Eras**

First date of Japanese Era	Era name	Era name in Kanji with UTF-16 hexadecimal encoding	Valid year values
1868-09-08	Meiji	NX'660E6CBB'	01-45
1912-07-30	Taisho	NX'59276B63'	01-15
1926-12-25	Showa	NX'662D548C'	01-64
1989-01-08	Heisei	NX'5E736210'	01-999 (01 = 1989)

"Example: date-and-time picture strings"

Example: date-and-time picture strings

This is an example of picture strings that are recognized by date and time services.

Table 69. **Examples of date-and-time picture strings**

Picture strings	Examples	Comments
YYMMDD YYYYMMDD	880516 19880516	
YYYY-MM-DD	1988-05-16	1988-5-16 would also be valid input.
<JJJJ> YY.MM.DD	*Showa* 63.05.16	*Showa* is a Japanese Era name. *Showa* 63 equals 1988.
MMDDYY MM/DD/YY ZM/ZD/YY MM/DD/YYYY MM/DD/Y	050688 05/06/88 5/6/88 05/06/1988 05/06/8	One-digit year format (Y) is valid for output only.
DD.MM.YY DD-RRRR-YY DD MMM YY DD Mmmmmmmmm YY ZD Mmmmmmmmz YY Mmmmmmmmz ZD, YYYY ZDMMMMMMMMzYY	09.06.88 09-VI -88 09 JUN 88 09 June 88 9 June 88 June 9, 1988 9JUNE88	Z suppresses zeros and blanks.
YY.DDD YYDDD YYYY/DDD	88.137 88137 1988/137	Julian date
YYMMDDHHMISS YYYYMMDDHHMISS YYYY-MM-DD HH:MI:SS.999 WWW, ZM/ZD/YY HH:MI AP Wwwwwwwwwz, DD Mmm YYYY, ZH:MI AP	880516204229 19880516204229 1988-05-16 20:42:29.046 MON, 5/16/88 08:42 PM Monday, 16 May 1988, 8:42 PM	Timestamp—valid only for CEESECS and CEEDATM. If used with CEEDATE, time positions are filled with zeros. If used with CEEDAYS, HH, MI, SS, and 999 fields are ignored.
Note: Lowercase characters can be used only for alphabetic picture terms.		

Century window

To process two-digit years in the year 2000 and beyond, the date and time callable services use a sliding scheme by which all two-digit years are assumed to lie within a 100-year interval starting 80 years before the current system date:



In the year 2004 for example, 100 years spanning from 1924 to 2023 is the default century window for the date and time callable services. In the year 2004, years 24 through 99 are recognized as 1924-1999, and years 00 through 23 are recognized as 2000-2023.

By year 2080, all two-digit years will be recognized as 20*nn*. In 2081, 00 will be recognized as year 2100.

Some applications might need to set up a different 100-year interval. For example, banks often deal with 30-year bonds, which could be due 01/31/25. The two-digit year 25 would be interpreted as 1925 using the current default century window. The CEESCEN callable service allows you to change the century window. A companion service, CEEQCEN, queries the current century window.

You can use CEEQCEN and CEESCEN, for example, to cause a subroutine to use a different interval for date processing than that used by its parent routine. Before returning, the subroutine should reset the interval to its previous value.

"Example: querying and changing the century window"

Example: querying and changing the century window

The following example demonstrates how to query, set, and restore the starting point of the century window using the CEEQCEN and CEESCEN services.

The example calls CEEQCEN to obtain an integer (here, `OLDCEN`) that tells how many years ago the current century window began.

It then temporarily changes the starting point of the current century window to a new value (here, `TEMPCEN`) by calling CEESCEN with that value. Because the century window is set to 30, any two-digit years that follow the CEESCEN call are assumed to lie within the 100-year interval starting 30 years before the current system date.

Finally, after it processes dates (not shown) using the temporary century window, the example again calls CEESCEN to reset the starting point of the century window to its original value.

```
 WORKING-STORAGE SECTION.
 77 OLDCEN  PIC S9(9) COMP.
 77 TEMPCEN PIC S9(9) COMP.
 77 QCENFC  PIC X(12).
 . . .
 77 SCENFC1 PIC X(12).
 77 SCENFC2 PIC X(12).
 . . .
 PROCEDURE DIVISION.
     . . .
** Call CEEQCEN to retrieve and save current century window
```

```
     CALL "CEEQCEN" USING OLDCEN, QCENFC.
** Call CEESCEN to temporarily change century window to 30
     MOVE 30 TO TEMPCEN.
     CALL "CEESCEN" USING TEMPCEN, SCENFC1.
** Perform date processing with two-digit years
     . . .
** Call CEESCEN again to reset century window
     CALL "CEESCEN" USING OLDCEN, SCENFC2.
     . . .
     GOBACK.
```

RELATED REFERENCES

Appendix E, “Date and time callable services,” on page 529

Part 8. Appendixes

© Copyright IBM Corp. 1995, 2004

Appendix A. Summary of differences with host COBOL

IBM COBOL for AIX implements certain functions differently from the way Enterprise COBOL for z/OS implements them. This section describes the differences in the following functions:

- "Compiler options"
- "Data representation"
- "Environment variables" on page 507
- "File specification" on page 507
- "Interlanguage communication (ILC)" on page 507
- "Input and output" on page 508
- "Run-time options" on page 508
- "Source code line size" on page 508
- "Language elements" on page 508

Compiler options

COBOL for AIX treats the following compiler options as comments: `ADV`, `AWO`, `BINARY`, `BUFSIZE`, `CODEPAGE`, `DATA`, `DECK`, `DBCS`, `FASTSRT`, `FLAGMIG`, `INTDATE`, `LANGUAGE`, `NAME`, `OUTDD`, and `RENT` (the compiler always produces reentrant code). These options are flagged with I-level messages.

COBOL for AIX treats the `NOADV` compiler option as a comment. It is flagged with a W-level message. If you specify this option, the application might yield unexpected results when you use a `WRITE` statement with the `ADVANCING` phrase.

For OO COBOL applications, you can specify the `-host` option of the `cob2_j` command, any setting of the `CHAR` or `FLOAT` compiler options, or both. However, you must specify any floating-point items that are used as method arguments or parameters, and any arguments to JNI services, in native format (for example, by using the `NATIVE` phrase on the data description entry).

Data representation

External decimal data

Sign representation for external decimal data is based on ASCII or EBCDIC depending on the setting of the `CHAR` compiler option (`NATIVE` or `EBCDIC`) and whether the `USAGE` clause is specified with the `NATIVE` phrase. COBOL for AIX processes the sign representation of external decimal data consistently with the processing that occurs on the host with the compiler option `NUMPROC(NOPFD)` in effect.

Packed-decimal data

Sign representation for unsigned packed-decimal numbers is different between COBOL for AIX and host COBOL. COBOL for AIX always uses a sign nibble of `x'C'` for unsigned packed-decimal numbers. Host COBOL uses a sign nibble of `x'F'` for unsigned packed-decimal numbers. If you are going to share data files that

© Copyright IBM Corp. 1995, 2004

contain packed-decimal numbers between AIX and z/OS, it is recommended that you use signed packed-decimal numbers instead of unsigned packed-decimal numbers.

Floating-point data

You can use the FLOAT(S390) compiler option to indicate that floating-point data items are in the zSeries data representation (hexadecimal) as opposed to the native (IEEE) format.

Do not specify the zSeries formats of floating-point items as arguments on INVOKE statements or as method parameters. You must specify these arguments and parameters in the native formats in order for them to be interoperable with the Java data types.

National data

COBOL for AIX and host COBOL use UTF-16 big-endian format for national data.

EBCDIC and ASCII data

You can specify the EBCDIC collating sequence for alphanumeric data items using the following language elements:

- ALPHABET clause
- PROGRAM COLLATING SEQUENCE clause
- COLLATING SEQUENCE phrase of the SORT or MERGE statement

You can specify the CHAR(EBCDIC) compiler option to indicate that DISPLAY data items are in the zSeries data representation (EBCDIC).

Code-page determination for data conversion

For alphabetic, alphanumeric, DBCS, and national data items, the source code page used for implicit conversion of native characters is determined from the locale in effect at run time.

For alphanumeric, DBCS, and national literals, the source code page used for implicit conversion of characters is determined from the locale in effect at compile time.

DBCS character strings

Under COBOL for AIX, ASCII DBCS character strings are not delimited with the shift-in and shift-out characters except possibly with the dummy shift-in and shift-out characters as discussed below.

Use the SOSI compiler option to indicate that AIX workstation shift-out (X'1E') and shift-in (X'1F') control characters delimit DBCS character strings in the source program, including user-defined words, DBCS literals, alphanumeric literals, national literals, and comments. Host shift-out and shift-in control characters (X'0E' and X'0F', respectively) are usually converted to workstation shift-out and shift-in control characters when COBOL for AIX source code is downloaded, depending on the download method that you use.

Using control characters X'00' through X'1F' within an alphanumeric literal can yield unpredictable results.

Environment variables

COBOL for AIX recognizes these environment variables:

- *assignment-name*
- COBMSGS
- COBPATH
- COBRTOPT
- DB2DBDFT
- EBCDIC_CODEPAGE
- ENCINA_CDS_ROOT
- ENCINA_SFS_DATA_VOLUME
- ENCINA_SFS_INDEX_VOLUME
- ENCINA_VSAM_AUTO_FLUSH
- ENCINA_VSAM_CACHE
- LANG
- LC_ALL
- LC_COLLATE
- LC_CTYPE
- LC_MESSAGES
- LC_TIME
- LOCPATH
- NLSPATH
- TMP
- TZ

File specification

COBOL for AIX treats all files as single volume files. All other file specifications are treated as comments. This change affects the following: `REEL`, `UNIT`, `MULTIPLE FILE TAPE` clause, and `CLOSE. . .UNIT/REEL`.

Interlanguage communication (ILC)

ILC is available with C/C++ and PL/I programs.

The following is a list of differences in ILC behavior on the AIX workstation compared to using ILC on the host with Language Environment:

- There are differences in termination behavior when a COBOL `STOP RUN`, a C exit(), or a PL/I `STOP` is used.
- There is no coordinated condition handling on the workstation. Avoid using a C longjmp() that crosses COBOL programs.
- On the host, the first program that is invoked within the process and that is enabled for Language Environment is considered to be the "main" program. On AIX, the first COBOL program invoked within the process is considered to be the main program by COBOL. This difference affects language semantics that are sensitive to the definition of the run unit (the execution unit that starts with a main program). For example, a `STOP RUN` results in the return of control to the invoker of the main program, which in a mixed-language environment might be different as stated above.

For more information about ILC, see the related concept below about preinitialization of the COBOL run-time environment.

Input and output

COBOL for AIX supports input and output for sequential, relative, and indexed files by using the STL file system and VSAM file system. Line-sequential input and output is supported by using the native byte stream file support of the platform.

Sizes and values are different for the file status *data-name* returned from the file system.

COBOL for AIX does not provide direct support for tape drives or diskette drives.

Run-time options

COBOL for AIX does not recognize the following host run-time options and treats them as not valid: `AIXBLD`, `ALL31`, `CBLPSHPOP`, `CBLQDA`, `COUNTRY`, `HEAP`, `MSGFILE`, `NATLANG`, `SIMVRD`, and `STACK`.

On the host, you can use the `STORAGE` run-time option to initialize COBOL `WORKING-STORAGE`. With COBOL for AIX, use the `WSCLEAR` compiler option.

Source code line size

A COBOL source line can contain fewer than 72 characters. A line ends on column 72 or where a new-line control character is found.

Language elements

The following table lists the language elements that are different between the host and COBOL for AIX compilers. Many host COBOL clauses and phrases are syntax checked but have no effect on the execution of the program under COBOL for AIX. These clauses and phrases should have minimal effect on existing applications that you download. COBOL for AIX recognizes and processes most host COBOL language syntax even if the language element has no functional effect.

Table 70. **Language differences between Enterprise COBOL for z/OS and COBOL for AIX**

Language element	Implementation
`ACCEPT` statement	Under COBOL for AIX, *environment-name* and the associated environment-variable value, if set, determines file identification.
`APPLY WRITE-ONLY` clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
`ASSIGN` clause	Different syntax for *assignment-name*. `ASSIGN. . .USING` *data-name* is not supported under host COBOL.
`BLOCK CONTAINS` clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
`CALL` statement	A file name as a `CALL` argument is not supported under COBOL for AIX.
`CLOSE` statement	The following phrases are syntax checked, but have no effect on the execution of the program under COBOL for AIX: `FOR REMOVAL`, `WITH NO REWIND`, and `UNIT/REEL`.
`CODE-SET` clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.

Table 70. **Language differences between Enterprise COBOL for z/OS and COBOL for AIX** *(continued)*

Language element	Implementation
DATA RECORDS clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
DISPLAY statement	Under COBOL for AIX, *environment-name* and the associated environment-variable value, if set, determines file identification.
File status *data-name-1*	Some values and meanings for file status 9*x* are different under host COBOL than under COBOL for AIX.
File status *data-name-8*	The format and values are different depending on the platform and the file system.
LABEL RECORD clause	LABEL RECORD IS *data-name*, USE. . .AFTER. . .LABEL PROCEDURE, and GO TO MORE-LABELS are syntax checked, but have no effect on the execution of the program under COBOL for AIX. These language elements are processed by the compiler; however, the user label declaratives are not called at run time.
MULTIPLE FILE TAPE	Syntax checked, but has no effect on the execution of the program under COBOL for AIX. On the AIX workstation, all files are treated as single volume files.
OPEN statement	The following phrases are syntax checked, but have no effect on the execution of the program under COBOL for AIX: REVERSED and WITH NO REWIND.
PASSWORD clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
POINTER, PROCEDURE-POINTER, and FUNCTION-POINTER data items	Under host COBOL, POINTER and FUNCTION-POINTER data items are defined as 4 bytes; a PROCEDURE-POINTER data item is defined as 8 bytes. Under COBOL for AIX, the size of these data items is 4 bytes.
READ. . .PREVIOUS	Under COBOL for AIX only, allows you to read the previous record for relative or indexed files with DYNAMIC access mode.
RECORD CONTAINS clause	The RECORD CONTAINS n CHARACTERS clause is accepted with one exception: RECORD CONTAINS 0 CHARACTERS is syntax checked, but has no effect on the execution of the program under COBOL for AIX.
RECORDING MODE clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX for relative, indexed, and line-sequential files. RECORDING MODE U is syntax checked, but has no effect on the execution of the program for sequential files.
RERUN clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
RESERVE clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
SAME AREA clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
SAME SORT clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
SORT-CONTROL special register	The contents of this special register differ between host and workstation COBOL.
SORT-CORE-SIZE special register	The contents of this special register differ between host and workstation COBOL.
SORT-FILE-SIZE special register	Syntax checked, but has no effect on the execution of the program under COBOL for AIX. Values in this special register are not used.
SORT-MESSAGE special register	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.

Table 70. **Language differences between Enterprise COBOL for z/OS and COBOL for AIX** *(continued)*

Language element	Implementation
SORT-MODE-SIZE special register	Syntax checked, but has no effect on the execution of the program under COBOL for AIX. Values in this special register are not used.
SORT MERGE AREA clause	Syntax checked, but has no effect on the execution of the program under COBOL for AIX.
START. . .	Under COBOL for AIX, the following relational operators are allowed: IS LESS THAN, IS <, IS NOT GREATER THAN, IS NOT >, IS LESS THAN OR EQUAL TO, IS <=
WRITE statement	Under COBOL for AIX, if you specify WRITE. . .ADVANCING with environment names C01 through C12 or S01 through S05, one line is advanced.
Names known to the platform environment	The following names are identified differently: *program-name*, *text-name*, *library-name*, *assignment-name*, file name in the SORT-CONTROL special register, *basis-name*, DISPLAY or ACCEPT target identification, and system-dependent names.

RELATED CONCEPTS
Chapter 29, "Preinitializing the COBOL run-time environment," on page 449

RELATED TASKS
Chapter 24, "Porting applications between platforms," on page 397
"Setting the locale" on page 106

RELATED REFERENCES
"CHAR" on page 203

Appendix B. zSeries host data type considerations

The following are considerations, restrictions, and limitations that apply to the use of zSeries host data types. The CHAR and FLOAT compiler options determine whether zSeries host data types or native data types are used.

CICS access

There is no zSeries host data type support for COBOL programs that are translated by the CICS translator and run on TXSeries.

Date and time callable services

You can use the date and time callable services with the zSeries host data types. All of the parameters passed to the callable services must be in zSeries host data type format. You cannot mix native and host data types in the same call to a date and time service.

Floating-point overflow exceptions

Due to differences in the limits of floating-point data representations on the AIX workstation and the zSeries host, it is possible if FLOAT(HEX) is in effect that a floating-point overflow exception could occur during conversion between the two formats. For example, you might get the following message on the workstation when you run a program that executes successfully on the host:

```
IWZ053S An overflow occurred on conversion to floating point
```

To avoid this problem, you must be aware of the maximum floating-point values supported on each platform for the respective data types. The limits are shown in the following table.

Table 71. **Maximum floating-point values**

Data type	Maximum workstation value	Maximum zSeries host value
COMP-1	*(2**128 - 2**4) (approx. *3.4028E+38)	*(16**63 - 16**57) (approx. *7.2370E+75)
COMP-2	*(2**1024 - 2**971) (approx. *1.7977E+308)	*(16**63 - 16**49) (approx. *7.2370E+75)
* Indicates that the value can be positive or negative.		

As shown above, the host can carry a larger COMP-1 value than the workstation and the workstation can carry a larger COMP-2 value than the host.

DB2

The zSeries host data type compiler options can be used with DB2 programs.

Object-oriented syntax for Java interoperability

The zSeries format of floating-point data items must not be specified for arguments or returning items in INVOKE statements.

© Copyright IBM Corp. 1995, 2004

Distributed Computing Environment applications

The zSeries host data type compiler options should not be used with Distributed Computing Environment programs.

File data

- EBCDIC data and hexadecimal binary data can be read from and written to any sequential, relative, or indexed files. No automatic conversion takes place.
- If you are accessing files that contain host data, use the compiler options `COLLSEQ(EBCDIC)`, `CHAR(EBCDIC)`, and `FLOAT(S390)` to process EBCDIC character data and hexadecimal floating-point data that is acquired from these files.

SORT

All of the zSeries host data types can be used as sort keys.

RELATED CONCEPTS
"Formats for numeric data" on page 34

RELATED TASKS
"Coding interoperable data types in COBOL and Java" on page 388

RELATED REFERENCES
Chapter 13, "Compiler options," on page 199

Appendix C. 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 515

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 IBM COBOL Set for AIX:

- 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.

© Copyright IBM Corp. 1995, 2004

RELATED CONCEPTS
"Formats for numeric data" on page 34
"Fixed-point versus floating-point arithmetic" on page 45

RELATED REFERENCES
"Fixed-point data and intermediate results" on page 515
"Floating-point data and intermediate results" on page 520
"Arithmetic expressions in nonarithmetic statements" on page 521
"ARITH" on page 201

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 (*COBOL for AIX 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 *ir1*.
2. Multiply B by C yielding *ir2*.
3. Divide E into D yielding *ir3*.
4. Add A to ir2 yielding *ir4*.
5. Subtract *ir3* from *ir4* yielding *ir5*.
6. Add *ir5* to *ir1* yielding Y.

RELATED CONCEPTS

"Arithmetic expressions" on page 41

RELATED REFERENCES

"Terminology used for intermediate results" on page 514

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* 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* + *dmax*	Number of places carried for *ir*
>30	<*dmax* =*dmax*	Any value	30-*d* integer and *d* decimal places
	>*dmax*	<30 =30	*i* integer and 30-*i* decimal places
		>30	30-*dmax* integer and *dmax* 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* + *dmax*	Number of places carried for *ir*
<31 =31	Any value	Any value	*i* integer and *d* decimal places
>31	<*dmax* =*dmax*	Any value	31-*d* integer and *d* decimal places
	>*dmax*	<31 =31	*i* integer and 31-*i* decimal places
		>31	31-*dmax* integer and *dmax* 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 514
"Truncated intermediate results" on page 518
"Binary data and intermediate results" on page 518
"Floating-point data and intermediate results" on page 520
"Intrinsic functions evaluated in fixed-point arithmetic" on page 518
"ARITH" on page 201
SIZE ERROR phrases (*COBOL for AIX 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 514
"Fixed-point data and intermediate results" on page 515

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 34

RELATED REFERENCES
"Fixed-point data and intermediate results" on page 515
"ARITH" on page 201

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 515
"ARITH" on page 201

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	*Inner-dmax*	**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 514
"Fixed-point data and intermediate results" on page 515
"Floating-point data and intermediate results"
"ARITH" on page 201

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 *dmax* 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 514
"ARITH" on page 201

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 45

RELATED REFERENCES

"Terminology used for intermediate results" on page 514
"Fixed-point data and intermediate results" on page 515
"Floating-point data and intermediate results" on page 520
IF statement (*COBOL for AIX Language Reference*)
EVALUATE statement (*COBOL for AIX Language Reference*)
Conditional expressions (*COBOL for AIX Language Reference*)

Appendix D. 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 525
"Preventing overlay when adding elements to a variable table" on page 525

RELATED REFERENCES

"Effects of change in ODO object value" on page 524
OCCURS DEPENDING ON clause (*COBOL for AIX 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.

© Copyright IBM Corp. 1995, 2004

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 523) 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 (*COBOL for AIX 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:

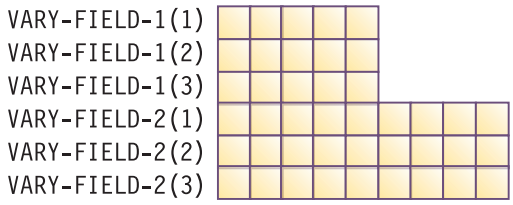
1. Save the variably located data items that follow the table in another data area.
2. Increment the value of the ODO object.
3. Move data into the new table element (if needed).

4. Restore the variably located data items from the data area where you saved them.

In the following example, suppose you want to add an element to the table VARY-FIELD-1, whose number of elements depends on the ODO object CONTROL-1. VARY-FIELD-1 is followed by the nonsubordinate variably located data item GROUP-ITEM-1, whose elements could potentially be overlaid.

```
WORKING-STORAGE SECTION.
01  VARIABLE-REC.
    05  FIELD-1                              PIC X(10).
    05  CONTROL-1                            PIC S99.
    05  CONTROL-2                            PIC S99.
    05  VARY-FIELD-1 OCCURS 1 TO 10 TIMES
          DEPENDING ON CONTROL-1             PIC X(5).
    05  GROUP-ITEM-1.
        10  VARY-FIELD-2
              OCCURS 1 TO 10 TIMES
              DEPENDING ON CONTROL-2         PIC X(9).
01  STORE-VARY-FIELD-2.
    05  GROUP-ITEM-2.
        10  VARY-FLD-2
              OCCURS 1 TO 10 TIMES
              DEPENDING ON CONTROL-2         PIC X(9).
```

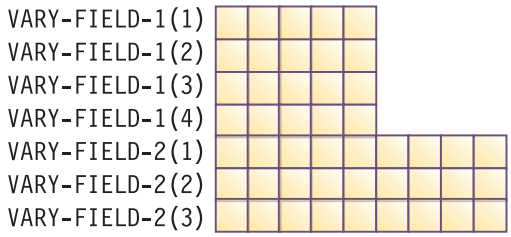
Each element of VARY-FIELD-1 has 5 bytes, and each element of VARY-FIELD-2 has 9 bytes. If CONTROL-1 and CONTROL-2 both contain the value 3, you can picture storage for VARY-FIELD-1 and VARY-FIELD-2 as follows:



To add a fourth element to VARY-FIELD-1, code as follows to prevent overlaying the first 5 bytes of VARY-FIELD-2. (GROUP-ITEM-2 serves as temporary storage for the variably located GROUP-ITEM-1.)

```
MOVE GROUP-ITEM-1 TO GROUP-ITEM-2.
ADD 1 TO CONTROL-1.
MOVE five-byte-field TO
  VARY-FIELD-1 (CONTROL-1).
MOVE GROUP-ITEM-2 TO GROUP-ITEM-1.
```

You can picture the updated storage for VARY-FIELD-1 and VARY-FIELD-2 as follows:



Note that the fourth element of VARY-FIELD-1 did not overlay the first element of VARY-FIELD-2.

Appendix E. Date and time callable services

With the date and time callable services, you can get the current local time and date in several formats and convert dates and times. Two callable services, CEEQCEN and CEESCEN, provide a predictable way to handle two-digit years, such as 91 for 1991 or 04 for 2004.

These are the available date and time callable services:

Table 72. **Date and time callable services**

Callable service	Description
CEECBLDY ("CEECBLDY—convert date to COBOL integer format" on page 531)	Converts character date value to COBOL integer date format. Day one is 01 January 1601 and the value is incremented by one for each subsequent day.
CEEDATE ("CEEDATE—convert Lilian date to character format" on page 534)	Converts dates in the Lilian format back to character values.
CEEDATM ("CEEDATM—convert seconds to character timestamp" on page 538)	Converts number of seconds to character timestamp.
CEEDAYS ("CEEDAYS—convert date to Lilian format" on page 542)	Converts character date values to the Lilian format. Day one is 15 October 1582 and the value is incremented by one for each subsequent day.
CEEDYWK ("CEEDYWK—calculate day of week from Lilian date" on page 545)	Provides day of week calculation.
CEEGMT ("CEEGMT—get current Greenwich Mean Time" on page 547)	Gets current Greenwich Mean Time (date and time).
CEEGMTO ("CEEGMTO—get offset from Greenwich Mean Time to local time" on page 549)	Gets difference between Greenwich Mean Time and local time.
CEEISEC ("CEEISEC—convert integers to seconds" on page 551)	Converts binary year, month, day, hour, second, and millisecond to a number representing the number of seconds since 00:00:00 15 October 1582.
CEELOCT ("CEELOCT—get current local date or time" on page 554)	Gets current date and time.
CEEQCEN ("CEEQCEN—query the century window" on page 556)	Queries the callable services century window.
CEESCEN ("CEESCEN—set the century window" on page 557)	Sets the callable services century window.
CEESECI ("CEESECI—convert seconds to integers" on page 559)	Converts a number representing the number of seconds since 00:00:00 15 October 1582 to seven separate binary integers representing year, month, day, hour, minute, second, and millisecond.
CEESECS ("CEESECS—convert timestamp to seconds" on page 562)	Converts character timestamps (a date and time) to the number of seconds since 00:00:00 15 October 1582.

© Copyright IBM Corp. 1995, 2004

Table 72. **Date and time callable services** *(continued)*

Callable service	Description
CEEUTC ("CEEUTC—get coordinated universal time" on page 566)	Same as CEEGMT.
IGZEDT4 ("IGZEDT4—get current date" on page 566)	Returns the current date with a four-digit year in the form YYYMMDD.

All of these date and time callable services allow source code compatibility with Enterprise COBOL for z/OS. There are, however, significant differences in the way conditions are handled.

These callable services are in addition to these date/time intrinsic functions:

Table 73. **Date and time intrinsic functions**

Intrinsic function	Description
`CURRENT-DATE`	Current date and time and difference from Greenwich mean time
`DATE-OF-INTEGER`[1]	Standard date equivalent (YYYYMMDD) of integer date
`DATE-TO-YYYYMMDD`[1]	Standard date equivalent (YYYYMMDD) of integer date with a windowed year, according to the specified 100-year interval
`DATEVAL`[1]	Date field equivalent of integer or alphanumeric date
`DAY-OF-INTEGER`[1]	Julian date equivalent (YYYYDDD) of integer date
`DAY-TO-YYYYDDD`[1]	Julian date equivalent (YYYYMMDD) of integer date with a windowed year, according to the specified 100-year interval
`INTEGER-OF-DATE`	Integer date equivalent of standard date (YYYYMMDD)
`INTEGER-OF-DAY`	Integer date equivalent of Julian date (YYYYDDD)
`UNDATE`[1]	Nondate equivalent of integer or alphanumeric date field
`YEAR-TO-YYYY`[1]	Expanded year equivalent (YYYY) of windowed year, according to the specified 100-year interval
`YEARWINDOW`[1]	Starting year of the century window specified by the `YEARWINDOW` compiler option
1. Behavior depends on the setting of the `DATEPROC` compiler option.	

"Example: formatting dates for output" on page 496

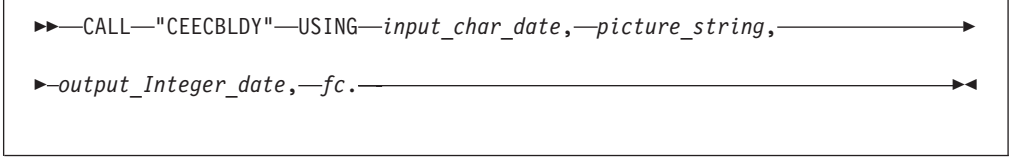
RELATED REFERENCES

CALL statement (*COBOL for AIX Language Reference*)
Function definitions (*COBOL for AIX Language Reference*)
"Feedback token" on page 497

CEECBLDY—convert date to COBOL integer format

CEECBLDY converts a string that represents a date into the number of days since 31 December 1600. This service is similar to CEEDAYS, except that it provides a string in COBOL integer format, which is compatible with COBOL intrinsic functions. Use CEECBLDY to access the century window of the date and time callable services and to perform date calculations with COBOL intrinsic functions.

CALL CEECBLDY syntax



***input_char_date* (input)**

A halfword length-prefixed character string, representing a date or timestamp, in a format conforming to that specified by *picture_string*.

The character string must contain between 5 and 255 characters, inclusive. *input_char_date* can contain leading or trailing blanks. Parsing for a date begins with the first nonblank character (unless the picture string itself contains leading blanks, in which case CEECBLDY skips exactly that many positions before parsing begins).

After parsing a valid date, as determined by the format of the date specified in *picture_string*, CEECBLDY ignores all remaining characters. Valid dates range between and include 01 January 1601 to 31 December 9999.

***picture_string* (input)**

A halfword length-prefixed character string, indicating the format of the date specified in *input_char_date*.

Each character in the *picture_string* corresponds to a character in *input_char_date*. For example, if you specify MMDDYY as the *picture_string*, CEECBLDY reads an *input_char_date* of 060288 as 02 June 1988.

If delimiters such as the slash (/) appear in the picture string, you can omit leading zeros. For example, the following calls to CEECBLDY:

```
MOVE '6/2/88' TO DATEVAL-STRING.
MOVE 6 TO DATEVAL-LENGTH.
MOVE 'MM/DD/YY' TO PICSTR-STRING.
MOVE 8 TO PICSTR-LENGTH.
CALL CEECBLDY USING DATEVAL, PICSTR, COBINTDTE, FC.

MOVE '06/02/88' TO DATEVAL-STRING.
MOVE 8 TO DATEVAL-LENGTH.
MOVE 'MM/DD/YY' TO PICSTR-STRING.
MOVE 8 TO PICSTR-LENGTH.
CALL CEECBLDY USING DATEVAL, PICSTR, COBINTDTE, FC.

MOVE '060288' TO DATEVAL-STRING.
MOVE 6 TO DATEVAL-LENGTH.
MOVE 'MMDDYY' TO PICSTR-STRING.
MOVE 6 TO PICSTR-LENGTH.
CALL CEECBLDY USING DATEVAL, PICSTR, COBINTDTE, FC.
```

```
MOVE '88154' TO DATEVAL-STRING.
MOVE 5 TO DATEVAL-LENGTH.
MOVE 'YYDDD' TO PICSTR-STRING.
MOVE 5 TO PICSTR-LENGTH.
CALL CEECBLDY USING DATEVAL, PICSTR, COBINTDTE, FC.
```

would each assign the same value, 141502 (02 June 1988), to COBINTDTE.

Whenever characters such as colons or slashes are included in the *picture_string* (such as HH:MI:SS YY/MM/DD), they count as placeholders but are otherwise ignored.

If *picture_string* includes a Japanese Era symbol <JJJJ>, the YY position in *input_char_date* is replaced by the year number within the Japanese Era. For example, the year 1988 equals the Japanese year 63 in the Showa era.

***output_Integer_date* (output)**

A 32-bit binary integer representing the COBOL integer date, the number of days since 31 December 1600. For example, 16 May 1988 is day number 141485.

If *input_char_date* does not contain a valid date, *output_Integer_date* is set to 0 and CEECBLDY terminates with a non-CEE000 symbolic feedback code.

Date calculations are performed easily on the *output_Integer_date*, because *output_Integer_date* is an integer. Leap year and end-of-year anomalies do not affect the calculations.

***fc* (output)**

A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 74. **CEECBLDY symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2EB	3	2507	Insufficient data was passed to CEEDAYS or CEESECS. The Lilian value was not calculated.
CEE2EC	3	2508	The date value passed to CEEDAYS or CEESECS was invalid.
CEE2ED	3	2509	The era passed to CEEDAYS or CEESECS was not recognized.
CEE2EH	3	2513	The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was not within the supported range.
CEE2EL	3	2517	The month value in a CEEISEC call was not recognized.
CEE2EM	3	2518	An invalid picture string was specified in a call to a date/time service.
CEE2EO	3	2520	CEEDAYS detected nonnumeric data in a numeric field, or the date string did not match the picture string.
CEE2EP	3	2521	The <JJJJ>, <CCCC>, or <CCCCCCCC> year-within-era value passed to CEEDAYS or CEESECS was zero.

Usage notes

- Call CEECBLDY only from COBOL programs that use the returned value as input to COBOL intrinsic functions. You should not use the returned value with other date and time callable services, nor should you call CEECBLDY from any non-COBOL programs. Unlike CEEDAYS, there is no inverse function of CEECBLDY, because it is only for COBOL users who want to use the date and time century window service together with COBOL intrinsic functions for date calculations. The inverse function of CEECBLDY is provided by the DATE-OF-INTEGER and DAY-OF-INTEGER intrinsic functions.
- To perform calculations on dates earlier than 1 January 1601, add 4000 to the year in each date, convert the dates to COBOL integer format, then do the calculation. If the result of the calculation is a date, as opposed to a number of days, convert the result to a date string and subtract 4000 from the year.
- By default, two-digit years lie within the 100-year range starting 80 years prior to the system date. Thus in 2004, all two-digit years represent dates between 1924 and 2023, inclusive. You can change this default range by using the CEESCEN callable service.

Example

```
CBL LIB
      ************************************************
      **                                            **
      ** Function: Invoke CEECBLDY callable service  **
      ** to convert date to COBOL integer format.    **
      ** This service is used when using the         **
      ** Century Window feature of the date and time **
      ** callable services mixed with COBOL          **
      ** intrinsic functions.                        **
      **                                            **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLDY.
      *
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  CHRDATE.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char    PIC X
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of CHRDATE.
       01  PICSTR.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char    PIC X
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of  PICSTR.
       01  INTEGER                 PIC S9(9) BINARY.
       01  NEWDATE                 PIC 9(8).
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                       REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
```

```
         03  Facility-ID     PIC XXX.
     02  I-S-Info            PIC S9(9) COMP.
*
 PROCEDURE DIVISION.
 PARA-CBLDAYS.
************************************************
** Specify input date and length              **
************************************************
     MOVE 25 TO Vstring-length of CHRDATE.
     MOVE '1 January 00'
         to Vstring-text of CHRDATE.
************************************************
** Specify a picture string that describes    **
** input date, and set the string's length.   **
************************************************
     MOVE 23 TO Vstring-length of PICSTR.
     MOVE 'ZD Mmmmmmmmmmmmmz YY'
               TO Vstring-text of PICSTR.
************************************************
** Call CEECBLDY to convert input date to a   **
** COBOL integer date                         **
************************************************
     CALL 'CEECBLDY' USING CHRDATE, PICSTR,
                           INTEGER, FC.
************************************************
** If CEECBLDY runs successfully, then compute **
**     the date of the 90th day after the     **
**     input date using Intrinsic Functions   **
************************************************
     IF CEE000 of FC  THEN
         COMPUTE INTEGER = INTEGER + 90
         COMPUTE NEWDATE = FUNCTION
             DATE-OF-INTEGER (INTEGER)
         DISPLAY NEWDATE
             ' is Lilian day: ' INTEGER
     ELSE
         DISPLAY 'CEEBLDY failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.
*
     GOBACK.
```

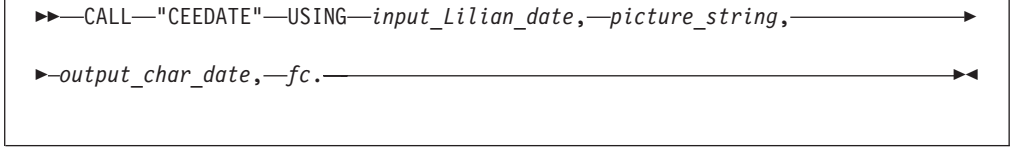
RELATED REFERENCES

"Picture character terms and strings" on page 498

CEEDATE—convert Lilian date to character format

CEEDATE converts a number representing a Lilian date to a date written in character format. The output is a character string, such as 2004/04/23.

CALL CEEDATE syntax



***input_Lilian_date* (input)**

A 32-bit integer representing the Lilian date. The Lilian date is the number

of days since 14 October 1582. For example, 16 May 1988 is Lilian day number 148138. The valid range of Lilian dates is 1 to 3,074,324 (15 October 1582 to 31 December 9999).

***picture_string* (input)**
A halfword length-prefixed character string, representing the desired format of *output_char_date*, for example `MM/DD/YY`. Each character in *picture_string* represents a character in *output_char_date*. If delimiters such as the slash (/) appear in the picture string, they are copied as is to *output_char_date*.

If *picture_string* includes a Japanese Era symbol `<JJJJ>`, the `YY` position in *output_char_date* is replaced by the year number within the Japanese Era. For example, the year 1988 equals the Japanese year 63 in the Showa era.

***output_char_date* (output)**
A fixed-length 80-character string that is the result of converting *input_Lilian_date* to the format specified by *picture_string*. If *input_Lilian_date* is invalid, *output_char_date* is set to all blanks and CEEDATE terminates with a non-CEE000 symbolic feedback code.

***fc* (output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 75. **CEEDATE symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2EG	3	2512	The Lilian date value passed in a call to CEEDATE or CEEDYWK was not within the supported range.
CEE2EM	3	2518	An invalid picture string was specified in a call to a date/time service.
CEE2EQ	3	2522	An era (<JJJJ>, <CCCC>, or <CCCCCCCC>) was used in a picture string passed to CEEDATE, but the Lilian date value was not within the supported range. The era could not be determined.
CEE2EU	2	2526	The date string returned by CEEDATE was truncated.
CEE2F6	1	2534	Insufficient field width was specified for a month or weekday name in a call to CEEDATE or CEEDATM. Output set to blanks.

Usage notes

- The inverse of CEEDATE is CEEDAYS, which converts character dates to the Lilian format.

Example

```
CBL LIB
      ************************************************
      **                                            **
      ** Function: CEEDATE - convert Lilian date to **
      **                     character format       **
      **                                            **
      ** In this example, a call is made to CEEDATE **
```

```
** to convert a Lilian date (the number of    **
** days since 14 October 1582) to a character **
** format (such as 6/22/98). The result is    **
** displayed.  The Lilian date is obtained    **
** via a call to CEEDAYS.                     **
**                                            **
************************************************
 IDENTIFICATION DIVISION.
 PROGRAM-ID. CBLDATE.
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01  LILIAN                  PIC S9(9) BINARY.
 01  CHRDATE                 PIC X(80).
 01  IN-DATE.
     02  Vstring-length      PIC S9(4) BINARY.
     02  Vstring-text.
         03  Vstring-char    PIC X
                     OCCURS 0 TO 256 TIMES
                     DEPENDING ON Vstring-length
                         of IN-DATE.
 01  PICSTR.
     02  Vstring-length      PIC S9(4) BINARY.
     02  Vstring-text.
         03  Vstring-char    PIC X
                     OCCURS 0 TO 256 TIMES
                     DEPENDING ON Vstring-length
                        of PICSTR.
 01  FC.
     02  Condition-Token-Value.
     COPY  CEEIGZCT.
         03  Case-1-Condition-ID.
             04  Severity    PIC S9(4) COMP.
             04  Msg-No      PIC S9(4) COMP.
         03  Case-2-Condition-ID
                   REDEFINES Case-1-Condition-ID.
             04  Class-Code  PIC S9(4) COMP.
             04  Cause-Code  PIC S9(4) COMP.
         03  Case-Sev-Ctl    PIC X.
         03  Facility-ID     PIC XXX.
     02  I-S-Info            PIC S9(9) COMP.
*
 PROCEDURE DIVISION.
 PARA-CBLDAYS.
************************************************
** Call CEEDAYS to convert date of 6/2/98 to   **
**     Lilian representation                    **
************************************************
     MOVE 6 TO Vstring-length of IN-DATE.
     MOVE '6/2/98' TO Vstring-text of IN-DATE(1:6).
     MOVE 8 TO Vstring-length of PICSTR.
     MOVE 'MM/DD/YY' TO Vstring-text of PICSTR(1:8).
     CALL 'CEEDAYS' USING IN-DATE, PICSTR,
                          LILIAN, FC.

************************************************
** If CEEDAYS runs successfully, display result**
************************************************
     IF  CEE000 of FC  THEN
         DISPLAY Vstring-text of IN-DATE
             ' is Lilian day: ' LILIAN
     ELSE
         DISPLAY 'CEEDAYS failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

************************************************
```

```
** Specify picture string that describes the   **
**  desired format of the output from CEEDATE, **
**  and the picture string's length.           **
************************************************
     MOVE 23 TO Vstring-length OF PICSTR.
     MOVE 'ZD Mmmmmmmmmmmmmz YYYY' TO
                 Vstring-text OF PICSTR(1:23).

************************************************
** Call CEEDATE to convert the Lilian date     **
**     to  a picture string.                    **
************************************************
     CALL 'CEEDATE' USING LILIAN, PICSTR,
                          CHRDATE, FC.

************************************************
** If CEEDATE runs successfully, display result**
************************************************
     IF CEE000 of FC  THEN
         DISPLAY 'Input Lilian date of ' LILIAN
             ' corresponds to:  ' CHRDATE
     ELSE
         DISPLAY 'CEEDATE failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

The table shows the sample output from CEEDATE.

input_Lilian_date	picture_string	output_char_date
148138	YY YYMM YY-MM YYMMDD YYYYMMDD YYYY-MM-DD YYYY-ZM-ZD <JJJJ> YY.MM.DD	98 9805 98-05 980516 19980516 1998-05-16 1998-5-16 *Showa* 63.05.16 (in a DBCS string)
148139	MM MMDD MM/DD MMDDYY MM/DD/YYYY ZM/DD/YYYY	05 0517 05/17 051798 05/17/1998 5/17/1998
148140	DD DDMM DDMMYY DD.MM.YY DD.MM.YYYY DD Mmm YYYY	18 1805 180598 18.05.98 18.05.1998 18 May 1998
148141	DDD YYDDD YY.DDD YYYY.DDD	140 98140 98.140 1998.140
148142	YY/MM/DD HH:MI:SS.99 YYYY/ZM/ZD ZH:MI AP	98/05/20 00:00:00.00 1998/5/20 0:00 AM

input_Lilian_date	picture_string	output_char_date

148143	`WWW., MMM DD, YYYY`
	`Www., Mmm DD, YYYY`
	
	`Wwwwwwwwww,`
	`Mmmmmmmmm DD, YYYY`
	
	`Wwwwwwwwwz,`
	`Mmmmmmmmmz DD, YYYY`
		SAT., MAY 21, 1998
		Sat., May 21, 1998
		
		Saturday,
		May 21, 1998
		
		Saturday,
		May 21, 1998

"Example: date-and-time picture strings" on page 500

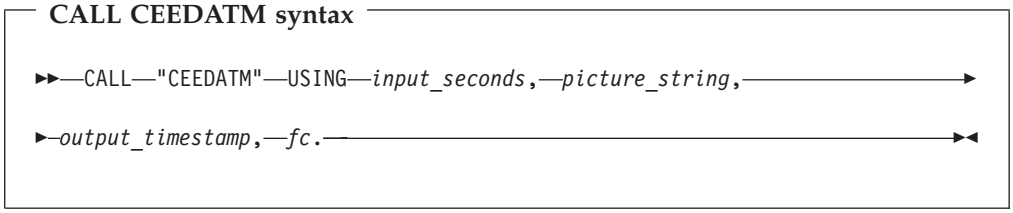
RELATED REFERENCES

"Picture character terms and strings" on page 498

CEEDATM—convert seconds to character timestamp

CEEDATM converts a number representing the number of seconds since 00:00:00 14 October 1582 to a character string format. The format of the output is a character string timestamp, such as `1988/07/26 20:37:00`.

CALL CEEDATM syntax



***input_seconds* (input)**

A 64-bit long floating-point number representing the number of seconds since 00:00:00 on 14 October 1582, not counting leap seconds.

For example, 00:00:01 on 15 October 1582 is second number 86,401 (24*60*60 + 01). The valid range of *input_seconds* is 86,400 to 265,621,679,999.999 (23:59:59.999 31 December 9999).

***picture_string* (input)**

A halfword length-prefixed character string, representing the desired format of *output_timestamp*, for example, `MM/DD/YY HH:MI AP`.

Each character in the *picture_string* represents a character in *output_timestamp*. If delimiters such as a slash (/) appear in the picture string, they are copied as is to *output_timestamp*.

If *picture_string* includes the Japanese Era symbol `<JJJJ>`, the `YY` position in *output_timestamp* represents the year within Japanese Era.

***output_timestamp* (output)**

A fixed-length 80-character string that is the result of converting *input_seconds* to the format specified by *picture_string*.

If necessary, the output is truncated to the length of *output_timestamp*.

If *input_seconds* is invalid, *output_timestamp* is set to all blanks and CEEDATM terminates with a non-CEE000 symbolic feedback code.

***fc* (output)**

A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 76. **CEEDATM symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2E9	3	2505	The input_seconds value in a call to CEEDATM or CEESECI was not within the supported range.
CEE2EA	3	2506	An era (<JJJJ>, <CCCC>, or <CCCCCCCC>) was used in a picture string passed to CEEDATM, but the input number-of-seconds value was not within the supported range. The era could not be determined.
CEE2EM	3	2518	An invalid picture string was specified in a call to a date or time service.
CEE2EV	2	2527	The timestamp string returned by CEEDATM was truncated.
CEE2F6	1	2534	Insufficient field width was specified for a month or weekday name in a call to CEEDATE or CEEDATM. Output set to blanks.

Usage notes: The inverse of CEEDATM is CEESECS, which converts a timestamp to number of seconds.

Example

```
CBL LIB
      ************************************************
      **                                            **
      ** Function: CEEDATM - convert seconds to     **
      **                     character timestamp    **
      **                                            **
      ** In this example, a call is made to CEEDATM **
      ** to convert a date represented in Lilian    **
      ** seconds (the number of seconds since       **
      ** 00:00:00 14 October 1582) to a character   **
      ** format (such as 06/02/88 10:23:45). The    **
      ** result is displayed.                       **
      **                                            **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLDATM.
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  DEST          PIC S9(9) BINARY VALUE 2.
       01  SECONDS                 COMP-2.
       01  IN-DATE.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char    PIC X
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of IN-DATE.
       01  PICSTR.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char    PIC X
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
```

```
                        of PICSTR.
 01  TIMESTP                 PIC X(80).
 01  FC.
     02  Condition-Token-Value.
     COPY  CEEIGZCT.
         03  Case-1-Condition-ID.
             04  Severity    PIC S9(4) COMP.
             04  Msg-No      PIC S9(4) COMP.
         03  Case-2-Condition-ID
                   REDEFINES Case-1-Condition-ID.
             04  Class-Code  PIC S9(4) COMP.
             04  Cause-Code  PIC S9(4) COMP.
         03  Case-Sev-Ctl    PIC X.
         03  Facility-ID     PIC XXX.
     02  I-S-Info            PIC S9(9) COMP.
*
 PROCEDURE DIVISION.
 PARA-CBLDATM.
************************************************
** Call CEESECS to convert timestamp of 6/2/88 **
**     at 10:23:45 AM to Lilian representation **
************************************************
     MOVE 20 TO Vstring-length of IN-DATE.
     MOVE '06/02/88 10:23:45 AM'
         TO Vstring-text of IN-DATE.
     MOVE 20 TO Vstring-length of PICSTR.
     MOVE 'MM/DD/YY HH:MI:SS AP'
         TO Vstring-text of PICSTR.
     CALL 'CEESECS' USING IN-DATE, PICSTR,
                          SECONDS, FC.

************************************************
** If CEESECS runs successfully, display result**
************************************************
     IF  CEE000 of FC  THEN
         DISPLAY Vstring-text of IN-DATE
             ' is Lilian second:  ' SECONDS
     ELSE
         DISPLAY 'CEESECS failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

************************************************
** Specify desired format of the output.       **
************************************************
     MOVE 35 TO Vstring-length OF PICSTR.
     MOVE 'ZD Mmmmmmmmmmmmmmz YYYY at HH:MI:SS'
             TO Vstring-text OF PICSTR.

************************************************
** Call CEEDATM to convert Lilian seconds to   **
**     a character timestamp                    **
************************************************
     CALL 'CEEDATM' USING SECONDS, PICSTR,
                          TIMESTP, FC.

************************************************
** If CEEDATM runs successfully, display result**
************************************************
     IF CEE000 of FC  THEN
         DISPLAY 'Input seconds of ' SECONDS
             ' corresponds to: ' TIMESTP
     ELSE
         DISPLAY 'CEEDATM failed with msg '
             Msg-No of FC UPON CONSOLE
```

```
    STOP RUN
END-IF.

GOBACK.
```

The table shows the sample output of CEEDATM.

input_seconds	picture_string	output_timestamp
12,799,191,601.000	YYMMDD HH:MI:SS YY-MM-DD YYMMDDHHMISS YY-MM-DD HH:MI:SS YYYY-MM-DD HH:MI:SS AP	880516 19:00:01 88-05-16 880516190001 88-05-16 19:00:01 1988-05-16 07:00:01 PM
12,799,191,661.986	DD Mmm YY DD MMM YY HH:MM WWW, MMM DD, YYYY ZH:MI AP Wwwwwwwwwz, ZM/ZD/YY HH:MI:SS.99	16 May 88 16 MAY 88 19:01 MON, MAY 16, 1988 7:01 PM Monday, 5/16/88 19:01:01.98
12,799,191,662.009	YYYY YY Y MM ZM RRRR MMM Mmm Mmmmmmmmm Mmmmmmmmmz DD ZD DDD HH ZH MI SS 99 999 AP WWW Www Wwwwwwwwww Wwwwwwwwwz	1988 88 8 05 5 V MAY May May May 16 16 137 19 19 01 02 00 009 PM MON Mon Monday Monday

"Example: date-and-time picture strings" on page 500

RELATED REFERENCES

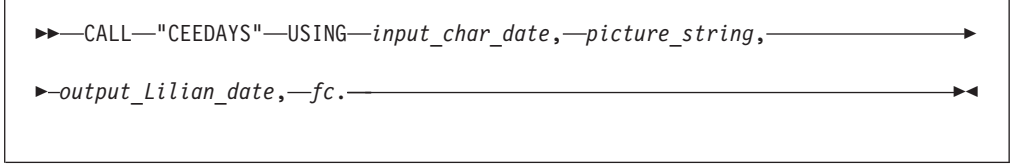
"Picture character terms and strings" on page 498

CEEDAYS—convert date to Lilian format

CEEDAYS converts a string representing a date into a Lilian format, which represents a date as the number of days from the beginning of the Gregorian calendar. CEEDAYS converts the specified *input_char_date* to a number representing the number of days since day zero in the Lilian format: Friday, 14 October, 1582.

Do not use CEEDAYS in combination with COBOL intrinsic functions. Use CEECBLDY for programs that use intrinsic functions.

CALL CEEDAYS syntax



***input_char_date* (input)**

A halfword length-prefixed character string, representing a date or timestamp, in a format conforming to that specified by *picture_string*.

The character string must contain between 5 and 255 characters, inclusive. *input_char_date* can contain leading or trailing blanks. Parsing for a date begins with the first nonblank character (unless the picture string itself contains leading blanks, in which case CEEDAYS skips exactly that many positions before parsing begins).

After parsing a valid date, as determined by the format of the date specified in *picture_string*, CEEDAYS ignores all remaining characters. Valid dates range between and include 15 October 1582 to 31 December 9999.

***picture_string* (input)**

A halfword length-prefixed character string, indicating the format of the date specified in *input_char_date*.

Each character in the *picture_string* corresponds to a character in *input_char_date*. For example, if you specify MMDDYY as the *picture_string*, CEEDAYS reads an *input_char_date* of 060288 as 02 June 1988.

If delimiters such as a slash (/) appear in the picture string, leading zeros can be omitted. For example, the following calls to CEEDAYS:

```
CALL CEEDAYS USING '6/2/88'  , 'MM/DD/YY', lildate, fc.
CALL CEEDAYS USING '06/02/88', 'MM/DD/YY', lildate, fc.
CALL CEEDAYS USING '060288'  , 'MMDDYY'  , lildate, fc.
CALL CEEDAYS USING '88154'   , 'YYDDD'   , lildate, fc.
```

would each assign the same value, 148155 (02 June 1988), to *lildate*.

Whenever characters such as colons or slashes are included in the *picture_string* (such as `HH:MI:SS YY/MM/DD`), they count as placeholders but are otherwise ignored.

If *picture_string* includes a Japanese Era symbol `<JJJJ>`, the `YY` position in *input_char_date* is replaced by the year number within the Japanese Era. For example, the year 1988 equals the Japanese year 63 in the Showa era.

output_Lilian_date **(output)**

A 32-bit binary integer representing the Lilian date, the number of days since 14 October 1582. For example, 16 May 1988 is day number 148138.

If *input_char_date* does not contain a valid date, *output_Lilian_date* is set to 0 and CEEDAYS terminates with a non-CEE000 symbolic feedback code.

Date calculations are performed easily on the *output_Lilian_date*, because it is an integer. Leap year and end-of-year anomalies do not affect the calculations.

fc **(output)**

A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 77. **CEEDAYS symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2EB	3	2507	Insufficient data was passed to CEEDAYS or CEESECS. The Lilian value was not calculated.
CEE2EC	3	2508	The date value passed to CEEDAYS or CEESECS was invalid.
CEE2ED	3	2509	The era passed to CEEDAYS or CEESECS was not recognized.
CEE2EH	3	2513	The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was not within the supported range.
CEE2EL	3	2517	The month value in a CEEISEC call was not recognized.
CEE2EM	3	2518	An invalid picture string was specified in a call to a date/time service.
CEE2EO	3	2520	CEEDAYS detected nonnumeric data in a numeric field, or the date string did not match the picture string.
CEE2EP	3	2521	The <JJJJ>, <CCCC>, or <CCCCCCCC> year-within-era value passed to CEEDAYS or CEESECS was zero.

Usage notes

- The inverse of CEEDAYS is CEEDATE, which converts *output_Lilian_date* from Lilian format to character format.
- To perform calculations on dates earlier than 15 October 1582, add 4000 to the year in each date, convert the dates to Lilian, then do the calculation. If the result of the calculation is a date, as opposed to a number of days, convert the result to a date string and subtract 4000 from the year.
- By default, two-digit years lie within the 100-year range starting 80 years prior to the system date. Thus in 2004, all two-digit years represent dates between 1924 and 2023, inclusive. You can change the default range by using the callable service CEESCEN.
- You can easily perform date calculations on the *output_Lilian_date*, because it is an integer. Leap-year and end-of-year anomalies are avoided.

Example

```
CBL LIB
      ******************************************
      **                                      **
      ** Function: CEEDAYS - convert date to  **
      **                     Lilian format    **
      **                                      **
      ******************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLDAYS.
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  CHRDATE.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char    PIC X
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of CHRDATE.
       01  PICSTR.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char    PIC X
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of PICSTR.
       01  LILIAN                  PIC S9(9) BINARY.
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                         REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
               03  Facility-ID     PIC XXX.
           02  I-S-Info            PIC S9(9) COMP.
      *
       PROCEDURE DIVISION.
       PARA-CBLDAYS.
      ************************************************
      ** Specify input date and length              **
      ************************************************
           MOVE 16 TO Vstring-length of CHRDATE.
           MOVE '1 January 2004'
               TO Vstring-text of CHRDATE.

      ************************************************
      ** Specify a picture string that describes    **
      ** input date, and the picture string's length.**
      ************************************************
           MOVE 25 TO Vstring-length of PICSTR.
           MOVE 'ZD Mmmmmmmmmmmmmz YYYY'
                   TO Vstring-text of PICSTR.

      ************************************************
      ** Call CEEDAYS to convert input date to a    **
      ** Lilian date                                **
      ************************************************
           CALL 'CEEDAYS' USING CHRDATE, PICSTR,
                                LILIAN, FC.

      ************************************************
      ** If CEEDAYS runs successfully, display result**
```

```
*********************************************
     IF  CEE000 of FC  THEN
         DISPLAY Vstring-text of CHRDATE
             ' is Lilian day: ' LILIAN
     ELSE
         DISPLAY 'CEEDAYS failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

"Example: date-and-time picture strings" on page 500

RELATED REFERENCES

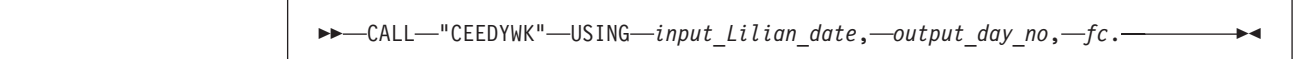
"Picture character terms and strings" on page 498

CEEDYWK—calculate day of week from Lilian date

CEEDYWK calculates the day of the week on which a Lilian date falls. The day of the week is returned to the calling routine as a number between 1 and 7.

The number returned by CEEDYWK is useful for end-of-week calculations.

CALL CEEDYWK syntax



***input_Lilian_date* (input)**

A 32-bit binary integer representing the Lilian date, the number of days since 14 October 1582.

For example, 16 May 1988 is day number 148138. The valid range of *input_Lilian_date* is between 1 and 3,074,324 (15 October 1582 and 31 December 9999).

***output_day_no* (output)**

A 32-bit binary integer representing *input_Lilian_date*'s day-of-week: 1 equals Sunday, 2 equals Monday, . . ., 7 equals Saturday.

If *input_Lilian_date* is invalid, *output_day_no* is set to 0 and CEEDYWK terminates with a non-CEE000 symbolic feedback code.

***fc* (output)**

A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 78. **CEEDYWK symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2EG	3	2512	The Lilian date value passed in a call to CEEDATE or CEEDYWK was not within the supported range.

Example

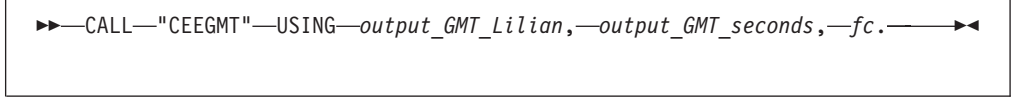
```
CBL LIB
      ***********************************************
      **                                           **
      ** Function: Call CEEDYWK to calculate the   **
      **           day of the week from Lilian date **
      **                                           **
      ** In this example, a call is made to CEEDYWK **
      ** to return the day of the week on which a  **
      ** Lilian date falls. (A Lilian date is the  **
      ** number of days since 14 October 1582)     **
      **                                           **
      ***********************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLDYWK.
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  LILIAN                  PIC S9(9) BINARY.
       01  DAYNUM                  PIC S9(9) BINARY.
       01  IN-DATE.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char        PIC X,
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of IN-DATE.
       01  PICSTR.
           02  Vstring-length      PIC S9(4) BINARY.
           02  Vstring-text.
               03  Vstring-char        PIC X,
                           OCCURS 0 TO 256 TIMES
                           DEPENDING ON Vstring-length
                               of PICSTR.
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                         REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
               03  Facility-ID     PIC XXX.
           02  I-S-Info            PIC S9(9) COMP.

       PROCEDURE DIVISION.
       PARA-CBLDAYS.
      ** Call CEEDAYS to convert date of 6/2/88 to
      **     Lilian representation
            MOVE 6 TO Vstring-length of IN-DATE.
            MOVE '6/2/88' TO Vstring-text of IN-DATE(1:6).
            MOVE 8 TO Vstring-length of PICSTR.
            MOVE 'MM/DD/YY' TO Vstring-text of PICSTR(1:8).
            CALL 'CEEDAYS' USING IN-DATE, PICSTR,
                LILIAN, FC.

      ** If CEEDAYS runs successfully, display result.
            IF  CEE000 of FC  THEN
                DISPLAY Vstring-text of IN-DATE
                    ' is Lilian day: ' LILIAN
            ELSE
                DISPLAY 'CEEDAYS failed with msg '
                    Msg-No of FC UPON CONSOLE
                STOP RUN
            END-IF.
```

```
 PARA-CBLDYWK.

** Call CEEDYWK to return the day of the week on
** which the Lilian date falls
     CALL 'CEEDYWK' USING LILIAN , DAYNUM , FC.

** If CEEDYWK runs successfully, print results
     IF CEE000 of FC  THEN
         DISPLAY 'Lilian day ' LILIAN
             ' falls on day ' DAYNUM
             ' of the week, which is a:'
** Select DAYNUM to display the name of the day
**     of the week.
           EVALUATE DAYNUM
             WHEN 1
               DISPLAY 'Sunday.'
             WHEN 2
               DISPLAY 'Monday.'
             WHEN 3
               DISPLAY 'Tuesday'
             WHEN 4
               DISPLAY 'Wednesday.'
             WHEN 5
               DISPLAY 'Thursday.'
             WHEN 6
               DISPLAY 'Friday.'
             WHEN 7
               DISPLAY 'Saturday.'
           END-EVALUATE
     ELSE
         DISPLAY 'CEEDYWK failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

CEEGMT—get current Greenwich Mean Time

CEEGMT returns the current Greenwich Mean Time (GMT) as both a Lilian date and as the number of seconds since 00:00:00 14 October 1582. GMT is also known as Coordinated Universal Time (UTC). The returned values are compatible with those generated and used by the other date and time callable services.

CALL CEEGMT syntax



***output_GMT_Lilian* (output)**

A 32-bit binary integer representing the current date in Greenwich, England, in the Lilian format (the number of days since 14 October 1582).

For example, 16 May 1988 is day number 148138. If GMT is not available from the system, *output_GMT_Lilian* is set to 0 and CEEGMT terminates with a non-CEE000 symbolic feedback code.

***output_GMT_seconds* (output)**

A 64-bit long floating-point number representing the current date and time in Greenwich, England, as the number of seconds since 00:00:00 on 14 October 1582, not counting leap seconds.

For example, 00:00:01 on 15 October 1582 is second number 86,401 (24*60*60 + 01). 19:00:01.078 on 16 May 1988 is second number 12,799,191,601.078. If GMT is not available from the system, *output_GMT_seconds* is set to 0 and CEEGMT terminates with a non-CEE000 symbolic feedback code.

***fc* (output)**

A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 79. **CEEGMT symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2E6	3	2502	The UTC/GMT was not available from the system.

Usage notes

- CEEDATE converts *output_GMT_Lilian* to a character date, and CEEDATM converts *output_GMT_seconds* to a character timestamp.
- In order for the results of this service to be meaningful, your system's clock must be set to the local time and the environment variable TZ must be set correctly.
- The values returned by CEEGMT are handy for elapsed time calculations. For example, you can calculate the time elapsed between two calls to CEEGMT by calculating the differences between the returned values.
- CEEUTC is identical to this service.

Example

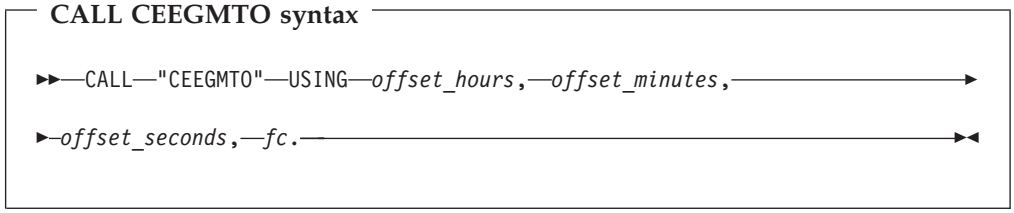
```
CBL LIB
      ************************************************
      **                                            **
      ** Function: Call CEEGMT to get current       **
      **           Greenwich Mean Time              **
      **                                            **
      ** In this example, a call is made to CEEGMT   **
      ** to return the current GMT as a Lilian date  **
      ** and as Lilian seconds. The results are      **
      ** displayed.                                 **
      **                                            **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. IGZTGMT.
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  LILIAN                 PIC S9(9) BINARY.
       01  SECS                   COMP-2.
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                         REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
```

```
        03  Facility-ID     PIC XXX.
    02  I-S-Info            PIC S9(9) COMP.
PROCEDURE DIVISION.
PARA-CBLGMT.
    CALL 'CEEGMT' USING LILIAN , SECS , FC.

    IF CEE000 of FC  THEN
        DISPLAY 'The current GMT is also '
            'known as Lilian day: ' LILIAN
        DISPLAY 'The current GMT in Lilian '
            'seconds is: ' SECS
    ELSE
        DISPLAY 'CEEGMT failed with msg '
            Msg-No of FC UPON CONSOLE
        STOP RUN
    END-IF.

    GOBACK.
```

CEEGMTO—get offset from Greenwich Mean Time to local time

CEEGMTO returns values to the calling routine representing the difference between the local system time and Greenwich Mean Time (GMT).

CALL CEEGMTO syntax



***offset_hours* (output)**

A 32-bit binary integer representing the offset from GMT to local time, in hours.

For example, for Pacific Standard Time, *offset_hours* equals -8.

The range of *offset_hours* is -12 to +13 (+13 = Daylight Savings Time in the +12 time zone).

If local time offset is not available, *offset_hours* equals 0 and CEEGMTO terminates with a non-CEE000 symbolic feedback code.

***offset_minutes* (output)**

A 32-bit binary integer representing the number of additional minutes that local time is ahead of or behind GMT.

The range of *offset_minutes* is 0 to 59.

If the local time offset is not available, *offset_minutes* equals 0 and CEEGMTO terminates with a non-CEE000 symbolic feedback code.

***offset_seconds* (output)**

A 64-bit long floating-point number representing the offset from GMT to local time, in seconds.

For example, Pacific Standard Time is eight hours behind GMT. If local time is in the Pacific time zone during standard time, CEEGMTO would return -28,800 (-8 * 60 * 60). The range of *offset_seconds* is -43,200 to +46,800. *offset_seconds* can be used with CEEGMT to calculate local date and time.

If the local time offset is not available from the system, *offset_seconds* is set to 0 and CEEGMTO terminates with a non-CEE000 symbolic feedback code.

***fc* (output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 80. **CEEGMTO symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2E7	3	2503	The offset from UTC/GMT to local time was not available from the system.

Usage notes

- CEEDATM is used to convert *offset_seconds* to a character timestamp.
- In order for the results of this service to be meaningful, your system's clock must be set to the local time and the environment variable TZ must be set correctly.

Example

```
CBL LIB
      ************************************************
      **                                            **
      ** Function:  Call CEEGMTO to get offset from  **
      **            Greenwich Mean Time to local     **
      **            time                             **
      **                                             **
      ** In this example, a call is made to CEEGMTO  **
      ** to return the offset from GMT to local time **
      ** as separate binary integers representing    **
      ** offset hours, minutes, and seconds. The     **
      ** results are displayed.                      **
      **                                             **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. IGZTGMTO.

       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  HOURS                   PIC S9(9) BINARY.
       01  MINUTES                 PIC S9(9) BINARY.
       01  SECONDS COMP-2.
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                         REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
               03  Facility-ID     PIC XXX.
           02  I-S-Info            PIC S9(9) COMP.
       PROCEDURE DIVISION.
       PARA-CBLGMTO.
```

```
CALL 'CEEGMTO' USING HOURS , MINUTES ,
    SECONDS , FC.

IF CEE000 of FC  THEN
    DISPLAY 'Local time differs from GMT '
        'by: ' HOURS ' hours, '
        MINUTES ' minutes, OR  '
        SECONDS ' seconds. '
ELSE
    DISPLAY 'CEEGMTO failed with msg '
        Msg-No of FC UPON CONSOLE
    STOP RUN
END-IF.

GOBACK.
```

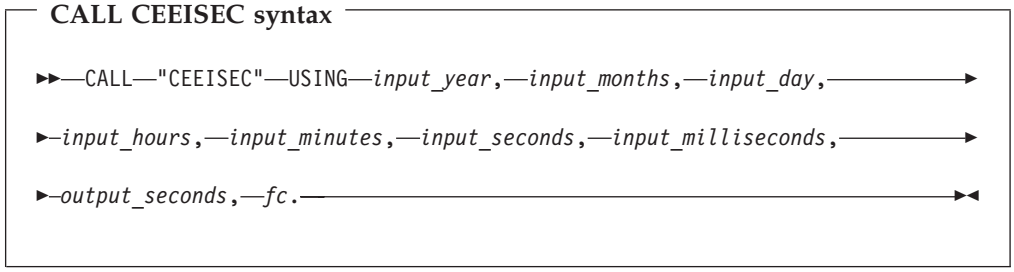
RELATED REFERENCES

CEEGMT ("CEEGMT—get current Greenwich Mean Time" on page 547)

CEEISEC—convert integers to seconds

CEEISEC converts separate binary integers representing year, month, day, hour, minute, second, and millisecond to a number representing the number of seconds since 00:00:00 14 October 1582. Use CEEISEC instead of CEESECS when the input is in numeric format rather than character format.

CALL CEEISEC syntax



***input_year* (input)**
A 32-bit binary integer representing the year.

The range of valid values for *input_year* is 1582 to 9999, inclusive.

***input_month* (input)**
A 32-bit binary integer representing the month.

The range of valid values for *input_month* is 1 to 12.

***input_day* (input)**
A 32-bit binary integer representing the day.

The range of valid values for *input_day* is 1 to 31.

***input_hours* (input)**
A 32-bit binary integer representing the hours.

The range of valid values for *input_hours* is 0 to 23.

***input_minutes* (input)**
A 32-bit binary integer representing the minutes.

The range of valid values for *input_minutes* is 0 to 59.

***input_seconds* (input)**
A 32-bit binary integer representing the seconds.

The range of valid values for *input_seconds* is 0 to 59.

***input_milliseconds* (input)**
A 32-bit binary integer representing milliseconds.

The range of valid values for *input_milliseconds* is 0 to 999.

***output_seconds* (output)**
A 64-bit long floating-point number representing the number of seconds since 00:00:00 on 14 October 1582, not counting leap seconds.

For example, 00:00:01 on 15 October 1582 is second number 86,401 (24*60*60 + 01). The valid range of *output_seconds* is 86,400 to 265,621,679,999.999 (23:59:59.999 31 December 9999).

If any input values are invalid, *output_seconds* is set to zero.

To convert *output_seconds* to a Lilian day number, divide *output_seconds* by 86,400 (the number of seconds in a day).

***fc* (output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 81. **CEEISEC symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2EE	3	2510	The hours value in a call to CEEISEC or CEESECS was not recognized.
CEE2EF	3	2511	The day parameter passed in a CEEISEC call was invalid for year and month specified.
CEE2EH	3	2513	The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was not within the supported range.
CEE2EI	3	2514	The year value passed in a CEEISEC call was not within the supported range.
CEE2EJ	3	2515	The milliseconds value in a CEEISEC call was not recognized.
CEE2EK	3	2516	The minutes value in a CEEISEC call was not recognized.
CEE2EL	3	2517	The month value in a CEEISEC call was not recognized.
CEE2EN	3	2519	The seconds value in a CEEISEC call was not recognized.

Usage notes: The inverse of CEEISEC is CEESECI, which converts number of seconds to integer year, month, day, hour, minute, second, and millisecond.

Example

```
CBL LIB
      ***********************************************
      **                                           **
      ** Function: Call CEEISEC to convert integers  **
      **           to seconds                      **
      **                                           **
```

```
************************************************
 IDENTIFICATION DIVISION.
 PROGRAM-ID. CBLISEC.
 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01  YEAR                    PIC S9(9) BINARY.
 01  MONTH                   PIC S9(9) BINARY.
 01  DAYS                    PIC S9(9) BINARY.
 01  HOURS                   PIC S9(9) BINARY.
 01  MINUTES                 PIC S9(9) BINARY.
 01  SECONDS                 PIC S9(9) BINARY.
 01  MILLSEC                 PIC S9(9) BINARY.
 01  OUTSECS                 COMP-2.
 01  FC.
     02  Condition-Token-Value.
     COPY  CEEIGZCT.
         03  Case-1-Condition-ID.
             04  Severity    PIC S9(4) COMP.
             04  Msg-No      PIC S9(4) COMP.
         03  Case-2-Condition-ID
                   REDEFINES Case-1-Condition-ID.
             04  Class-Code  PIC S9(4) COMP.
             04  Cause-Code  PIC S9(4) COMP.
         03  Case-Sev-Ctl    PIC X.
         03  Facility-ID     PIC XXX.
     02  I-S-Info            PIC S9(9) COMP.
 PROCEDURE DIVISION.
 PARA-CBLISEC.
************************************************
** Specify seven binary integers representing  **
** the date and time as input to be converted  **
** to Lilian seconds                           **
************************************************
     MOVE 2000 TO YEAR.
     MOVE 1 TO MONTH.
     MOVE 1 TO DAYS.
     MOVE 0 TO HOURS.
     MOVE 0 TO MINUTES.
     MOVE 0 TO SECONDS.
     MOVE 0 TO MILLSEC.
************************************************
** Call CEEISEC to convert the integers       **
** to seconds                                  **
************************************************
     CALL 'CEEISEC' USING YEAR, MONTH, DAYS,
                          HOURS, MINUTES, SECONDS,
                          MILLSEC, OUTSECS , FC.
************************************************
** If CEEISEC runs successfully, display result**
************************************************
     IF CEE000 of FC  THEN
         DISPLAY MONTH '/' DAYS '/' YEAR
           ' AT ' HOURS ':' MINUTES ':' SECONDS
           ' is equivalent to ' OUTSECS ' seconds'
     ELSE
         DISPLAY 'CEEISEC failed with msg '
           Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

CEELOCT—get current local date or time

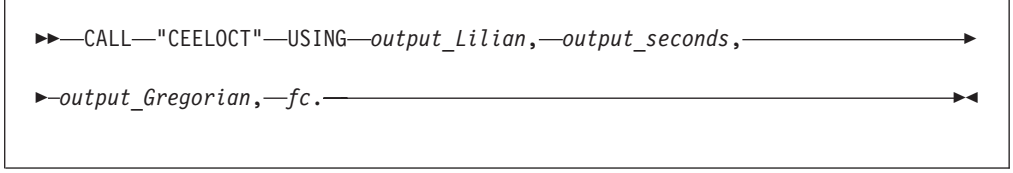
CEELOCT returns the current local date or time in three formats:

- Lilian date (the number of days since 14 October 1582)
- Lilian seconds (the number of seconds since 00:00:00 14 October 1582)
- Gregorian character string (in the form YYYYMMDDHHMISS999).

These values are compatible with other date and time callable services, and with existing language intrinsic functions.

CEELOCT performs the same function as calling the CEEGMT, CEEGMTO, and CEEDATM date and time services separately. CEELOCT, however, performs the same services with much greater speed.

CALL CEELOCT syntax



***output_Lilian* (output)**
A 32-bit binary integer representing the current local date in the Lilian format, that is, day 1 equals 15 October 1582, day 148,887 equals 4 June 1990.

If the local time is not available from the system, *output_Lilian* is set to 0 and CEELOCT terminates with a non-CEE000 symbolic feedback code.

***output_seconds* (output)**
A 64-bit long floating-point number representing the current local date and time as the number of seconds since 00:00:00 on 14 October 1582, not counting leap seconds. For example, 00:00:01 on 15 October 1582 is second number 86,401 (24*60*60 + 01). 19:00:01.078 on 4 June 1990 is second number 12,863,905,201.078.

If the local time is not available from the system, *output_seconds* is set to 0 and CEELOCT terminates with a non-CEE000 symbolic feedback code.

***output_Gregorian* (output)**
A 17-byte fixed-length character string in the form YYYYMMDDHHMISS999 representing local year, month, day, hour, minute, second, and millisecond.

If the format of *output_Gregorian* does not meet your needs, you can use the CEEDATM callable service to convert *output_seconds* to another format.

***fc* (output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 82. **CEELOCT symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2F3	3	2531	The local time was not available from the system.

Usage notes

- You can use the CEEGMT callable service to determine Greenwich Mean Time (GMT).
- You can use the CEEGMTO callable service to obtain the offset from GMT to local time.
- The character value returned by CEELOCT is designed to match that produced by existing intrinsic functions. The numeric values returned can be used to simplify date calculations.

Example

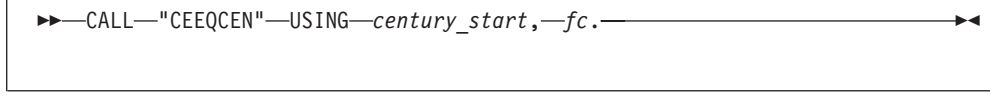
```
CBL LIB
      ************************************************
      **                                            **
      ** Function: Call CEELOCT to get current      **
      **           local time                       **
      **                                            **
      ** In this example, a call is made to CEELOCT **
      ** to return the current local time in Lilian **
      ** days (the number of days since 14 October  **
      ** 1582), Lilian seconds (the number of       **
      ** seconds since 00:00:00 14 October 1582),   **
      ** and a Gregorian string (in the form        **
      ** YYYMMDDMISS999). The Gregorian character   **
      ** string is then displayed.                  **
      **                                            **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLLOCT.
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  LILIAN                  PIC S9(9) BINARY.
       01  SECONDS                 COMP-2.
       01  GREGORN                 PIC X(17).
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                         REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
               03  Facility-ID     PIC XXX.
           02  I-S-Info            PIC S9(9) COMP.
       PROCEDURE DIVISION.
       PARA-CBLLOCT.
           CALL 'CEELOCT' USING LILIAN, SECONDS,
                                GREGORN, FC.
      ************************************************
      ** If CEELOCT runs successfully, display      **
      **     Gregorian character string             **
```

```
*********************************************
     IF CEE000 of FC  THEN
         DISPLAY 'Local Time is ' GREGORN
     ELSE
         DISPLAY 'CEELOCT failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

CEEQCEN—query the century window

CEEQCEN queries the century, which is a two-digit year value. When you want to change the setting, use CEEQCEN to get the setting and then use CEESCEN to save and restore the current setting.

CALL CEEQCEN syntax



***century_start* (output)**

An integer between 0 and 100 indicating the year on which the century window is based.

For example, if the date and time callable services default is in effect, all two-digit years lie within the 100-year window starting 80 years prior to the system date. CEEQCEN then returns the value 80. For example, in the year 2004, a value of 80 indicates to the date and time callable services that all two-digit years lie within the 100-year window starting 80 years before the system date (thus between 1924 and 2023, inclusive).

***fc* (output)**

A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 83. **CEEQCEN symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.

Example

```
CBL LIB
      ***********************************************
      **                                           **
      ** Function: Call CEEQCEN to query the       **
      **           date and time callable services **
      **           century window                  **
      **                                           **
      ** In this example, CEEQCEN is called to query **
      ** the date at which the century window starts **
      ** The century window is the 100-year window   **
      ** within which the date and time callable     **
      ** services assume all two-digit years lie.    **
      **                                           **
```

```
************************************************
 IDENTIFICATION DIVISION.
 PROGRAM-ID. CBLQCEN.

 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01  STARTCW                PIC S9(9) BINARY.
 01  FC.
     02  Condition-Token-Value.
     COPY  CEEIGZCT.
         03  Case-1-Condition-ID.
             04  Severity    PIC S9(4) COMP.
             04  Msg-No      PIC S9(4) COMP.
         03  Case-2-Condition-ID
                   REDEFINES Case-1-Condition-ID.
             04  Class-Code  PIC S9(4) COMP.
             04  Cause-Code  PIC S9(4) COMP.
         03  Case-Sev-Ctl    PIC X.
         03  Facility-ID     PIC XXX.
     02  I-S-Info            PIC S9(9) COMP.
 PROCEDURE DIVISION.

 PARA-CBLQCEN.
************************************************
** Call CEEQCEN to return the start of the     **
**     century window                           **
************************************************

     CALL 'CEEQCEN' USING STARTCW, FC.
************************************************
** CEEQCEN has no nonzero feedback codes to    **
**     check, so just display result.           **
************************************************
     IF CEE000 of FC  THEN
         DISPLAY 'The start of the century '
             'window is: ' STARTCW
     ELSE
         DISPLAY 'CEEQCEN failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

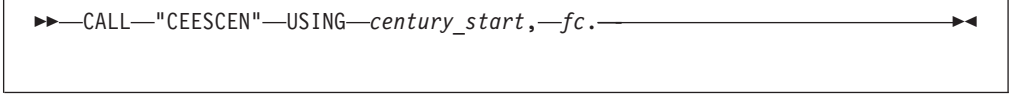
CEESCEN—set the century window

CEESCEN sets the century to a two-digit year value for use by other date and time callable services. Use it in conjunction with CEEDAYS or CEESECS when:

- You process date values containing two-digit years (for example, in the YYMMDD format).
- The default century interval does not meet the requirements of a particular application.

To query the century window, use CEEQCEN.

CALL CEESCEN syntax



century_start
An integer between 0 and 100, setting the century window.

A value of 80, for example, places all two-digit years within the 100-year window starting 80 years before the system date. In 2004, therefore, all two-digit years are assumed to represent dates between 1924 and 2023, inclusive.

***fc* (output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 84. **CEESCEN symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2E6	3	2502	The UTC/GMT was not available from the system.
CEE2F5	3	2533	The value passed to CEESCEN was not between 0 and 100.

Example

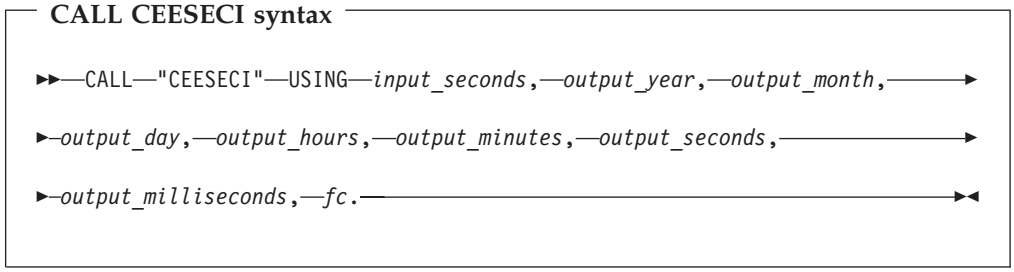
```
CBL LIB
      ************************************************
      **                                            **
      ** Function: Call CEESCEN to set the          **
      **           date and time callable services  **
      **           century window                   **
      **                                            **
      ** In this example, CEESCEN is called to change **
      ** the start of the century window to 30 years  **
      ** before the system date. CEEQCEN is then      **
      ** called to query that the change made.  A     **
      ** message that this has been done is then      **
      ** displayed.                                   **
      **                                            **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLSCEN.

       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  STARTCW                PIC S9(9) BINARY.
       01  FC.
           02  Condition-Token-Value.
           COPY  CEEIGZCT.
               03  Case-1-Condition-ID.
                   04  Severity    PIC S9(4) COMP.
                   04  Msg-No      PIC S9(4) COMP.
               03  Case-2-Condition-ID
                         REDEFINES Case-1-Condition-ID.
                   04  Class-Code  PIC S9(4) COMP.
                   04  Cause-Code  PIC S9(4) COMP.
               03  Case-Sev-Ctl    PIC X.
               03  Facility-ID     PIC XXX.
           02  I-S-Info            PIC S9(9) COMP.
       PROCEDURE DIVISION.
       PARA-CBLSCEN.
      ************************************************
      ** Specify 30 as century start, and two-digit
      **     years will be assumed to lie in the
```

```
**     100-year window starting 30 years before
**     the system date.
************************************************
     MOVE 30 TO STARTCW.

************************************************
** Call CEESCEN to change the start of the century
**     window.
************************************************
     CALL 'CEESCEN' USING STARTCW, FC.
     IF NOT CEE000 of FC  THEN
         DISPLAY 'CEESCEN failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

 PARA-CBLQCEN.
************************************************
** Call CEEQCEN to return the start of the century
**     window
************************************************
     CALL 'CEEQCEN' USING STARTCW, FC.

************************************************
** CEEQCEN has no nonzero feedback codes to
**     check, so just display result.
************************************************
         DISPLAY 'The start of the century '
             'window is: ' STARTCW
     GOBACK.
```

CEESECI—convert seconds to integers

CEESECI converts a number representing the number of seconds since 00:00:00 14 October 1582 to seven separate binary integers representing year, month, day, hour, minute, second, and millisecond. Use CEESECI instead of CEEDATM when the output is needed in numeric format rather than in character format.

CALL CEESECI syntax



input_seconds
A 64-bit long floating-point number representing the number of seconds since 00:00:00 on 14 October 1582, not counting leap seconds.

For example, 00:00:01 on 15 October 1582 is second number 86,401 (24*60*60 + 01). The range of valid values for *input_seconds* is 86,400 to 265,621,679,999.999 (23:59:59.999 31 December 9999).

If *input_seconds* is invalid, all output parameters except the feedback code are set to 0.

output_year **(output)**
A 32-bit binary integer representing the year.

The range of valid values for *output_year* is 1582 to 9999, inclusive.

output_month **(output)**
A 32-bit binary integer representing the month.

The range of valid values for *output_month* is 1 to 12.

output_day **(output)**
A 32-bit binary integer representing the day.

The range of valid values for *output_day* is 1 to 31.

output_hours **(output)**
A 32-bit binary integer representing the hour.

The range of valid values for *output_hours* is 0 to 23.

output_minutes **(output)**
A 32-bit binary integer representing the minutes.

The range of valid values for *output_minutes* is 0 to 59.

output_seconds **(output)**
A 32-bit binary integer representing the seconds.

The range of valid values for *output_seconds* is 0 to 59.

output_milliseconds **(output)**
A 32-bit binary integer representing milliseconds.

The range of valid values for *output_milliseconds* is 0 to 999.

fc **(output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 85. **CEESECI symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2E9	3	2505	The input_seconds value in a call to CEEDATM or CEESECI was not within the supported range.

Usage notes

- The inverse of CEESECI is CEEISEC, which converts separate binary integers representing year, month, day, hour, second, and millisecond to a number of seconds.
- If the input value is a Lilian date instead of seconds, multiply the Lilian date by 86,400 (number of seconds in a day), and pass the new value to CEESECI.

Example

```
CBL LIB
      ************************************************
      **                                            **
      ** Function: Call CEESECI to convert seconds   **
      **           to integers                      **
      **                                            **
      ** In this example a call is made to CEESECI   **
      ** to convert a number representing the number **
      ** of seconds since 00:00:00 14 October 1582   **
      ** to seven binary integers representing year, **
      ** month, day, hour, minute, second, and       **
```

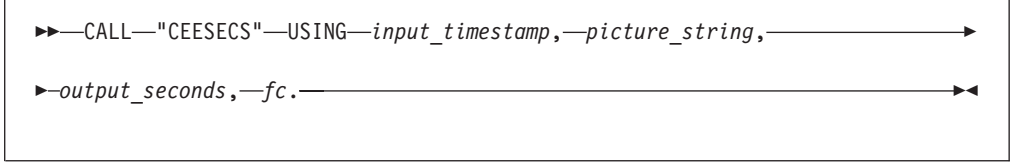
```
** millisecond.  The results are displayed in  **
** this example.                                 **
**                                               **
***************************************************
 IDENTIFICATION DIVISION.
 PROGRAM-ID. CBLSECI.

 DATA DIVISION.
 WORKING-STORAGE SECTION.
 01  INSECS                  COMP-2.
 01  YEAR                    PIC S9(9) BINARY.
 01  MONTH                   PIC S9(9) BINARY.
 01  DAYS                    PIC S9(9) BINARY.
 01  HOURS                   PIC S9(9) BINARY.
 01  MINUTES                 PIC S9(9) BINARY.
 01  SECONDS                 PIC S9(9) BINARY.
 01  MILLSEC                 PIC S9(9) BINARY.
 01  IN-DATE.
     02  Vstring-length      PIC S9(4) BINARY.
     02  Vstring-text.
         03  Vstring-char        PIC X,
                     OCCURS 0 TO 256 TIMES
                     DEPENDING ON Vstring-length
                         of IN-DATE.
 01  PICSTR.
     02  Vstring-length      PIC S9(4) BINARY.
     02  Vstring-text.
         03  Vstring-char        PIC X,
                     OCCURS 0 TO 256 TIMES
                     DEPENDING ON Vstring-length
                        of PICSTR.
 01  FC.
     02  Condition-Token-Value.
     COPY  CEEIGZCT.
         03  Case-1-Condition-ID.
             04  Severity    PIC S9(4) COMP.
             04  Msg-No      PIC S9(4) COMP.
         03  Case-2-Condition-ID
                   REDEFINES Case-1-Condition-ID.
             04  Class-Code  PIC S9(4) COMP.
             04  Cause-Code  PIC S9(4) COMP.
         03  Case-Sev-Ctl    PIC X.
         03  Facility-ID     PIC XXX.
     02  I-S-Info            PIC S9(9) COMP.
 PROCEDURE DIVISION.
 PARA-CBLSECS.
***************************************************
** Call CEESECS to convert timestamp of 6/2/88
**     at 10:23:45 AM to Lilian representation
***************************************************
     MOVE 20 TO Vstring-length of IN-DATE.
     MOVE '06/02/88 10:23:45 AM'
             TO Vstring-text of IN-DATE.
     MOVE 20 TO Vstring-length of PICSTR.
     MOVE 'MM/DD/YY HH:MI:SS AP'
             TO Vstring-text of PICSTR.
     CALL 'CEESECS' USING IN-DATE, PICSTR,
                          INSECS, FC.
     IF NOT CEE000 of FC  THEN
         DISPLAY 'CEESECS failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

 PARA-CBLSECI.
***************************************************
** Call CEESECI to convert seconds to integers
```

```
*************************************************
     CALL 'CEESECI' USING INSECS, YEAR, MONTH,
                          DAYS, HOURS,  MINUTES,
                          SECONDS, MILLSEC, FC.
*************************************************
** If CEESECI runs successfully, display results
*************************************************
     IF CEE000 of FC  THEN
         DISPLAY 'Input seconds of ' INSECS
             ' represents:'
         DISPLAY '   Year......... ' YEAR
         DISPLAY '   Month........ ' MONTH
         DISPLAY '   Day.......... ' DAYS
         DISPLAY '   Hour......... ' HOURS
         DISPLAY '   Minute....... ' MINUTES
         DISPLAY '   Second....... ' SECONDS
         DISPLAY '   Millisecond.. ' MILLSEC
     ELSE
         DISPLAY 'CEESECI failed with msg '
             Msg-No of FC UPON CONSOLE
         STOP RUN
     END-IF.

     GOBACK.
```

CEESECS—convert timestamp to seconds

CEESECS converts a string representing a timestamp into the number of Lilian seconds (number of seconds since 00:00:00 14 October 1582). This service makes it easier to perform time arithmetic, such as calculating the elapsed time between two timestamps.

CALL CEESECS syntax



***input_timestamp* (input)**

A halfword length-prefixed character string, representing a date or timestamp in a format matching that specified by *picture_string*.

The character string must contain between 5 and 80 picture characters, inclusive. *input_timestamp* can contain leading or trailing blanks. Parsing begins with the first nonblank character (unless the picture string itself contains leading blanks; in this case, CEESECS skips exactly that many positions before parsing begins).

After a valid date is parsed, as determined by the format of the date you specify in *picture_string*, all remaining characters are ignored by CEESECS. Valid dates range between and including the dates 15 October 1582 to 31 December 9999. A full date must be specified. Valid times range from 00:00:00.000 to 23:59:59.999.

If any part or all of the time value is omitted, zeros are substituted for the remaining values. For example:

```
1992-05-17-19:02 is equivalent to 1992-05-17-19:02:00
1992-05-17       is equivalent to 1992-05-17-00:00:00
```

picture_string **(input)**
A halfword length-prefixed character string, indicating the format of the date or timestamp value specified in *input_timestamp*.

Each character in the *picture_string* represents a character in *input_timestamp*. For example, if you specify MMDDYY HH.MI.SS as the *picture_string*, CEESECS reads an *input_char_date* of 060288 15.35.02 as 3:35:02 PM on 02 June 1988. If delimiters such as the slash (/) appear in the picture string, leading zeros can be omitted. For example, the following calls to CEESECS all assign the same value to data item *secs*:

```
CALL CEESECS USING '92/06/03 15.35.03',
                   'YY/MM/DD HH.MI.SS', secs, fc.
CALL CEESECS USING '92/6/3 15.35.03',
                   'YY/MM/DD HH.MI.SS', secs, fc.
CALL CEESECS USING '92/6/3 3.35.03 PM',
                   'YY/MM/DD HH.MI.SS AP', secs, fc.
CALL CEESECS USING '92.155 3.35.03 pm',
                   'YY.DDD   HH.MI.SS AP', secs, fc.
```

If *picture_string* includes a Japanese Era symbol <JJJJ>, the YY position in *input_timestamp* represents the year number within the Japanese Era. For example, the year 1988 equals the Japanese year 63 in the Showa era.

output_seconds **(output)**
A 64-bit long floating-point number representing the number of seconds since 00:00:00 on 14 October 1582, not counting leap seconds. For example, 00:00:01 on 15 October 1582 is second 86,401 (24*60*60 + 01) in the Lilian format. 19:00:01.12 on 16 May 1988 is second 12,799,191,601.12.

The largest value represented is 23:59:59.999 on 31 December 9999, which is second 265,621,679,999.999 in the Lilian format.

A 64-bit long floating-point value can accurately represent approximately 16 significant decimal digits without loss of precision. Therefore, accuracy is available to the nearest millisecond (15 decimal digits).

If *input_timestamp* does not contain a valid date or timestamp, *output_seconds* is set to 0 and CEESECS terminates with a non-CEE000 symbolic feedback code.

Elapsed time calculations are performed easily on the *output_seconds*, because it represents elapsed time. Leap year and end-of-year anomalies do not affect the calculations.

fc **(output)**
A 12-byte feedback code (optional) that indicates the result of this service.

The following symbolic conditions can result from this service:

Table 86. **CEESECS symbolic conditions**

Symbolic feedback code	Severity	Message number	Message text
CEE000	0	—	The service completed successfully.
CEE2EB	3	2507	Insufficient data was passed to CEEDAYS or CEESECS. The Lilian value was not calculated.
CEE2EC	3	2508	The date value passed to CEEDAYS or CEESECS was invalid.
CEE2ED	3	2509	The era passed to CEEDAYS or CEESECS was not recognized.

Table 86. **CEESECS symbolic conditions** *(continued)*

Symbolic feedback code	Severity	Message number	Message text
CEE2EE	3	2510	The hours value in a call to CEEISEC or CEESECS was not recognized.
CEE2EH	3	2513	The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was not within the supported range.
CEE2EK	3	2516	The minutes value in a CEEISEC call was not recognized.
CEE2EL	3	2517	The month value in a CEEISEC call was not recognized.
CEE2EM	3	2518	An invalid picture string was specified in a call to a date/time service.
CEE2EN	3	2519	The seconds value in a CEEISEC call was not recognized.
CEE2EP	3	2521	The <JJJJ>, <CCCC>, or <CCCCCCCC> year-within-era value passed to CEEDAYS or CEESECS was zero.
CEE2ET	3	2525	CEESECS detected nonnumeric data in a numeric field, or the timestamp string did not match the picture string.

Usage notes

- The inverse of CEESECS is CEEDATM, which converts *output_seconds* to character format.
- By default, two-digit years lie within the 100-year range starting 80 years prior to the system date. Thus in 2004, all two-digit years represent dates between 1924 and 2023, inclusive. You can change this range by using the callable service CEESCEN.

Example

```
CBL LIB
      ************************************************
      **                                            **
      ** Function: Call CEESECS to convert          **
      **           timestamp to number of seconds   **
      **                                            **
      ** In this example, calls are made to CEESECS **
      ** to convert two timestamps to the number of **
      ** seconds since 00:00:00 14 October 1582.    **
      ** The Lilian seconds for the earlier         **
      ** timestamp are then subtracted from the     **
      ** Lilian seconds for the later timestamp     **
      ** to determine the number of between the     **
      ** two.  This result is displayed.            **
      **                                            **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLSECS.

       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  SECOND1                 COMP-2.
       01  SECOND2                 COMP-2.
       01  TIMESTP.
```

```
    02  Vstring-length      PIC S9(4) BINARY.
    02  Vstring-text.
        03  Vstring-char        PIC X,
                    OCCURS 0 TO 256 TIMES
                    DEPENDING ON Vstring-length
                       of TIMESTP.
01  TIMESTP2.
    02  Vstring-length      PIC S9(4) BINARY.
    02  Vstring-text.
        03  Vstring-char        PIC X,
                    OCCURS 0 TO 256 TIMES
                    DEPENDING ON Vstring-length
                       of TIMESTP2.
01  PICSTR.
    02  Vstring-length      PIC S9(4) BINARY.
    02  Vstring-text.
        03  Vstring-char        PIC X,
                    OCCURS 0 TO 256 TIMES
                    DEPENDING ON Vstring-length
                       of PICSTR.
01  FC.
    02  Condition-Token-Value.
    COPY  CEEIGZCT.
        03  Case-1-Condition-ID.
            04  Severity    PIC S9(4) COMP.
            04  Msg-No      PIC S9(4) COMP.
        03  Case-2-Condition-ID
                  REDEFINES Case-1-Condition-ID.
            04  Class-Code  PIC S9(4) COMP.
            04  Cause-Code  PIC S9(4) COMP.
        03  Case-Sev-Ctl    PIC X.
        03  Facility-ID     PIC XXX.
    02  I-S-Info            PIC S9(9) COMP.
PROCEDURE DIVISION.

PARA-SECS1.
************************************************
** Specify first timestamp and a picture string
**     describing the format of the timestamp
**     as input to CEESECS
************************************************
    MOVE 25 TO Vstring-length of TIMESTP.
    MOVE '1969-05-07 12:01:00.000'
            TO Vstring-text of TIMESTP.
    MOVE 25 TO Vstring-length of PICSTR.
    MOVE 'YYYY-MM-DD HH:MI:SS.999'
            TO Vstring-text of PICSTR.

************************************************
** Call CEESECS to convert the first timestamp
** to Lilian seconds
************************************************
    CALL 'CEESECS' USING TIMESTP, PICSTR,
                         SECOND1, FC.
    IF NOT CEE000 of FC  THEN
        DISPLAY 'CEESECS failed with msg '
            Msg-No of FC UPON CONSOLE
        STOP RUN
    END-IF.

PARA-SECS2.
************************************************
** Specify second timestamp and a picture string
**     describing the format of the timestamp as
**     input to CEESECS.
************************************************
    MOVE 25 TO Vstring-length of TIMESTP2.
```

```
           MOVE '2004-01-01 00:00:01.000'
                   TO Vstring-text of TIMESTP2.
           MOVE 25 TO Vstring-length of PICSTR.
           MOVE 'YYYY-MM-DD HH:MI:SS.999'
                   TO Vstring-text of PICSTR.

      ***********************************************
      ** Call CEESECS to convert the second timestamp
      **     to Lilian seconds
      ***********************************************
           CALL 'CEESECS' USING TIMESTP2, PICSTR,
                                SECOND2, FC.
           IF NOT CEE000 of FC  THEN
               DISPLAY 'CEESECS failed with msg '
                   Msg-No of FC UPON CONSOLE
               STOP RUN
           END-IF.

       PARA-SECS2.
      ***********************************************
      ** Subtract SECOND2 from SECOND1 to determine the
      **     number of seconds between the two timestamps
      ***********************************************
           SUBTRACT SECOND1 FROM SECOND2.
           DISPLAY 'The number of seconds between '
               Vstring-text OF TIMESTP ' and '
               Vstring-text OF TIMESTP2 ' is: ' SECOND2.

           GOBACK.
```

"Example: date-and-time picture strings" on page 500

RELATED REFERENCES

"Picture character terms and strings" on page 498

CEEUTC—get coordinated universal time

CEEUTC is identical to CEEGMT.

RELATED REFERENCES

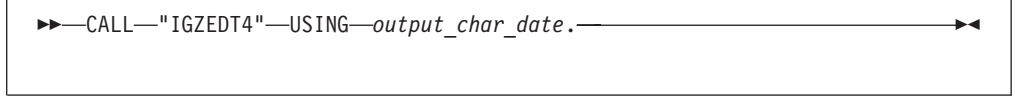
CEEGMT ("CEEGMT—get current Greenwich Mean Time" on page 547)

IGZEDT4—get current date

In addition to the previous date and time callable services, COBOL for AIX supports the VS COBOL II callable service IGZEDT4.

IGZEDT4 returns the current date with a four-digit year in the form YYYYMMDD.

CALL IGZEDT4 syntax



***output_char_date* (output)**

An 8-byte fixed-length character string in the form YYYYMMDD representing current year, month, and day.

Usage notes: IGZEDT4 is not supported under CICS.

Example

```
CBL LIB
      ************************************************
      ** Function: IGZEDT4 - get current date in the  **
      **                     format YYYYMMDD.         **
      ************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. CBLEDT4.
       . . .
       DATA DIVISION.
       WORKING-STORAGE SECTION.
       01  CHRDATE                 PIC S9(8) USAGE DISPLAY.
       . . .
       PROCEDURE DIVISION.
       PARA-CBLEDT4.
      ************************************************
      ** Call IGZEDT4.
      ************************************************
           CALL 'IGZEDT4' USING BY REFERENCE CHRDATE.
      ************************************************
      ** IGZEDT4 has no nonzero return code to
      **     check, so just display result.
      ************************************************
           DISPLAY 'The current date is: '
               CHRDATE
           GOBACK.
```

Appendix F. 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 573
"XML GENERATE exceptions" on page 578
"XML conformance" on page 575
XML specification

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
- 200,001-265,535

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*
- *External ASCII code page*
- *External EBCDIC code page*

For definitions of the terms, see the related task below on understanding the encoding of XML documents.

Table 87. **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.

© Copyright IBM Corp. 1995, 2004

Table 87. **XML PARSE exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
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.
4	The parser found the markup 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.
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 ']]>' without the matching opening character sequence '<![CDATA['.	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 '–' (two hyphens) not followed by '>'.	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.

Table 87. **XML PARSE exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
12	A processing instruction target name was 'xml' 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.
13	The parser found an invalid digit in a hexadecimal character reference (of the form &#x*dddd*;).	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 &#*dddd*;).	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 external EBCDIC code page is supported, but the document encoding declaration did not specify a supported EBCDIC code page.	The parser uses the encoding specified by the external EBCDIC code page.
71	The basic document encoding was EBCDIC, and the document encoding declaration specified a supported EBCDIC encoding, but the external EBCDIC code page is not supported.	The parser uses the encoding specified by the document encoding declaration.

Table 87. **XML PARSE exceptions that allow continuation** *(continued)*

Code	Description	Parser action on continuation
72	The basic document encoding was EBCDIC, the external EBCDIC code page is not supported, and the document did not contain an encoding declaration.	The parser uses EBCDIC code page 1140 (USA, Canada, . . . Euro Country Extended Code Page).
73	The basic document encoding was EBCDIC, but neither the external EBCDIC code page 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).
80	The basic document encoding was ASCII, and the external ASCII code page is supported, but the document encoding declaration did not specify a supported ASCII code page.	The parser uses the encoding specified by the external ASCII code page.
81	The basic document encoding was ASCII, and the document encoding declaration specified a supported ASCII encoding, but the external ASCII code page is not supported.	The parser uses the encoding specified by the document encoding declaration.
82	The basic document encoding was ASCII, but the external ASCII code page is not supported, and 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 neither the external ASCII code page nor the document encoding declaration specified a supported ASCII code page.	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 external EBCDIC code page 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 external EBCDIC code page. If you set `XML-CODE` to the CCSID for the document encoding declaration (by subtracting 100,000), the parser uses this encoding.
200,001 - 265,535	The external ASCII code page and the document encoding declaration specified different supported ASCII code pages. `XML-CODE` contains the CCSID for the encoding declaration plus 200,000.	If you set `XML-CODE` to zero before returning from the `EXCEPTION` event, the parser uses the encoding specified by the external ASCII code page. If you set `XML-CODE` to the CCSID for the document encoding declaration (by subtracting 200,000), the parser uses this encoding.

RELATED TASKS

"Understanding the encoding of XML documents" on page 318
"Handling errors in parsing XML documents" on page 321

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 88. **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.
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.

Table 88. **XML PARSE exceptions that do not allow continuation** *(continued)*

Code	Description
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 ':'.
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.

Table 88. **XML PARSE exceptions that do not allow continuation** *(continued)*

Code	Description
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.
317	The parser cannot determine the document encoding. The document might be damaged.
318	The basic document encoding was UTF-8, which the parser does not support.
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.
322	The document data item was a native alphanumeric data item, but the basic document encoding was EBCDIC.
323	The document data item was a host alphanumeric data item, 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 321

XML conformance

The XML parser that is included in COBOL for AIX 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 '<'."

   T*he 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 303

RELATED REFERENCES
XML specification
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 89. **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 multibyte data-name contained a character that, when converted to Unicode, was not valid in an XML element name.
402	The first character of a multibyte 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.
410	The external code page is not supported for conversion to Unicode.
411	The external code page is not a supported single-byte EBCDIC code page.
412	The external code page is not a supported single-byte ASCII code page.
413	The document data item was alphanumeric, but the run-time locale was not consistent with the compile-time locale.
600-699	Internal error. Please report the error to your service representative.

RELATED TASKS
"Handling errors in generating XML output" on page 336

Appendix G. 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 these definitions:

- Sample COBOL data definitions that correspond to the Java JNI types
- JNINativeInterface, the JNI environment structure that contains function pointers for accessing the JNI callable services

JNI.cpy is in the `include` subdirectory of the COBOL install directory (typically /usr/lpp/cobol/include). JNI.cpy 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.
```

© Copyright IBM Corp. 1995, 2004

```
* 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" on page 195
"Accessing JNI services" on page 383

Appendix H. COBOL SYSADATA file contents

When you use the ADATA compiler option, the compiler produces a file that contains program data. You can use this file (instead of the compiler listing) to extract information about the compiled program. For example, you can extract information about the compiled program for symbolic debugging tools or cross-reference tools.

"Example: SYSADATA" on page 587

RELATED REFERENCES

"ADATA" on page 201
"Existing compiler options affecting the SYSADATA file"
"SYSADATA record types" on page 586
"SYSADATA record descriptions" on page 588

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.

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
0044	AX_STMT	Symbol Cross Reference record
0046	AN_STMT	Nested Program record

© Copyright IBM Corp. 1995, 2004

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 587

RELATED REFERENCES
"SYSADATA record types"
"COMPILE" on page 206
"EXIT" on page 211
"NUMBER" on page 224
"TEST" on page 234

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 90. **SYSADATA record types**

Record type	What it does
"Job identification record - X'0000'" on page 590	Provides information about the environment used to process the source data
"ADATA identification record - X'0001'" on page 591	Provides common information about the records in the SYSADATA file
"Compilation unit start/end record - X'0002'" on page 592	Marks the beginning and ending of compilation units in a source file
"Options record - X'0010'" on page 592	Describes the compiler options used for the compilation
"External symbol record - X'0020'" on page 602	Describes all external names in the program, definitions and references
"Parse tree record - X'0024'" on page 603	Defines a node in the parse tree of the program

Table 90. **SYSADATA record types** *(continued)*

Record type	What it does
"Token record - X'0030'" on page 617	Defines a source token
"Source error record - X'0032'" on page 617	Describes errors in source program statements
"Source record - X'0038'" on page 618	Describes a single source line
"COPY REPLACING record - X'0039'" on page 618	Describes an instance of text replacement as a result of a match of `COPY. . .REPLACING` *operand-1* with text in the copybook being copied in
"Symbol record - X'0042'" on page 619	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 630	Describes references to a single symbol
"Nested program record - X'0046'" on page 631	Describes the name and nesting level of a program
"Library record - X'0060'" on page 632	Describes the library files and members used from each library
"Statistics record - X'0090'" on page 633	Describes the statistics about the compilation
"EVENTS record - X'0120'" on page 633	EVENTS records are recorded in the SYSADATA file to provide compatibility with COBOL/370(TM). 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

Type	Description
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(TM) processors.

All undefined fields and unused values are reserved.

RELATED REFERENCES
"Common header section"
"Job identification record - X'0000'" on page 590
"ADATA identification record - X'0001'" on page 591
"Compilation unit start/end record - X'0002'" on page 592
"Options record - X'0010'" on page 592
"External symbol record - X'0020'" on page 602
"Parse tree record - X'0024'" on page 603
"Token record - X'0030'" on page 617
"Source error record - X'0032'" on page 617
"Source record - X'0038'" on page 618
"COPY REPLACING record - X'0039'" on page 618
"Symbol record - X'0042'" on page 619
"Symbol cross-reference record - X'0044'" on page 630
"Nested program record - X'0046'" on page 631
"Library record - X'0060'" on page 632
"Statistics record - X'0090'" on page 633
"EVENTS record - X'0120'" on page 633

Common header section

The header section, common for all record types. For MVS(TM) 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 91. **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 91. **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 92. **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 *n* 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(*n*)	The name of the input file for the compilation
...Volume serial number	CL(*n*)	The volume serial number of the (first) volume on which the input file resides
...Member name	CL(*n*)	Where applicable, the name of the member in the input file

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.

ADATA identification record - X'0001'

The following table shows the contents of the ADATA identification record:

Table 93. **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 Windows and AIX, only bytes 5-8 of the field are used as a fullword binary field that contains the time.
CCSID[1]	XL2	Coded Character Set Identifier
Character-set flags	XL1	**X'80'** EBCDIC (IBM-037) **X'40'** ASCII (IBM-1252)
Code-page name length	XL2	Length of the code-page name that follows
Code-page name	CL(*n*)	Name of the code page

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.

Compilation unit start/end record - X'0002'

The following table shows the contents of the compilation unit start/end record:

Table 94. **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 95. **SYSADATA options record**

Field	Size	Description
Option byte 0	XL1	**1111 1111** Reserved for future use

Table 95. **SYSADATA options record** *(continued)*

Field	Size	Description
Option byte 1	XL1	**1... ....** Bit 1 = DECK, Bit 0 = NODECK **.1.. ....** Bit 1 = ADATA, Bit 0 = NOADATA **..1. ....** Bit 1 = COLLSEQ(EBCDIC), Bit 0 = COLLSEQ(LOCALE|BINARY) (Windows and AIX only) **...1 ....** Bit 1 = SEPOBJ, Bit 0 = NOSEPOBJ (Windows and AIX only) **.... 1...** Bit 1 = NAME, Bit 0 = NONAME **.... .1..** Bit 1 = OBJECT, Bit 0 = NOOBJECT **.... ..1.** Bit 1 = SQL, Bit 0 = NOSQL **.... ...1** Bit 1 = CICS, Bit 0 = NOCICS
Option byte 2	XL1	**1... ....** Bit 1 = OFFSET, Bit 0 = NOOFFSET (host only) **.1.. ....** Bit 1 = MAP, Bit 0 = NOMAP **..1. ....** Bit 1 = LIST, Bit 0 = NOLIST **...1 ....** Bit 1 = DBCSXREF, Bit 0 = NODBCSXREF **.... 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. **.... .1..** Bit 1 = SOURCE, Bit 0 = NOSOURCE **.... ..1.** Bit 1 = VBREF, Bit 0 = NOVBREF **.... ...1** Bit 1 = XREF, Bit 0 = not XREF. See also flag at bit 4 above.

Table 95. **SYSADATA options record** *(continued)*

Field	Size	Description
Option byte 3	XL1	**1... ....** Bit 1 = FLAG imbedded diagnostics level specified (a value *y* is specified as in FLAG(*x*,*y*)) **.1.. ....** Bit 1 = FLAGSTD, Bit 0 = NOFLAGSTD **..1. ....** Bit 1 = NUM, Bit 0 = NONUM **...1 ....** Bit 1 = SEQUENCE, Bit 0 = NOSEQUENCE **.... 1...** Bit 1 = SOSI, Bit 0 = NOSOSI (Windows and AIX only) **.... .1..** Bit 1 = NSYMBOL(NATIONAL), Bit 0 = NSYMBOL(DBCS) **.... ..1.** Bit 1 = PROFILE, Bit 0 = NOPROFILE (Windows and AIX only) **.... ...1** Bit 1 = WORD, Bit 0 = NOWORD
Option byte 4	XL1	**1... ....** Bit 1 = ADV, Bit 0 = NOADV **.1.. ....** Bit 1 = APOST, Bit 0 = QUOTE **..1. ....** Bit 1 = DYNAM, Bit 0 = NODYNAM **...1 ....** Bit 1 = AWO, Bit 0 = NOAWO **.... 1...** Bit 1 = RMODE specified, Bit 0 = RMODE(AUTO) **.... .1..** Bit 1 = RENT, Bit 0 = NORENT **.... ..1.** Bit 1 = RES - this flag will always be set on for COBOL. **.... ...1** Bit 1 = RMODE(24) Bit 0 = RMODE(ANY)

Table 95. **SYSADATA options record** *(continued)*

Field	Size	Description
Option byte 5	XL1	**1... ....** Reserved for compatibility **.1.. ....** Bit 1 = OPT, Bit 0 = NOOPT **..1. ....** Bit 1 = LIB, Bit 0 = NOLIB **...1 ....** Bit 1 = DBCS, Bit 0 = NODBCS **.... 1...** Bit 1 = OPT(FULL), Bit 0 = not OPT(FULL) **.... .1..** Bit 1 = SSRANGE, Bit 0 = NOSSRANGE **.... ..1.** Bit 1 = TEST, Bit 0 = NOTEST **.... ...1** Bit 1 = PROBE, Bit 0 = NOPROBE (Windows only)
Option byte 6	XL1	**..1. ....** Bit 1 = NUMPROC(PFD), Bit 0 = NUMPROC(NOPFD) **...1 ....** Bit 1 = NUMCLS(ALT), Bit 0 = NUMCLS(PRIM) **.... .1..** Bit 1 = BINARY(S390), Bit 0 = BINARY(NATIVE) (Windows and AIX only) **.... ..1.** Bit 1 = TRUNC(STD), Bit 0 = TRUNC(OPT) **.... ...1** Bit 1 = ZWB, Bit 0 = NOZWB **11.. 1...** Reserved for future use
Option byte 7	XL1	**1... ....** Bit 1 = ALOWCBL, Bit 0 = NOALOWCBL (Windows and AIX only) **.1.. ....** Bit 1 = TERM, Bit 0 = NOTERM **..1. ....** Bit 1 = DUMP, Bit 0 = NODUMP **...1 11..** Reserved **.... ..1.** Bit 1 = CURRENCY, Bit 0 = NOCURRENCY **.... ...1** Reserved

Table 95. **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(*nnnn*) or SIZE(*nnnn*K) **.... .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) (Windows and AIX 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 95. **SYSADATA options record** *(continued)*

Field	Size	Description
Option byte D	XL1	**1... ....** Bit 1 = DLL Bit 0 = NODLL (host only) **.1.. ....** Bit 1 = EXPORTALL, Bit 0 = NOEXPORTALL (host only) **..1. ....** Bit 1 = CODEPAGE (host only) **...1 ....** Bit 1 = DATEPROC, Bit 0 = NODATEPROC **.... 1...** Bit 1 = DATEPROC(FLAG), Bit 0 = DATEPROC(NOFLAG) **.... .1..** Bit 1 = YEARWINDOW **.... ..1.** Bit 1 = WSCLEAR, Bit 0 = NOWSCLEAR (Windows and AIX only) **.... ...1** Bit 1 = BEOPT, Bit 0 = NOBEOPT (Windows and AIX only)
Option byte E	XL1	**1... ....** Bit 1 = DATEPROC(TRIG), Bit 0 = DATEPROC(NOTRIG) **.1.. ....** Bit 1 = DIAGTRUNC, Bit 0 = NODIAGTRUNC **.... .1..** Bit 1 = LSTFILE(UTF-8), Bit 0 = LSTFILE(LOCALE) (Windows and AIX only) **..11 1.11** Reserved for future use
Option byte F	XL1	**1111 1111** Reserved for future use
Flag 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

Table 95. **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 95. **SYSADATA options record** *(continued)*

Field	Size	Description
TEST(hook,sym,sep) suboptions (host only)	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 95. **SYSADATA options record** *(continued)*

Field	Size	Description
CallInterface suboptions	XL1	**1... ....** Bit 1 = CallInterface(System) (Windows and AIX only) **.1.. ....** Bit 1 = CallInterface(OptLink) (Windows only) **...1 ....** Bit 1 = CallInterface(Cdecl) (Windows only) **.... 1...** Bit 1 = CallInterface(System(Desc)) (Windows and AIX 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 95. **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	**1... ....** Bit 1 = IGYCLIBR in user region **.1.. ....** Bit 1 = IGYCSCAN in user region **..1. ....** Bit 1 = IGYCDSCN in user region **...1 ....** Bit 1 = IGYCGROU in user region **.... 1...** Bit 1 = IGYCPSCN in user region **.... .1..** Bit 1 = IGYCPANA in user region **.... ..1.** Bit 1 = IGYCFGEN in user region **.... ...1** Bit 1 = IGYCPGEN in user region
Phase residence bits byte 2	XL1	**1... ....** Bit 1 = IGYCOPTM in user region **.1.. ....** Bit 1 = IGYCLSTR in user region **..1. ....** Bit 1 = IGYCXREF in user region **...1 ....** Bit 1 = IGYCDMAP in user region **.... 1...** Bit 1 = IGYCASM1 in user region **.... .1..** Bit 1 = IGYCASM2 in user region **.... ..1.** Bit 1 = IGYCDIAG in user region **.... ...1** Reserved for future use
Phase residence bits bytes 3 and 4	XL2	Reserved
Reserved	CL8	Reserved for future use
OUTDD name	CL(*n*)	OUTDD name
RWT	CL(*n*)	Reserved word table identifier
DBCS ORDPGM	CL(*n*)	DBCS Ordering program name
DBCS ENCTBL	CL(*n*)	DBCS Encode table name
INEXIT name	CL(*n*)	SYSIN user-exit name

Table 95. **SYSADATA options record** *(continued)*

Field	Size	Description
PRTEXIT name	CL(*n*)	SYSPRINT user-exit name
LIBEXIT name	CL(*n*)	'Library' user-exit name
ADEXIT name	CL(*n*)	ADATA user-exit name

External symbol record - X'0020'

The following table shows the contents of the external symbol record:

Table 96. **SYSADATA external symbol record**

Field	Size	Description
Section type	XL1	**X'00'** PROGRAM-ID Name Main entry point name **X'01'** ENTRY Name Secondary entry point name **X'02'** External Reference Referenced external entry point **X'04'** N/A for COBOL **X'05'** N/A for COBOL **X'06'** N/A for COBOL **X'0A'** N/A for COBOL **X'12'** Internal Reference Referenced internal subprogram **X'C0'** External CLASS Name OO COBOL CLASS definition **X'C1'** METHOD-ID Name OO COBOL Method definition **X'C6'** Method Reference OO COBOL Method reference **X'FF'** N/A for COBOL Types X'12', X'C0', X'C1' and X'C6X' are for COBOL only.
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(*n*)	The external name

Table 96. **SYSADATA external symbol record** *(continued)*

Field	Size	Description
Alias Section name	CL(*n*)	N/A for COBOL

Parse tree record - X'0024'

The following table shows the contents of the parse tree record:

Table 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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 97. **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-INTEGER **0039** INTEGER-OF-DAY **0040** DATE-OF-INTEGER **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 97. **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 97. **SYSADATA parse tree record** *(continued)*

Field	Size	Description
		For Relational Operator type: **0008** LESS **0009** LESS OR EQUAL **0010** EQUAL **0011** NOT EQUAL **0012** GREATER **0013** GREATER OR EQUAL **0014** AND **0015** OR **0016** CLASS CONDITION **0017** NOT CLASS CONDITION
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	The Symbol Id of the node, if it is a user-name of one of the following types: • data entry • identifier • file-name • index-name • procedure-name • condition-name • mnemonic-name This value corresponds to the Symbol ID in a Symbol (Type 42) record, except for procedure-names where it corresponds to the Paragraph ID. For all other node types this value is zero.
Section Symbol Id	FL4	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. For all other node types this value is zero.
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	Information about the node: **X'80'** Reserved **X'40'** Generated node, no tokens
Reserved	CL3	Reserved for future use

Token record - X'0030'

The following table shows the contents of the token record:

Table 98. **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 99. **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 100. **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 *n* 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 *n* 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 *n* 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 *n* 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(*n*)	

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 101. **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 101. **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 102. **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	**X'00'** Unique name; no qualification needed. **X'01'** This data item needs qualification. The name is not unique within the program. This field applies *only* when this data item is NOT the level-01 name.
Symbol type	XL1	**X'68'** Class-name (Class-ID) **X'58'** Method-name **X'40'** Data-name **X'20'** Procedure-name **X'10'** Mnemonic-name **X'08'** Program-name **X'81'** Reserved The following are ORed into the above types, when applicable: **X'04'** External **X'02'** Global

Table 102. **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 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
Clauses	XL1	Clauses specified in symbol definition. For numeric, alphanumeric, group, and index symbols **1... ....** Value **.1.. ....** Indexed **..1. ....** Redefines **...1 ....** Renames **.... 1...** Occurs **.... .1..** Has Occurs keys **.... ..1.** Occurs Depending On **.... ...1** Occurs in parent For both file types **1... ....** Select **.1.. ....** Assign **..1. ....** Rerun **...1 ....** Same area **.... 1...** Same record area **.... .1..** Recording mode **.... ..1.** Reserved **.... ...1** Record

Table 102. **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 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
Data flags 1	XL1	For both file types, and numeric, alphanumeric, group, and index symbols **1... ....** Redefined **.1.. ....** Renamed **..1. ....** Synchronized **...1 ....** Implicitly redefined **.... 1...** Date field **.... .1..** Implicit redefines **.... ..1.** FILLER **.... ...1** Level 77

Table 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
Data flags 2	XL1	For numeric symbols **1... ....** Binary **.1.. ....** External floating point **..1. ....** Internal floating point **...1 ....** Packed **.... 1...** Zoned **.... .1..** Scaled negative **.... ..1.** Numeric edited **.... ...1** Reserved for future use For alphanumeric symbols (including Group items) **1... ....** Alphabetic **.1.. ....** Alphanumeric **..1. ....** Alphanumeric edited **...1 ....** Group contains its own ODO object **.... 1...** DBCS item **.... .1..** Group variable length **.... ..1.** EGCS item **.... ...1** EGCS edited

Table 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
		For both file types **1... ....** Object of ODO in record **.1.. ....** Subject of ODO in record **..1. ....** Sequential access **...1 ....** Random access **.... 1...** Dynamic access **.... .1..** Locate mode **.... ..1.** Record area **.... ...1** Reserved for future use Field will be zero for all other data types.
Data flags 3	XL1	For both file types **1... ....** All records are the same length **.1.. ....** Fixed length **..1. ....** Variable length **...1 ....** Undefined **.... 1...** Spanned **.... .1..** Blocked **.... ..1.** Apply write only **.... ...1** Same sort merge area Field will be zero for all other data types.

Table 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
File organization	XL1	For both file types **1... ....** QSAM **.1.. ....** ASCII **..1. ....** Standard label **...1 ....** User label **.... 1...** VSAM sequential **.... .1..** VSAM indexed **.... ..1.** VSAM relative **.... ...1** Line sequential Field will be zero for all other data types.
USAGE clause	FL1	**X'00'** USAGE IS DISPLAY **X'01'** USAGE IS COMP-1 **X'02'** USAGE IS COMP-2 **X'03'** USAGE IS PACKED-DECIMAL or USAGE IS COMP-3 **X'04'** USAGE IS BINARY, USAGE IS COMP, or USAGE IS COMP-4 **X'05'** USAGE IS DISPLAY-1 **X'06'** USAGE IS POINTER **X'07'** USAGE IS INDEX **X'08'** USAGE IS PROCEDURE-POINTER **X'09'** USAGE IS OBJECT-REFERENCE **X'0B'** NATIONAL **X'0A'** FUNCTION-POINTER
Sign clause	FL1	**X'00'** No SIGN clause **X'01'** SIGN IS LEADING **X'02'** SIGN IS LEADING SEPARATE CHARACTER **X'03'** SIGN IS TRAILING **X'04'** SIGN IS TRAILING SEPARATE CHARACTER
Indicators	FL1	**X'01'** Has JUSTIFIED clause. Right-justified attribute is in effect. **X'02'** Has BLANK WHEN ZERO clause.

Table 102. **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	For host: **01** Base Locator File **02** Base Locator Working-Storage **03** Base Locator Linkage Section **05** Base Locator Special regs **07** Indexed by variable **09** COMREG special reg **10** UPSI switch **13** Base Locator for Varloc items **14** Base Locator for Extern data **15** Base Locator Alphanumeric FUNC **16** Base Locator Alphanumeric EVAL **17** Base Locator for Object data **19** Base Locator for Local-Storage **20** Factory Data **21** XML-TEXT For Windows and AIX: **01** Base Locator File **02** Base Locator Linkage Section **03** Base Locator for Varloc items **04** Base Locator for Extern data **05** Base Locator for Object data **10** Base Locator Working-Storage **11** Base Locator Special regs **12** Base Locator Alphanumeric FUNC **13** Base Locator Alphanumeric EVAL **14** Indexed by variable **16** COMREG special reg **17** UPSI switch **22** Base Locator for Local-Storage

Table 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
Date format	FL1	Date format: **01** YY **02** YYXX **03** YYXXXX **04** YYXXX **05** YYYY **06** YYYYXX **07** YYYYXXXX **08** YYYYXXX **09** YYX **10** YYYYX **22** XXYY **23** XXXXYY **24** XXXYY **26** XXYYYY **27** XXXXYYYY **28** XXXYYYY **29** XYY **30** XYYYY
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 102. **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 Assignment name length for file 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. 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 External CLASS name length for CLASS-ID	HL2	Number of characters in the symbol value, zero if symbol has no initial value. Number of characters in the external CLASS name for CLASS-ID
ODO Symbol name ID for data-name ID of ASSIGN date name if file name	FL4	If data-name, ID of the ODO symbol name—zero if ODO not specified. 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 Assignment-name for file-name	CL(*n*)	The `PICTURE` character string *exactly* as the user types it in. The character string includes all symbols, parentheses, and replication factor. 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.
...Key Sequence	FL1	Ascending or Descending Indicator. **X'00'** `DESCENDING` **X'01'** `ASCENDING`

Table 102. **SYSADATA symbol record** *(continued)*

Field	Size	Description
...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(*n*)	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(*n*)	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(*n*)	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 103. **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 103. **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(*n*)	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

1. The reference flag field and the statement number field occur as many times as the number of references field dictates.

   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.

   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.

Nested program record - X'0046'

The following table shows the contents of the nested program record:

Table 104. **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 104. **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(*n*)	The program name

Library record - X'0060'

The following table shows the contents of the library record:

Table 105. **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(*n*)	The name of the library from which the COPY/INCLUDE member was retrieved
Library volume	CL(*n*)	The volume identification of the volume where the library resides
Library ddname	CL(*n*)	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(*n*)	The name of the COPY/BASIS member that has been used

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 106. **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(*n*)	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 107. **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(*n*)	The EVENTS data as previously presented in the SYSEVENT file

Appendix I. Run-time messages

Messages for COBOL for AIX contain a message prefix, message number, severity code, and descriptive text. The message prefix is always IWZ, followed by the message number. The severity code is either I (information), W (warning), S (severe), or C (critical). The message text provides a brief explanation of the condition.

In the following example message:

```
IWZ2519S  The seconds value in a CEEISEC call was not recognized.
```

- The message prefix is IWZ.
- The message number is 2519.
- The severity code is S.
- The message text is "The seconds value in a CEEISEC call was not recognized."

The date and time callable services messages also contain a symbolic feedback code, which represents the first 8 bytes of a 12-byte condition token. You can think of the symbolic feedback code as the nickname for a condition. Note that the callable services messages contain a four-digit message number.

To see a complete list at your terminal of the messages in the message catalog, issue the command:

```
dspcat cobol2run.cat
```

To see the content of only the message whose message number is *nnnn*, issue the command:

```
dspcat cobol2run.cat nnnn
```

When running your application from the command line, you can capture any run-time messages that were issued by redirecting stdout and stderr to a file. For example:

```
program-name program-arguments >combined-output-file 2>&1
```

The following example shows how to write the output to separate files:

```
program-name program-arguments >output-file 2>error-file
```

Table 108. **Run-time messages**

Message number	Message text
"IWZ006S" on page 642	The reference to table *table-name* by verb number *verb-number* on line *line-number* addressed an area outside the region of the table.
"IWZ007S" on page 643	The reference to variable-length group *group-name* by verb number *verb-number* on line *line-number* addressed an area outside the maximum defined length of the group.
"IWZ012I" on page 643	Invalid run unit termination occurred while sort or merge is running.
"IWZ013S" on page 643	Sort or merge requested while sort or merge is running in a different thread.

© Copyright IBM Corp. 1995, 2004

Table 108. **Run-time messages** *(continued)*

"IWZ026W" on page 644	The SORT-RETURN special register was never referenced, but the current content indicated the sort or merge operation in program *program-name* on line number *line-number* was unsuccessful. The sort or merge return code was *return code*.
"IWZ029S" on page 644	Argument-1 for function *function-name* in program *program-name* at line *line-number* was less than zero.
"IWZ030S" on page 644	Argument-2 for function *function-name* in program *program-name* at line *line-number* was not a positive integer.
"IWZ036W" on page 645	Truncation of high order digit positions occurred in program *program-name* on line number *line-number*.
"IWZ037I" on page 645	The flow of control in program *program-name* proceeded beyond the last line of the program. Control returned to the caller of the program *program-name*.
"IWZ038S" on page 645	A reference modification length value of *reference-modification-value* on line *line-number* which was not equal to 1 was found in a reference to data item *data-item*.
"IWZ039S" on page 645	An invalid overpunched sign was detected.
"IWZ040S" on page 646	An invalid separate sign was detected.
"IWZ045S" on page 646	Unable to invoke method *method-name* on line number *line number* in program *program-name*.
"IWZ047S" on page 647	Unable to invoke method *method-name* on line number *line number* in class *class-name*.
"IWZ048W" on page 647	A negative base was raised to a fractional power in an exponentiation expression. The absolute value of the base was used.
"IWZ049W" on page 647	A zero base was raised to a zero power in an exponentiation expression. The result was set to one.
"IWZ050S" on page 647	A zero base was raised to a negative power in an exponentiation expression.
"IWZ051W" on page 648	No significant digits remain in a fixed-point exponentiation operation in program *program-name* due to excessive decimal positions specified in the operands or receivers.
"IWZ053S" on page 648	An overflow occurred on conversion to floating point.
"IWZ054S" on page 648	A floating point exception occurred.
"IWZ055W" on page 648	An underflow occurred on conversion to floating point. The result was set to zero.
"IWZ058S" on page 649	Exponent overflow occurred.
"IWZ059W" on page 649	An exponent with more than nine digits was truncated.
"IWZ060W" on page 649	Truncation of high order digit positions occurred.
"IWZ061S" on page 649	Division by zero occurred.

Table 108. **Run-time messages** *(continued)*

"IWZ063S" on page 650	An invalid sign was detected in a numeric edited sending field in *program-name* on line number *line-number*.
"IWZ064S" on page 650	A recursive call to active program *program-name* in compilation unit *compilation-unit* was attempted.
"IWZ065I" on page 650	A CANCEL of active program *program-name* in compilation unit *compilation-unit* was attempted.
"IWZ066S" on page 651	The length of external data record *data-record* in program *program-name* did not match the existing length of the record.
"IWZ071S" on page 651	ALL subscripted table reference to table *table-name* by verb number *verb-number* on line *line-number* had an ALL subscript specified for an OCCURS DEPENDING ON dimension, and the object was less than or equal to 0.
"IWZ072S" on page 651	A reference modification start position value of *reference-modification-value* on line *line-number* referenced an area outside the region of data item *data-item*.
"IWZ073S" on page 651	A nonpositive reference modification length value of *reference-modification-value* on line *line-number* was found in a reference to data item *data-item*.
"IWZ074S" on page 652	A reference modification start position value of *reference-modification-value* and length value of *length* on line *line-number* caused reference to be made beyond the rightmost character of data item *data-item*.
"IWZ075S" on page 652	Inconsistencies were found in EXTERNAL file *file-name* in program *program-name*. The following file attributes did not match those of the established external file: *attribute-1 attribute-2 attribute-3 attribute-4 attribute-5 attribute-6 attribute-7*.
"IWZ076W" on page 652	The number of characters in the INSPECT REPLACING CHARACTERS BY data-name was not equal to one. The first character was used.
"IWZ077W" on page 653	The lengths of the INSPECT data items were not equal. The shorter length was used.
"IWZ078S" on page 653	ALL subscripted table reference to table *table-name* by verb number *verb-number* on line *line-number* will exceed the upper bound of the table.
"IWZ096C" on page 653	Dynamic call of program *program-name* failed. Message variants include: • A load of module *module-name* failed with an error code of *error-code*. • A load of module *module-name* failed with a return code of *return-code*. • Dynamic call of program *program-name* failed. Insufficient resources. • Dynamic call of program *program-name* failed. COBPATH not found in environment. • Dynamic call of program *program-name* failed. Entry *entry-name* not found. • Dynamic call failed. The name of the target program does not contain any valid characters. • Dynamic call of program *program-name* failed. The load module *load-module* could not be found in the directories identified in the COBPATH environment variable.

Table 108. **Run-time messages** *(continued)*

"IWZ097S" on page 654	Argument-1 for function *function-name* contained no digits.
"IWZ100S" on page 654	Argument-1 for function *function-name* was less than or equal to -1.
"IWZ103S" on page 654	Argument-1 for function *function-name* was less than zero or greater than 99.
"IWZ104S" on page 654	Argument-1 for function *function-name* was less than zero or greater than 99999.
"IWZ105S" on page 654	Argument-1 for function *function-name* was less than zero or greater than 999999.
"IWZ151S" on page 655	Argument-1 for function *function-name* contained more than 18 digits.
"IWZ152S" on page 655	Invalid character *character* was found in column *column-number* in argument-1 for function *function-name*.
"IWZ155S" on page 655	Invalid character *character* was found in column *column-number* in argument-2 for function *function-name*.
"IWZ156S" on page 655	Argument-1 for function *function-name* was less than zero or greater than 28.
"IWZ157S" on page 656	The length of Argument-1 for function *function-name* was not equal to 1.
"IWZ158S" on page 656	Argument-1 for function *function-name* was less than zero or greater than 29.
"IWZ159S" on page 656	Argument-1 for function *function-name* was less than 1 or greater than 3067671.
"IWZ160S" on page 656	Argument-1 for function *function-name* was less than 16010101 or greater than 99991231.
"IWZ161S" on page 656	Argument-1 for function *function-name* was less than 1601001 or greater than 9999365.
"IWZ162S" on page 657	Argument-1 for function *function-name* was less than 1 or greater than the number of positions in the program collating sequence.
"IWZ163S" on page 657	Argument-1 for function *function-name* was less than zero.
"IWZ165S" on page 657	A reference modification start position value of *start-position-value* on line *line number* referenced an area outside the region of the function result of *function-result*.
"IWZ166S" on page 657	A nonpositive reference modification length value of *length* on line *line-number* was found in a reference to the function result of *function-result*.
"IWZ167S" on page 657	A reference modification start position value of *start-position* and length value of *length* on line *line-number* caused reference to be made beyond the rightmost character of the function result of *function-result*.
"IWZ168W" on page 658	SYSPUNCH/SYSPCH will default to the system logical output device. The corresponding environment variable has not been set.
"IWZ170S" on page 658	Illegal data type for DISPLAY operand.
"IWZ171I" on page 658	*string-name* is not a valid run-time option.

Table 108. **Run-time messages** *(continued)*

"IWZ172I" on page 659	The string *string-name* is not a valid suboption of the run-time option *option-name*.
"IWZ173I" on page 659	The suboption string *string-name* of the run-time option *option-name* must be *number* characters long. The default will be used.
"IWZ174I" on page 659	The suboption string *string-name* of the run-time option *option-name* contains one or more invalid characters. The default will be used.
"IWZ175S" on page 659	There is no support for routine *routine-name* on this system.
"IWZ176S" on page 659	Argument-1 for function *function-name* was greater than *decimal-value*.
"IWZ177S" on page 660	Argument-2 for function *function-name* was equal to *decimal-value*.
"IWZ178S" on page 660	Argument-1 for function *function-name* was less than or equal to *decimal-value*.
"IWZ179S" on page 660	Argument-1 for function *function-name* was less than *decimal-value*.
"IWZ180S" on page 660	Argument-1 for function *function-name* was not an integer.
"IWZ181I" on page 660	An invalid character was found in the numeric string *string* of the run-time option *option-name*. The default will be used.
"IWZ182I" on page 661	The number *number* of the run-time option *option-name* exceeded the range of *min-range* to *max-range*. The default will be used.
"IWZ183S" on page 661	The function name in _IWZCOBOLInit did a return.
"IWZ200S" on page 661	Error detected during *I/O operation* for file *file-name*. File status is: *file-status*.
"IWZ200S" on page 661	STOP or ACCEPT failed with an I/O error, *error-code*. The run unit is terminated.
"IWZ201C" on page 662	
"IWZ203W" on page 662	The code page in effect is not a DBCS code page.
"IWZ204W" on page 663	An error occurred during conversion from ASCII DBCS to EBCDIC DBCS.
"IWZ221S" on page 663	ICU converter for code page, *codepage value,* can not be opened.
"IWZ222S" on page 663	Data conversion via ICU failed with error code *error code value*.
"IWZ223S" on page 663	Close of ICU converter failed with error code *error code value*.
"IWZ224S" on page 664	ICU collator for the locale value, *locale value*, can not be opened. The error code is *error code value*.
"IWZ225S" on page 664	Unicode case mapping function via ICU failed with error code *error code value*.
"IWZ230W" on page 664	The conversion table for the current codeset, *ASCII codeset-id*, to the EBCDIC codeset, *EBCDIC codeset-id*, is not available. The default ASCII to EBCDIC conversion table will be used.
"IWZ230W" on page 664	The EBCDIC code page specified, *EBCDIC codepage*, is not consistent with the locale *locale*, but will be used as requested.

Table 108. **Run-time messages** *(continued)*

"IWZ230W" on page 665	The EBCDIC code page specified, *EBCDIC codepage*, is not supported. The default EBCDIC code page, *EBCDIC codepage*, will be used.
"IWZ230S" on page 665	The EBCDIC conversion table cannot be opened.
"IWZ230S" on page 665	The EBCDIC conversion table cannot be built.
"IWZ230S" on page 665	The main program was compiled with both the `-host` flag and the `CHAR(NATIVE)` option, which are not compatible.
"IWZ231S" on page 666	Query of current locale setting failed.
"IWZ232W" on page 666	Message variants include: • An error occurred during the conversion of data item *data-name* to EBCDIC in program *program-name* on line number *decimal-value*. • An error occurred during the conversion of data item *data-name* to ASCII in program *program-name* on line number *decimal-value*. • An error occurred during the conversion to EBCDIC for data item *data-name* in program *program-name* on line number *decimal-value*. • An error occurred during the conversion to ASCII for data item *data-name* in program *program-name* on line number *decimal-value*. • An error occurred during the conversion from ASCII to EBCDIC in program *program-name* on line number *decimal-value*. • An error occurred during the conversion from EBCDIC to ASCII in program *program-name* on line number *decimal-value*.
"IWZ233S" on page 666	COBOL program *program-name* cannot be run because it was compiled with the `NOTHREAD` compiler option and linked with the multithreaded library.
"IWZ240S" on page 667	The base year for program *program-name* was outside the valid range of 1900 through 1999. The sliding window value *window-value* resulted in a base year of *base-year*.
"IWZ241S" on page 667	The current year was outside the 100-year window, *year-start* through *year-end*, for program *program-name*.
"IWZ242S" on page 667	There was an invalid attempt to start an XML PARSE statement.
"IWZ243S" on page 668	There was an invalid attempt to end an XML PARSE statement.
"IWZ250S" on page 668	Internal error: the call to JNI_GetCreatedJavaVMs returned an error, return code *nn*.
"IWZ251S" on page 668	Internal error: *n* active Java VMs were detected, when only 1 was expected.
"IWZ253S" on page 668	More than *nn* JVM initialization options was specified.
"IWZ254S" on page 669	Internal error: the call to JNI_CreateJavaVM returned an error.
"IWZ255S" on page 669	Internal error: the call to GetEnv returned code *nn* because the current thread is not attached to the JVM.
"IWZ256S" on page 669	Internal error: the call to GetEnv returned code *nn* because the JVM version is not supported.

Table 108. **Run-time messages** *(continued)*

"IWZ257S" on page 669	Internal error: the call to GetEnv returned the unrecognized return code *nn*.
"IWZ258S" on page 670	Internal error: GetByteArrayElements was unable to acquire a pointer to the instance data.
"IWZ259S" on page 670	Unable to acquire a direct pointer to the instance data. The installed JVM does not support pinned byte arrays.
"IWZ258S" on page 670	The Java class *name* could not be found.
"IWZ813S" on page 670	Insufficient storage was available to satisfy a get storage request.
"IWZ901S" on page 671	Message variants include: • Program exits due to severe or critical error. • Program exits: more than ERRCOUNT errors occurred.
"IWZ902S" on page 671	The system detected a decimal-divide exception.
"IWZ903S" on page 671	The system detected a data exception.
"IWZ907S" on page 671	Message variants include: • Insufficient storage. • Insufficient storage. Cannot get *number-bytes* bytes of space for *storage*.
"IWZ993W" on page 672	Insufficient storage. Cannot find space for message *message-number*.
"IWZ994W" on page 672	Cannot find message *message-number* in message-catalog.
"IWZ995C" on page 672	Message variants include: • *System exception* signal received while executing routine *routine-name* at offset 0x*offset-value*. • *System exception* signal received while executing code at location 0x*offset-value*. • *System exception* signal received. The location could not be determined.
"IWZ2502S" on page 672	The UTC/GMT was not available from the system.
"IWZ2503S" on page 673	The offset from UTC/GMT to local time was not available from the system.
"IWZ2505S" on page 673	The input_seconds value in a call to CEEDATM or CEESECI was not within the supported range.
"IWZ2506S" on page 673	An era (<JJJJ>, <CCCC>, or <CCCCCCCC>) was used in a picture string passed to CEEDATM, but the input number-of-seconds value was not within the supported range. The era could not be determined.
"IWZ2507S" on page 674	Insufficient data was passed to CEEDAYS or CEESECS. The Lilian value was not calculated.
"IWZ2508S" on page 674	The date value passed to CEEDAYS or CEESECS was invalid.
"IWZ2509S" on page 674	The era passed to CEEDAYS or CEESECS was not recognized.

Table 108. **Run-time messages** *(continued)*

"IWZ2510S" on page 674	The hours value in a call to CEEISEC or CEESECS was not recognized.
"IWZ2511S" on page 675	The day parameter passed in a CEEISEC call was invalid for year and month specified.
"IWZ2512S" on page 675	The Lilian date value passed in a call to CEEDATE or CEEDYWK was not within the supported range.
"IWZ2513S" on page 675	The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was not within the supported range.
"IWZ2514S" on page 676	The year value passed in a CEEISEC call was not within the supported range.
"IWZ2515S" on page 676	The milliseconds value in a CEEISEC call was not recognized.
"IWZ2516S" on page 676	The minutes value in a CEEISEC call was not recognized.
"IWZ2517S" on page 677	The month value in a CEEISEC call was not recognized.
"IWZ2518S" on page 677	An invalid picture string was specified in a call to a date/time service.
"IWZ2519S" on page 677	The seconds value in a CEEISEC call was not recognized.
"IWZ2520S" on page 677	CEEDAYS detected nonnumeric data in a numeric field, or the date string did not match the picture string.
"IWZ2521S" on page 678	The <JJJJ>, <CCCC>, or <CCCCCCCC> year-within-era value passed to CEEDAYS or CEESECS was zero.
"IWZ2522S" on page 678	An era (<JJJJ>, <CCCC>, or <CCCCCCCC>) was used in a picture string passed to CEEDATE, but the Lilian date value was not within the supported range. The era could not be determined.
"IWZ2525S" on page 678	CEESECS detected nonnumeric data in a numeric field, or the timestamp string did not match the picture string.
"IWZ2526S" on page 679	The date string returned by CEEDATE was truncated.
"IWZ2527S" on page 679	The timestamp string returned by CEEDATM was truncated.
"IWZ2531S" on page 679	The local time was not available from the system.
"IWZ2533S" on page 680	The value passed to CEESCEN was not between 0 and 100.
"IWZ2534W" on page 680	Insufficient field width was specified for a month or weekday name in a call to CEEDATE or CEEDATM. Output set to blanks.

IWZ006S

The reference to table *table-name* by verb number *verb-number* on line *line-number* addressed an area outside the region of the table.

Explanation: When the SSRANGE option is in effect, this message is issued to indicate that a fixed-length table has been subscripted in a way that exceeds the defined size of the table, or, for variable-length tables, the maximum size of the table.

The range check was performed on the composite of the subscripts and resulted in an address outside the region of the table. For variable-length tables, the address is outside the region of the table defined when all OCCURS DEPENDING ON objects are at their maximum values; the ODO object's current value is not considered. The check was not performed on individual subscripts.

Programmer response: Ensure that the value of literal subscripts and/or the value of variable subscripts as evaluated at run-time do not exceed the subscripted dimensions for subscripted data in the failing statement.

System action: The application was terminated.

IWZ007S

The reference to variable-length group *group-name* by verb number *verb-number* on line *line-number* addressed an area outside the maximum defined length of the group.

Explanation: When the SSRANGE option is in effect, this message is issued to indicate that a variable-length group generated by OCCURS DEPENDING ON has a length that is less than zero, or is greater than the limits defined in the OCCURS DEPENDING ON clauses.

The range check was performed on the composite length of the group, and not on the individual OCCURS DEPENDING ON objects.

Programmer response: Ensure that OCCURS DEPENDING ON objects as evaluated at run-time do not exceed the maximum number of occurrences of the dimension for tables within the referenced group item.

System action: The application was terminated.

IWZ012I

Invalid run unit termination occurred while sort or merge is running.

Explanation: A sort or merge initiated by a COBOL program was in progress and one of the following was attempted:

1. A STOP RUN was issued.
2. A GOBACK or an EXIT PROGRAM was issued within the input procedure or the output procedure of the COBOL program that initiated the sort or merge. Note that the GOBACK and EXIT PROGRAM statements are allowed in a program called by an input procedure or an output procedure.

Programmer response: Change the application so that it does not use one of the above methods to end the sort or merge.

System action: The application was terminated.

IWZ013S

Sort or merge requested while sort or merge is running in a different thread.

Explanation: Running sort or merge in two or more threads at the same time is not supported.

Programmer response: Always run sort or merge in the same thread. Alternatively, include code before each call to the sort or merge that determines if sort or merge is running in another thread. If sort or merge is running in another thread, then wait for that thread to finish. If it isn't, then set a flag to indicate sort or merge is running and call sort or merge.

System action: The thread is terminated.

IWZ026W

The SORT-RETURN special register was never referenced, but the current content indicated the sort or merge operation in program *program-name* on line number *line-number* was unsuccessful. The sort or merge return code was *return code*.

Explanation: The COBOL source does not contain any references to the sort-return register. The compiler generates a test after each sort or merge verb. A nonzero return code has been passed back to the program by Sort/Merge.

Programmer response: Determine why the Sort/Merge was unsuccessful and fix the problem. Possible return codes are:

```
501   Invalid function
502   Invalid record type
503   Invalid record length
504   Type length error
505   Invalid type
506   Mismatched number of keys
507   Type too long
508   Invalid key offset
509   Invalid scending
510   Invalid overlapping keys
511   No key defined
512   No input specified
513   No output specified
514   Mixed type input files
515   Mixed type output files
516   Invalid input work buffer
517   Invalid output work buffer
518   COBOL input ioerr
519   COBOL output ioerr
520   Unsupported function
521   Invalid key
522   Invalid using file
523   Invalid giving file
524   No work directory supplied
525   Work directory nonexist
526   Sortcommon not allocated
527   No storage for sortcommon
528   Binary buffer not allocated
529   LS buffer not allocated
530   Work space allocation failed
531   FCB allocation failed
```

System action: No system action was taken.

IWZ029S

Argument-1 for function *function-name* in program *program-name* at line *line-number* was less than zero.

Explanation: An illegal value for argument-1 was used.

Programmer response: Ensure that argument-1 is greater than or equal to zero.

System action: The application was terminated.

IWZ030S

Argument-2 for function *function-name* in program *program-name* at line *line-number* was not a positive integer.

Explanation: An illegal value for argument-1 was used.

Programmer response: Ensure that argument-2 is a positive integer.

System action: The application was terminated.

IWZ036W

Truncation of high order digit positions occurred in program *program-name* on line number *line-number*.

Explanation: The generated code has truncated an intermediate result (that is, temporary storage used during an arithmetic calculation) to 30 digits; some of the truncated digits were not 0.

Programmer response: See the related concepts below for a description of intermediate results.

System action: No system action was taken.

IWZ037I

The flow of control in program *program-name* proceeded beyond the last line of the program. Control returned to the caller of the program *program-name*.

Explanation: The program did not have a terminator (STOP, GOBACK, or EXIT), and control fell through the last instruction.

Programmer response: Check the logic of the program. Sometimes this error occurs because of one of the following logic errors:

- The last paragraph in the program was only supposed to receive control as the result of a PERFORM statement, but due to a logic error it was branched to by a GO TO statement.
- The last paragraph in the program was executed as the result of a "fall-through" path, and there was no statement at the end of the paragraph to end the program.

System action: The application was terminated.

IWZ038S

A reference modification length value of *reference-modification-value* on line *line-number* which was not equal to 1 was found in a reference to data item *data-item*.

Explanation: The length value in a reference modification specification was not equal to 1. The length value must be equal to 1.

Programmer response: Check the indicated line number in the program to ensure that any reference modified length values are (or will resolve to) 1.

System action: The application was terminated.

IWZ039S

An invalid overpunched sign was detected.

Explanation: The value in the sign position was not valid.

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:	0, 1, 2, 3, 8, 9, A, and B
Negative:	4, 5, 6, 7, C, D, E, and F

Signs generated internally are 3 for positive and unsigned, and 7 for negative.

Given X'*ds*', where *d* represents the digit and *s* is the sign representation, the valid sign representations for internal decimal (`USAGE PACKED-DECIMAL`) COBOL data are:

Positive:	A, C, E, and F
Negative:	B and D

Signs generated internally are `C` for positive and unsigned, and `D` for negative.

Programmer response: This error might have occurred because of a REDEFINES clause involving the sign position or a group move involving the sign position, or the position was never initialized. Check for the above cases.

System action: The application was terminated.

IWZ040S

An invalid separate sign was detected.

Explanation: An operation was attempted on data defined with a separate sign. The value in the sign position was not a plus (+) or a minus (-).

Programmer response: This error might have occurred because of a REDEFINES clause involving the sign position or a group move involving the sign position, or the position was never initialized. Check for the above cases.

System action: The application was terminated.

IWZ045S

Unable to invoke method *method-name* on line number *line number* in program *program-name*.

Explanation: The specific method is not supported for the class of the current object reference.

Programmer response: Check the indicated line number in the program to ensure that the class of the current object reference supports the method being invoked.

System action: The application was terminated.

IWZ047S

Unable to invoke method *method-name* on line number *line number* in class *class-name*.

Explanation: The specific method is not supported for the class of the current object reference.

Programmer response: Check the indicated line number in the class to ensure that the class of the current object reference supports the method being invoked.

System action: The application was terminated.

IWZ048W

A negative base was raised to a fractional power in an exponentiation expression. The absolute value of the base was used.

Explanation: A negative number raised to a fractional power occurred in a library routine.

The value of a negative number raised to a fractional power is undefined in COBOL. If a SIZE ERROR clause had appeared on the statement in question, the SIZE ERROR imperative would have been used. However, no SIZE ERROR clause was present, so the absolute value of the base was used in the exponentiation.

Programmer response: Ensure that the program variables in the failing statement have been set correctly.

System action: No system action was taken.

IWZ049W

A zero base was raised to a zero power in an exponentiation expression. The result was set to one.

Explanation: The value of zero raised to the power zero occurred in a library routine.

The value of zero raised to the power zero is undefined in COBOL. If a SIZE ERROR clause had appeared on the statement in question, the SIZE ERROR imperative would have been used. However, no SIZE ERROR clause was present, so the value returned was one.

Programmer response: Ensure that the program variables in the failing statement have been set correctly.

System action: No system action was taken.

IWZ050S

A zero base was raised to a negative power in an exponentiation expression.

Explanation: The value of zero raised to a negative power occurred in a library routine.

The value of zero raised to a negative number is not defined. If a SIZE ERROR clause had appeared on the statement in question, the SIZE ERROR imperative would have been used. However, no SIZE ERROR clause was present.

Programmer response: Ensure that the program variables in the failing statement have been set correctly.

System action: The application was terminated.

IWZ051W

No significant digits remain in a fixed-point exponentiation operation in program *program-name* due to excessive decimal positions specified in the operands or receivers.

Explanation: A fixed-point calculation produced a result that had no significant digits because the operands or receiver had too many decimal positions.

Programmer response: Modify the `PICTURE` clauses of the operands or the receiving numeric item as needed to have additional integer positions and fewer decimal positions.

System action: No system action was taken.

IWZ053S

An overflow occurred on conversion to floating point.

Explanation: A number was generated in the program that is too large to be represented in floating point.

Programmer response: You need to modify the program appropriately to avoid an overflow.

System action: The application was terminated.

IWZ054S

A floating point exception occurred.

Explanation: A floating-point calculation has produced an illegal result. Floating point calculations are done using IEEE floating point arithmetic, which can produce results called NaN (Not a Number). For example, the result of 0 divided by 0 is NaN.

Programmer response: Modify the program to test the arguments to this operation so that NaN is not produced.

System action: The application was terminated.

IWZ055W

An underflow occurred on conversion to floating point. The result was set to zero.

Explanation: On conversion to floating point, the negative exponent exceeded the limit of the hardware. The floating point value was set to zero.

Programmer response: No action is necessary, although you may want to modify the program to avoid an underflow.

System action: No system action was taken.

IWZ058S

Exponent overflow occurred.

Explanation: Floating point exponent overflow occurred in a library routine.

Programmer response: Ensure that the program variables in the failing statement have been set correctly.

System action: The application was terminated.

IWZ059W

An exponent with more than nine digits was truncated.

Explanation: Exponents in fixed point exponentiations may not contain more than nine digits. The exponent was truncated back to nine digits; some of the truncated digits were not 0.

Programmer response: No action is necessary, although you may want to adjust the exponent in the failing statement.

System action: No system action was taken.

IWZ060W

Truncation of high-order digit positions occurred.

Explanation: Code in a library routine has truncated an intermediate result (that is, temporary storage used during an arithmetic calculation) back to 30 digits; some of the truncated digits were not 0.

Programmer response: See the related concepts below for a description of intermediate results.

System action: No system action was taken.

IWZ061S

Division by zero occurred.

Explanation: Division by zero occurred in a library routine. Division by zero is not defined. If a SIZE ERROR clause had appeared on the statement in question, the SIZE ERROR imperative would have been used. However, no SIZE ERROR clause was present.

Programmer response: Ensure that the program variables in the failing statement have been set correctly.

System action: The application was terminated.

IWZ063S

An invalid sign was detected in a numeric edited sending field in *program-name* on line number *line-number*.

Explanation: An attempt has been made to move a signed numeric edited field to a signed numeric or numeric edited receiving field in a MOVE statement. However, the sign position in the sending field contained a character that was not a valid sign character for the corresponding PICTURE.

Programmer response: Ensure that the program variables in the failing statement have been set correctly.

System action: The application was terminated.

IWZ064S

A recursive call to active program *program-name* in compilation unit *compilation-unit* was attempted.

Explanation: COBOL does not allow reinvocation of an internal program which has begun execution, but has not yet terminated. For example, if internal programs A and B are siblings of a containing program, and A calls B and B calls A, this message will be issued.

Programmer response: Examine your program to eliminate calls to active internal programs.

System action: The application was terminated.

IWZ065I

A CANCEL of active program *program-name* in compilation unit *compilation-unit* was attempted.

Explanation: An attempt was made to cancel an active internal program. For example, if internal programs A and B are siblings in a containing program and A calls B and B cancels A, this message will be issued.

Programmer response: Examine your program to eliminate cancellation of active internal programs.

System action: The application was terminated.

IWZ066S

The length of external data record *data-record* in program *program-name* did not match the existing length of the record.

Explanation: While processing External data records during program initialization, it was determined that an External data record was previously defined in another program in the run-unit, and the length of the record as specified in the current program was not the same as the previously defined length.

Programmer response: Examine the current file and ensure the External data records are specified correctly.

System action: The application was terminated.

IWZ071S

ALL subscripted table reference to table *table-name* by verb number *verb-number* on line *line-number* had an ALL subscript specified for an OCCURS DEPENDING ON dimension, and the object was less than or equal to 0.

Explanation: When the SSRANGE option is in effect, this message is issued to indicate that there are 0 occurrences of dimension subscripted by ALL.

The check is performed against the current value of the OCCURS DEPENDING ON object.

Programmer response: Ensure that ODO objects of ALL-subscripted dimensions of any subscripted items in the indicated statement are positive.

System action: The application was terminated.

IWZ072S

A reference modification start position value of *reference-modification-value* on line *line-number* referenced an area outside the region of data item *data-item*.

Explanation: The value of the starting position in a reference modification specification was less than 1, or was greater than the current length of the data item that was being reference modified. The starting position value must be a positive integer less than or equal to the number of characters in the reference modified data item.

Programmer response: Check the value of the starting position in the reference modification specification.

System action: The application was terminated.

IWZ073S

A nonpositive reference modification length value of *reference-modification-value* on line *line-number* was found in a reference to data item *data-item*.

Explanation: The length value in a reference modification specification was less than or equal to 0. The length value must be a positive integer.

Programmer response: Check the indicated line number in the program to ensure that any reference modified length values are (or will resolve to) positive integers.

System action: The application was terminated.

IWZ074S

A reference modification start position value of *reference-modification-value* and length value of *length* on line *line-number* caused reference to be made beyond the rightmost character of data item *data-item*.

Explanation: The starting position and length value in a reference modification specification combine to address an area beyond the end of the reference modified data item. The sum of the starting position and length value minus one must be less than or equal to the number of characters in the reference modified data item.

Programmer response: Check the indicated line number in the program to ensure that any reference modified start and length values are set such that a reference is not made beyond the rightmost character of the data item.

System action: The application was terminated.

IWZ075S

Inconsistencies were found in EXTERNAL file *file-name* in program *program-name*. The following file attributes did not match those of the established external file: *attribute-1 attribute-2 attribute-3 attribute-4 attribute-5 attribute-6 attribute-7*.

Explanation: One or more attributes of an external file did not match between two programs that defined it.

Programmer response: Correct the external file. For a summary of file attributes which must match between definitions of the same external file.

System Action: The application was terminated.

IWZ076W

The number of characters in the INSPECT REPLACING CHARACTERS BY data-name was not equal to one. The first character was used.

Explanation: A data item which appears in a `CHARACTERS` phrase within a `REPLACING` phrase in an `INSPECT` statement must be defined as being one character in length. Because of a reference modification specification for this data item, the resultant length value was not equal to one. The length value is assumed to be one.

Programmer response: You may correct the reference modification specifications in the failing `INSPECT` statement to ensure that the reference modification length is (or will resolve to) 1; programmer action is not required.

System action: No system action was taken.

IWZ077W

The lengths of the INSPECT data items were not equal. The shorter length was used.

Explanation: The two data items which appear in a `REPLACING` or `CONVERTING` phrase in an `INSPECT` statement must have equal lengths, except when the second such item is a figurative constant. Because of the reference modification for one or both of these data items, the resultant length values were not equal. The shorter length value is applied to both items, and execution proceeds.

Programmer response: You may adjust the operands of unequal length in the failing `INSPECT` statement; programmer action is not required.

System action: No system action was taken.

IWZ078S

ALL subscripted table reference to table *table-name* by verb number *verb-number* on line *line-number* will exceed the upper bound of the table.

Explanation: When the `SSRANGE` option is in effect, this message is issued to indicate that a multidimensional table with ALL specified as one or more of the subscripts will result in a reference beyond the upper limit of the table.

The range check was performed on the composite of the subscripts and the maximum occurrences for the ALL subscripted dimensions. For variable-length tables the address is outside the region of the table defined when all OCCURS DEPENDING ON objects are at their maximum values; the ODO object's current value is not considered. The check was not performed on individual subscripts.

Programmer response: Ensure that OCCURS DEPENDING ON objects as evaluated at run-time do not exceed the maximum number of occurrences of the dimension for table items referenced in the failing statement.

System action: The application was terminated.

IWZ096C

Dynamic call of program *program-name* failed. Message variants include: • **A load of module *module-name* failed with an error code of *error-code*.** • **A load of module *module-name* failed with a return code of *return-code*.** • **Dynamic call of program *program-name* failed. Insufficient resources.** • **Dynamic call of program *program-name* failed. COBPATH not found in environment.** • **Dynamic call of program *program-name* failed. Entry *entry-name* not found.** • **Dynamic call failed. The name of the target program does not contain any valid characters.** • **Dynamic call of program *program-name* failed. The load module *load-module* could not be found in the directories identified in the COBPATH environment variable.**

Explanation: A dynamic call failed due to one of the reasons listed in the message variants above. In the above, the value of *error-code* is the errno set by `load`.

Programmer response: Check that COBPATH is defined. Check that the module exists: AIX has graphical interfaces for showing directories and files. You can also use the `ls` command. Check that the name of the module to be loaded matches the name of the entry called. Check that the module to be loaded is built correctly using the appropriate `cob2` options.

System action: The application was terminated.

IWZ097S

Argument-1 for function *function-name* contained no digits.

Explanation: Argument-1 for the indicated function must contain at least 1 digit.

Programmer response: Adjust the number of digits in Argument-1 in the failing statement.

System action: The application was terminated.

IWZ100S

Argument-1 for function *function* was less than or equal to -1.

Explanation: An illegal value was used for Argument-1.

Programmer response: Ensure that argument-1 is greater than -1.

System action: The application was terminated.

IWZ103S

Argument-1 for function *function-name* was less than zero or greater than 99.

Explanation: An illegal value was used for Argument-1.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ104S

Argument-1 for function *function-name* was less than zero or greater than 99999.

Explanation: An illegal value was used for Argument-1.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ105S

Argument-1 for function *function-name* was less than zero or greater than 999999.

Explanation: An illegal value was used for Argument-1.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ151S

Argument-1 for function *function-name* contained more than 18 digits.

Explanation: The total number of digits in Argument-1 of the indicated function exceeded 18 digits.

Programmer response: Adjust the number of digits in Argument-1 in the failing statement.

System action: The application was terminated.

IWZ152S

Invalid character *character* was found in column *column-number* in argument-1 for function *function-name* .

Explanation: A nondigit character other than a decimal point, comma, space or sign (+,-,CR,DB) was found in argument-1 for NUMVAL/NUMVAL-C function.

Programmer response: Correct argument-1 for NUMVAL or NUMVAL-C in the indicated statement.

System action: The application was terminated.

IWZ155S

Invalid character *character* was found in column *column-number* in argument-2 for function *function-name* .

Explanation: Illegal character was found in argument-2 for NUMVAL-C function.

Programmer response: Check that the function argument does follow the syntax rules.

System action: The application was terminated.

IWZ156S

Argument-1 for function *function-name* was less than zero or greater than 28.

Explanation: Input argument to function FACTORIAL is greater than 28 or less than 0.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ157S

The length of Argument-1 for function *function-name* was not equal to 1.

Explanation: The length of input argument to ORD function is not 1.

Programmer response: Check that the function argument is only 1 byte long.

System action: The application was terminated.

IWZ158S

Argument-1 for function *function-name* was less than zero or greater than 29.

Explanation: Input argument to function FACTORIAL is greater than 29 or less than 0.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ159S

Argument-1 for function *function-name* was less than 1 or greater than 3067671.

Explanation: The input argument to DATE-OF-INTEGER or DAY-OF-INTEGER function is less than 1 or greater than 3067671.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ160S

Argument-1 for function *function-name* was less than 16010101 or greater than 99991231.

Explanation: The input argument to function INTEGER-OF-DATE is less than 16010101 or greater than 99991231.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ161S

Argument-1 for function *function-name* was less than 1601001 or greater than 9999365.

Explanation: The input argument to function INTEGER-OF-DAY is less than 1601001 or greater than 9999365.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ162S

Argument-1 for function *function-name* was less than 1 or greater than the number of positions in the program collating sequence.

Explanation: The input argument to function CHAR is less than 1 or greater than the highest ordinal position in the program collating sequence.

Programmer response: Check that the function argument is in the valid range.

System action: The application was terminated.

IWZ163S

Argument-1 for function *function-name* was less than zero.

Explanation: The input argument to function RANDOM is less than 0.

Programmer response: Correct the argument for function RANDOM in the failing statement.

System action: The application was terminated.

IWZ165S

A reference modification start position value of *start-position-value* on line *line number* referenced an area outside the region of the function result of *function-result*.

Explanation: The value of the starting position in a reference modification specification was less than 1, or was greater than the current length of the function result that was being reference modified. The starting position value must be a positive integer less than or equal to the number of characters in the reference modified function result.

Programmer response: Check the value of the starting position in the reference modification specification and the length of the actual function result.

System action: The application was terminated.

IWZ166S

A nonpositive reference modification length value of *length* on line *line-number* was found in a reference to the function result of *function-result*.

Explanation: The length value in a reference modification specification for a function result was less than or equal to 0. The length value must be a positive integer.

Programmer response: Check the length value and make appropriate correction.

System action: The application was terminated.

IWZ167S

A reference modification start position value of *start-position* and length value of *length* on line *line-number* caused reference to be made beyond the rightmost character of the function result of *function-result*.

Explanation: The starting position and length value in a reference modification specification combine to address an area beyond the end of the reference modified function result. The sum of the starting position and length value minus one must be less than or equal to the number of characters in the reference modified function result.

Programmer response: Check the length of the reference modification specification against the actual length of the function result and make appropriate corrections.

System action: The application was terminated.

IWZ168W

SYSPUNCH/SYSPCH will default to the system logical output device. The corresponding environment variable has not been set.

Explanation: COBOL environment names (such as SYSPUNCH/SYSPCH) are used as the environment variable names corresponding to the mnemonic names used on ACCEPT and DISPLAY statements. Set them equal to files, not existing directory names. To set environment variables, use the `export` command.

You can set environment variables either persistently or temporarily.

Programmer response: If you do not want SYSPUNCH/SYSPCH to default to the screen, set the corresponding environment variable.

System action: No system action was taken.

IWZ170S

Illegal data type for DISPLAY operand.

Explanation: An invalid data type was specified as the target of the DISPLAY statement.

Programmer response: Specify a valid data type. The following data types are **not** valid:

- Data items defined with `USAGE IS PROCEDURE-POINTER`
- Data items defined with `USAGE IS OBJECT REFERENCE`
- Data items or index names defined with `USAGE IS INDEX`

System action: The application was terminated.

IWZ171I

***string-name* is not a valid run-time option.**

Explanation: *string-name* is not a valid option.

Programmer response: "CHECK" on page 249, "DEBUG" on page 250, "ERRCOUNT" on page 250, "FILESYS" on page 250, "TRAP" on page 251, and "UPSI" on page 252 are valid run-time options.

System action: *string-name* is ignored.

IWZ172I

The string *string-name* is not a valid suboption of the run-time option *option-name*.

Explanation: *string-name* was not in the set of recognized values.

Programmer response: Remove the invalid suboption *string* from the run-time option *option-name*.

System action: The invalid suboption is ignored.

IWZ173I

The suboption string *string-name* of the run-time option *option-name* must be *number of* characters long. The default will be used.

Explanation: The number of characters for the suboption string *string-name* of run-time option *option-name* is invalid.

Programmer response: If you do not want to accept the default, specify a valid character length.

System action: The default value will be used.

IWZ174I

The suboption string *string-name* of the run-time option *option-name* contains one or more invalid characters. The default will be used.

Explanation: At least one invalid character was detected in the specified suboption.

Programmer response: If you do not want to accept the default, specify valid characters.

System action: The default value will be used.

IWZ175S

There is no support for routine *routine-name* on this system.

Explanation: *routine-name* is not supported.

Programmer response:

System action: The application was terminated.

IWZ176S

Argument-1 for function *function-name* was greater than *decimal-value*.

Explanation: An illegal value for argument-1 was used.

Programmer response: Ensure argument-1 is less than or equal to *decimal-value*.

System action: The application was terminated.

IWZ177S

Argument-2 for function *function-name* was equal to *decimal-value*.

Explanation: An illegal value for argument-2 was used.

Programmer response: Ensure argument-1 is not equal to *decimal-value*.

System action: The application was terminated.

IWZ178S

Argument-1 for function *function-name* was less than or equal to *decimal-value*.

Explanation: An illegal value for Argument-1 was used.

Programmer response: Ensure that Argument-1 is greater than *decimal-value*.

System action: The application was terminated.

IWZ179S

Argument-1 for function *function-name* was less than *decimal-value*.

Explanation: An illegal value for Argument-1 was used.

Programmer response: Ensure that Argument-1 is equal to or greater than *decimal-value*.

System action: The application was terminated.

IWZ180S

Argument-1 for function *function-name* was not an integer.

Explanation: An illegal value for Argument-1 was used.

Programmer response: Ensure that Argument-1 is an integer.

System action: The application was terminated.

IWZ181I

An invalid character was found in the numeric string *string* of the run-time option *option-name*. The default will be used.

Explanation: *string* did not contain all decimal numeric characters.

Programmer response: If you do not want the default value, correct the run-time option's string to contain all numeric characters.

System action: The default will be used.

IWZ182I

The number *number* of the run-time option *option-name* exceeded the range of *min-range* to *max-range*. The default will be used.

Explanation: *number* exceeded the range of *min-range* to *max-range*.

Programmer response: Correct the run-time option's string to be within the valid range.

System action: The default will be used.

IWZ183S

The function name in _iwzCOBOLInit did a return.

Explanation: The run unit termination exit routine returned to the function that invoked the routine (the function specified in `function_code`).

Programmer response: Rewrite the function so that the run unit termination exit routine does a longjump or exit instead of return to the function.

System action: The application was terminated.

IWZ200S

Error detected during *I/O operation* for file *file-name*. File status is: *file-status*.

Explanation: An error was detected during a file I/O operation. No file status was specified for the file and no applicable error declarative is in effect for the file.

Programmer response: Correct the condition described in this message. You can specify the FILE STATUS clause for the file if you want to detect the error and take appropriate actions within your source program.

System action: The application was terminated.

IWZ200S

STOP or ACCEPT failed with an I/O error, *error-code*. The run unit is terminated.

Explanation: A STOP or ACCEPT statement failed.

Programmer response: Check that the STOP or ACCEPT refers to a legitimate file or terminal device.

System action: The application was terminated.

IWZ201C

Message variants include:
Access Intent List Error.
Concurrent Opens Exceeds Maximum.
Cursor Not Selecting a Record Position.
Data Stream Syntax Error.
Duplicate Key Different Index.
Duplicate Key Same Index.
Duplicate Record Number.
File Temporarily Not Available.
File system cannot be found.
File Space Not Available.
File Closed with Damage.
Invalid Key Definition.
Invalid Base File Name.
Key Update Not Allowed by Different Index.
Key Update Not Allowed by Same Index.
No Update Intent on Record.
Not Authorized to Use Access Method.
Not Authorized to Directory.
Not Authorized to Function.
Not authorized to File.
Parameter Value Not Supported.
Parameter Not Supported.
Record Number Out of Bounds.
Record Length Mismatch.
Resource Limits Reached in Target System.
Resource Limits Reached in Source System.
Address Error.
Command Check.
Duplicate File Name.
End of File Condition.
Existing Condition.
File Handle Not Found.
Field Length Error.
File Not Found.
File Damaged.
File is Full.
File In Use.
Function Not Supported.
Invalid Access Method.
Invalid Data Record.
Invalid Key Length.
Invalid File Name.
Invalid Request.
Invalid Flag.
Object Not Supported.
Record Not Available.
Record Not Found.
Record Inactive.
Record Damaged.
Record In Use.
Update Cursor Error.

Explanation: An error was detected during a file I/O operation for a VSAM file. No file status was specified for the file and no applicable error declarative is in effect for the file.

Programmer response: Correct the condition described in this message. For details, see the *VSAM in a Distributed Environment* for AIX.

System action: The application was terminated.

IWZ203W

The code page in effect is not a DBCS code page.

Explanation: References to DBCS data were made with a non-DBCS code page in effect.

Programmer response: For DBCS data, specify a valid DBCS code page. Valid DBCS code pages are:

Country	**Code page**
Japan	IBM-932
Korea	IBM-1363
China (Simplified - Mainland)	IBM-1386

Country	Code page
China (Traditional - Region of Taiwan)	

Note: The code pages listed above might not be supported for a specific version or release of that platform.

System Action: No system action was taken.

IWZ204W

An error occurred during conversion from ASCII DBCS to EBCDIC DBCS.

Explanation: A Kanji or DBCS class test failed due to an error detected during the ASCII character string EBCDIC string conversion.

Programmer response: Verify that the locale in effect is consistent with the ASCII character string being tested. No action is likely to be required if the locale setting is correct. The class test is likely to indicate the string to be non-Kanji or non-DBCS correctly.

System action: No system action was taken.

IWZ221S

The ICU converter for the code page, *codepage value*, can not be opened. The error code is *error code value*.

Explanation: The ICU converter to convert between the code page and UTF-16 cannot be opened.

Programmer response: Verify that the code-page value is valid according to Code page names (*COBOL for AIX Language Reference*). If the code-page value is valid, contact your IBM representative.

System action: The application was terminated.

IWZ222S

Data conversion via ICU failed with error code *error code value*.

Explanation: The data conversion through ICU failed.

Programmer response: Contact your IBM representative.

System action: The application was terminated.

IWZ223S

Close of ICU converter failed with error code *error code value*.

Explanation: The close of an ICU converter failed.

Programmer response: Contact your IBM representative.

System action: The application was terminated.

IWZ224S

ICU collator for the locale value, *locale value*, can not be opened. The error code is *error code value*.

Explanation: The ICU collator for the locale cannot be opened.

Programmer response: Contact your IBM representative.

System action: The application was terminated.

IWZ225S

Unicode case mapping function via ICU failed with error code *error code value*.

Explanation: The ICU case mapping function failed.

Programmer response: Contact your IBM representative.

System action: The application was terminated.

IWZ230W

The conversion table for the current code set, *ASCII codeset-id*, to the EBCDIC code set, *EBCDIC codeset-id*, is not available. The default ASCII to EBCDIC conversion table will be used.

Explanation: The application has a module that was compiled with the `CHAR(EBCDIC)` compiler option. At run-time a translation table will be built to handle the conversion from the current ASCII code page to an EBCDIC code page specified by the EBCDIC_CODEPAGE environment variable. This error occurred because either a conversion table is not available for the specified code pages, or the specification of the EBCDIC_CODE page is invalid. Execution will continue with a default conversion table based on ASCII code page IBM-1252 and EBCDIC code page IBM-037.

Programmer response: Verify that the EBCDIC_CODEPAGE environment variable has a valid value.

If EBCDIC_CODEPAGE is not set, the default value, IBM-037, will be used. This is the default code page used by Enterprise COBOL for z/OS.

System action: No system action was taken.

IWZ230W

The EBCDIC code page specified, *EBCDIC codepage*, is not consistent with the locale *locale*, but will be used as requested.

Explanation: The application has a module that was compiled with the `CHAR(EBCDIC)` compiler option. This error occurred because the code page specified is not the same language as the current locale.

Programmer response: Verify that the EBCDIC_CODEPAGE environment variable is valid for this locale.

System action: No system action was taken.

IWZ230W

The EBCDIC code page specified, *EBCDIC codepage*, is not supported. The default EBCDIC code page, *EBCDIC codepage*, will be used.

Explanation: The application has a module that was compiled with the `CHAR(EBCDIC)` compiler option. This error occurred because the specification of the EBCDIC_CODEPAGE environment variable is invalid. Execution will continue with the default host code page that corresponds to the current locale.

Programmer response: Verify that the EBCDIC_CODEPAGE environment variable has a valid value.

System action: No system action was taken.

IWZ230S

The EBCDIC conversion table cannot be opened.

Explanation: The current system installation does not include the translation table for the default ASCII and EBCDIC code pages.

Programmer response: Reinstall the compiler and run time. If the problem still persists, call your IBM representative.

System action: The application was terminated.

IWZ230S

The EBCDIC conversion table cannot be built.

Explanation: The ASCII to EBCDIC conversion table has been opened, but the conversion failed.

Programmer response: Retry the execution from a new window.

System action: The application was terminated.

IWZ230S

The main program was compiled with both the `-host` flag and the `CHAR(NATIVE)` option, which are not compatible.

Explanation: Compilation with both the `-host` flag and the `CHAR(NATIVE)` option is not supported.

Programmer response: Either remove the `-host` flag, or remove the `CHAR(NATIVE)` option. The `-host` flag sets `CHAR(EBCDIC)`.

System action: The application was terminated.

IWZ231S

Query of current locale setting failed.

Explanation: A query of the execution environment failed to identify a valid locale setting. The current locale needs to be established to access appropriate message files and set the collating order. It is also used by the date/time services and for EBCDIC character support.

Programmer response: Check the settings for the following environment variable:

LANG
This should be set to a locale that has been installed on your machine. Enter `locale -a` to get a list of the valid values. The default value is en_US.

System action: The application was terminated.

IWZ232W

Message variants include:

- **An error occurred during the conversion of data item *data-name* to EBCDIC in program *program-name* on line number *decimal-value*.**
- **An error occurred during the conversion of data item *data-name* to ASCII in program *program-name* on line number *decimal-value*.**
- **An error occurred during the conversion to EBCDIC for data item *data-name* in program *program-name* on line number *decimal-value*.**
- **An error occurred during the conversion to ASCII for data item *data-name* in program *program-name* on line number *decimal-value*.**
- **An error occurred during the conversion from ASCII to EBCDIC in program *program-name* on line number *decimal-value*.**
- **An error occurred during the conversion from EBCDIC to ASCII in program *program-name* on line number *decimal-value*.**

Explanation: The data in an identifier could not be converted between ASCII and EBCDIC formats as requested by the `CHAR(EBCDIC)` compiler option.

Programmer response: Check that the appropriate ASCII and EBCDIC locales are installed and selected. Check that the data in the identifier is valid and can be represented in both ASCII and EBCDIC format.

System action: No system action was taken. The data remains in its unconverted form.

IWZ233S

COBOL program *program-name* cannot be run because it was compiled with the NOTHREAD compiler option and linked with the multithreaded library.

Explanation: Non-CICS programs must be compiled with the THREAD compiler option if they are linked with the multithreaded library.

Programmer response: Compile the program with the THREAD compiler option, or use cob2 (rather than cob2_r, cob2_j or cob2_r4) to link it with the static library.

System action: The application was terminated.

IWZ240S

The base year for program *program-name* was outside the valid range of 1900 through 1999. The sliding window value *window-value* resulted in a base year of *base-year*.

Explanation: When the 100-year window was computed using the current year and the sliding window value specified with the YEARWINDOW compiler option, the base year of the 100-year window was outside the valid range of 1900 through 1999.

Programmer response: Examine the application design to determine if it will support a change to the YEARWINDOW option value. If the application can run with a change to the YEARWINDOW option value, then compile the program with an appropriate YEARWINDOW option value. If the application cannot run with a change to the YEARWINDOW option value, then convert all date fields to expanded dates and compile the program with NODATEPROC.

System action: The application was terminated.

IWZ241S

The current year was outside the 100-year window, *year-start* through *year-end*, for program *program-name*.

Explanation: The current year was outside the 100-year fixed window specified by the YEARWINDOW compiler option value.

For example, if a COBOL program is compiled with YEARWINDOW(1920), the 100-year window for the program is 1920 through 2019. When the program is run in the year 2020, this error message would occur since the current year is not within the 100-year window.

Programmer response: Examine the application design to determine if it will support a change to the YEARWINDOW option value. If the application can run with a change to the YEARWINDOW option value, then compile the program with an appropriate YEARWINDOW option value. If the application cannot run with a change to the YEARWINDOW option value, then convert all date fields to expanded dates and compile the program with NODATEPROC.

System action: The application was terminated.

IWZ242S

There was an invalid attempt to start an XML PARSE statement.

Explanation: An XML PARSE statement initiated by a COBOL program was already in progress when another XML PARSE statement was attempted by the same COBOL program. Only one XML PARSE statement can be active in a given invocation of a COBOL program.

Programmer response: Change the application so that it does not initiate another XML PARSE statement from within the same COBOL program.

System action: The application is terminated.

IWZ243S

There was an invalid attempt to end an XML PARSE statement.

Explanation: An XML PARSE statement initiated by a COBOL program was in progress and one of the following actions was attempted:

- A GOBACK or an EXIT PROGRAM statement was issued within the COBOL program that initiated the XML PARSE statement.
- A user handler associated with the program that initiated the XML PARSE statement moved the condition handler resume cursor and resumed the application.

Programmer response: Change the application so that it does not use one of the above methods to end the XML PARSE statement.

System action: The application is terminated.

IWZ250S

Internal error: the call to JNI_GetCreatedJavaVMs returned an error, return code *nn*.

Explanation: The call to the JNI_GetCreatedJavaVMs function returned an error with a return code of *nn*.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ251S

Internal error: *n* active Java VMs were detected, when only 1 was expected.

Explanation: Multiple active Java VMs were detected, when only one Java VM was expected.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ253S

More than *nn* JVM initialization options was specified.

Explanation: In the COBJVMINITOPTIONS environment variable, you specified more Java initialization options than the maximum allowable number of options. The limit is 256.

Programmer response: Specify fewer options in the COBJVMINITOPTIONS environment variable.

System action: Application execution is terminated.

IWZ254S

Internal error: the call to JNI_CreateJavaVM returned an error.

Explanation: The call to JNI_CreateJavaVM returned an error.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ255S

Internal error: the call to GetEnv returned code *nn* because the current thread is not attached to the JVM.

Explanation: The call to GetEnv returned code *nn* because the current thread is not attached to the JVM.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ256S

Internal error: the call to GetEnv returned code *nn* because the JVM version is not supported.

Explanation: The call to GetEnv returned code *nn* because the JVM version is not supported.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ257S

Internal error: the call to GetEnv returned the unrecognized return code *nn*.

Explanation: The call to GetEnv returned the unrecognized return code *nn*.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ258S

Internal error: GetByteArrayElements was unable to acquire a pointer to the instance data.

Explanation: The GetByteArrayElements service was unable to acquire a pointer to the instance data.

Programmer response: Contact your IBM representative.

System action: Application execution is terminated.

IWZ259S

Unable to acquire a direct pointer to instance data. The installed JVM does not support pinned byte arrays.

Explanation: You are running with an unsupported JVM, such as Sun 1.4.1, that doesn't support pinned byte arrays. For more information on pinning, see The Java Native Interface.

Programmer response: Run a supported JVM.

System action: Application execution is terminated.

IWZ260S

The Java class *name* could not be found.

Explanation: Your program references a class name that is not defined or specified in the CLASSPATH environment variable.

Programmer response: Check the program that references *name*, and either correct the reference or provide the missing *name*.class.

System action: Application execution is terminated.

IWZ813S

Insufficient storage was available to satisfy a get storage request.

Explanation: There was not enough free storage available to satisfy a get storage or reallocate request. This message indicates that storage management could not obtain sufficient storage from the operating system.

Programmer response: Ensure that you have sufficient storage available to run your application.

System action: No storage is allocated.

Symbolic feedback code: CEE0PD

IWZ901S

Message variants include: • **Program exits due to severe or critical error.** • **Program exits: more than ERRCOUNT errors occurred.**

Explanation: Every severe or critical message is followed by an IWZ901 message. An IWZ901 message is also issued if you used the ERRCOUNT run-time option and the number of warning messages exceeds ERRCOUNT.

Programmer response: See the severe or critical message, or increase ERRCOUNT.

System action: The application was terminated.

IWZ902S

The system detected a decimal-divide exception.

Explanation: An attempt to divide a number by 0 was detected.

Programmer response: Modify the program. For example, add ON SIZE ERROR to the flagged statement.

System action: The application was terminated.

IWZ903S

The system detected a data exception.

Explanation: An operation on packed decimal or zoned decimal data failed because the data contained an invalid value.

Programmer response: Verify the data is valid packed decimal or zoned decimal data.

System action: The application was terminated.

IWZ907S

Message variants include: • **Insufficient storage.** • **Insufficient storage. Cannot get *number-bytes* bytes of space for *storage*.**

Explanation: The run-time library requested virtual memory space and the operating system denied the request.

Programmer response: Your program uses a large amount of virtual memory and it ran out of space. The problem is usually not due to a particular statement, but is associated with the program as a whole. Look at your use of OCCURS clauses and reduce the size of your tables.

System action: The application was terminated.

IWZ993W

Insufficient storage. Cannot find space for message *message-number*.

Explanation: The run-time library requested virtual memory space and the operating system denied the request.

Programmer response: Your program uses a large amount of virtual memory and it ran out of space. The problem is usually not due to a particular statement, but is associated with the program as a whole. Look at your use of OCCURS clauses and reduce the size of your tables.

System action: No system action was taken.

IWZ994W

Cannot find message *message-number* in message-catalog.

Explanation: The run-time library cannot find either the message catalog or a particular message in the message catalog.

Programmer response: Check that the COBOL library and messages were correctly installed and that LANG and NLSPATH are specified correctly.

System action: No system action was taken.

IWZ995C

Message variants include: • ***system exception* signal received while executing routine *routine-name* at offset 0x*offset-value*.** • ***system exception* signal received while executing code at location 0x*offset-value*.** • ***system exception* signal received. The location could not be determined.**

Explanation: The operating system has detected an illegal action, such as an attempt to store into a protected area of memory or the operating system has detected that you pressed the interrupt key (typically the Control-C key, but it can be reconfigured).

Programmer response: If the signal was due to an illegal action, run the program under the debugger and it will give you more precise information as to where the error occurred. An example of this type of error is a pointer with an illegal value.

System action: The application was terminated.

IWZ2502S

The UTC/GMT was not available from the system.

Explanation: A call to CEEUTC or CEEGMT failed because the system clock was in an invalid state. The current time could not be determined.

Programmer response: Notify systems support personnel that the system clock is in an invalid state.

System action: All output values are set to 0.

Symbolic feedback code: CEE2E6

IWZ2503S

The offset from UTC/GMT to local time was not available from the system.

Explanation: A call to CEEGMTO failed because either (1) the current operating system could not be determined, or (2) the time zone field in the operating system control block appears to contain invalid data.

Programmer response: Notify systems support personnel that the local time offset stored in the operating system appears to contain invalid data.

System action: All output values are set to 0.

Symbolic feedback code: CEE2E7

IWZ2505S

The input_seconds value in a call to CEEDATM or CEESECI was not within the supported range.

Explanation: The input_seconds value passed in a call to CEEDATM or CEESECI was not a floating-point number between 86,400.0 and 265,621,679,999.999 The input parameter should represent the number of seconds elapsed since 00:00:00 on 14 October 1582, with 00:00:00.000 15 October 1582 being the first supported date/time, and 23:59:59.999 31 December 9999 being the last supported date/time.

Programmer response: Verify that input parameter contains a floating-point value between 86,400.0 and 265,621,679,999.999.

System action: For CEEDATM, the output value is set to blanks. For CEESECI, all output parameters are set to 0.

Symbolic feedback code: CEE2E9

IWZ2506S

An era (<JJJJ>, <CCCC>, or <CCCCCCCC>) was was used in a picture string passed to CEEDATM, but the input number-of-seconds value was not within the supported range. The era could not be determined.

Explanation: In a CEEDATM call, the picture string indicates that the input value is to be converted to an era; however the input value that was specified lies outside the range of supported eras.

Programmer response: Verify that the input value contains a valid number-of-seconds value within the range of supported eras.

System action: The output value is set to blanks.

IWZ2507S

Insufficient data was passed to CEEDAYS or CEESECS. The Lilian value was not calculated.

Explanation: The picture string passed in a CEEDAYS or CEESECS call did not contain enough information. For example, it is an error to use the picture string 'MM/DD' (month and day only) in a call to CEEDAYS or CEESECS, because the year value is missing. The minimum information required to calculate a Lilian value is either (1) month, day and year, or (2) year and Julian day.

Programmer response: Verify that the picture string specified in a call to CEEDAYS or CEESECS specifies, as a minimum, the location in the input string of either (1) the year, month, and day, or (2) the year and Julian day.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EB

IWZ2508S

The date value passed to CEEDAYS or CEESECS was invalid.

Explanation: In a CEEDAYS or CEESECS call, the value in the DD or DDD field is not valid for the given year and/or month. For example, 'MM/DD/YY' with '02/29/90', or 'YYYY.DDD' with '1990.366' are invalid because 1990 is not a leap year. This code may also be returned for any nonexistent date value such as June 31st, January 0.

Programmer response: Verify that the format of the input data matches the picture string specification and that input data contains a valid date.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EC

IWZ2509S

The era passed to CEEDAYS or CEESECS was not recognized.

Explanation: The value in the <JJJJ>, <CCCC>, or <CCCCCCCC> field passed in a call to CEEDAYS or CEESECS does not contain a supported era name.

Programmer response: Verify that the format of the input data matches the picture string specification and that the spelling of the era name is correct. Note that the era name must be a proper DBCS string where the '<' position must contain the first byte of the era name.

System action: The output value is set to 0.

IWZ2510S

The hours value in a call to CEEISEC or CEESECS was not recognized.

Explanation: (1) In a CEEISEC call, the hours parameter did not contain a number between 0 and 23, or (2) in a CEESECS call, the value in the HH (hours) field does not contain a number between 0 and 23, or the "AP" (a.m./p.m.) field is present and the HH field does not contain a number between 1 and 12.

Programmer response: For CEEISEC, verify that the hours parameter contains an integer between 0 and 23. For CEESECS, verify that the format of the input data matches the picture string specification, and that the hours field contains a value between 0 and 23, (or 1 and 12 if the "AP" field is used).

System action: The output value is set to 0.

Symbolic feedback code: CEE2EE

IWZ2511S

The day parameter passed in a CEEISEC call was invalid for year and month specified.

Explanation: The day parameter passed in a CEEISEC call did not contain a valid day number. The combination of year, month, and day formed an invalid date value. Examples: year=1990, month=2, day=29; or month=6, day=31; or day=0.

Programmer response: Verify that the day parameter contains an integer between 1 and 31, and that the combination of year, month, and day represents a valid date.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EF

IWZ2512S

The Lilian date value passed in a call to CEEDATE or CEEDYWK was not within the supported range.

Explanation: The Lilian day number passed in a call to CEEDATE or CEEDYWK was not a number between 1 and 3,074,324.

Programmer response: Verify that the input parameter contains an integer between 1 and 3,074,324.

System action: The output value is set to blanks.

Symbolic feedback code: CEE2EG

IWZ2513S

The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was not within the supported range.

Explanation: The input date passed in a CEEISEC, CEEDAYS, or CEESECS call was earlier than 15 October 1582, or later than 31 December 9999.

Programmer response: For CEEISEC, verify that the year, month, and day parameters form a date greater than or equal to 15 October 1582. For CEEDAYS and CEESECS, verify that the format of the input date matches the picture string specification, and that the input date is within the supported range.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EH

IWZ2514S

The year value passed in a CEEISEC call was not within the supported range.

Explanation: The year parameter passed in a CEEISEC call did not contain a number between 1582 and 9999.

Programmer response: Verify that the year parameter contains valid data, and that the year parameter includes the century, for example, specify year 1990, not year 90.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EI

IWZ2515S

The milliseconds value in a CEEISEC call was not recognized.

Explanation: In a CEEISEC call, the milliseconds parameter (*input_milliseconds*) did not contain a number between 0 and 999.

Programmer response: Verify that the milliseconds parameter contains an integer between 0 and 999.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EJ

IWZ2516S

The minutes value in a CEEISEC call was not recognized.

Explanation: (1) In a CEEISEC call, the minutes parameter (*input_minutes*) did not contain a number between 0 and 59, or (2) in a CEESECS call, the value in the MI (minutes) field did not contain a number between 0 and 59.

Programmer response: For CEEISEC, verify that the minutes parameter contains an integer between 0 and 59. For CEESECS, verify that the format of the input data matches the picture string specification, and that the minutes field contains a number between 0 and 59.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EK

IWZ2517S

The month value in a CEEISEC call was not recognized.

Explanation: (1) In a CEEISEC call, the month parameter (*input_month*) did not contain a number between 1 and 12, or (2) in a CEEDAYS or CEESECS call, the value in the MM field did not contain a number between 1 and 12, or the value in the MMM, MMMM, etc. field did not contain a correctly spelled month name or month abbreviation in the currently active National Language.

Programmer response: For CEEISEC, verify that the month parameter contains an integer between 1 and 12. For CEEDAYS and CEESECS, verify that the format of the input data matches the picture string specification. For the MM field, verify that the input value is between 1 and 12. For spelled-out month names (MMM, MMMM, etc.), verify that the spelling or abbreviation of the month name is correct in the currently active National Language.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EL

IWZ2518S

An invalid picture string was specified in a call to a date/time service.

Explanation: The picture string supplied in a call to one of the date/time services was invalid. Only one era character string can be specified.

Programmer response: Verify that the picture string contains valid data. If the picture string contains more than one era descriptor, such as both <JJJJ> and <CCCC>, then change the picture string to use only one era.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EM

IWZ2519S

The seconds value in a CEEISEC call was not recognized.

Explanation: (1) In a CEEISEC call, the seconds parameter (*input_seconds*) did not contain a number between 0 and 59, or (2) in a CEESECS call, the value in the SS (seconds) field did not contain a number between 0 and 59.

Programmer response: For CEEISEC, verify that the seconds parameter contains an integer between 0 and 59. For CEESECS, verify that the format of the input data matches the picture string specification, and that the seconds field contains a number between 0 and 59.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EN

IWZ2520S

CEEDAYS detected nonnumeric data in a numeric field, or the date string did not match the picture string.

Explanation: The input value passed in a CEEDAYS call did not appear to be in the format described by the picture specification, for example, nonnumeric characters appear where only numeric characters are expected.

Programmer response: Verify that the format of the input data matches the picture string specification and that numeric fields contain only numeric data.

System action: The output value is set to 0.

Symbolic feedback code: CEE2EO

IWZ2521S

The <JJJJ>, <CCCC>, or <CCCCCCCC> year-within-era value passed to CEEDAYS or CEESECS was zero.

Explanation: In a CEEDAYS or CEESECS call, if the YY or ZYY picture token is specified, and if the picture string contains one of the era tokens such as <CCCC> or <JJJJ>, then the year value must be greater than or equal to 1 and must be a valid year value for the era. In this context, the YY or ZYY field means year within era.

Programmer response: Verify that the format of the input data matches the picture string specification and that the input data is valid.

System action: The output value is set to 0.

IWZ2522S

An era (<JJJJ>, <CCCC>, or <CCCCCCCC>) was used in a picture string passed to CEEDATE, but the Lilian date value was not within the supported range. The era could not be determined.

Explanation: In a CEEDATE call, the picture string indicates that the Lilian date is to be converted to an era, but the Lilian date lies outside the range of supported eras.

Programmer response: Verify that the input value contains a valid Lilian day number within the range of supported eras.

System action: The output value is set to blanks.

IWZ2525S

CEESECS detected nonnumeric data in a numeric field, or the timestamp string did not match the picture string.

Explanation: The input value passed in a CEESECS call did not appear to be in the format described by the picture specification. For example, nonnumeric characters

appear where only numeric characters are expected, or the a.m./p.m. field (AP, A.P., etc.) did not contain the strings 'AM' or 'PM'.

Programmer response: Verify that the format of the input data matches the picture string specification and that numeric fields contain only numeric data.

System action: The output value is set to 0.

Symbolic feedback code: CEE2ET

IWZ2526S

The date string returned by CEEDATE was truncated.

Explanation: In a CEEDATE call, the output string was not large enough to contain the formatted date value.

Programmer response: Verify that the output string data item is large enough to contain the entire formatted date. Ensure that the output parameter is at least as long as the picture string parameter.

System action: The output value is truncated to the length of the output parameter.

Symbolic feedback code: CEE2EU

IWZ2527S

The timestamp string returned by CEEDATM was truncated.

Explanation: In a CEEDATM call, the output string was not large enough to contain the formatted timestamp value.

Programmer response: Verify that the output string data item is large enough to contain the entire formatted timestamp. Ensure that the output parameter is at least as long as the picture string parameter.

System action: The output value is truncated to the length of the output parameter.

Symbolic feedback code: CEE2EV

IWZ2531S

The local time was not available from the system.

Explanation: A call to CEELOCT failed because the system clock was in an invalid state. The current time cannot be determined.

Programmer response: Notify systems support personnel that the system clock is in an invalid state.

System action: All output values are set to 0.

Symbolic feedback code: CEE2F3

IWZ2533S

The value passed to CEESCEN was not between 0 and 100.

Explanation: The *century_start* value passed in a CEESCEN call was not between 0 and 100, inclusive.

Programmer response: Ensure that the input parameter is within range.

System action: No system action is taken; the 100-year window assumed for all two-digit years is unchanged.

Symbolic feedback code: CEE2F5

IWZ2534W

Insufficient field width was specified for a month or weekday name in a call to CEEDATE or CEEDATM. Output set to blanks.

Explanation: The CEEDATE or CEEDATM callable services issues this message whenever the picture string contained MMM, MMMMMZ, WWW, Wwww, etc., requesting a spelled out month name or weekday name, and the month name currently being formatted contained more characters than can fit in the indicated field.

Programmer response: Increase the field width by specifying enough Ms or Ws to contain the longest month or weekday name being formatted.

System action: The month name and weekday name fields that are of insufficient width are set to blanks. The rest of the output string is unaffected. Processing continues.

Symbolic feedback code: CEE2F6

RELATED CONCEPTS
Appendix C, “Intermediate results and arithmetic precision,” on page 513

RELATED TASKS
“Generating a list of compiler error messages” on page 185
“Setting environment variables” on page 169

RELATED REFERENCES
COBOL for AIX Language Reference

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 95141-1099
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.

© Copyright IBM Corp. 1995, 2004

Trademarks

The following terms are trademarks of International Business Machines Corporation in the United States, or other countries, or both:

AIX
CICS
COBOL/370
Database 2
DB2
DB2 Universal Database
DFSORT
Encina
IBM
Language Environment
MVS
OS/390
S/390
TXSeries
z/OS
zSeries

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.

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.

* **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`.

© Copyright IBM Corp. 1995, 2004

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.

IBM has defined an extension to ASCII (characters 128-255).

ASCII-based multibyte code page. A UTF-8, EUC, or ASCII DBCS code page. Each ASCII-based multibyte code page includes both single-byte and multibyte characters. The encoding of the single-byte characters is the ASCII encoding.

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 and UTF-16 characters. In this format, the least significant byte of a binary data item is at the highest address and the least significant byte of a UTF-16 character is at the highest address. Compare with *"little-endian" on page 695*.

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.

buffer. A portion of storage that is used to hold input or output data temporarily.

built-in function. See *"intrinsic function" on page 694*.

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" on page 686*.

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-TO-YYYYMMDD, DAY-TO-YYYYDDD, and YEAR-TO-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" on page 686*.

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” on page 704*.

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-1252 and on the host is IBM-1047.

code point. A unique bit pattern that is defined in a coded character set (code page). Graphic symbols and control characters are assigned to code points.

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). An IBM-defined number in the range 1 to 65,535 that identifies a specific code page.

*** 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” on page 687* and *“negated combined condition” on page 696*.

*** 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 `YYXX`.
  - 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 YYXX`.
- `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 standard compiler-directing statements are COPY, REPLACE, and USE.

compiler directive. A directive that causes the compiler to take a specific action during compilation. COBOL for AIX has one compiler directive, CALLINTERFACE. You can code CALLINTERFACE directives within a program to use specific interface conventions for specific CALL statements.

* **complex condition.** A condition in which one or more logical operators act upon one or more conditions. See also *"condition"*, *"negated simple condition" on page 696*, and *"negated combined condition" on page 696*.

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(TM) 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. 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" on page 702*, *"complex condition"*, *"negated simple condition" on page 696*, *"combined condition" on page 686*, and *"negated combined condition" on page 696*.

* **conditional expression.** A simple condition or a complex condition specified in an EVALUATE, IF, PERFORM, or SEARCH statement. See also *"simple condition" on page 702* 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.

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 *COBOL for AIX Language Reference*).

The term *date field* refers to both *expanded date field* and *windowed date field*. See also *"nondate" on page 696*.

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 *COBOL for AIX Language Reference*)

DBCS. See *"double-byte character set (DBCS)" on page 689*.

*** 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.

* **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.

Distributed Debugger. A client-server application 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 Distributed Debugger uses a graphical user interface in which you can issue commands to control the execution (remote or local) of your program.

* **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.
```

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" on page 705*.

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 option, or a CALL *identifier* statement in a program.

* **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
+	Plus
-	Minus
CR	Credit
DB	Debit
Z	Zero suppress
*	Check protect
$	Currency sign
,	Comma (decimal point)
.	Period (decimal point)
/	Slant (virgule, slash)

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*.

encoding unit. See *"character encoding unit" on page 685*.

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.
```

*** 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.

execution time. See *"run time" on page 701*.

execution-time environment. See *"run-time environment" on page 701*.

expanded date field. A date field containing an expanded (four-digit) year. See also *"date field" on page 688* 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" on page 704*.

*** 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 ASCII XML documents, the code page indicated by the current run-time locale. For EBCDIC XML documents, either:

- The code page specified in the EBCDIC_CODEPAGE environment variable
- The default EBCDIC code page selected for the current run-time locale if the EBCDIC_CODEPAGE environment variable is not set

* **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" on page 705*.

* **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.

* **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 z/OS UNIX System Services.

* **high-order end.** The leftmost character of a string of characters.

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)" on page 694.*

`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 COBOL for AIX bootstrap routine. It must be link-edited with any module that contains a COBOL for AIX 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. COBOL for AIX does not support *multiple inheritance*; a subclass has exactly one immediate superclass.

inheritance hierarchy. See *"class hierarchy" on page 685*.

* **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.

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 AIX.

* **intrarecord 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.

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 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.

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.

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 a shared library.

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

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 processors use to store binary data and UTF-16 characters. In this format, the most significant byte of a binary data item is at the highest address and the most significant byte of a UTF-16 character is at the highest address. Compare with *"big-endian" on page 684*.

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)" on page 696*.

* **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.

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.

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" on page 687* and *"combined condition" on page 686*.

* **negated simple condition.** The NOT logical operator immediately followed by a simple condition. See also *"condition" on page 687* and *"simple condition" on page 702*.

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 instance. See *"object"*.

* **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" on page 701*.

* **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" on page 702*.

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" on page 694*.

* **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.

* **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" on page 684*.

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 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.

* **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

* **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" on page 695*.

* **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.

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.

* **routine-name.** A user-defined word that identifies a procedure written in a language other than COBOL.

RSD file system. The record sequential delimited file system is a workstation file system that supports

sequential files, including the full Standard COBOL 85 sequential I/O language and all of the extensions described in *COBOL for AIX Language Reference*, unless exceptions are explicitly noted. An RSD file supports all COBOL data types in fixed-length records, can be edited by most file editors, and can be read by programs written in other languages.

* **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 by means of COBOL `CALL` or `INVOKE` statements and function at run time as an entity.

S

SBCS. See *"single-byte character set (SBCS)" on page 702*.

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 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.

* **77-level-description-entry.** A data description entry that describes a noncontiguous data item with the level-number 77.

SFS file system. The Encina Structured File Server file system is a record-oriented file system that supports sequential and key-indexed file access. SFS files can be shared with PL/I applications.

shared library. A library created by the linker that contains at least one subroutine that can be used by multiple processes. Programs and subroutines are linked as usual, but the code common to different subroutines is combined in one library file that can be loaded at run time and shared by many programs. A key to identify the shared library file is left in the header of each subroutine.

* **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" on page 687* and *"negated simple condition" on page 696*.

single-byte character set (SBCS). A set of characters in which each character is represented by a single byte. See also *"ASCII" on page 684* and *"EBCDIC (Extended Binary-Coded Decimal Interchange Code)" on page 689*.

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*
- *ISO 1989:1985, Programming languages - COBOL*, as amended by *ISO/IEC 1989/AMD1:1992, Programming languages - COBOL: Intrinsic function module*

* **statement.** A syntactically valid combination of words, literals, and separators, beginning with a verb, written in a COBOL source program.

STL file system. The Standard language file system is the native workstation file system for COBOL and PL/I. This system supports sequential, relative, and indexed files, including the full Standard COBOL 85

input and output language and all of the extensions described in *COBOL for AIX Language Reference*, unless exceptions are explicitly noted.

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" on page 685*.

* **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 graphic 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-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.

token highlighting. In the COBOL editor, a feature that enables you to view the token types of the programming language in different colors and fonts. This feature makes the structure of the program more obvious. You use the Token Attributes window to customize the appearance of the types of tokens.

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. COBOL for AIX 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.

* **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.

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" on page 688* 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" on page 685*. Compare with *"expanded year" on page 690*.

* **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" on page 691*.

List of resources

COBOL for AIX

Installation Guide, SC18-9285

Language Reference, SC18-9257

Programming Guide, SC18-9256

VSAM File System Reply Messages, SC18-9286

Related publications

AIX

Commands Reference: Volume 1, a - c, SC23-4115

Commands Reference: Volume 2, d - h, SC23-4116

Commands Reference: Volume 3, l - m, SC23-4117

Commands Reference: Volume 4, n - r, SC23-4118

Commands Reference: Volume 5, s - u, SC23-4119

Commands Reference: Volume 6, v - z, SC23-4120

General Programming Concepts: Writing and Debugging Programs, SC23-4128

COBOL

COBOL Millennium Language Extensions Guide, SC26-9266

DB2 Universal Database(TM)

DB2 Universal Database Application Development Guide: Building and Running Applications, SC09-4825

DB2 Universal Database Application Development Guide: Programming Client Applications, SC09-4826

DB2 Universal Database Application Development Guide: Programming Server Applications, SC09-4827

DB2 Universal Database Command Reference, SC09-4828

DB2 Universal Database SQL Reference Volume 1, SC09-4844

DB2 Universal Database SQL Reference Volume 2, SC09-4845

Java

The Java Language Specification, Second Edition, by Gosling et al., 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

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

TXSeries for Multiplatforms

CICS Administration Reference, SC09-4459

CICS Application Programming Guide, SC09-4460

CICS Application Programming Reference, SC09-4461

CICS Problem Determination Guide, SC09-4465

Encina Administration Guide Volume 2: Server Administration, SC09-4474

Encina SFS Programming Guide, SC09-4483

Unicode and character representation

Unicode, www.unicode.org/

Character Data Representation Architecture Reference and Registry, SC09-2190

XML

XML specification, www.w3c.org/XML/

© Copyright IBM Corp. 1995, 2004

Index

Special characters

_iwzGetCCSID: convert code-page ID to CCSID
  example 116
  syntax 115
_iwzGetLocaleCP: get locale and EBCDIC code-page values
  example 116
  syntax 115
-? cob2 option 188
-# cob2 option 182, 188
-c cob2 option 186
-cmain cob2 option 187
-comprc_ok cob2 option 187
-Fxxx cob2 option 188
-g cob2 option
  for debugging 188
-host cob2 option
  for host data format 187
-I cob2 option
  searching copybooks 187
-main cob2 option
  specifying main program 188
-o cob2 option
  specifying main program 188
-p cob2 option
  analyzing performance 188
-pg cob2 option 188
-q cob2 option 187
-v cob2 option 188
? cob2 option 188
.adt file 201
.lst file suffix 185
.profile file, setting environment variables in 170
.wlist file 220
*CBL statement 243
*CONTROL statement 243
>>CALLINT statement 243

Numerics

16-MB line
  performance options 490

A

abends
  using ERRCOUNT run-time option to induce 250
ACCEPT statement
  assigning input 27
  using in GUI applications 176
ACCEPT statement, environment variables used on 176
accessibility of this document xiii
accessing files using environment variables 172
ADATA compiler option 201
adding alternate indexes 128
adding records to files 142
ADDRESS special register, CALL statement 418
addresses
  incrementing 422
  NULL value 421
  passing between programs 421
  passing entry point addresses 424
ADEXIT suboption of EXIT compiler option 212, 215
AIX, porting to 403
ALL subscript 43, 65
ALPHABET clause, establishing collating sequence 8
alphabetic data, comparing to national 103
alphanumeric data, comparing to national 103
alphanumeric date fields, contracting 476
alternate collating sequence 8, 153
alternate file system
  file system ID 172
  using environment variables 172
alternate index
  adding 128
  definition 133
alternate index file
  DCE CDS name 120
  specifying data volume for 126
ANNUITY intrinsic function 44
APOST compiler option 227
applications, porting
  architectural differences between platforms 397
  language differences between workstation and mainframe 397
  mainframe to workstation
    choosing compiler options 397
    running mainframe applications on the workstation 399
  using COPY to isolate platform-specific code 398
  Windows to AIX 403
  workstation to mainframe
    workstation-only language features 402
    workstation-only names 403
arguments
  describing in calling program 418
  passing between C/C++ and COBOL 413
  passing between COBOL and C/C++ 414, 415
  passing BY VALUE 413
  specifying OMITTED 419
  testing for OMITTED 419
  testing for OMITTED arguments 419
  to main program 429
ARITH compiler option 201
arithmetic
  calculation on dates
    convert date to COBOL integer format (CEECBLDY) 531
    convert date to Lilian format (CEEDAYS) 542
    convert timestamp to number of seconds (CEESECS) 562
    get current Greenwich Mean Time (CEEGMT) 547
  COMPUTE statement simpler to code 41
  error handling 158
  with intrinsic functions 42
arithmetic comparisons 46
arithmetic evaluation
  data format conversion 38
  examples 45, 47
  fixed-point versus floating-point 45
  intermediate results 513
  performance tips 483
  precedence 41, 515
  precision 513
arithmetic expression
  as reference modifier 86
  description of 41
  in nonarithmetic statement 521
  in parentheses 41
  with MLE 471
arithmetic operation
  with MLE 467, 471
arrays
  in COBOL 30
  Java 389
ASCII
  converting to EBCDIC 90
  DBCS portability 401
  portability considerations 399
ASCII files
  CODE-SET clause 12
  OPTCD= parameter in DCB 12
assembler
  from LIST option 488
  programs
    listing of 220, 488
assembler language programs
  debugging 273
ASSIGN clause 10
assigning values 23
assignment name, environment variable 172
assumed century window for nondates 466
AT END (end-of-file) 160
attribute methods 355
ATTRIBUTE-CHARACTER XML event 308
ATTRIBUTE-CHARACTERS XML event 308
ATTRIBUTE-NAME XML event 308

© Copyright IBM Corp. 1995, 2004

ATTRIBUTE-NATIONAL-CHARACTER XML event 309
avoiding coding errors 481
awk command for padding records 126

B

backward branches 482
Base class
  equating to java.lang.Object 346
  using for java.lang.Object 346
base file 120
base locator 268
basic document encoding 319
Batch compilation 228
batch debugging, activating 250
big-endian
  converting to little-endian 98
  format for data representation 202
  representation of integers 403
  representation of national characters 403
BINARY compiler option 202
binary data item
  general description 35
  intermediate results 518
  synonyms 33
  using efficiently 35, 483
binary data, data representation 202
binary search of a table 64
BLOCK CONTAINS clause
  FILE SECTION entry 12
branch, implicit 75
BY VALUE, valid data types 413
byte order mark 98

C

C/C++
  and COBOL 411
  communicating with COBOL 411
  data types, correspondence with COBOL 412
  functions called from COBOL, example 413
  functions calling COBOL, example 414, 415
  multiple calls to a COBOL program 411
cache 129
caching, client-side
  description 129
  environment variable for 174
  insert caching 129
  read caching 129
call conventions 210
CALL identifier 437
call interface conventions
  SYSTEM 203
CALL statement
  BY CONTENT 417
  BY REFERENCE 418
  BY VALUE 417
  CALL identifier 410
  CALL literal 410
  effect of CALLINT option 202
CALL statement *(continued)*
  effect of DYNAM compiler option 210
  exception condition 165
  for error handling 166
  handling of programs name in 226
  overflow condition 165
  to invoke date and time services 495
  USING 418
  with ON EXCEPTION 165
  with ON OVERFLOW 18, 165
callable services
  _iwzGetCCSID: convert code page ID to CCSID 115
  _iwzGetLocaleCP: get locale and EBCDIC code-page values 115
  CEECBLDY—convert date to COBOL integer format 531
  CEEDATE—convert Lilian date to character format 534
  CEEDATM—convert seconds to character timestamp 538
  CEEDAYS—convert date to Lilian format 542
  CEEDYWK—calculate day of week from Lilian date 545
  CEEGMT—get current Greenwich Mean Time 547
  CEEGMTO—get offset from Greenwich Mean Time to local time 549
  CEEISEC—convert integers to seconds 551
  CEELOCT—get current local time 554
  CEEQCEN—query the century window 556
  CEESCEN—set the century window 557
  CEESECI—convert seconds to integers 559
  CEESECS—convert timestamp to number of seconds 562
  CEEUTC—get Coordinated Universal Time 566
  IGZEDT4—get current date with four-digit year 566
CALLINT compiler option 202
CALLINT statement 243
calls
  between COBOL and C/C++ under CICS 284
  dynamic 410
  exception condition 165
  LINKAGE SECTION 419
  overflow condition 165
  passing arguments 418
  passing data 417
  receiving parameters 418
  recursive 416
  specifying OMITTED arguments 419
  static 410
  to date and time services 495
  to JNI services 383
CANCEL statement
  handling of programs name in 226
case structure 69
CBL statement 181, 243
CCSID
  conflict 324
  definition 97
  of PARSE statement 305
  of XML document 305, 319
  of XML documents 319
CEECBLDY—convert date to COBOL integer format
  example 531
  syntax 531
CEEDATE—convert Lilian date to character format
  example 535
  syntax 534
  table of sample output 537
CEEDATM—convert seconds to character timestamp
  CEESECI callable service 559
  example 539
  syntax 538
  table of sample output 541
CEEDAYS—convert date to Lilian format
  example 544
  syntax 542
CEEDYWK—calculate day of week from Lilian date
  example 546
  syntax 545
CEEGMT—get current Greenwich Mean Time
  example 548
  syntax 547
CEEGMTO—get offset from Greenwich Mean Time to local time
  example 550
  syntax 549
CEEISEC—convert integers to seconds
  example 552
  syntax 551
CEELOCT—get current local time
  example 555
  syntax 554
CEEQCEN—query the century window
  example 556
  syntax 556
CEESCEN—set the century window
  example 558
  syntax 557
CEESECI—convert seconds to integers
  example 560
  syntax 559
CEESECS—convert timestamp to number of seconds
  example 564
  syntax 562
century window
  assumed for nondates 466
  CEECBLDY callable service 533
  CEEDAYS callable service 543
  CEEQCEN callable service 556
  CEESCEN callable service 557
  CEESECS callable service 564
  concept 501
  fixed 458
  sliding 458
CESN transaction 281

chained list processing 421, 422
changing
  characters to numbers 89
  file-name 10
  title on source listing 6
CHAR compiler option 203
CHAR intrinsic function 91
character set, definition 97
character strings 212
character timestamp
  converting Lilian seconds to (CEEDATM) 538
    example 539
  converting to COBOL integer format (CEECBLDY) 531
    example 533
  converting to Lilian seconds (CEESECS) 562
    example 562
CHECK run-time option 249
CHECK(OFF) run-time option 490
checking errors, flagging at run time 249
checking for valid data
  conditional expressions 71
  numeric 40
Chinese GB 18030 data
  processing 102
CICS
  accessing CICS files from non-CICS applications 284
  ASCII-EBCDIC differences 282
  calls between COBOL and C/C++ 284
  coding restrictions 281
  commands relevant to COBOL 281
  compiler options 285
  compiler restrictions 281
  debugging programs 285
  effect of TRAP run-time option 251
  performance considerations 481
  preparing COBOL applications to run under CICS 281
  programming considerations 281
  programs 281
  restrictions
    OO programs 341
  run-time options 285
  system date 282
  using dynamic calls 283
CICS compiler option
  restriction in OO programs 341
cicsmap command 281
cicstcl command 281
cicsterm command 281
class
  defining 344
  definition of 341
  factory data 371
  instance data 348
  name
    external 347, 359
    in a program 346
  object 370
    obtaining reference with JNI 384
class condition
  coding 71
class condition *(continued)*
  numeric 40
  test 71, 255
CLASSPATH environment variable 172, 197
client
  defining 357
  definition of 357
client-side caching
  description 129
  environment variable for 174
  insert caching 129
  read caching 129
clustered files 122
cob2 command
  -# option 182
  command-line argument format 429
  description 179
  examples using, for compiling 180
  examples using, for linking 190
  modifying configuration file 182
  options 186
    modifying defaults 182
  stanza used 182
cob2 stanza 182
cob2_j command
  command-line argument format 429
  description 179
  for compiling OO applications 195
  for linking OO applications 196
  for OO applications 179
  options 186
  stanza used 182
cob2_j stanza 182
cob2_r command
  command-line argument format 429
  description 179
  for threaded or CICS applications 179
  options 186
  stanza used 182
  threading example 446
cob2_r stanza 182
cob2_r4 command
  command-line argument format 429
  description 179
  for SFS file system 180
  for SFS file system applications 179
  options 186
cob2.cfg configuration file 182
COBCPYEXT environment variable 171
COBJVMINITOPTIONS environment variable 172, 198
COBLSTDIR environment variable 171
COBMSGS environment variable 172
COBOL
  and C/C++ 411
  and Java 383
    compiling 195
    linking 196
    running 197
    structuring applications 379
  called by C/C++ functions, example 414, 415
  calling C/C++ functions, example 413
COBOL *(continued)*
  data types, correspondence with C/C++ 412
  object-oriented
    compiling 195
    linking 196
COBOL 85 Standard
  definition xiii
COBOL client, example 374
COBOL for AIX
  run-time messages 635
COBOL language usage with SQL statements 278
COBOL terms 21
COBOPT environment variable 171
COBPATH environment variable 173
COBRTOPT environment variable 173
code
  copy 493
  optimized 488
code page
  accessing 115
  conflict 324
  definition 97
  euro currency support 48
  in effect 107
  of XML document 324
  querying 115
  specifying 320
  valid 112
  with COBOL 107
code point, definition 97
CODE-SET clause 12
coded character set
  definition 97
coded characters set
  in XML documents 319
CODEPAGE compiler option
  for national literals 99
  with conversions 100
coding
  class definition 344
  clients 357
  condition tests 72
  constructor methods 371
  DATA DIVISION 11
  decisions 67
  efficiently 481
  ENVIRONMENT DIVISION 7
  EVALUATE statement 69
  factory definition 370
  factory methods 371
  file input/output 131
  for files
    example 136
    overview 136
  for SFS files, example 127
  IDENTIFICATION DIVISION 5
  IF statement 67
  input/output
    example 136
    overview 136
  instance methods 349, 368
  interoperable data types 388
  loops 75
  OO programs 341
  PROCEDURE DIVISION 15

coding *(continued)*
programs to run under CICS 281
restrictions for programs for CICS 281
subclass definition 366
tables 51
techniques 11, 481
test conditions 72
collating sequence
alternate 8
ASCII 8
EBCDIC 8
HIGH-VALUE 8
ISO 7-bit code 8
locale definition 108
LOW-VALUE 8
MERGE 8
national language support 110
NATIVE 8
nonnumeric comparisons 8
SEARCH ALL 8
SORT 8
specifying 8
symbolic characters in the 9
the ordinal position of a character 91
COLLSEQ compiler option 205
columns in tables 51
command prompt, defining environment variables 169
command-line arguments 429
COMMENT XML event 308
COMMON attribute 6, 406
COMP (COMPUTATIONAL) 35
COMP-1 (COMPUTATIONAL-1) 36, 484
COMP-2 (COMPUTATIONAL-2) 36, 484
COMP-3 (COMPUTATIONAL-3) 36
COMP-4 (COMPUTATIONAL-4) 35
COMP-5 (COMPUTATIONAL-5) 35
comparing
national and alphabetic or alphanumeric 103
national and group 104
national and numeric 103
national data 103
NCOLLSEQ influence 103
object references 360
of date fields 462
compatibility mode 31, 513
compatible dates
in comparisons 462
with MLE 463
compilation statistics 266
COMPILE compiler option
description 206
use NOCOMPILE to find syntax errors 258
compile-time considerations
compiler-directed errors 185
compiling programs 187
compiling without linking 186
display cob2 help 188
display compile and link steps 188
error messages
determining what severity level to produce 216
severity levels 184
compile-time considerations *(continued)*
executing compile and link steps after display 188
using a nondefault configuration file 188
compiler
calculation of intermediate results 514
date-related messages, analyzing 474
generating list of error messages 185
invoking 179
limits 11
messages
choosing severity to be flagged 259
determining what severity level to produce 216
embedding in source listing 259
severity levels 184
compiler listings
getting 263
specifying output directory 171
compiler options
ADATA 201
APOST 227
ARITH 201
BINARY 202
CALLINT 202
CHAR 203
COLLSEQ 205
COMPILE 206
CURRENCY 207
DATEPROC 208
DIAGTRUNC 209
DYNAM 210, 490
ENTRYINT 210
EXIT 211
FLAG 216, 259
FLAGSTD 217
FLOAT 218
for application portability 397
for CICS 285
for debugging 257
LIB 219
LINECOUNT 220
LIST 220, 263
LSTFILE 221
MAP 221, 262, 263
MAXMEM 222
NCOLLSEQ 223
NOCOMPILE 258
NSYMBOL 223
NUMBER 224, 264
on compiler invocation 265
OPTIMIZE 225, 488, 490
PGMNAME 226
PROFILE 227
QUOTE 227
SEPOBJ 228
SEQUENCE 229, 258
SIZE 230
SOSI 230
SOURCE 231, 263
SPACE 232
specifying
cob2 command 179
cob2_j command 179
compiler options *(continued)*
specifying *(continued)*
cob2_r command 179
cob2_r4 command 179
environment variable 171
in shell script 180
using COBOPT 171
specifying PROCESS (CBL) statement 181
SPILL 232
SQL 233, 279
SSRANGE 233, 258, 490
status 265
TERMINAL 234
TEST 234, 262, 490
THREAD 235
TRUNC 236, 490
VBREF 238, 263
WSCLEAR 239
XREF 239, 261
YEARWINDOW 240
ZWB 241
compiler-directing statements 243
list 18
overview 18
compiling
for SFS file system 180
OO applications
cob2_j command 195
example 197
compiling and linking
OO applications
cob2_j command 196
example 197
completion code
merge 154
sort 154
complex OCCURS DEPENDING ON
basic forms of 523
complex ODO item 523
variably located data item 524
variably located group 524
computation
arithmetic data items 483
constant data items 482
duplicate 483
subscript 486
COMPUTATIONAL (COMP) 35
COMPUTATIONAL-1 (COMP-1) 36, 484
COMPUTATIONAL-2 (COMP-2) 36, 484
COMPUTATIONAL-3 (COMP-3)
date fields, potential problems 476
description 36
COMPUTATIONAL-4 (COMP-4) 35
COMPUTATIONAL-5 (COMP-5) 35
computer, describing 7
concatenating data items 79
condition handling 250
date and time services and 495
condition testing 72
condition-name 465
conditional expression
EVALUATE statement 68
IF statement 67
PERFORM statement 76
conditional statement
in EVALUATE statement 68

conditional statement *(continued)*
list of 17
overview 17
with NOT phrase 18
with object references 360
configuration file
default 182
modifying 182
stanzas 183
tailoring 182
CONFIGURATION SECTION 7
conformance requirements
RETURNING phrase 362
USING phrase 362
considerations
zSeries host data type 511
constants
computations 482
data items 482
description 22
figurative 23
contained program integration 489
CONTENT-CHARACTER XML event 310
CONTENT-CHARACTERS XML event 310
CONTENT-NATIONAL-CHARACTER XML event 310
continuation
of program 159
syntax checking 207
CONTINUE statement 68
contracting alphanumeric dates 476
control
in nested programs 406
program flow 67
transfer 405
CONTROL statement 243
convert character format to Lilian date (CEEDAYS) 542
convert Lilian date to character format (CEEDATE) 534
converting data items
between code pages 90
characters to numbers 89
Chinese GB 18030 102
data formats 38
INSPECT statement 87
national data
with ACCEPT 28
with DISPLAY 28
with DISPLAY-OF 100
with MOVE 100
with NATIONAL-OF 100
reversing order of characters 89
to integers 87
to uppercase or lowercase 89
UTF-8 101
with intrinsic functions 88
converting files to expanded date form, example 461
coprocessor, DB2 277
copy code, obtaining from user-supplied module 211
copy libraries
example 494
COPY name
file suffixes searched 171
COPY statement 243, 245
example 494
nested 214, 493
uses for portability 398
copybook 245
ODBC3D.CPY sample 297
ODBC3EG.CPY sample 293
ODBC3P.CPY 294
search rules 245
supplied ODBC3EG.CPY 293
using 493
with ODBC 292
copybooks 171
searching for 187
specifying search paths with SYSLIB 171
with ODBC 292
COUNT IN phrase 337
counting
data items 87
generated XML characters 328
counting data items 87
creating
alternate index files 126
objects 364
SFS files
environment variables for 126
sfsadmin command for 128
cross-reference
data and procedure names 261
embedded 263
list 239
program-name 271
special definition symbols 271
verb list 238
verbs 263
CURRENCY compiler option 207
currency signs
euro 48
hexadecimal literals 48
multiple-character 47
using 47
CURRENT-DATE intrinsic function 44
customizing
setting environment variables 169

D

data
concatenating 79
efficient execution 481
format conversion 38
format, numeric types 33
grouping 420
incompatible 40
joining 79
naming 12
numeric 31
passing 417
record size 12
splitting 81
validating 40
data and procedure name cross-reference, description 261
data areas, dynamic 210
DATA compiler option
performance considerations 490
data definition 267
data definition attribute codes 267
data description entry 11
DATA DIVISION
client 359
coding 11
description 11
factory data 371
factory method 372
FD entry 11
FILE SECTION 11
instance data 348, 368
instance method 351
limits 11
LINKAGE SECTION 14
listing 263
mapping of items 221, 263
OCCURS clause 51
restrictions 11
WORKING-STORAGE SECTION 11
data item
coding Java types 387
common, in subprogram linkage 419
concatenating 79
converting characters to numbers 89
converting to uppercase or lowercase 89
converting with INSPECT 87
converting with intrinsic functions 88
counting 87
evaluating with intrinsic functions 91
finding the smallest or largest in group 91
index 54
numeric 31
reference modification 84
referencing substrings 84
replacing 87
reversing characters 89
splitting 81
unused 225
variably located 524
data manipulation
nonnumeric data 79
DATA RECORDS clause 12
data representation
compiler option affecting 202
portability 399
data types
correspondence between COBOL and C/C++ 412
data-name
cross-reference 270
in MAP listing 267
OMITTED 12
date and time
format
converting from character format to COBOL integer format (CEECBLDY) 531
converting from character format to Lilian format (CEEDAYS) 542
converting from integers to seconds (CEEISEC) 551

date and time *(continued)*
format *(continued)*
converting from Lilian format to character format (CEEDATE) 534
converting from seconds to character timestamp (CEEDATM) 538
converting from seconds to integers (CEESECI) 559
converting from timestamp to number of seconds (CEESECS) 562
getting date and time (CEELOCT) 554
services
CEECBLDY—convert date to COBOL integer format 531
CEEDATE—convert Lilian date to character format 534
CEEDATM—convert seconds to character timestamp 538
CEEDAYS—convert date to Lilian format 542
CEEDYWK—calculate day of week from Lilian date 545
CEEGMT—get current Greenwich Mean Time 547
CEEGMTO—get offset from Greenwich Mean Time to local time 549
CEEISEC—convert integers to seconds 551
CEELOCT—get current local time 554
CEEQCEN—query the century window 556
CEESCEN—set the century window 557
CEESECI—convert seconds to integers 559
CEESECS—convert timestamp to number of seconds 562
CEEUTC—get Coordinated Universal Time 566
condition feedback 497
condition handling 495
examples of using 496
feedback code 495
invoking with a CALL statement 495
list of 529
overview 529
performing calculations with 496
picture strings 498
return code 495
RETURN-CODE special register 495
syntax 562
date arithmetic 471
date comparisons 462
date field expansion
advantages 458
description 460
date fields
potential problems 476
date information, formatting 175
date operations
intrinsic functions 29
date processing with internal bridges
advantages 458
date windowing
advantages 458
example 464
how to control 473
MLE approach 458
when not supported 464
DATE-COMPILED paragraph 5
DATE-OF-INTEGER intrinsic function 44
DATEPROC compiler option
analyzing warning-level messages 474
description 208
DATEVAL intrinsic function 473
day of week, calculating with CEEDYWK 545
DB2
bind file name 280
bind file name, default 280
COBOL language usage with SQL statements 278
coding considerations 277
coprocessor 277
ignored options 280
options 279
package name 280
package name, default 280
return codes 279
SQL INCLUDE statement 278
SQL statements 277
DB2DBDFT environment variable 171, 279
DB2INCLUDE environment variable 278
DBCS
comparison 71
converting 106
encoding 99
user-defined words in XREF output 261
DCE Cell Directory Service (CDS)
Encina SFS file-names 120
Encina SFS server name 120
dce_login, and CICS 281
DEBUG run-time option 250
Debug Tool
compiler options for maximum support 262
debugging
activating batch features 250
approaches 253
assembler 273
CICS programs 285
producing symbolic information 188
useful compiler options 257
user exits 273
using COBOL language features 253
with message offset information 272
debugging, language features
class test 255
debugging declaratives 255
file status keys 254
INITIALIZE statements 255
scope terminators 253
debugging, language features *(continued)*
SET statements 255
declarative procedures
EXCEPTION/ERROR 161
USE FOR DEBUGGING 255
defining
files
example 136
overview 136
SFS files, example 127
deleting records from files 143
delimited scope statement
description of 17
nested 19
depth in tables 52
DESC suboption of CALLINT compiler option 203
DESCRIPTOR suboption of CALLINT compiler option 203
diagnostics, program 265
DIAGTRUNC compiler option 209
differences with host COBOL 505
direct-access
direct indexing 55
directories
adding a path to 187
for error listing file 185
specifying path 173
dirty read 130
DISK compiler option 199
DISPLAY (USAGE IS)
encoding 99
external decimal 34
DISPLAY statement
displaying data values 28
using in debugging 253
using in GUI applications 176
DISPLAY statement, environment variables used on 176
DISPLAY-OF intrinsic function
using 100
with XML document 320
do loop 76
do-until 76
do-while 76
document encoding declaration 319
DOCUMENT-TYPE-DECLARATION XML event 307
documentation of program 7
dspcat command, listing messages with 635
dumps, when not produced 251
duplicate computations 483
DYNAM compiler option
description 210
performance considerations 490
dynamic calls
using in a CICS environment 283
dynamic linking 410
resolution of shared library references 434
dynamic loading, requirements 173

E

E-level error message 184, 259

EBCDIC
converting to ASCII 90
DBCS portability 401
portability considerations 399
EBCDIC_CODEPAGE environment variable 173
efficiency of coding 481
embedded cross-reference
description 263
example 271
embedded error messages 259
embedded MAP summary 262, 267, 268
embedded SQL
advantages 287
Encina SFS file system
accessing SFS files
example 127
overview 126
description 122
fully qualified DCE CDS file-names 122
improving performance 129
nonhierarchical 122
system administration of 123
Encina SFS files
accessing 284
example 127
overview 126
adding alternate indexes 128
alternate index file-name 120
base file-name 120
COBOL coding example 127
compiling for 180
creating alternate index files 126
creating SFS files
environment variables for 126
sfsadmin command for 128
determining available data volumes 126
file-names 122
fully qualified DCE CDS name 127
identifying 119
improving performance 129
nontransactional access 123
organization 122
primary and secondary indexes 122
processing 121
specifying data volume for 126
Encina SFS server
fully qualfied DCE CDS name 120
specifying server name 126
ENCINA_CDS_ROOT environment variable 173
ENCINA_SFS_DATA_VOLUME environment variable 173
ENCINA_SFS_INDEX_VOLUME environment variable 173
ENCINA_VSAM_AUTO_FLUSH environment variable 174
ENCINA_VSAM_CACHE environment variable 174
enclave 405
encoding
description 99
language characters 97
XML documents 318
XML output 336
encoding declaration
preferable to omit 320
specifying 320
ENCODING-DECLARATION XML event 307
END-OF-CDATA-SECTION XML event 311
END-OF-DOCUMENT XML event 311
END-OF-ELEMENT XML event 309
end-of-file phrase (AT END) 160
enhancing XML output 332
example 333
entry point
call convention 210
definition 433
ENTRY label 405
function-pointer data item 424
passing entry addresses of 424
procedure-pointer data item 424
ENTRY statement
handling of programs name in 226
ENTRYINT compiler option 210
environment differences, zSeries and the workstation 401
ENVIRONMENT DIVISION
class 346
client 358
collating sequence coding 8
CONFIGURATION SECTION 7
description 7
INPUT-OUTPUT SECTION 7
instance method 351
subclass 367
environment variables
accessing 170
accessing files with 172
assignment name 172
CLASSPATH 197
COBJVMINITOPTIONS 198
COBMSGS 172
COBOPT 171
COBPATH 171, 173
COBRTOPT 173
DB2DBDFT 171
EBCDIC_CODEPAGE 173
ENCINA_CDS_ROOT 173
ENCINA_SFS_DATA_VOLUME 173
ENCINA_SFS_INDEX_VOLUME 173
ENCINA_VSAM_AUTO_FLUSH 174
ENCINA_VSAM_CACHE 174
example of setting and accessing 178
LANG 175
LC_TIME 175
LIBPATH 175, 197
library-name 171, 245
LOCPATH 175
NLSPATH 175
PATH 176
precedence 170
run time 172
setting
in .profile 170
in command shell 169
in program 170
overview 169
environment variables *(continued)*
SYSIN, SYSIPT, SYSOUT, SYSLIST, SYSLST, CONSOLE, SYSPUNCH, SYSPCH 176
SYSLIB 171, 195
text-name 171, 245
TMP 176
TZ 176
used by the compiler 170
environment-name 7
environment, preinitializing 411
ERRCOUNT run-time options 250
ERRMSG, for generating list of error messages 185
error
arithmetic 158
handling 157
message table, example 58
error messages
appearing in abbreviated form 175
compiler
choosing severity to be flagged 259
correcting source 184
determining what severity level to produce 216
embedding in source listing 259
format 186
generating a list of 185
location in listing 186
severity levels 184
compiler-directed 185
run-time
format 635
incomplete or abbreviated 194
list of 635
listing with dspcat command 635
setting national language 175
errors
flagging at run time 249
ESTAE exits, affected by TRAP run-time option 251
euro currency sign 48
EVALUATE statement
case structure 68, 69
structured programming 481
evaluating data item contents
class test 40, 71
INSPECT statement 87
intrinsic functions 91
examples
CEECBLDY—convert date to COBOL integer format 533
CEEDATE—convert Lilian date to character format 535
CEEDATM—convert seconds to character format 539
CEEDAYS—convert date to Lilian format 544
CEEDYWK—calculate day of week from Lilian date 546
CEEGMT—get current GMT 548
CEEGMTO—get offset from Greenwich Mean Time to local time 550
CEEISEC—convert integers to seconds 552

examples *(continued)*
CEELOCT—get current local time 555
CEEQCEN—query century window 556
CEESCEN—set century window 558
CEESECI—convert seconds to integers 560
CEESECS—convert timestamp to number of seconds 564
IGZEDT4—get current date with four-digit year 567
exception condition 165
exception handling
with Java 385
EXCEPTION XML event 311
EXCEPTION/ERROR declarative
description 161
file status key 162
exceptions, intercepting 251
EXIT compiler option 211
exit modules
called for SYSADATA data set 215
debugging 273
loading and invoking 213
when used in place of library-name 214
when used in place of SYSLIB 214
when used in place of SYSPRINT 215
EXIT PROGRAM statement
in main program 406
in subprogram 406
expanded IF statement 67
explicit scope terminator 18
exponentiation
evaluated in fixed-point arithmetic 516
evaluated in floating-point arithmetic 521
performance tips 484
export command, defining environment variables 169
export command, path search order 170
export file 192
extended mode 31, 513
external class-name 347, 359
EXTERNAL clause
example for files 426, 427
for data items 425
used for input/output 426
external code page, definition 319
external data
sharing 426
external decimal data item 34
external file 12, 426
external floating-point data item 34

F

factoring expressions 482
factory data
defining 371
definition of 341
making it accessible 371
private 371
factory definition, coding 370
factory methods
defining 371
definition of 341
hiding 372
invoking 373
using to wrap procedural programs 379
FACTORY paragraph
factory data 371
factory methods 371
factory section, defining 370
FD (file description) entry 12
feedback token
date and time services and 497
figurative constants
definition 23
national characters as 99
file access mode
dynamic 134
for indexed files 133
for line-sequential files 132
for relative files 133
for sequential files 132
random 134
sequential 133
summary table of 131
file conversion
with millennium language extensions 460
file description (FD) entry 12
file organization
indexed 133
line-sequential 132
overview 131
relative 133
sequential 132
file position indicator 138, 141
FILE SECTION
BLOCK CONTAINS clause 12
CODE-SET clause 12
DATA RECORDS clause 12
description 11
EXTERNAL clause 12
FD entry 12
GLOBAL clause 12
LABEL RECORDS clause 12
LINAGE clause 12
OMITTED 12
RECORD CONTAINS clause 12
record description 11
RECORD IS VARYING 12
RECORDING MODE clause 12
VALUE OF 12
FILE STATUS clause
file loading 142
using 161
with VSAM return code 163
file status code
using 159
file status key
checking for successful OPEN 161, 162
set for error handling 254
to check for I/O errors 161
used with VSAM return code 163
file suffixes
for error messages listing 185
file-name
change 10
specification 12
file-system support
Encina SFS 250
RSD 250
SFS (Encina) 250
STL 250
using FILESYS run-time option 250
VSAM 250
files
accessing Encina SFS 126
accessing using environment variables 172
adding records to 142
affected by TRAP run-time option 251
associating program files to external files 7
changing name 10
clustered 122
COBOL coding
example 136
overview 136
comparison of file organizations 131
deleting records from 143
describing 11
Encina SFS 119
accessing 284
file position indicator 138, 141
identifying 119
identifying to the operating system 10
linker 191
export 192
import 191
library 192
multiple, compiling 179
opening 138
padding records with blanks 126
processing
Encina SFS files 121
RSD files 121
SFS (Encina) files 121
STL files 121
VSAM files 121
reading records from 141
replacing records in 143
RSD 119
SFS (Encina) 119
accessing 284
STL 119
updating records in 144
usage explanation 10
VSAM 119
FILESYS run-time option 250
finding
date of compilation 94
largest or smallest data item 91
length of data items 93
fixed century window 458
fixed-point arithmetic
comparisons 46
evaluation 45
example evaluations 47
exponentiation 516

fixed-point data
binary 35
conversions between fixed- and floating-point data 38
external decimal 34
intermediate results 515
packed-decimal 36
planning use of 483
FLAG compiler option
compiler output 260
description 216
using 259
flags and switches 72
FLAGSTD compiler option 217
FLOAT compiler option 218
floating-point arithmetic
comparisons 46
evaluation 45
example evaluations 47
exponentiation 521
floating-point data
conversions between fixed- and floating-point data 38
external floating point 34
intermediate results 520
internal 36
performance considerations 400
planning use of 483
portability considerations 400
four-digit years 498
freeing object instances 365
fucntion-pointer data item
passing parameters to callable services 424
full date field expansion
advantages 458
fully qualified DCE CDS name
description 120
specifying for SFS files 127
function-pointer data item
addressing JNI services 579
entry address for entry point 424

G

garbage collection 365
GB 18030 data 102
converting 102
generating XML output 327
get and set methods 355
getenv() to access environment variables 170
GETMAIN, saving address of 212
GLOBAL clause for files 15
global names 409
GOBACK statement
in main program 406
in subprogram 406
Greenwich Mean Time (GMT)
getting offset to local time from (CEEGMTO) 549
return Lilian date and Lilian seconds (CEEGMT) 547
Gregorian character string
returning local time as a (CEELOCT) 554
example 555
group item
comparing to national 104
variably located 524
grouping data 420

H

header on listing 6
help files
setting national language 175
specifying path name 175
hexadecimal
portability considerations 400
hexadecimal literal
as currency sign 48
national 98
hiding factory methods 372

I

I-level message 184, 259
IDENTIFICATION DIVISION
class 346
CLASS-ID paragraph 346, 367
client 357
coding 5
DATE-COMPILED paragraph 5
listing header example 6
method 350
PROGRAM-ID paragraph 5
required paragraphs 5
subclass 367
TITLE statement 6
IEEE
portability considerations 400
IF statement
coding 67
nested 68
with null branch 67
IGZEDT4—get current date with four-digit year 566
imperative statement, list 17
implicit scope terminator 18
import file 191
incompatible data 40
incrementing addresses 422
index
data item 55
in Encina SFS files 122
key, detecting faulty 164
range checking 258
table 54
index-name subscripting 55
indexed file organization 133
indexed files
Encina SFS files 122
file access mode 133
indexing
example 59
preferred to subscripting 485
tables 55
INEXIT suboption of EXIT option 211, 213
inheritance hierarchy, definition of 343
init_routine 449
INITIAL attribute 6, 406
INITIALIZE statement
examples 24
loading table values 56
using for debugging 255
initializing
a table 56
instance data 364
the run-time environment 449
inline PERFORM 75
input
from files 119
overview 131
input procedure
coding 150
requires RELEASE or RELEASE FROM 150
restrictions 151
INPUT-OUTPUT SECTION 7
input/output
checking for errors 161
coding
example 136
overview 136
GUI applications 176
introduction 119
logic flow after error 159
processing errors
VSAM files 159
input/output coding
AT END (end-of-file) phrase 160
checking for successful operation 161
checking VSAM return code 163
detecting faulty index key 164
error handling techniques 159
EXCEPTION/ERROR declaratives 161
insert cache 129
INSPECT statement 87
inspecting data 87
instance
creating 364
definition of 341
deleting 365
instance data
defining 348, 368
definition of 341
making it accessible 355
private 348
instance methods
defining 349, 368
definition of 341
invoking overridden 363
overloading 354
overriding 353
INTEGER intrinsic function 87
INTEGER-OF-DATE intrinsic function 44
integers
converting Lilian seconds to (CEESECI) 559
converting to Lilian seconds (CEEISEC) 551
interlanguage communication
between COBOL and C/C++ 411
between COBOL and Java 383
intermediate results 513

internal bridges
advantages 458
example 460
for date processing 459
internal floating-point data
bytes required 36
defining 36
uses for 36
interoperable data types 388
intrinsic functions
as reference modifier 87
compatibility with CEELOCT callable service 554
converting character data items 88
DATEVAL 473
evaluating data items 91
example of
ANNUITY 44
CHAR 91
CURRENT-DATE 44
DISPLAY-OF 101
INTEGER 87
INTEGER-OF-DATE 44
LENGTH 43, 92, 93
LOG 45
LOWER-CASE 89
MAX 43, 65, 91, 92
MEAN 45
MEDIAN 45, 65
MIN 87
NATIONAL-OF 101
NUMVAL 89
NUMVAL-C 43, 89
ORD 91
ORD-MAX 65, 92
PRESENT-VALUE 44
RANGE 45, 65
REM 45
REVERSE 89
SQRT 45
SUM 65
UPPER-CASE 89
WHEN-COMPILED 94
intermediate results 518, 521
introduction to 28
nesting 29
numeric functions
examples of 42
nested 43
special registers as arguments 43
table elements as arguments 43
type of integer, floating-point, mixed 42
uses for 42
processing table elements 65
simplifying coding 493
UNDATE 473
INVALID KEY phrase 164
INVOKE statement
use with PROCEDURE DIVISION RETURNING 425
using to create objects 364
using to invoke methods 361
with ON EXCEPTION 362, 373
invoking
compiler and linker 179
date and time services 495
invoking *(continued)*
factory or static methods 373
instance methods 361

J

Java
and COBOL 383
compiling 195
linking 196
running 197
structuring applications 379
array classes 387
arrays
declaring 389
example 392
manipulating 390
boolean array 389
boolean type 388
byte array 389
byte type 388
char array 389
char type 388
class types 388
double array 390
double type 388
example
exception handling 385
processing an array 392
exception
catching 385
example 385
handling 385
throwing 385
float array 390
float type 388
global references 386
JNI services 387
managing 386
object 386
passing 386
int array 389
int type 388
interoperability 383
interoperable data types, coding 388
jstring class 387
libraries
specified in cob2.cfg 182
updating 195
local references 386
deleting 386
freeing 387
JNI services 387
managing 386
object 386
passing 386
per multithreading 386
saving 386
long array 389
long type 388
methods
access control 387
object array 389
record class 387
running with COBOL 197
sharing data with 387
short array 389
Java *(continued)*
short type 388
string array 389
strings
declaring 389
manipulating 392
supported releases 197
Java virtual machine
exceptions 385
initializing 198
object references 386
java.lang.Object
referring to as Base 346
javac command 195
JNI
accessing services 383
comparing object references 360
converting local references to global 364
environment structure 383
addressability for 384
exception handling services 385
Java array services 390
Java string services 392
libraries
specified in cob2.cfg 182
updating 195
obtaining class object reference 384
restrictions when using 384
Unicode services 392
UTF-8 services 393
JNI.cpy
for compiling 195
for JNINativeInterface 383
listing 579
JNIEnvPtr special register 383
JNINativeInterface
environment structure 383
JNI.cpy 383
job stream 405
jstring Java class 387

L

LABEL RECORDS clause
FILE SECTION entry 12
LANG environment variable 175
language features for debugging
DISPLAY statements 253
last-used state 406
lazy write
enabling 130
environment variable for 174
LC_ALL environment variable 175
LC_COLLATE environment variable 175
LC_CTYPE environment variable 175
LC_MESSAGES environment variable 175
LC_TIME environment variable 175
LENGTH intrinsic function 91
example 43, 93
variable-length results 92
versus LENGTH OF special register 93
with national data 93
length of data items, finding 93

LENGTH OF special register
passing 418
using 93
level definition 267
level-88 item
conditional expressions 71
for windowed date fields 465
restriction 465
switches and flags 72
LIB compiler option 219
LIBEXIT suboption of EXIT option 212, 214
libjava.a 196
LIBPATH environment variable 175, 197
library components, redistributing 194
library file 192
library text
specifying path for 171, 245
library-name
alternative if not specified 187
specifying path for library text 171, 245
library-name, when not used 214
Lilian date
calculate day of week from (CEEDYWK) 545
convert date to (CEEDAYS) 542
convert date to COBOL integer format (CEECBLDY) 531
convert output_seconds to (CEEISEC) 552
convert to character format (CEEDATE) 534
get current local date or time as a (CEELOCT) 554
get GMT as a (CEEGMT) 547
using as input to CEESECI callable service 560
limits of the compiler 11
LINAGE clause 12
line number 266
line-sequential files
file access mode 132
organization 132
LINECOUNT compiler option 220
LINKAGE SECTION
description 419
run unit 14
with recursive calls 14
with the THREAD option 14
linkages, data 412
linker
errors 193
file defaults 193
files 191
export 192
import 191
library 192
invoking 179, 189
resolution of references to shared libraries 434
search rules 192
specifying options 189
linking
examples 190
programs 189
static 433
linking OO applications
cob2_j command 196
example 197
LIST compiler option
description 220
getting output 263
use in debugging 272
list of resources 707
listings
data and procedure name cross-reference 261
embedded error messages 259
generating a short listing 263
line numbers, user-supplied 264
sorted cross-reference of program names 271
terms used in MAP output 268
literals 22
little-endian
converting to big-endian 98
format for data representation 202
representation of integers 403
representation of national characters 403
loading a table dynamically 56
local names 409
local references, converting to global 364
local time
getting (CEELOCT) 554
LOCAL-STORAGE SECTION
client 359
comparison with WORKING-STORAGE 13, 360
locale
accessing 115
and messages 107
definition 106
list of supported values 112
querying 115
setting 108
shown in listing 261, 266
value syntax 109
verifying 108
locale categories 108
locale information database
specifying search path name 175
LOCPATH environment variable 175
LOG intrinsic function 45
loops
coding 75
conditional 76
do 76
in a table 77
performed a definite number of times 76
LOWER-CASE intrinsic function 89
lst file suffix 185
LSTFILE compiler option 221

M

main program
and subprograms 405
arguments to 429
specifying with cob2 187, 188
MAP compiler option
description 221
MAP compiler option *(continued)*
embedded MAP summary 263
example 266, 267, 269
nested program map 263
example 269
symbols used in output 268
terms used in output 268
using 262, 263
mapping of DATA DIVISION items 263
mathematics
intrinsic functions 42, 45
MAX intrinsic function
example 43, 65
using 91
MAXMEM compiler option 222
MEAN intrinsic function 45, 65
MEDIAN intrinsic function 45, 65
merge
completion code 154
concepts 147
description 147
determining success 154
diagnostic message 155
error number 155
files, describing 148
MERGE statement
description 148, 152
MERGE work files 176
message catalogs
specifying path name 175
messages
appearing in abbreviated form 175
compiler
choosing severity to be flagged 259
date-related 474
determining what severity level to produce 216
embedding in source listing 259
generating a list of 185
millennium language extensions 474
severity levels 184
compiler-directed 185
offset information 272
run-time
format 635
incomplete or abbreviated 194
list of 635
listing with dspcat command 635
setting national language 175
when not produced 251
METHOD-ID paragraph 350
methods
constructor 371
factory 371
hiding factory 372
instance 349, 368
invoking 361, 373
invoking superclass 363
Java access control 387
obtaining passed arguments 352
overloading 354
overriding 353, 372
PROCEDURE DIVISION RETURNING 425
returning a value from 353

methods *(continued)*
signature 350
millennium language extensions
assumed century window 466
compatible dates 463
concepts 456
date windowing 455
DATEPROC compiler option 208
nondates 467
objectives 457
principles 456
YEARWINDOW compiler option 240
MIN intrinsic function 87, 91
MIXED suboption of PGMNAME 227
MLE 456
mnemonic-name
SPECIAL-NAMES paragraph 7
modules, exit
loading and invoking 213
MOVE statement
using 26
with national items 26, 100
multiple currency signs
example 48
using 47
multiple inheritance, not permitted 344, 366
multiple thread environment, running in 235
multitasking 442
multithreading
choosing data section
in an OO client 360
control transfer issues 445
effect on return code 416
example 446
limitations on COBOL 446
overview 441
preparing COBOL programs for 441
recursion 444
scope of language elements
program invocation instance scoped elements 443
run-unit scoped elements 443
synchronizing access to resources 446
terminology 441
THREAD compiler option
restrictions under 235
when to choose 444

N

name declaration
searching for 409
naming
programs 5
national comparison 71
national data
comparing to alphabetic or alphanumeric 103
comparing to groups 104
comparing to numeric 103
converting 100
Chinese GB 18030 102
example 101
UTF-8 101
national data *(continued)*
DISPLAY-OF intrinsic 100
in conditional expression 102
in XML document 318
input with ACCEPT 28
joining 79
LENGTH intrinsic function 93
LENGTH OF special register 93
literal 98
MOVE statement 26
NATIONAL-OF intrinsic 100
output with DISPLAY 28
reference modification 85
setting locale 108
specifying 98
spliting 81
tallying and replacing 87
national language setting 175
national language support (NLS)
collating sequence 110
considerations 104
locale sensitivity 106
locale-sensitive collating 110
overview 95
national languages
locale 115
run-time use 95
NATIONAL-OF intrinsic function
using 100
with XML document 320
NCOLLSEQ compiler option 223
nested COPY statement 214, 493
nested delimited scope statements 19
nested IF statement
coding 68
CONTINUE statement 68
EVALUATE statement preferred 68
with null branches 68
nested intrinsic functions 43
nested program integration 489
nested program map
description 263
example 269
nested programs
calling 406
conventions for using 406
description 407
map 263, 269
scope of names 409
transfer of control 406
nesting level
program 266, 269
statement 266
NLSPATH environment variable 175
NOCOMPILE compiler option
use of to find syntax errors 258
NODESC suboption of CALLINT compiler option 203
NODESCRIPTOR suboption of CALLINT compiler option 203
nondates
with MLE 467
NOSSRANGE compiler option
affect on checking errors 249
Notices 681
NSYMBOL compiler option
description 223
NSYMBOL compiler option *(continued)*
for national data items 98
for national literals 98
null branch 68
null-terminated strings 83, 421
NUMBER compiler option
description 224
for debugging 264
numeric class test 40
numeric comparison 71
numeric data
binary
USAGE IS BINARY 35
USAGE IS COMPUTATIONAL (COMP) 35
USAGE IS COMPUTATIONAL-4 (COMP-4) 35
USAGE IS COMPUTATIONAL-5 (COMP-5) 35
comparing to national 103
conversions between fixed- and floating-point data 38
defining 31
editing symbols 32
external decimal
USAGE IS DISPLAY 34
external floating-point
USAGE IS DISPLAY 34
format conversions between fixed- and floating-point 38
internal floating-point
USAGE IS COMPUTATIONAL-1 (COMP-1) 36
USAGE IS COMPUTATIONAL-2 (COMP-2) 36
packed-decimal
USAGE IS COMPUTATIONAL-3 (COMP-3) 36
USAGE IS PACKED-DECIMAL 36
PICTURE clause 31, 32
storage formats 33
zoned decimal
USAGE IS DISPLAY 34
numeric editing symbol 32
numeric intrinsic functions
example of
ANNUITY 44
CURRENT-DATE 44
INTEGER 87
INTEGER-OF-DATE 44
LENGTH 43, 92
LOG 45
MAX 43, 65, 91, 92
MEAN 45
MEDIAN 45, 65
MIN 87
NUMVAL 89
NUMVAL-C 43, 89
ORD 91
ORD-MAX 65
PRESENT-VALUE 44
RANGE 45, 65
REM 45
SQRT 45
SUM 65
nested 43

numeric intrinsic functions *(continued)*
special registers as arguments 43
table elements as arguments 43
types of integer, floating-point, mixed 42
uses for 42
numeric-edited data item 32
NUMVAL intrinsic function 89
NUMVAL-C intrinsic function
example 43
using 89

O

object
creating 364
definition of 341
deleting 365
object code
generating 206
object instances, definition of 341
OBJECT paragraph
instance data 348, 368
instance methods 349
object references
comparing 360
converting from local to global 364
setting 361
typed 360
universal 360
OBJECT-COMPUTER paragraph 7
object-oriented COBOL
compiling 195
linking 196
example 197
preparing applications 196
restrictions
CICS compiler option 341
DYNAM compiler option 210
EXEC CICS statements 341
EXEC SQL statements 341
SQL compiler option 341
running 197
writing OO programs 341
objectives of millennium language extensions 457
OCCURS clause 51, 485
OCCURS DEPENDING ON (ODO) clause
complex 523
initializing ODO elements 62
optimization 485
simple 60
variable-length tables 60
ODBC 287
accessing return values 291
advantages 287
background 288
CALL interface convention 299
driver manager 288
embedded SQL 287
installing and configuring the drivers 288
mapping of C data types 288
passing a COBOL pointer to 289
supplied copybooks 292
ODBC3D.CPY example 297
ODBC *(continued)*
supplied copybooks *(continued)*
ODBC3P.CPY example 294
sample 293
using APIs from COBOL 288
OMITTED parameters 495
OMITTED phrase for omitting arguments 419
ON EXCEPTION phrase
INVOKE statement 362, 373
ON SIZE ERROR
with windowed date fields 471
OPEN operation code 213
OPEN statement
file availability 138
file status key 161
opening files 138
using environment variables 172
operational force
description 130
environment variable for 174
suppressing 130
optimization
avoid ALTER statement 482
avoid backward branches 482
BINARY data items 483
consistent data 484
constant computations 482
constant data items 482
contained program integration 489
duplicate computations 483
effect of compiler options on 489
effect on parameter passing 419
effect on performance 481
factor expressions 482
index computations 486
indexing 485
nested program integration 489
OCCURS DEPENDING ON 485
out-of-line PERFORM 482
packed-decimal data items 484
performance implications 485
structured programming 481
subscript computations 486
subscripting 485
table elements 485
top-down programming 482
unused data items 225
OPTIMIZE compiler option
description 225
effect on parameter passing 419
effect on performance 488
performance considerations 490
using 488
optimizer 488
options
specifying linker 189
ORD intrinsic function 91
ORD-MAX intrinsic function 65, 92
ORD-MIN intrinsic function 92
order of evaluation
arithmetic operators 41, 515
out-of-line PERFORM 75
output
overview 131
to files 119
output procedure
requires RETURN or RETURN INTO statement 151
restrictions 151
using 151
overflow condition 157, 165
overloading instance methods 354
overriding
factory methods 372
instance methods 353

P

PACKED-DECIMAL
synonym 33
packed-decimal data item
date fields, potential problems 476
description 36
using efficiently 36, 484
padding records with blanks 126
page
depth 12
page header 266
customized 265
default 265
paragraph
grouping 77
introduction 16
parameter
in main program 429
parameter list
address of with INEXIT 213
for ADEXIT 215
for PRTEXIT 215
parameters
describing in called program 418
parsing
XML documents 303, 305
passing data between programs
addresses 421
BY CONTENT 417
BY REFERENCE 417
BY VALUE 417
called program 418
calling program 418
EXTERNAL data 425
JNI services 384
language used 418
OMITTED arguments 419
with Java 387
PATH environment variable 176
path name
for copybook search 187, 245
library text 171, 245
multiple, specifying 171, 245
precedence 170
specifying for catalogs and help files 175
specifying for executable programs 176
specifying for locale information database 175
specifying with LIB compiler option 219
PERFORM statement
. . .THRU 77
coding loops 75

PERFORM statement *(continued)*
for a table 58
indexing 55
inline 75
out-of-line 75
performed a definite number of times 76
TEST AFTER 76
TEST BEFORE 76
TIMES 76
UNTIL 76
VARYING 77
VARYING WITH TEST AFTER 77
WITH TEST AFTER . . . UNTIL 76
WITH TEST BEFORE . . . UNTIL 76
performance
arithmetic expressions 484
COBNDX i2.environment variable for SFS 174
coding 481
coding tables 485
compiler option
DYNAM 490
FLOAT 400
OPTIMIZE 488, 490
SSRANGE 490
TEST 490
THREAD 236
TRUNC 236, 490
creating a trace file 188
data usage 483
effect of compiler options on 489
environment variable for SFS 174
exponentiations 484
improving for SFS files
enabling client-side caching 129
reducing frequency of saving changes 130
suppressing operational force 130
in a CICS environment 481
OCCURS DEPENDING ON 485
optimizer 488
planning arithmetic evaluations 483
programming style 481
run-time considerations 481
table handling 486
variable subscript data format 54
worksheet 491
performing calculations
date and time services and 496
period, as scope terminator 18
PGMNAME compiler option 226
physical
record 12
PICTURE clause
determining symbol used 207
numeric data 31
picture strings
date and time services and 498
platform differences 401
pointer data item
description 30
incrementing addresses with 422
NULL value 421
used to pass addresses 421
used to process chained list 421, 422
portability 397
portability *(continued)*
environment differences 401
run-time differences between mainframe and the workstation 402
porting applications
architectural differences between platforms 397
language differences between workstation and mainframe 397
mainframe to workstation
choosing compiler options 397
running mainframe applications on the workstation 399
multitasking 403
using COPY to isolate platform-specific code 398
Windows to AIX 403
workstation to mainframe
workstation-only compiler options 402
workstation-only language features 402
workstation-only names 403
porting your program 32
potential problems with date fields 476
precedence
arithmetic operators 41, 515
preinitializing the COBOL environment 411, 449
PRESENT-VALUE intrinsic function 44
PRINT compiler option 199
printer files 132
procedure and data name cross-reference, description 261
PROCEDURE DIVISION
client 358
description 15
in subprograms 420
instance method 352
RETURNING 16
statements
compiler-directing 18
conditional 17
delimited scope 17
imperative 17
terminology 15
USING 16
PROCEDURE DIVISION RETURNING
methods, use of 425
procedure-pointer data item
entry address for entry point 424
passing parameters to callable services 424
rules for using 424
SET statement and 424
PROCESS statement 181
processes 441
processing
chained list 421, 422
tables 58
using indexing 59
using subscripting 58
PROCESSING-INSTRUCTION-DATA XML event 309
PROCESSING-INSTRUCTION-TARGET XML event 309
producing XML output 327
PROFILE compiler option 227
profile file, setting environment variables in 170
profiling support, PROFILE option 227
program
attribute codes 269
decisions
EVALUATE statement 68
IF statement 67
loops 76
PERFORM statement 76
switches and flags 72
diagnostics 265
entry points, call convention 210
limitations 481
main 405
nesting level 266
statistics 266
structure 5
subprogram 405
PROGRAM COLLATING SEQUENCE clause 8
program names, handling of case 226
PROGRAM-ID paragraph
coding 5
COMMON attribute 6
INITIAL attribute 6
program-name cross-reference 271
programs, running 193
PRTEXIT suboption of EXIT option 212, 215
putenv() to set environment variables 170

Q

QUOTE compiler option 227

R

RANGE intrinsic function 45, 65
read cache 129
reading records from files
dynamically 141
randomly 141
sequentially 141
receiving field 81
record
description 11
format 131
RECORD CONTAINS clause
FILE SECTION entry 12
RECORDING MODE clause
QSAM files 12
records, affected by TRAP run-time option 251
recursive calls
and the LINKAGE SECTION 14
coding 416
identifying 6
redistributing library components 194
reentrant code 505
reference modification
example 85
national data 85
out-of-range values 85

reference modification *(continued)*
tables 54, 85
reference modifier
arithmetic expression as 86
intrinsic function as 87
variables as 85
relate items to system-names 7
relation condition 71
relative files
file access mode 133
organization 133
RELEASE FROM statement
compared to RELEASE 150
example 150
RELEASE statement
compared to RELEASE FROM 150
with SORT 150
REM intrinsic function 45
replacing
data items 87
records in files 143
REPOSITORY paragraph
class 346
client 358
coding 7
subclass 367
representation
data 40
sign 39
restrictions
input/output procedures 151
OO programs 341
subscripting 54
return code
compiler 184
feedback code from date and time services 495
from DB2 279
RETURN-CODE special register 416, 425, 495
VSAM files 163
when control returns to operating system 416
RETURN INTO statement 151
RETURN statement 151
RETURN-CODE special register
considerations for DB2 279
not set by INVOKE 362
passing data between programs 425
value after call to date and time service 495
when control returns to operating system 416
with nonthreaded support 416
with threaded support 416
RETURNING phrase
INVOKE statement 362
methods, use of 425
PROCEDURE DIVISION header 353
REVERSE intrinsic function 89
reversing characters 89
RMODE compiler option
performance considerations 490
ROUNDED phrase 514
rows in tables 52
RSD file system 125
RSD files
identifying 119
processing 121
run time
arguments 429
changing file-name 10
differences between platforms 399
messages 635
performance considerations 481
run unit 405
role in multithreading 441
run-time environment variables
LC_ALL 175
LC_COLLATE 175
LC_CTYLE 175
LC_MESSAGES 175
run-time environment, preinitializing 449
run-time loading, restrictions on 438
run-time messages
appearing in abbreviated form 175
format 635
incomplete or abbreviated 194
list of 635
listing with dspcat command 635
setting national language 175
run-time options
CHECK 249
CHECK(OFF) 490
DEBUG 250
ERRCOUNT 250
FILESYS 250
for CICS 285
specifying 173, 175
TRAP 251
ON SIZE ERROR 158
UPSI 252
running OO applications 197
running programs 193

S

S-level error message 184, 259
scope of names 409
scope terminator
aids in debugging 253
explicit 17, 18
implicit 18
SEARCH ALL statement
binary search 64
indexing 55, 62
ordered table 64
search rules for linker 192
SEARCH statement
examples 63
indexing 55
nesting 63
serial search 63
searching a table 62
searching for name declarations 409
section
declarative 20
description of 16
grouping 77
SELECT clause
vary input-output file 10
SELECT OPTIONAL 138
SELF 361
sending field 81
sentence 16
separate digit sign 32
SEPOBJ compiler option 228
SEQUENCE compiler option 229, 258
sequential files
file access mode 132
organization 132
serial search 63
SET condition-name TO TRUE statement
example 76, 77
switches and flags 73
SET statement
for procedure-pointer data items 424
handling of programs name in 226
setting object references 361
using for debugging 255
setting
linker options 189
switches and flags 73
SFS (Encina) file system
accessing SFS files
example 127
overview 126
description 122
fully qualified DCE CDS file-names 122
improving performance 129
nonhierarchical 122
system administration of 123
SFS (Encina) files
accessing 284
example 127
overview 126
adding alternate indexes 128
alternate index file-name 120
base file-name 120
COBOL coding example 127
compiling for 180
creating alternate index files 126
creating SFS files
environment variables for 126
sfsadmin command for 128
determining available data volumes 126
file-names 122
fully qualified DCE CDS name 127
identifying 119
improving performance 129
nontransactional access 123
organization 122
primary and secondary indexes 122
processing 121
specifying data volume for 126
SFS (Encina) server
fully qualified DCE CDS name 120
specifying server name 126
sfsadmin command
adding alternate indexes 128
creating indexed files 128
description 123
determining available data volumes 126
shared libraries
advantages and disadvantages 434
building 433

shared libraries *(continued)*
example 434
CICS considerations 283
creating for OO 196
definition 433
for Java interoperability 196
overview 434
purpose 434
resolution of references 434
setting directory path 173
subprograms and outermost programs 433
using with Java interoperability 197
using with OO 197
sharing
data 409, 425
with Java 387
files 409, 426
sharing data 14
shell script, compiling using 180
short listing, example 264
sign condition 71, 469
sign representation 39
signature
definition of 350
must be unique 350
SIZE compiler option 230
sliding century window 458
sort
alternate collating sequence 153
completion code 154
concepts 147
criteria 152
description 147
determining success 154
diagnostic message 155
error number 155
files, describing 148
input procedures 150
more than one 147
output procedures 151
restrictions on input/output procedures 151
terminating 156
Sort File Description (SD) entry
example 149
SORT statement
description 152
SORT work files 176
SORT-RETURN special register 156
SOSI compiler option 230
SOURCE and NUMBER output, example 266
source code
line number 266, 267, 269
listing, description 263
SOURCE compiler option 231, 263
SOURCE-COMPUTER paragraph 7
SPACE compiler option 232
special feature specification 7
special register
ADDRESS 418
arguments in intrinsic functions 43
JNIEnvPtr 383
LENGTH OF 93, 418
SORT-RETURN 155, 156
WHEN-COMPILED 94
special register *(continued)*
XML-CODE 312
XML-EVENT 312
XML-NTEXT 312
XML-TEXT 312
SPECIAL-NAMES paragraph
coding 7
SPILL compiler option 232
splitting data items 81
SQL compiler option 233, 279
restriction in OO programs 341
SQL INCLUDE statement 278
SQL statements
use for DB2 services 277
SQLCA 278
SQLCODE 279
SQLSTATE 279
SQRT intrinsic function 45
SSRANGE compiler option
CHECK(OFF) run-time option 490
description 233
performance considerations 490
using 258
STANDALONE-DECLARATION XML event 307
STANDARD clause, FD entry 12
stanza
adding 183
attributes in configuration file 183
cob2 182
cob2_j 182
cob2_r 182
description 182
START-OF-CDATA-SECTION XML event 310
START-OF-DOCUMENT XML event 307
START-OF-ELEMENT XML event 308
statement
compiler-directing 18
conditional 17
definition 16
delimited scope 17
explicit scope terminator 18
imperative 17
implicit scope terminator 18
statement nesting level 266
static data, definition of 341
static linking 410
advantages and disadvantages 433
overview 433
static methods
definition of 341
invoking 373
statistics
intrinsic functions 45
STL file system
description 123
return codes 124
STL files
identifying 119
processing 121
STOP RUN statement
in main program 406
in subprogram 406
storage
mapping 263
STRING statement
example of 79
overflow condition 157
using 79
strings
Java 389
manipulating 392
null-terminated 421
structured programming 482
structuring OO applications 379
subclass
definition of 366
instance data 368
subprogram
and main program 405
description 405
in shared library 433
linkage 405
common data items 419
PROCEDURE DIVISION in 420
subscript
computations 486
range checking 258
subscripting
example of processing a table 58
index-names 55
literal 53
reference modification 54
relative 54
restrictions 54
variable 53
substrings
reference modification 84
referencing table items 85
SUM intrinsic function 65
SUPER 363
surrogate values 102
switch-status condition 71
switches and flags
defining 72
description 72
resetting 73
SYMBOLIC CHARACTERS clause 9
symbolic constant 482
symbols used in MAP output 268
syntax errors
finding with NOCOMPILE compiler option 258
SYSADATA
output 201
SYSADATA file
example 587
file contents 585
record descriptions 588
record types 586
SYSADATA records
exit module called 215
supplying modules 211
SYSIN
supplying alternative modules 211
SYSIN, SYSIPT, SYSOUT, SYSLIST, SYSLST, CONSOLE, SYSPUNCH, SYSPCH environment variables 176
SYSLIB
supplying alternative modules 211
when not used 214
SYSLIB environment variable 171, 195

SYSPRINT
supplying alternative modules 211
when not used 215
system date
under CICS 282
SYSTEM suboption of CALLINT compiler option 203
system-name 7
SYSTERM data set
sending messages to 234

T

table
assigning values 57
columns 51
compare to array 30
defining 51
depth 52
description 30
dynamically loading 56
efficient coding 485, 486
handling 51
identical element specifications 485
index 54
initialize 56
intrinsic functions 65
loading values in 56
looping through 77
making reference 53
one-dimensional 51
reference modification 54
referencing table entry substrings 85
rows 52
searching 62
subscripts 53
three-dimensional 52
two-dimensional 52
variable-length 60
TALLYING option 87
temporary work-file location
specifying with TMP 176
term_routine 450
TERMINAL compiler option 234
terminal, sending messages to 234
terms used in MAP output 268
test
conditions 76
data 71
numeric operand 71
UPSI switch 71
TEST AFTER 76
TEST BEFORE 76
TEST compiler option
description 234
for full advantage of Debug Tool 262
performance considerations 490
THREAD compiler option
and the LINKAGE SECTION 14
default for cob2_j and cob2_r4 235
description 235
for Java interoperability 195
for OO COBOL 195
used with cob2_r4 180
used with SFS file system 180
three-digit years 498
time information, formatting 175
time-zone information
specifying with TZ 176
time, getting local (CEELOCT) 554
timestamp 538, 562
TITLE statement
controlling header on listing 6
TMP environment variable 176
top-down programming
constructs to avoid 482
trademarks 682
transferring control
between COBOL programs 406
called program 405
calling program 405
main and subprograms 405
nested programs 407
transforming COBOL data to XML 327
translating CICS into COBOL 281
TRAP run-time option 251
ON SIZE ERROR 158
TRUNC compiler option
description 236
performance considerations 490
tuning considerations, performance 489, 490
two-digit years
querying within 100-year range (CEEQCEN) 556
example 556
setting within 100-year range (CEESCEN) 557
example 558
valid values for 498
typed object references 360
TZ environment variable 176

U

U-level error message 184, 259
UNDATE intrinsic function 473
Unicode
description 97
encoding 99
JNI services 392
run-time support 95
universal object references 360
UNKNOWN-REFERENCE-IN-ATTRIBUTE XML event 311
UNKNOWN-REFERENCE-IN-CONTENT XML event 311
UNSTRING statement
example 81
overflow condition 157
using 81
UPPER suboption of PGMNAME 226
UPPER-CASE intrinsic function 89
uppercase 89
UPSI run-time options 252
UPSI switches, setting 252
USAGE clause
incompatible data 40
IS INDEX 55
OBJECT REFERENCE 360
USE FOR DEBUGGING declarative 250
USE FOR DEBUGGING declaratives 255
user-defined condition 71
user-exit work area 212
USING phrase
INVOKE statement 362
PROCEDURE DIVISION header 352
UTF-16
encoding for national data 97
UTF-8
JNI services 393
UTF-8 data
converting 101
for ASCII invariant characters 97
processing 101

V

valid data
numeric 40
VALUE clause
assigning table values 57
data description entry 57
large literals with COMP-5 36
large, with TRUNC(BIN) 237
VALUE IS NULL 421
VALUE OF clause 12
variable
as reference modifier 85
description 21
variable-length records
OCCURS DEPENDING ON (ODO) clause 485
variable-length table 60
variables, environment
accessing 170
assignment name 172
COBCPYEXT 171
COBLSTDIR 171
COBMSGS 172
COBOPT 171
COBPATH 173
COBRTOPT 173
EBCDIC_CODEPAGE 173
ENCINA_CDS_ROOT 173
ENCINA_SFS_DATA_VOLUME 173
ENCINA_SFS_INDEX_VOLUME 173
ENCINA_VSAM_AUTO_FLUSH 174
ENCINA_VSAM_CACHE 174
example of setting and accessing 178
LANG 175
LC_TIME 175
LIBPATH 175
library-name 171, 245
LOCPATH 175
NLSPATH 175
PATH 176
precedence 170
run time 172
setting
in .profile 170
in command shell 169
in program 170
overview 169
SYSIN, SYSIPT, SYSOUT, SYSLIST, SYSLST, CONSOLE, SYSPUNCH, SYSPCH 176
SYSLIB 171
text-name 171, 245
TMP 176
TZ 176

variables, environment *(continued)*
used by the compiler 170
variably located data item 524
variably located group 524
VBREF compiler option
description 238
output example 272
using 263
verb cross-reference listing
description 263
verbs used in program 263
VERSION-INFORMATION XML event 307
VSAM file system 122
VSAM files
error processing 159
identifying 119
in a multithreaded environment 446
processing 121
return codes 163

W

W-level message 184, 259
WHEN phrase
EVALUATE statement 69
SEARCH statement 63
WHEN-COMPILED intrinsic function
example 94
versus WHEN-COMPILED special register 94
WHEN-COMPILED special register 94
WITH DEBUGGING MODE clause 250
wlist file 220
WORKING-STORAGE
initializing 239
WORKING-STORAGE SECTION 13
client 359
comparison with LOCAL-STORAGE 13, 360
factory data 371
instance data 348, 368
instance method 351
multithreading considerations 360
workstation and workstation COBOL
differences from host 505
wrapper, definition of 379
wrapping procedure-oriented programs 379
writing compatible code 402
WSCLEAR compiler option 239

X

XML declaration
restriction 305
specifying encoding declaration 320
XML document
accessing 304
basic document encoding 319
coded character sets 319
document encoding declaration 319
effect of CHAR(EBCDIC) 305
encoding 318, 336
enhancing 332
example 333
XML document *(continued)*
external code page 319
generating 327
example 329
handling parsing errors 321
national language 318
parser 303
parsing 305
example 316
processing 303
specifying code page 320
XML declaration 305
XML event
ATTRIBUTE-CHARACTER 308
ATTRIBUTE-CHARACTERS 308
ATTRIBUTE-NAME 308
ATTRIBUTE-NATIONAL-CHARACTER 309
COMMENT 308
CONTENT-CHARACTER 310
CONTENT-CHARACTERS 310
CONTENT-NATIONAL-CHARACTER 310
DOCUMENT-TYPE-DECLARATION 307
ENCODING-DECLARATION 307
END-OF-CDATA-SECTION 311
END-OF-DOCUMENT 311
END-OF-ELEMENT 309
EXCEPTION 311
PROCESSING-INSTRUCTION-DATA 309
PROCESSING-INSTRUCTION-TARGET 309
STANDALONE-DECLARATION 307
START-OF-CDATA-SECTION 310
START-OF-DOCUMENT 307
START-OF-ELEMENT 308
UNKNOWN-REFERENCE-IN-ATTRIBUTE 311
UNKNOWN-REFERENCE-IN-CONTENT 311
VERSION-INFORMATION 307
XML events
description 303
processing 306
processing procedure 305
XML exception codes
for generating 337, 578
for parsing
handleable 569
not handleable 573
XML GENERATE statement
COUNT IN 337
NOT ON EXCEPTION 329
ON EXCEPTION 336
XML generation
counting generated characters 328
description 327
enhancing output 332
example 333
example 329
handling errors 336
ignored data items 328
overview 327
XML output
encoding 336
XML output *(continued)*
enhancing 332
example 333
generating 327
example 329
XML PARSE statement
description 303
NOT ON EXCEPTION 321
ON EXCEPTION 321
using 305
XML parser
conformance 575
description 303
XML parsing
CCSID conflict 324
code-page conflict 324
description 305
effect CHAR(EBCDIC) 305
overview 303
special registers 312
terminating 323
XML declaration 305
XML processing procedure
example 316
specifying 305
using special registers 312
writing 312
XML-CODE special register
description 312
using in generating 329
using in parsing 303
with generating exceptions 336
with parsing exceptions 321
XML-EVENT special register
description 312
using 303, 306
XML-NTEXT special register
description 312
using 303
XML-TEXT special register
description 312
using 303
XREF compiler option 239, 261
XREF output
data-name cross-references 270
program-name cross-references 271

Y

year field expansion 460
year windowing
advantages 458
how to control 473
MLE approach 458
when not supported 464
year-last date fields 462
YEARWINDOW compiler option
description 240

Z

zero comparison 469
zoned decimal 34
zSeries host data type considerations 511
ZWB compiler option 241

Readers' Comments — We'd Like to Hear from You

COBOL for AIX
Programming Guide
Version 2.0

Publication No. SC18-9256-00

Overall, how satisfied are you with the information in this book?

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Overall satisfaction	☐	☐	☐	☐	☐

How satisfied are you that the information in this book is:

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Accurate	☐	☐	☐	☐	☐
Complete	☐	☐	☐	☐	☐
Easy to find	☐	☐	☐	☐	☐
Easy to understand	☐	☐	☐	☐	☐
Well organized	☐	☐	☐	☐	☐
Applicable to your tasks	☐	☐	☐	☐	☐

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. _____

Readers' Comments — We'd Like to Hear from You
SC18-9256-00

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
J87/D325
555 Bailey Avenue
San Jose, CA
U.S.A. 95141-9989

Fold and Tape | **Please do not staple** | Fold and Tape

SC18-9256-00

Cut or Fold
Along Line



Program Number: 5724-H44

Printed in USA

SC18-9256-00

