

z/OS



Resource Measurement Facility Performance Management Guide

z/OS



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Note

Before using this information and the product it supports, be sure to read the general information under "Notices" on page F-1.

Second Edition, October 2001

This is a major revision of SC33-7992-00.

This edition applies to Version 1 Release 2 of z/OS (5694-A01) and to all subsequent releases and modifications until otherwise indicated in new editions.

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Contents

Figures	vii
Tables	xi
About This Book	xiii
Who Should Use This Book	xiii
When to Use This Book	xiii
How This Book Is Organized	xiii
The z/OS RMF Library	xiv
Related Information	xiv
Using LookAt to Look up Message Explanations	xv
Summary of Changes	xvii
What's New in z/OS Version 1 Release 2	xvii
Online Reporting of the License Manager	xvii
Reporting of Report Class Periods	xvii
Enhanced Reporting for the Coupling Facilities	xvii
History of Changes	xviii
What's New in z/OS Version 1 Release 1	xviii
Chapter 1. Performance Overview	1-1
Defining Performance Management	1-2
Setting Performance Goals	1-2
Planning System Capacity	1-3
Benefits of Capacity Planning	1-3
Common Mistakes in Capacity Planning	1-3
Performance Management versus Capacity Planning	1-4
Using RMF	1-5
What Sampling Cycle and Reporting Interval Should You Use?	1-6
Analyzing Transaction Response Time	1-7
General Formulas	1-7
GROUP Report	1-8
Analyzing Workload Characteristics	1-9
Identifying Workloads	1-9
Measuring Resource Utilization by Workload	1-10
Using Monitor I Reports to Analyze Workloads	1-11
Analyzing Processor Characteristics	1-13
Analyzing Workload I/O Characteristics	1-16
Analyzing Processor Storage Characteristics	1-18
Processor Speed Indicators	1-20
Where Do You Go from Here?	1-22
Chapter 2. Diagnosing a Problem: The First Steps	2-1
What Is a Performance Problem?	2-2
Getting Started: A Top-Down Approach to Tuning	2-3
Where to Start Sysplex Monitoring?	2-4
Monitor III Sysplex Summary Report	2-4
Monitor III Response Time Distribution Report	2-4
Monitor III Work Manager Delays Report	2-5
Postprocessor Workload Activity Report	2-5
Monitor III Indicators	2-6
Identifying the Major Delay in a Response Time Problem	2-13
Using Monitor III Reports	2-14

Monitoring Daily Performance: System Indicators	2-20
Summary of Major System Indicators	2-21
Using Monitor I Reports	2-23
Where Do You Go from Here?	2-39

Chapter 3. Analyzing Processor Activity	3-1
Do You Have a Processor Problem?	3-2
Monitor III Indicators	3-2
Monitor I Indicators	3-8
Is Your Processor Idle due to Other Bottlenecks?	3-12
DELAY for Processor: Guidelines for Improvement	3-13
Determine CPU 'Holders'	3-13
Review Dispatching Priorities	3-14
Check for CPU Delay due to Other LPARs	3-15
Check LPAR Balancing Using the CPC Capacity Report	3-15
Processor USING: Trimming Activities.	3-16
Check for Loops	3-16
Check for Slip Traps	3-18
Reduce I/O	3-18
Decrease Monitor Overhead	3-19
Tune System Address Spaces	3-19
Tracing	3-19
Calculate Your Capture Ratio	3-19
Redesign Application	3-19
Install More CPU Power.	3-19
Summary	3-20

Chapter 4. Analyzing I/O Activity	4-1
Do You have an I/O Problem?	4-2
I/O Subsystem Health Check	4-4
Understand your Business Priorities	4-4
Review CPU and Processor Storage	4-4
Establish a Baseline Measurement	4-4
Improving I/O Performance with the Enterprise Storage Server	4-5
Introduction	4-5
Architecture	4-5
z/OS Parallel Sysplex I/O Management	4-6
ESS Performance Features	4-6
Cache Performance	4-10
CACHE	4-10
DASD	4-11
Cache Management with ESS	4-11
Cache Subsystem Activity Report	4-13
Using Monitor III Cache Reporting	4-23
DASD Indicators and Guidelines.	4-25
Response Time Components	4-25
Spreadsheet Reports	4-26
General DASD Guidelines	4-28
DASD Performance in the Sysplex	4-38
Analyzing Specific DASD Problems	4-39
Performance Analysis on Data Set Level.	4-43
Improving Your DASD Performance	4-45
Tape Indicators and Guidelines	4-47
Identifying Tape-bound Jobs	4-47
RMF Measurements	4-47
Response Time Components	4-48

General Tape Indicators	4-49
Improving Your Tape Performance	4-50
Summary	4-51
Chapter 5. Analyzing Processor Storage Activity	5-1
Do You Have a Processor Storage Problem?	5-2
Monitor III Indicators	5-3
Monitor I Indicators	5-8
General Storage Recommendations	5-14
Decrease Storage Demand	5-14
Increase Storage	5-14
Auxiliary Storage Tuning.	5-14
Prioritize Access to Processor Storage	5-14
Tune DASD	5-14
Summary	5-15
Chapter 6. Analyzing Sysplex Activity	6-1
Understanding Workload Activity Data for IMS or CICS	6-2
Interpreting the Workload Activity Report	6-2
Problem: Very Large Percentages in the Response Time Breakdown.	6-6
Problem: Response Time Breakdown Data is All Zero	6-8
Problem: More Executed Transactions Than Ended Transactions	6-9
Problem: Execution Time is Greater Than Response Time	6-11
Problem: Large SWITCH Time in CICS Execution Phase	6-12
Problem: Decreased Number of Ended Transaction with Increased Response Times.	6-13
Analyzing Coupling Facility Activity	6-15
Using the Postprocessor Report	6-15
Spreadsheet Report	6-29
Using the Monitor III Online Reports	6-30
Factors Affecting Coupling Facility Performance	6-32
Appendix A. PR/SM LPAR Considerations	A-1
Understanding the Partition Data Report	A-2
Defining Logical Processors.	A-4
Appendix B. The Intelligent Resource Director.	B-1
Overview.	B-2
Dynamic Channel Path Management	B-2
Introduction to Dynamic Channel Path Management.	B-2
Value of Dynamic Channel Path Management	B-3
Reporting of Dynamic Channel Path Management	B-3
Channel Subsystem Priority Queuing	B-4
Introduction to Channel Subsystem Priority Queuing.	B-4
Value of Channel Subsystem Priority Queuing	B-5
Reporting of Channel Subsystem Priority Queuing	B-5
LPAR CPU Management	B-5
Introduction to LPAR CPU Management	B-5
Value of LPAR CPU Management	B-7
LPAR CPU Management Decision Controls	B-7
LPAR CPU Management Controls	B-8
Reporting of LPAR CPU Management	B-8
Appendix C. Data-In-Memory.	C-1
Introduction.	C-2
Current Implementations	C-3

Batch LSR Subsystem	C-3
DFSORT Hipersorting	C-3
Hiperbatch	C-4
VIO to Expanded Storage	C-4
VSAM Large Buffer Pools	C-5
Virtual Lookaside Facility	C-5
DB2 Buffer Pool	C-5
CICS Shared Data Tables	C-5
Virtual Fetch	C-6
Methodology Roadmap	C-6
Appendix D. Other Delays	D-1
Enqueue Delays	D-2
ENQ Report	D-2
Major Names	D-2
HSM Delays	D-4
HSM Report	D-4
JES Delays	D-5
OPER Delays	D-5
Unknown Delays	D-5
Glossary	E-1
Notices	F-1
Programming Interface Information	F-2
Trademarks	F-2
Index	X-1

Figures

1-1.	End-to-End Response Time Components	1-7
1-2.	Monitor III Group Response Time Report	1-8
1-3.	System Resource Summary by Workload	1-10
1-4.	Monitor I CPU Activity Report - Part 1	1-11
1-5.	Workload Activity Report - Service Class	1-12
1-6.	Workload Activity Report - Service Policy	1-12
1-7.	Processor Utilization by Workload.	1-13
1-8.	I/O Activity by Workload	1-16
1-9.	Workload Activity Report - I/O Activity	1-17
1-10.	Processor Storage by Workload	1-18
1-11.	Workload Activity Report - Processor Storage Use	1-19
2-1.	Simplified View of Performance Management	2-3
2-2.	Monitor III Sysplex Summary Report	2-6
2-3.	Monitor III Sysplex Summary Report - GO Mode.	2-7
2-4.	Monitor III Response Time Distribution Report	2-10
2-5.	Monitor III Work Manager Delays Report	2-12
2-6.	End-to-End Response Time Components	2-13
2-7.	Monitor III Group Response Time Report	2-15
2-8.	Monitor III Storage Delays Report.	2-16
2-9.	Monitor III Delay Report	2-16
2-10.	Monitor III Job Delays Report	2-17
2-11.	Monitor III Workflow/Exceptions Report.	2-18
2-12.	Summary of Major System Indicators	2-21
2-13.	Monitor I CPU Activity Report	2-23
2-14.	CPU Contention	2-25
2-15.	Monitor I CPU Activity Report - Partition Data Report Section	2-26
2-16.	Monitor I Channel Path Activity Report	2-27
2-17.	Monitor I I/O Queuing Activity Report	2-28
2-18.	Monitor I DASD Activity Report.	2-29
2-19.	DASD Summary	2-31
2-20.	Response Time of Top-10 Volumes	2-32
2-21.	Monitor I Paging Activity Report - Page 3	2-33
2-22.	Monitor I Page/Swap Data Set Activity Report	2-34
2-23.	Workload Activity Report	2-35
2-24.	Monitor I Virtual Storage Activity Report - Common Storage Summary	2-37
3-1.	Monitor III Group Response Time Report	3-3
3-2.	Monitor III Delay Report.	3-4
3-3.	Monitor III Workflow/Exceptions Report	3-5
3-4.	Monitor III Processor Delays Report	3-6
3-5.	Monitor I CPU Activity Report.	3-8
3-6.	CPU Contention Report	3-10
3-7.	Monitor I CPU Activity Report - Partition Data Report Section	3-11
3-8.	Monitor III Job Delays Report	3-13
3-9.	Monitor II Address Space State Data Report.	3-14
3-10.	Monitor III CPC Capacity Report	3-15
3-11.	Monitor III Processor Delays Report	3-16
3-12.	Monitor III Job Delays Report	3-17
3-13.	Monitor III Workflow/Exceptions Report.	3-18
4-1.	z/OS Traditional Device Serialization	4-7
4-2.	Device Queuing in a Parallel Access Volume Environment	4-9
4-3.	Cache Performance Management: The Key	4-10
4-4.	Cache Subsystem Activity Report - Summary Report	4-13
4-5.	Cache Subsystem Activity Report - Top-20 Reports.	4-14

4-6.	Cache Subsystem Activity Report - Status and Overview	4-15
4-7.	Cache Subsystem Activity Report - Device Overview	4-18
4-8.	Cache Subsystem Activity Report - RAID Rank Activity	4-18
4-9.	Cache Subsystem Activity Report - Device Report	4-19
4-10.	Overview Report for Cached DASD Device	4-20
4-11.	Cache Hits Overview Report	4-21
4-12.	Cache Trend Report.	4-21
4-13.	CACHSUM Report	4-23
4-14.	CACHDET Report	4-24
4-15.	DASD Response Time Components	4-25
4-16.	DASD Summary Report	4-26
4-17.	Activity of Top-10 Volumes	4-27
4-18.	Response Time of Top-10 Volumes	4-28
4-19.	Monitor I DASD Activity Report.	4-29
4-20.	Shared DASD Activity Report	4-38
4-21.	Monitor III System Information Report	4-39
4-22.	Monitor III Delay Report	4-40
4-23.	Monitor III Device Delays Report	4-41
4-24.	Monitor III Device Resource Delays Report	4-42
4-25.	Monitor III - Device Resource Delays Report.	4-43
4-26.	Monitor III - Data Set Delays by Volume	4-43
4-27.	Monitor III - Data Set Delays by Job	4-44
4-28.	Monitor III - Data Set Delays by Data Set	4-45
4-29.	Monitor I Magnetic Tape Device Activity Report.	4-48
5-1.	Monitor III System Information Report.	5-3
5-2.	Monitor III Delay Report.	5-5
5-3.	Monitor III Storage Delays Report	5-6
5-4.	Monitor I Paging Activity Report - Page 1	5-8
5-5.	Monitor I Paging Activity Report - Page 2	5-10
5-6.	Monitor I Page/Swap Data Set Activity Report	5-11
5-7.	Monitor I DASD Activity Report.	5-12
6-1.	Hotel Reservations Service Class	6-2
6-2.	Response Time Breakdown of CICSHR accessing DBCTL	6-3
6-3.	Point-of-Sale Service Class	6-4
6-4.	Response Time Breakdown of CICSPS accessing DBCTL with IMS V5	6-4
6-5.	CICS User Transactions Service Class	6-5
6-6.	Response Time Percentages Greater than 100	6-6
6-7.	Response Time Breakdown Percentages all Zero	6-8
6-8.	Executed Transactions greater than Ended Transactions.	6-9
6-9.	Execution Time Greater than Response Time	6-11
6-10.	High SWITCH time in a CICS Execution Environment	6-12
6-11.	Coupling Facility Activity Report - Usage Summary	6-15
6-12.	Coupling Facility Activity Report - Structure Activity	6-20
6-13.	Coupling Facility Activity Report - Subchannel Activity	6-26
6-14.	Coupling Facility Activity Report - CF to CF Activity	6-28
6-15.	Coupling Facility Structure Activity	6-29
6-16.	CFOVER Report	6-30
6-17.	CFACT Report.	6-31
6-18.	CFSYS Report.	6-32
A-1.	CPU Activity Report	A-2
A-2.	Partition Data Report.	A-3
B-1.	CHANNEL Report	B-3
B-2.	IOQUEUE Report	B-4
B-3.	LPAR Cluster - Example 1	B-6
B-4.	LPAR Cluster - Example 2.	B-6
B-5.	LPAR Cluster Report	B-8

B-6.	Partition Data Report	B-10
C-1.	Data-In-Memory Roadmap.	C-7
D-1.	Monitor III Enqueue Delays Report.	D-2
D-2.	Monitor III HSM Delays Report	D-4

Tables

1.	RMF Library	xiv
3-1.	Processor Indicators in Monitor III and Monitor I	3-2
5-1.	Processor Storage Indicators in Monitor III and Monitor I.	5-2

About This Book

The z/OS Resource Measurement Facility (RMF) is a performance management tool that is designed to measure selected areas of system activity and present the data collected in the form of *system management facility (SMF)* records, formatted printed reports, or formatted display reports. Use RMF to report on resource usage, evaluate system performance and identify reasons for performance problems.

This book offers a practical, task-oriented approach to analyzing performance issues using RMF. Covering the most frequently asked questions, it offers guidelines and suggestions concerning performance management of a z/OS sysplex.

Who Should Use This Book

Anyone involved in understanding, measuring, and improving the performance of z/OS systems. This book assumes that the reader has a basic understanding of RMF and how z/OS systems work. The detailed description of all RMF functions and reports is available in *RMF User's Guide* and *RMF Report Analysis*.

When to Use This Book

Use this book when you are trying to improve the performance of your z/OS sysplex. Reasons could include:

- Complaints are coming in from users
- Service level objectives are not being met
- Ongoing performance monitoring showing adverse trends
- Resource usage is changing
- Furthering your own understanding

Furthermore, this book give hints how to use RMF measurements for preparing the migration from compatibility mode to goal mode.

Do not use this book when your efforts have taken you beyond the scope of RMF and MVS performance. For example:

- Network tuning
- Detailed internal subsystem tuning for DB2

How This Book Is Organized

This book contains the following chapters:

Chapter 1. Performance Overview

The chapter describes performance concepts common to all z/OS systems.

Chapter 2. Diagnosing a Problem: The First Steps

This chapter helps you analyze a performance problem to determine which resource is constrained, and thus where you should proceed with further analysis.

Chapter 3. Analyzing Processor Activity

Here, you find information for further analysis of CPU constraints.

Chapter 4. Analyzing I/O Activity

This chapter concentrates on the analysis of I/O constraints (Cache subsystem, DASD, and tape).

Chapter 5. Analyzing Processor Storage Activity

The analysis of processor storage constraints (central storage and paging subsystem) will be explained in this chapter.

Chapter 6. Analyzing Sysplex Activity

This chapter covers key indicators for workload management and coupling facility performance aspects.

Appendix A. PR/SM LPAR Considerations

Here, you find performance considerations for systems running in LPAR mode.

Appendix B. The Intelligent Resource Director

This appendix describes the functions of the Intelligence Resource Director and its reporting in RMF.

Appendix C. Data-In-Memory

This appendix concentrates on Data-in-Memory techniques.

Appendix D. Other Delays

The last appendix discusses some delays shown in Monitor III that have not been covered before.

You should not need to read this book cover-to-cover to find it useful. Feel free to turn directly to the topic of immediate interest to you.

The z/OS RMF Library

This table shows the shortened titles, full titles, and order numbers of the books in the RMF library for z/OS. This book uses the shortened titles when referring to other books.

Table 1. RMF Library

Short Title Used in This Book	Title	Order Number
Books available as Hardcopy and Softcopy		
<i>RMF User's Guide</i>	<i>z/OS RMF User's Guide</i>	SC33-7990
<i>RMF Report Analysis</i>	<i>z/OS RMF Report Analysis</i>	SC33-7991
<i>RMF Performance Management Guide</i>	<i>z/OS RMF Performance Management Guide</i>	SC33-7992
<i>RMF Messages and Codes</i>	<i>z/OS RMF Messages and Codes</i>	SC33-7993
<i>RMF Programmer's Guide</i>	<i>z/OS RMF Programmer's Guide</i>	SC33-7994
<i>RMF Reference Summary</i>	<i>z/OS RMF Reference Summary</i>	SX33-9033
Softcopy documentation as part of the <i>z/OS Collection</i> (SK3T-4269 (CD-Rom) and SK3T-4271 (DVD))		
<i>RMF NewsFLASH</i>	<i>z/OS RMF NewsFLASH</i>	SC33-7995

Related Information

For additional information on z/OS, see the *z/OS Information Roadmap*, SA22-7500.

Using LookAt to Look up Message Explanations

LookAt is an online facility that allows you to look up explanations for z/OS messages and system abends.

Using LookAt to find information is faster than a conventional search because LookAt goes directly to the explanation.

LookAt can be accessed from the Internet or from a TSO command line.

You can use LookAt on the Internet at:

www.ibm.com/servers/eserver/zseries/zos/bkserv/lookat/lookat.html

To use LookAt as a TSO command, LookAt must be installed on your host system. You can obtain the LookAt code for TSO from the LookAt Web site by clicking on the **News and Help** link or from the *z/OS Collection*, SK3T-4269.

To find a message explanation from a TSO command line, simply enter: **lookat** *message-id* as in the following:

```
lookat erb100i
```

This results in direct access to the message explanation for message ERB100I.

To find a message explanation from the LookAt Web site, simply enter the message ID and select the release you are working with.

Summary of Changes

What's New in z/OS Version 1 Release 2

Summary of Changes for SC33-7992-01 z/OS Version 1 Release 2

This book contains information previously presented in *RMF Performance Management Guide*, SC33-7992-00, which supports the Resource Measurement Facility.

This book includes terminology, maintenance, and editorial changes. Technical changes or additions to the text are indicated by a vertical line to the left of the change.

The following information describes the enhancements that are being distributed with z/OS Version 1 Release 2. It is indicated by a vertical line to the left of the text.

Online Reporting of the License Manager

A new Monitor III **CPC Capacity** report is available which provides information about defined and consumed processor capacity of all partitions in a CPC (central processor complex) which special emphasis on License Manager aspects.

This report is available as SPE and needs to be installed as APAR OW49807 (available in September/October time frame).

Reporting of Report Class Periods

Statistics on response times is a key performance metric used for groups of work having response time objectives. WLM report classes allow aggregation of performance data so that you can evaluate performance of applications independent of the definition how they are managed. Now, reporting of report classes is available with the same granularity as for service classes.

This can be seen in the Postprocessor **WLMGL** report, and in several Monitor III reports: **GROUP**, **STORS**, **SYSINFO**, **SYSRTD**, **SYSSUM**, and **SYSWKM**.

Enhanced Reporting for the Coupling Facilities

CF duplexing ensures high application availability in a Parallel Sysplex. The performance management aspects which have to be covered for CF duplexing are provided by RMF in the Postprocessor **CF Activity** report about new peer CF connectivity. This enables you to evaluate and monitor your CF configuration, and you can apply the necessary changes to tune accommodation of new structure instances resulting from system-managed duplexing.

History of Changes

What's New in z/OS Version 1 Release 1

The following information describes the enhancements that are being distributed with z/OS Version 1 Release 1. It is indicated by a vertical line to the left of the text.

There is one release RMF 2.10 that can run in OS/390 2.10 as well as in z/OS V1R1. Nevertheless, some new functions are available only when z/OS is running on a zSeries 900 server.

Intelligent Resource Director (IRD)

The Workload Manager is extended to work with PR/SM on zSeries 900 (z900) servers to dynamically expand resources that are available across LPARs.

An **LPAR cluster** is defined as the set of logical partitions in a single CEC that belong to the same parallel sysplex. Based on business goals, WLM can direct PR/SM to enable or disable CP capacity for an LPAR, without human intervention. This combination of WLM working with PR/SM on a z900 server is called IRD.

IRD is made up of three parts which work together to help increase your business' productivity:

- **LPAR CPU Management**

Based on workload resource demand, the Workload Manager is able to dynamically adjust the number of logical processors and the weight of a logical partition. This allows the system to distribute the CPU resource in an LPAR cluster to partitions where the CPU demand is high.

The dynamic adjustment of processor resources within the partitions is reflected in the Postprocessor **CPU Activity (Partition Data)** report which provides LPAR views as well as aggregated views on LPAR cluster level.

- **Dynamic Channel Path Management**

Dynamic Channel Path Management provides the capability to dynamically assign channels to control units in order to respond to peaks in demand for I/O channel bandwidth. This is possible by allowing you to define pools of so-called managed channels that are not related to a specific control unit. With the help of the Workload Manager, channels can float between control units to best service the work according to their goals and their importance.

All channel and I/O queuing reports have been extended to differentiate static channels from floating channels.

- **Channel Subsystem Priority Queuing**

This topic is not reflected directly in any RMF report.

This powerful triad of functions can increase your productivity by putting your most business-critical work first.

IBM License Manager

The IBM License Manager is the base for a new software pricing model. It allows vendors to enable their products for licensed software management by customers and is the basic tool IBM will use to implement the **Workload License Charges** pricing model on z900 servers.

The Postprocessor **CPU Activity (Partition Data)** report will show CPU resource consumption within an LPAR in terms of millions of service units (MSUs) and the

corresponding LPAR MSU defined capacity. This helps you to understand how much of the defined capacity an LPAR is consuming.

FICON Director

RMF offers new reporting capabilities for the FICON director. Due to the different technology and implementation compared to ESCON, the new Postprocessor **FICON Director Activity** report will provide information about director and port activities. This will assist you in analyzing performance problems and in capacity planning.

Goal Mode Enhancements

The Workload Manager has implemented some enhancements to help increase production use of goal mode. They are

- Classification by System Name
- Separation of Production from Test CICS/IMS Regions
- Address Space Storage Isolation
- Pro-active CPU Protection

This is done by new specifications (CPU protection and storage protection) in the service policy.

RMF supports these enhancements in the **WLMGL** Postprocessor report and in several online reports:

- Monitor II ARD/ARDJ report
- Monitor III SYSWKM report
- Monitor III DELAY report
- Monitor III JOB report
- Monitor III STORF report
- Monitor III ENCLAVE report - Details

Chapter 1. Performance Overview

Let's Start with an Overview

This chapter contains an overview of key performance topics. It explains the concepts and terms we will be using throughout the book:

- Performance Management Definition
- Service Level Agreements
- Capacity Planning Concepts
- Using RMF
- Components of Transaction Response Time
- Analyzing Workload Characteristics
 - Processor
 - Processor Storage
 - I/O Activity
- Processor Speed Indicators

Defining Performance Management

Performance management means monitoring and allocating data processing resources to applications according to *Service Level Agreements* (SLA) or informal objectives. It involves an ongoing cycle of measuring, planning, and modifying.

The goal of performance management is to make the best use of your current resources, to meet your current objectives without excessive tuning effort.

Setting Performance Goals

The human view of the performance of a system is often subjective, emotional and difficult to manage to. However, meeting the business needs of the users is the reason the system exists.

To match business needs with subjective perception, the concept of SLA was introduced.

The SLA is a contract that objectively describes such measurables as:

- Average transaction response time for network, I/O, CPU, or total
- The distribution of these response times (for example, 90% TSO trivial at less than 0.2 of a second)
- Transaction volumes
- System availability

A *transaction* is a business unit of work and can be a CICS end user interaction, a batch job, etc. Ideally, the definition of a transaction is from a user's point of view.

Planning System Capacity

We can define capacity planning as:

A process of planning for sufficient computer capacity in a cost-effective manner to meet the service needs for all users.

Capacity planning involves asking the following questions:

- How much of your computer resources are being used?
 - CPU
 - Processor storage
 - I/O
 - Network
- Which workloads are consuming the resources (workload distribution)?
- What are the expected growth rates?
- When will the demands on current resources impact service levels?

Benefits of Capacity Planning

An effective capacity planning process provides:

- A mapping of business objectives (user requirements) into quantifiable *information technology (IT)* resources.
- Management oriented reporting of service, resource usage and cost. In an objective way this makes clear what is involved in providing users with good performance.
- Input for making business decisions which involve IT.
- A way to avoid surprises.

Common Mistakes in Capacity Planning

Things to avoid include:

- **Forgetting the concept of balanced systems.** Remember that it takes a combination of resources to process work: CPU, processor storage, and I/O. Increasing the capacity of one resource by itself, may not allow more work to be processed.
- **Ignoring latent demand.** Latent demand is work that is 'hidden' and waiting to be unleashed. One way to begin quantifying latent demand is to note your peak-to-average ratio (e.g. peak hour CPU busy compared to prime-shift average CPU busy). This ratio will drop as latent demand builds up so track it and compare it to your current system (see *Balanced Systems and Capacity Planning* for more details). Relieving *any* bottleneck (for example, upgrading constrained CPU, increasing network bandwidth, or improving I/O subsystem) will release latent demand.
- **Being out of touch with business forecasts.** This one is obvious, but can be difficult to avoid. The capacity planner needs to stay informed of business plans that will impact IT resource requirements (for example, departmental growth, new applications, and mergers).
- **Ignoring complexity.** Factors other than transaction growth will increase demand on IT resources. Enhancements to existing applications, new government regulations, growing databases, etc - all can result in an increase in resource consumption. This means that "the same" transaction running today may require 10-15% more resource than it did last year.

Performance management

- **Striving for total precision.** Many variables will impact your capacity plan (growth projections, resource capacity estimates, measurement precision, politics). A plan which achieves an accuracy of $\pm 10\%$ is considered good. Your time is probably better spent on reasonability checks on your input than on trying to achieve total accuracy.

Performance Management versus Capacity Planning

These two disciplines have much in common. Performance management concentrates on allocating existing resources to meet service objectives. Capacity planning is a means of predicting resources needed to meet future service objectives.

Similar approaches can be used for both; here are some examples:

- Rules of thumb
- Comparison with other systems
- Parametric methods
 - Transaction profile (10 read calls, 2 update calls, 8 physical I/Os)
 - Cost of function (CICS: 15ms per physical I/O in a 3390 non-cached)
- Analytic (queuing theory) models: For example the IBM capacity planning tool CP90.
- Simulation, using a computer program that has the essential logic of the system: for example the Snap/Shot modelling system from IBM.
- Benchmarks, *Teleprocessing Network Simulator (TPNS)*.

In addition, performance and capacity work tend to require similar input data from the system. In particular, both require resource consumption by workload data (see “Analyzing Workload Characteristics” on page 1-9).

Using RMF

RMF issues reports about performance problems as they occur, so that your installation can take action before the problems become critical.

Your installation can use RMF to:

- Determine that your system is running smoothly
- Detect system bottlenecks caused by contention for resources
- Evaluate the service your installation provides to different groups of users
- Identify the workload delayed and the reason for the delay
- Monitor system failures, system stalls, and failures of selected applications

RMF comes with three monitors, Monitor I, II and III. Monitor III with its ability to determine the 'cause of delay' is where we start:

Monitor III provides short term data collection and online reports for continuous monitoring of system status and solving performance problems.

Monitor III is a good place to begin system tuning. It allows the system tuner to distinguish between delays for important jobs and delays for jobs that are not as important to overall system performance.

Monitor I provides long term data collection for system workload and resource utilization. The Monitor I session is continuous, and measures various areas of system activity over a long period of time.

You can get Monitor I reports directly as real-time reports for each completed interval (single-system reports only), or you let run the **Postprocessor** to create the reports, either as single-system or as sysplex reports. Many installations produce daily reports of RMF data for ongoing performance management. In this publication, sometimes a report is called a Monitor I report (for example, the Workload Activity report) although it can be created only by the Postprocessor.

Monitor II provides online measurements on demand for use in solving immediate problems.

A Monitor II session can be regarded as a snapshot session. Unlike the continuous Monitor I session, a Monitor II session generates a requested report from a single data sample. Since Monitor II is an ISPF application, you might use Monitor II and Monitor III simultaneously in split-screen mode to get different views of the performance of your system.

In addition, you can use the **Spreadsheet Reporter** for further processing the measurement data on a workstation by help of spreadsheet applications. The following chapters provide sample reports including the name of the corresponding macro.

You find a detailed description on how to create the reports and records and on how to use the macros in the *RMF User's Guide*.

There is another function in RMF to exploit the workstation for monitoring and analyzing your system, called **RMF Performance Monitoring (RMF PM)**, formerly known as PM of OS/390. You find a detailed description on how to use this function in the *RMF User's Guide*.

Performance management

This book will discuss key RMF indicators from the different monitors that can be used in a daily report and in problem diagnosis.

What Sampling Cycle and Reporting Interval Should You Use?

For Monitor III: Use the default sampling cycle of 1 second, with the default of 100 seconds for the reporting interval. Adjust this interval if needed to match a problem occurrence that you are investigating.

For Monitor I: Again use the default sampling cycle of 1 second. For the reporting interval, the default of 30 minutes is fine to start with. Adjust this if you prefer, or if you need to home in on a problem.

Analyzing Transaction Response Time

To characterize the performance of a transaction you need to understand its different response time components.

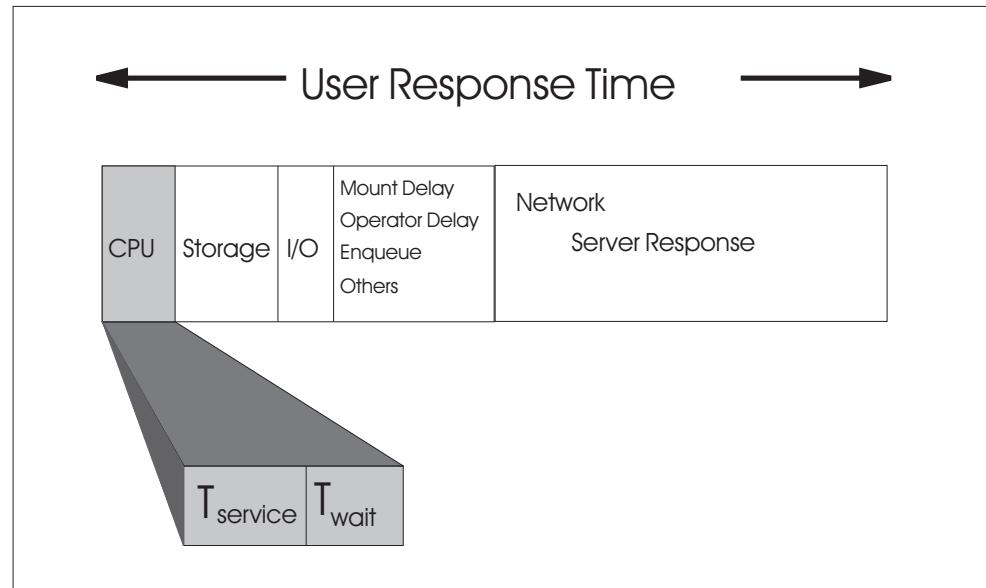


Figure 1-1. End-to-End Response Time Components

The reasons you should care about this are:

- For capacity planning you need to know resource consumption.
- For performance management you need to break down response time into components, to see where tuning can be done.

General Formulas

Response time is made up of service time (the time actual work is done) and waiting time (the time waiting for resource): $T_r = T_s + T_w$

- T_r is Response Time
- T_s is Service Time
- T_w is Waiting Time (that is Queue time or Delay in RMF Monitor III).

Similarly total transaction service and wait times are made up of the individual resource service and wait times.

$$T_s = T_s(\text{CPU}) + T_s(\text{I/O}) + T_s(\text{TP}) + T_s(\text{Other})$$

$$T_w = T_w(\text{CPU}) + T_w(\text{I/O}) + T_w(\text{TP}) + T_w(\text{Storage}) + T_w(\text{Other})$$

The Monitor I Workload Activity report shows some of this data for a group of transactions (service or report class). This applies for TSO and batch work (and potentially CICS, with interval recording).

The Monitor III Group Response Time report also shows this data, with a more useful breakdown of response time components (see Figure 1-2 on page 1-8).

GROUP Report

RMF V1R2 Group Response Time											
Command ==>											
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec	
Class: TSOPROD		Period: 1		Description: TSO Production							
Primary Response Time Component:				Storage delay for local paging							
WFL		Users		Frames		Vector		EXCP		PgIn	
%		TOT ACT		%ACT		UTIL		Rate		Rate	
50		2 1		5		0		3.2		4.1	
										TRANS	
										Ended	
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Figure 1-2. Monitor III Group Response Time Report

Report Analysis

See Response Time ACT field for a breakdown of the components of response time. Think of USING as service time (T_s) and DELAY as wait time (T_w)

- AVG USG: $0.57 + 0.97 = 1.54$ sec
- Average Delay: $0.11 + 0.17 + 1.25 + 0.34 = 1.87$ sec

So here, if you were investigating a response time problem, STOR would be the best starting point.

Monitor III provides insight into the components of response. With an emphasis on causes of *delay*, it shows you the resources for which work is being delayed and the address spaces which are holding the resources.

Analyzing Workload Characteristics

Much of performance work is done, not at the individual transaction level, but at a larger *workload* level. Understanding resource requirements by workload is key to effective performance management.

The reasons you should analyze your workload are:

- To understand your system's behavior
- For setting your SLA
- For tuning
 - Where is the pain?
 - Interactions with other workloads
- For input to the capacity planning process
 - Workload growth projections
 - Processor requirements
 - Storage requirements
 - DASD requirements
 - Network requirements

Identifying Workloads

You will need to identify the different types of work in your system. Usually this is done at a service class level. To assign work to service classes you must classify the various workloads by their unique characteristics and requirements, that is:

- Response time needs
- Resource consumption (CPU, Storage, I/O)
- Priority
- Anticipated growth

Examples of workload identification at the service class level include:

- Trivial TSO (first period)
- Non-trivial TSO
- Batch
- Production CICS
- Development CICS
- IMS
- Graphics application

Ideally, you may want to take workload differentiation one level further, matching workloads to true business functions (for example, claims processing and order fulfillment). This may require more detailed data from SMF records.

RMF reports data about different workloads grouped into categories which you have defined as *workloads* and *service classes* in your service policy.

The appropriate grouping of workloads is important.

- If you have different applications which should be managed according to the same goals, you should define the same **service class** for them. Applications with different goals need to be assigned to different service classes.

Workload characteristics

- If you want to get separate reporting for different applications in the same service class, you can define separate **report classes** for each of them. Reporting for report classes is possible with the same level of detail (report class period) as for service classes.

Measuring Resource Utilization by Workload

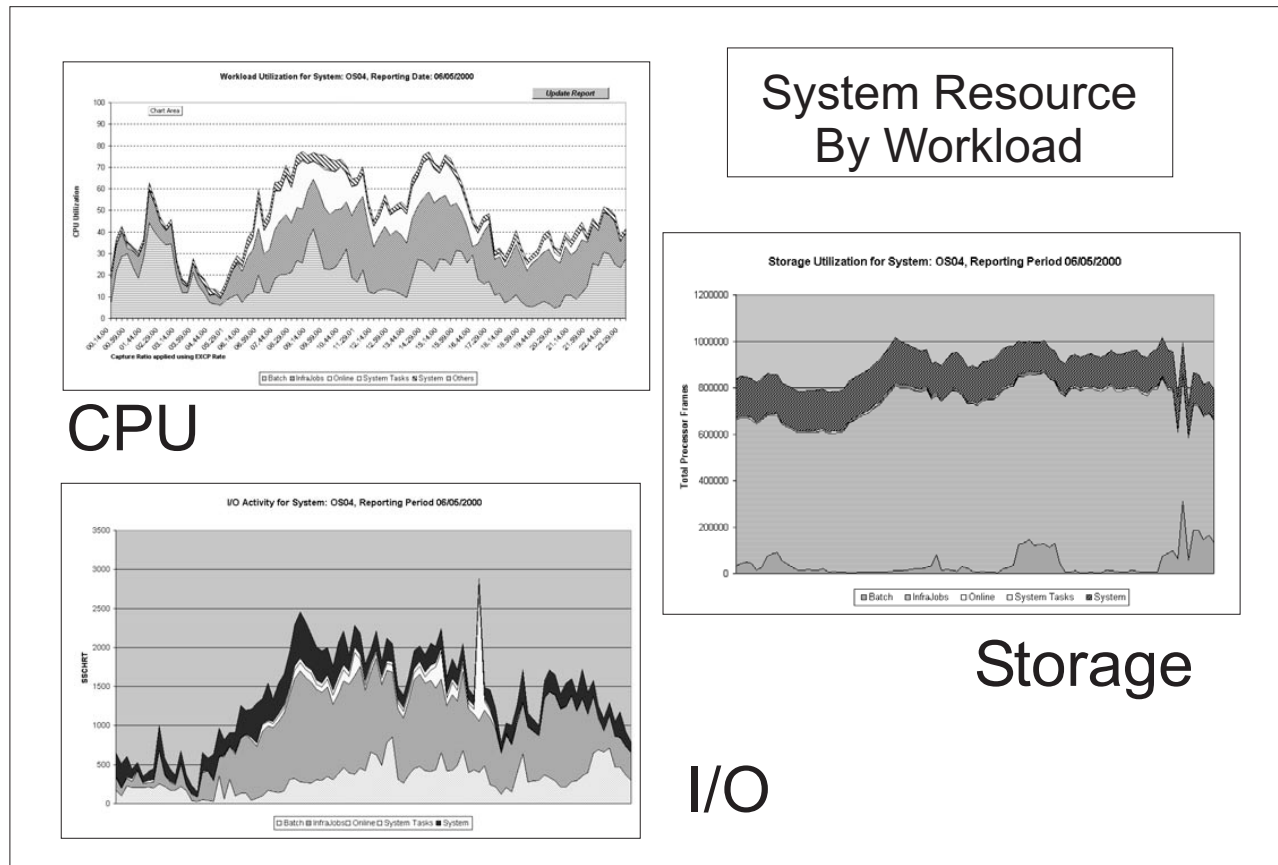


Figure 1-3. System Resource Summary by Workload

This figure illustrates one way to report your resource utilization by workload.

You can use the Spreadsheet Reporter to create spreadsheet files from Postprocessor data and to display them graphically. The following chapters show how to use the sample macros for creating the graphics that help you in understanding and analyzing the performance of your system.

In a similar fashion (could be graphical or numeric) you will need to record such data to:

- Measure resource consumption:
 - CPU utilization
 - Processor storage usage (*central storage* (CS) and *expanded storage* (ES))
 - I/O rates
- Understand what makes up response time:
 - Waiting for and using the resources
 - Use Monitor III Group Response Time report
- Understand the factors that influence the above

Virtual storage is another type of resource. While not as dynamic as I/O, CPU, or processor storage, virtual storage is one of the basic resources that you need to plan, even though you cannot buy it. Virtual storage can have a critical impact on delivery of service to end users: an *initial program load (IPL)* is required when not enough virtual storage is available.

RMF can measure virtual storage. It should be monitored, and the Virtual Storage report helps you verify the size of the different MVS components, as explained in “Virtual Storage Report” on page 2-37.

Using Monitor I Reports to Analyze Workloads

The CPU Activity report and the Workload Activity report provide the data you can use for a workload analysis.

CPU Activity Report - Part 1

C P U A C T I V I T Y							PAGE	1
z/OS V1R2		SYSTEM ID OS04		DATE 03/14/2001		INTERVAL 14.59.996		
		RPT VERSION V1R2 RMF		TIME 09.29.00		CYCLE 1.000 SECONDS		
CPU 9672 MODEL Z97								
CPU	ONLINE TIME	LPAR BUSY	MVS BUSY	CPU SERIAL	I/O TOTAL	% I/O INTERRUPTS		
NUMBER	PERCENTAGE	TIME PERC	TIME PERC	NUMBER	INTERRUPT RATE	HANDLED VIA TPI		
0	100.00	76.93	99.15	045104	320.9	0.33		
1	100.00	76.85	99.13	145104	324.0	0.22		
2	100.00	76.86	99.09	245104	321.6	0.22		
3	100.00	76.87	98.99	345104	329.5	0.25		
4	100.00	76.89	99.01	445104	325.9	0.33		
5	100.00	76.87	98.88	545104	328.7	0.36		
6	100.00	76.88	98.86	645104	338.4	0.46		
7	100.00	76.85	98.73	745104	341.1	0.51		
8	100.00	76.82	98.59	845104	335.9	0.67		
TOTAL/AVERAGE		76.87	98.94		2966	0.37		

Figure 1-4. Monitor I CPU Activity Report - Part 1

The first part of this report provides an overview on all processors belonging to this system.

Workload characteristics

Workload Activity Report

W O R K L O A D A C T I V I T Y														
z/OS V1R2			SYSPLEX SPLEX01			DATE 06/05/2001			INTERVAL 14.59.628			MODE = GOAL		
			RPT VERSION V1R2 RMF			TIME 09.29.00								
POLICY ACTIVATION DATE/TIME 06/02/2001 10.43.08														
- WORKLOAD & SERVICE CLASS PERIODS -														
REPORT BY: POLICY=SP000010			WORKLOAD=WLONLINE			SERVICE CLASS=SCONL006			RESOURCE GROUP=*NONE					
						CRITICAL =NONE								
						DESCRIPTION =DB2 Production								
TRANSACTIONS		TRANS.-TIME	HHH.MM.SS.TTT	--DASD I/O--	---	SERVICE---	--SERVICE RATES--	PAGE-IN RATES	----	STORAGE----				
AVG	28.23	ACTUAL	769	SSCHRT	41.4	IOC	0	ABSRPTN	1660	SINGLE	0.0	AVG	0.00	
MPL	28.23	EXECUTION	768	RESP	2.9	CPU	42164K	TRX SERV	1660	BLOCK	0.0	TOTAL	0.00	
ENDED	7288	QUEUED	0	CONN	2.4	MSO	0	TCB	581.6	SHARED	0.0	CENTRAL	0.00	
END/S	8.10	R/S AFFINITY	0	DISC	0.0	SRB	0	SRB	0.0	HSP	0.0	EXPAND	0.00	
#SWAPS	0	INELIGIBLE	0	Q+PEND	0.5	TOT	42164K	RCT	0.0	HSP MISS	0.0			
EXCTD	0	CONVERSION	0	IOSQ	0.0	/SEC	46869	IIT	0.0	EXP SNGL	0.0	SHARED	0.00	
AVG ENC	0.00	STD DEV	1.918					HST	0.0	EXP BLK	0.0			
REM ENC	0.00							APPL %	64.6	EXP SHR	0.0			
MS ENC	0.00													
PER IMPORTANCE		PERF	--TRANSACTIONS--	-----RESPONSE TIME-----				-EX VEL%-	-CPU--	-EXE--				
		INDX	-NUMBER-	----	---	ACTUAL---	TOTAL	GOAL ACT	USING%	DELAY%				
1	2	0.7	4937 68	00.00.00.300	75%	89.2%	60.5%	64.2	5.8	3.4				
2	3	0.5	1584 22	00.00.02.000	70%	97.0%		72.0	5.8	2.3				
3	5	0.4	767 11					20 51.7	2.3	2.2				
TOTAL			7288 100											

Figure 1-5. Workload Activity Report - Service Class

W O R K L O A D A C T I V I T Y													PAGE	1	
z/OS V1R2			SYSPLEX SPLEX01			DATE 06/05/2001			INTERVAL 14.59.628			MODE = GOAL			
			RPT VERSION V1R2 RMF			TIME 09.29.00									
POLICY ACTIVATION DATE/TIME 06/02/2001 10.43.08															
- WORKLOAD & SERVICE CLASS PERIODS -															
POLICY ACTIVATION DATE/TIME 06/02/2001 10.43.08															
----- SERVICE POLICY															
REPORT BY: POLICY=SP000010															
Default Policy															
TRANSACTIONS TRANS.-TIME HHH.MM.SS.TTT --DASD I/O-- ---SERVICE--- --SERVICE RATES-- PAGE-IN RATES ----STORAGE----															
AVG 203.75		ACTUAL		16.29.483		SSCHRT 1955		IOC 17400K		ABSRPTN 2473		SINGLE 0.0		AVG 4711.96	
MPL 203.70		EXECUTION		3.092		RESP 13.8		CPU 386675K		TRX SERV 2472		BLOCK 0.0		TOTAL 959830	
ENDED 15298		QUEUED		15.35.046		CONN 3.0		MSO 19213K		TCB 5333.7		SHARED 0.0		CENTRAL 403598	
END/S 17.00		R/S AFFINITY		0		DISC 9.5		SRB 29845K		SRB 411.7		HSP 0.0		EXPAND 556232	
#SWAPS 6378		INELIGIBLE		52.969		Q+PEND 0.6		TOT 453133K		RCT 5.4		HSP MISS 0.0			
EXCTD 6937		CONVERSION		4		IOSQ 0.7		/SEC 503690		IIT 44.7		EXP SNGL 0.7		SHARED 584.45	
AVG ENC 0.00		STD DEV		3.48.42.725						HST 0.2		EXP BLK 0.2			
REM ENC 0.00										APPL %		644.2		EXP SHR 0.0	
MS ENC 0.00															

Figure 1-6. Workload Activity Report - Service Policy

The Workload Activity report shows workload-related data on resource consumption with different levels of detail. The above examples summarizes data for one service class (SCONL006) which is DB2 Production and for the total system (*service policy*).

Analyzing Processor Characteristics

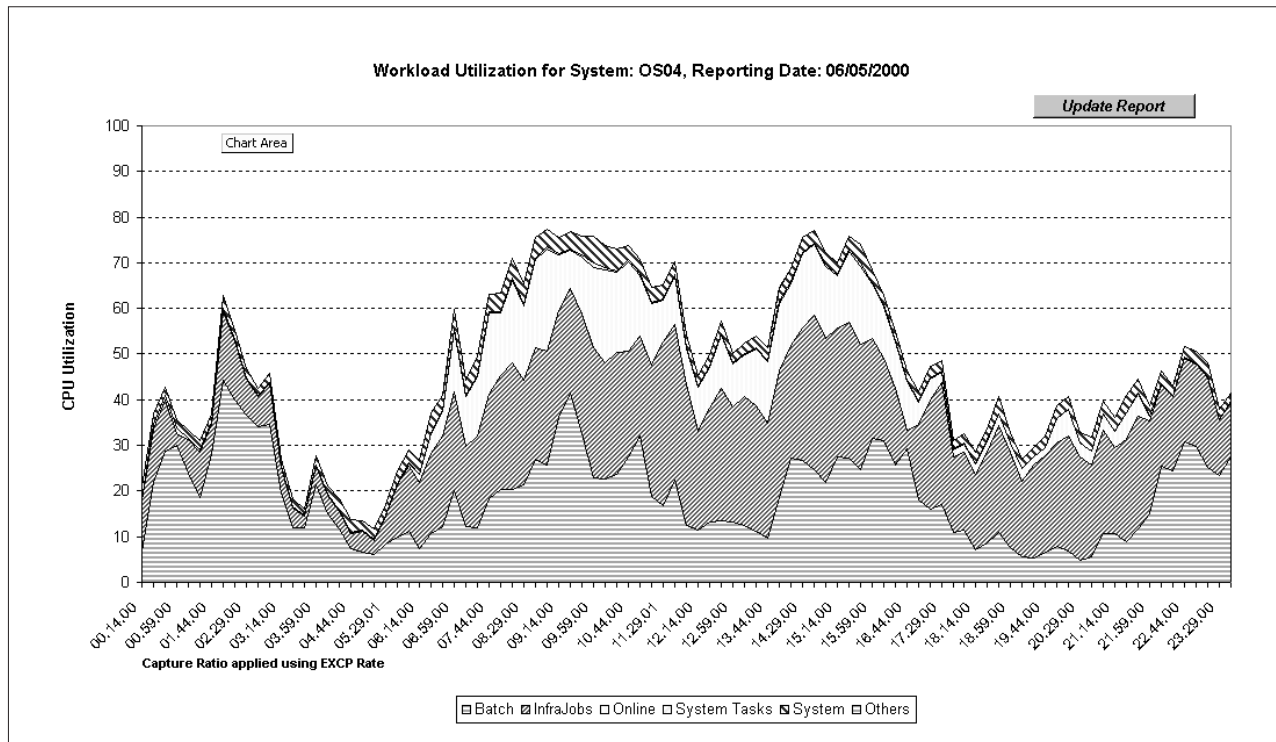


Figure 1-7. Processor Utilization by Workload. Spreadsheet Reporter macro RMFY9WKL.XLS (Workload Trend Report) - DayUtilization

This section will discuss how to measure CPU utilization by workload. Our approach is to convert *application time* for each service class into overall percent of CPU used for that workload. The total of all these numbers is the base for the APPL% value in the report.

The concept of *capture ratio (CR)* must be understood in order to do this. Simply put, the CPU time reported for the sum of all your workloads never adds up to the total CPU time used by the system. The total CPU time reported for all your workloads will typically account for 85-90% of the total CPU time used. This is not an error. It is the best level of accuracy that the reporting tools can achieve, *in a consistent, repeatable manner*.

The *uncaptured* time is sometimes, misleadingly, called system overhead. This is not so, most of it is genuine user work — it is either a political or philosophical view whether activities like paging are seen as genuine work or just overhead, it depends ...

Thus the capture ratio is:

$$CR = \frac{\text{Captured CPU Time}}{\text{Total CPU Time}}$$

The question then becomes: how do you account for the uncaptured, though real, CPU time? The answer is to distribute the uncaptured time among your workloads, so that the total CPU time is accounted for. Several approaches to doing this will be discussed.

Workload characteristics

How to Compute CPU Time per Workload Type

Following are the basic steps for computing CPU time by workload. Graphing CPU consumption over time (for example, by hour or by day) can help you understand your workload flow, as shown in Figure 1-7 as an example of a Spreadsheet Reporter macro.

1. Calculate total CPU time in seconds:

$$\text{Total CPU time} = \text{MVS Busy \%} * \text{Interval} * \text{\#CPs}$$

If your system is running in an PR/SM environment, the calculation has to be performed using LPAR BUSY and the number of logical processors.

2. Get the captured time for all address spaces.

The Workload Activity report shows the percentage of application time. It is based on the sum of *task control block (TCB)* time, *service request block (SRB)* time, *region control task (RCT)* time, *I/O interrupt (IIT)* time, and *hiperspace service (HST)* time, and is calculated as:

$$\text{APPL\%} = \frac{(\text{TCB} + \text{SRB} + \text{RCT} + \text{IIT} + \text{HST})}{\text{Interval}} * 100$$

$$\text{Captured time} = (\text{APPL\%} / 100) * \text{Interval}$$

This results in the uncaptured CPU time:

$$\text{Uncaptured CPU time} = \text{Total CPU time} - \text{Captured time}$$

3. Calculate the capture ratio:

$$\text{CR} = \frac{\text{Captured CPU Time}}{\text{Total CPU Time}}$$

4. Get application (captured) percentage for one workload you are interested in:

This APPL% value represents the percentage based on one processor. You get the percentage based on the total capacity by:

$$\text{Total Captured \%} = \frac{\text{APPL\%}}{\text{\#CPs}}$$

5. Distribute uncaptured time based on the capture ratio:

$$\text{Total \%} = \frac{\text{Total Captured \%}}{\text{CR}}$$

There are more ways to distribute the uncaptured time, see “Methods of Distributing Uncaptured Time” on page 1-15 for a discussion of this topic.

Report Analysis

Figure 1-4, Figure 1-5, and Figure 1-6 give us the following values:

- Total CPU time = $0.7687 \times 900 \times 9 = 6226.47$ sec
- Captured time (POLICY) = $6.442 \times 900 = 5797.8$ sec
- Uncaptured time = $6226.47 - 5797.8 = 428.67$ sec
- Capture ratio = $5797.8 / 6226.47 = 0.93$
- DB2 (Service Class SCONL006) = 64.6 % of one processor

Figure 1-7 is a graphic being created with the Spreadsheet Reporter, it shows the workload utilization for different service classes during one day. The macro provides different ways to distribute the uncaptured time.

Methods of Distributing Uncaptured Time

To get a full picture of CPU consumption, the uncaptured time needs to be distributed across the workloads. There are several methods of doing this:

1. Not bad: By workload APPL time - as done in the previous calculation.
2. Better: By workload I/O rate (% of system total)
3. Best:
 - a. Distribute uncaptured time by I/O rate, AND...
 - b. Distribute system address space (AS) time to relevant users, e.g.
 - VTAM time: to TSO and CICS
 - JES time: to TSO and BATCH
 - etc.
4. Probably not worth the effort: Regression analysis, etc.

How to Compute CPU Time per Transaction

There are times when additional detail of CPU utilization is needed. For capacity planning especially, you may need to know the average CPU time consumed per transaction. This is a simple calculation, dividing application time by number of transactions.

Report Analysis

Figure 1-5 on page 1-12 gives us the following values for DB2 (Service Class SCONL006):

- ENDED TRANSACTIONS: 7288
- APPL% * INTERVAL : 581.4 sec (Application time)

This results in

$$\text{CPU time per transaction} = \frac{581400}{7288} = 80 \text{ msec}$$

Workload characteristics

Analyzing Workload I/O Characteristics

It can also be useful to know the I/O rate each different workload generates. This is especially useful in capacity planning, but also for performance management - a change in workload I/O rates (or relative I/O content) can significantly change its performance.

Base for the following graphic are these OVW statements:

```
OVW(IOBATCH(SSCHRT(W.WLBATCH)))  
OVW(IOINFRA(SSCHRT(W.WLINFRA)))  
OVW(IOONLIN(SSCHRT(W.WLONLINE)))  
OVW(IOSYSTK(SSCHRT(W.WLSYSTEM)))  
OVW(IOSYSYM(SSCHRT(W.SYSTEM)))
```

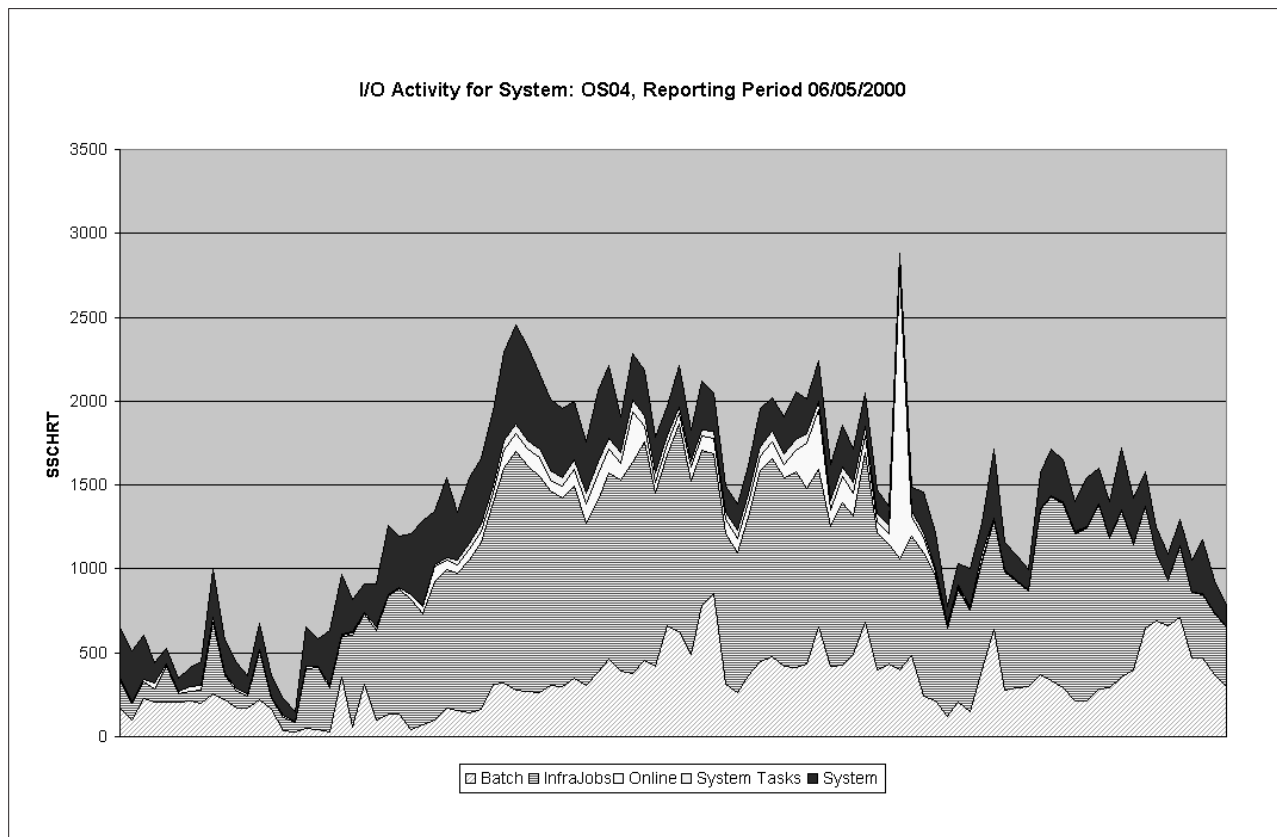


Figure 1-8. I/O Activity by Workload

Workload characteristics

REPORT BY: POLICY=SP000010		WORKLOAD=WLONLINE	SERVICE CLASS=SCONL006		RESOURCE GROUP=*NONE		
			CRITICAL =NONE				
			DESCRIPTION =DB2 Production				
TRANSACTIONS	TRANS.-TIME	HHH.MM.SS.TTT	--DASD I/O--	---SERVICE---	--SERVICE RATES--	PAGE-IN RATES	----STORAGE----
AVG 28.23	ACTUAL	769	SSCHRT 41.4	IOC 0	ABSRPTN 1660	SINGLE 0.0	AVG 0.00
MPL 28.23	EXECUTION	768	RESP 2.9	CPU 42164K	TRX SERV 1660	BLOCK 0.0	TOTAL 0.00
ENDED 7288	QUEUED	0	CONN 2.4	MSO 0	TCB 581.6	SHARED 0.0	CENTRAL 0.00
END/S 8.10	R/S AFFINITY	0	DISC 0.0	SRB 0	SRB 0.0	HSP 0.0	EXPAND 0.00
#SWAPS 0	INELIGIBLE	0	Q+PEND 0.5	TOT 42164K	RCT 0.0	HSP MISS 0.0	
EXCTD 0	CONVERSION	0	IOSQ 0.0	/SEC 46869	IIT 0.0	EXP SNGL 0.0	SHARED 0.00
AVG ENC 0.00	STD DEV	1.918			HST 0.0	EXP BLK 0.0	
REM ENC 0.00					APPL % 64.6	EXP SHR 0.0	
MS ENC 0.00							

REPORT BY: POLICY=SP000010

Default Policy

TRANSACTIONS	TRANS.-TIME	HHH.MM.SS.TTT	--DASD I/O--	---SERVICE---	--SERVICE RATES--	PAGE-IN RATES	----STORAGE----
AVG 203.75	ACTUAL	16.29.483	SSCHRT 1955	IOC 17400K	ABSRPTN 2473	SINGLE 0.0	AVG 4711.96
MPL 203.70	EXECUTION	3.092	RESP 13.8	CPU 386675K	TRX SERV 2472	BLOCK 0.0	TOTAL 959830
ENDED 15298	QUEUED	15.35.046	CONN 3.0	MSO 19213K	TCB 5333.7	SHARED 0.0	CENTRAL 403598
END/S 17.00	R/S AFFINITY	0	DISC 9.5	SRB 29845K	SRB 411.7	HSP 0.0	EXPAND 556232
#SWAPS 6378	INELIGIBLE	52.969	Q+PEND 0.6	TOT 453133K	RCT 5.4	HSP MISS 0.0	
EXCTD 6937	CONVERSION	4	IOSQ 0.7	/SEC 503690	IIT 44.7	EXP SNGL 0.7	SHARED 584.45
AVG ENC 0.00	STD DEV	3.48.42.725			HST 0.2	EXP BLK 0.2	
REM ENC 0.00					APPL % 644.2	EXP SHR 0.0	
MS ENC 0.00							

Figure 1-9. Workload Activity Report - I/O Activity

The Workload Activity report shows directly the I/O activities by workload in the value SSCHRT. This is the number of start subchannels (SSCH) per second and gives the number of DASD non-paging I/Os.

Report Analysis

We see the following numbers in the sample report:

Workload	SSCH/second
DB2 Production	41.4
Policy - Total System	1955

Workload characteristics

Analyzing Processor Storage Characteristics

As with CPU and I/O, it is useful to build a clear picture of processor storage use on your system. The Workload Activity report can give you a good start on the processor storage use by workload, at the workload level.

The Spreadsheet Reporter does not contain a macro for displaying storage utilization by workload. But you can create very easily a graphic as shown in the following example. Assuming that you have the workloads WLBATCH, WLINFRA, WLONLINE, and WLSYSTEM, you can use the following OVW statements to create the required spreadsheet data:

```
OVW(TOTBATCH(STOTOT(W.WLBATCH)))  
OVW(TOTINFRA(STOTOT(W.WLINFRA)))  
OVW(TOTONLIN(STOTOT(W.WLONLINE)))  
OVW(TOTSYSK(STOTOT(W.WLSYSTEM)))  
OVW(TOTSYSTEM(STOTOT(W.SYSTEM)))
```

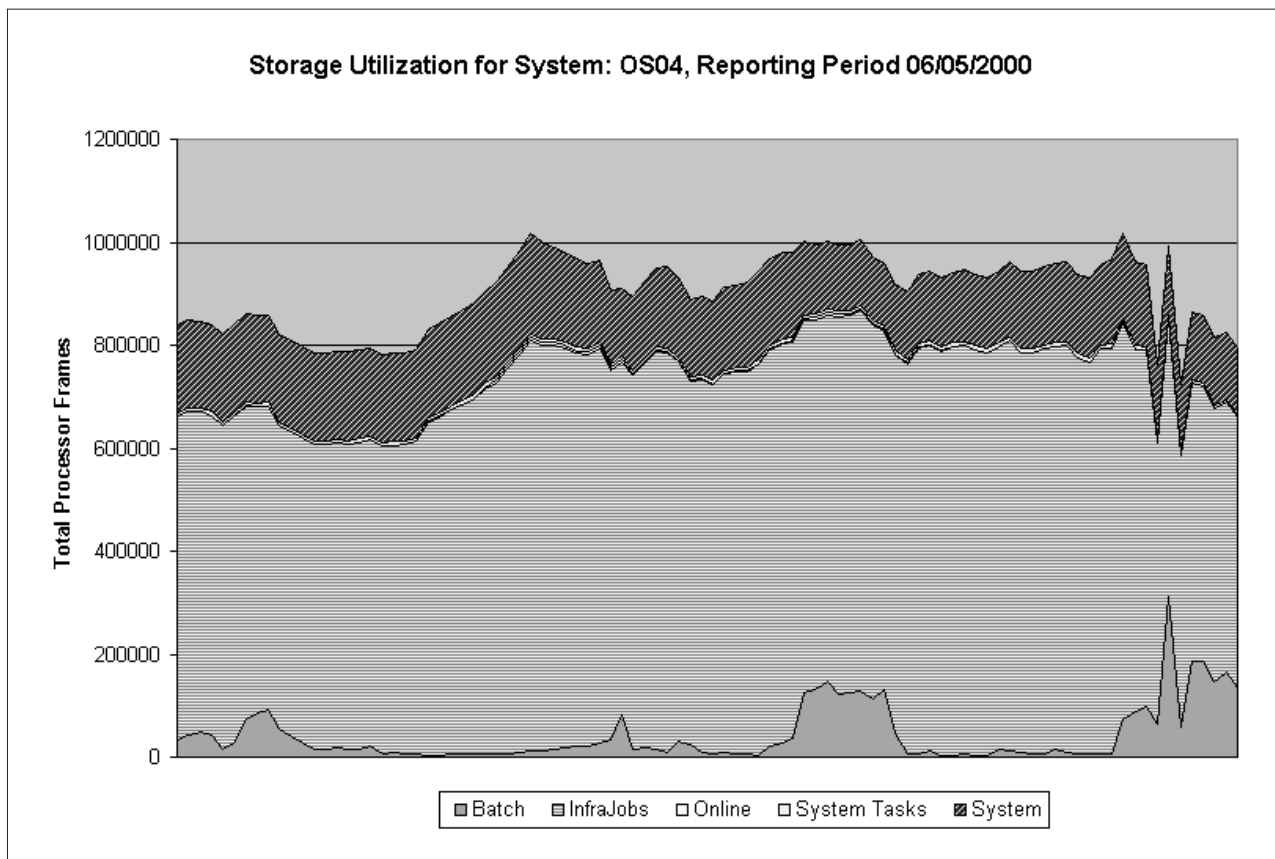


Figure 1-10. Processor Storage by Workload

Of course, you can display this in more detail by using other OVW conditions, for example STOCEN and STOEXP instead of STOTOT. You find a detailed description of all OVW conditions in chapter "Overview and Exception Conditions" in the *RMF User's Guide*.

Workload Activity Report

REPORT BY: POLICY=SP000010		WORKLOAD=WLONLINE		SERVICE CLASS=SCONL000		RESOURCE GROUP=*NONE	
				CRITICAL =NONE			
				DESCRIPTION =Normal 3-period TSO work			
TRANSACTIONS	TRANS.-TIME	HHH.MM.SS.TTT	--DASD I/O--	---SERVICE---	--SERVICE RATES--	PAGE-IN RATES	----STORAGE----
AVG 1.69	ACTUAL	4.821	SSCHRT 30.6	IOC 192865	ABSRPTN 2675	SINGLE 0.0	AVG 1616.34
MPL 1.69	EXECUTION	4.812	RESP 4.9	CPU 3710K	TRX SERV 2670	BLOCK 0.0	TOTAL 2727.02
ENDED 1459	QUEUED	8	CONN 3.2	MSO 84455	TCB 51.2	SHARED 0.0	CENTRAL 561.35
END/S 1.62	R/S AFFINITY	0	DISC 0.9	SRB 72522	SRB 1.0	HSP 0.0	EXPAND 2165.67
#SWAPS 1568	INELIGIBLE	0	Q+PEND 0.6	TOT 4060K	RCT 0.8	HSP MISS 0.0	
EXCTD 0	CONVERSION	0	IOSQ 0.2	/SEC 4513	IIT 0.4	EXP SNGL 3.9	SHARED 0.00
AVG ENC 0.00	STD DEV	2.31.597			HST 0.0	EXP BLK 0.0	
REM ENC 0.00					APPL % 5.9	EXP SHR 0.1	
MS ENC 0.00							

Figure 1-11. Workload Activity Report - Processor Storage Use

Processor Storage Use is given in the fields:

AVG # of processor frames on average per swapped-in AS in the group.

TOTAL # of processor frames on average for all AS in the group.

TOTAL = AVERAGE * MPL

This total is also broken out into CENTRAL and EXPAND(ed) storage use.

If your system is running on a zSeries processor, all fields in the RMF reports which are related to expanded storage will be empty. Expanded storage is not supported anymore in the zArchitecture.

This workload use of processor storage will account for most, but not all, of the processor storage on your system. To account for the rest, you should also look at:

- System area use of storage (see Monitor I Paging Activity report)
- Available frames (see Monitor I Paging Activity report)
- Swapped-out users (both in CS & ES - see Monitor II ASD report)

It can also be useful to know how much paging your individual workloads are doing. From the Workload Activity report, you also get paging data, from the fields:

SINGLE Page-ins per second from DASD

BLOCK Page-ins per second from DASD, for blocked pages

EXP SNGL Page-ins per second from ES

EXP BLK Page-ins per second from ES, for blocked pages

Use this paging information to help decide whether a workload's current processor storage is sufficient (see Chapter 5. Analyzing Processor Storage Activity for more detail on paging).

Monitor II and III also provide processor storage use (and paging) data, down to the AS level.

Workload characteristics

Processor Speed Indicators

This section presents some of the terms and formulas used in discussing CPU performance and capacity.

- **Cycle Time**

$\text{CPU time} = \text{Path length} * (\text{Cycles} / \text{Instruction}) * \text{Cycle time}$

- Path length depends on the instruction set and the compiler
- Cycles/instruction depends on the design (e.g. microcoding of instructions)
- Cycle time depends on the technology (for example, CPU model)

Thus, cycle time by itself is not a complete indicator of CPU speed.

- **MIPS**

This term depends on cycle time and number of cycles per instructions, it is only valid for comparison if the instruction sets are the same.

In common usage today, MIPS are used as a single number to reflect relative processor capacity. As with any single-number capacity indicator, your experience may vary considerably. These numbers are often based on vendor announcements.

By the way, *MIPS* means *Millions of Instructions Per Second* (some people say *Misleading Information about Processor Speed*). There does not exist a term *MIP* which often is used erroneously. A small processor has a speed of 1 MIPS, not 1 MIP.

- **SRM Constant — MSU**

The SRM constant is a number derived by product engineering to normalize the speed of a CPU, so that a given amount of work would report the same service unit consumption on different processors. This removes the need to redesign your IPS performance parameters each time you upgrade your CPU.

Service Units (SU) are typically used by the *System Resource Manager* (SRM) as a basis for resource management.

$\text{Service Units} = \text{CPU seconds} * \text{SRM constant}$

Many installations who have to charge the users do so on the basis of SUs. This is a reasonable approximation of relative capacity. But of course, *any* single-number metric for processor capacity comparison can be misleading, and LSPR numbers, based on your own workload mix, are the best to use. You get more details about this in the following section that describes ITR and LSPR.

The SRM constants are contained in internal tables within MVS and are published in the *z/OS MVS Initialization and Tuning Guide*. The SUs are reported in many Monitor I and Monitor III reports.

The power of a system can be characterized also in terms of MSUs (millions of service units per hour). These numbers are published in the LSPR documentation.

- **Internal Throughput Rate (ITR)**

ITR numbers are measurements by workload type which determine the capability of a machine in terms of the number of transactions per CPU second. This is important, since processor capacity varies according to the workload mix.

$$\text{ITR} = \frac{\text{Number of transactions}}{\text{CPU time}}$$

ITR is a function of:

- CPU speed
- Operating system
- Transaction characteristics (workloads differ)

ITRs are derived from the LSPR methodology. See *Large Systems Performance Reference* for details. ITR provides a reliable basis for measuring capacity and performance.

- **External Throughput Rate (ETR)**

$$\text{ETR} = \frac{\text{Number of transactions}}{\text{Elapsed time}} = \text{ITR} * \text{CPU utilization}$$

Any bottleneck, internal or external to the system, will effect the ETR. Examples include: I/O constraints, tape mount delay and paging delay. Thus it is more difficult to get a repeatable measure than with ITR.

- **Relative Processor Power (RPP)**

RPP is the ratio of ITRs for a specific workload mix (usually 25% Batch, 25% TSO, 25% CICS, and 25% IMS) for different machines. RPP is normalized to a base machine.

So, if a given function takes a certain amount of RPPs, you can estimate how much it would consume on a different machine by using the formula:

$$\text{Your utilization} = \frac{\text{Used RPPs} * 100}{\text{Your machine RPPs}}$$

- **MFLOPS**

MFLOPS = millions of floating point instructions per second. Used only in numerically intensive computing (scientific/technical).

In summary, various numbers may commonly be used as rough indicators of CPU capacity. Remember that most of these are very rough approximations only, and your actual capacity may vary significantly.

To get the most accurate assessment of CPU capacity for your workload, differences in workload processing characteristics must be taken into account using a methodology such as that described in the *Large Systems Performance Reference*. You find the most current version via

<http://www.s390.ibm.com/lspr/zSeries.html>

Where Do You Go from Here?

Having reviewed some of the main MVS performance concepts, the following chapters will discuss how to recognize and resolve specific performance problems.

One thought to bear in mind on your journey:

You can only do so much as a system programmer; you need help from your application and data base designers. A poorly written application can nullify a lot of system tuning effort. If you have design reviews in progress, get involved. Use the reviews to stress that you need reasonable call structures to data bases, practical data base design etc.

You may not get as many birthday cards, but...

Chapter 2. Diagnosing a Problem: The First Steps

Let's Start the Diagnosis

This chapter explains the first steps on your way to performance management:

- How to recognize a performance problem
- How to find that system in the sysplex that contributes most to the problem
- How to find the major cause of the problem (CPU, processor storage, I/O, etc).

Generally, there are two different approaches:

- One for response time problems (primarily using Monitor III delay reports)
- And one for system indicators showing stress (primarily using Monitor I/II resource-usage reports)
- How to continue by reading the other chapters in this book for further problem analysis and resolution

What Is a Performance Problem?

There are many views on what constitutes a performance problem. Most of them revolve around unacceptably high response times or resource usage, which we can collectively refer to as "pain." The need for performance investigation and analysis is for example indicated by:

- Bad or erratic response time
 - Service level objectives are being exceeded
 - Users complaining about slow response
 - Unexpected changes in response times or resource utilizations
- Other indicators showing stress
 - Monitor III Workflow/Exceptions
 - System resource indicators (for example, paging rates, DASD response)
 - Expected throughput on the system not being attained

Ultimately, you will have to decide for yourself whether a given situation is a problem worth pursuing or not. This will be based on your own experience, knowledge of your system, and sometimes politics. We will simply assume for the following discussions that you are trying to relieve some sort of numerically quantifiable "pain" in your system.

Generally, a performance problem is the result of some workload not getting the resource(s) it needs to complete in a timely manner. Or, less common, the resource is obtained but is not fast enough to provide the desired response time.

There are three ways to gain the resource needed:

- Buy it.
- Create the illusion you bought it. This is known as tuning. Capability to do this implies you have been previously wasting resources. Like purchasing, there is a cost. The cost is people; while it may be higher, it is always less visible than purchase.
- Steal it (take it from a less important application). Again there is a cost. Here the cost is lower service to the application from which the resources were stolen.

If none of these options are technically or financially possible, it will be necessary to change users' (and management's) expectations.

You may have experienced the situation where you complete an extensive performance analysis only to conclude that no further tuning or stealing of resources can be done. One of the goals of this book is to assist you in determining whether you have reached this point.

Getting Started: A Top-Down Approach to Tuning

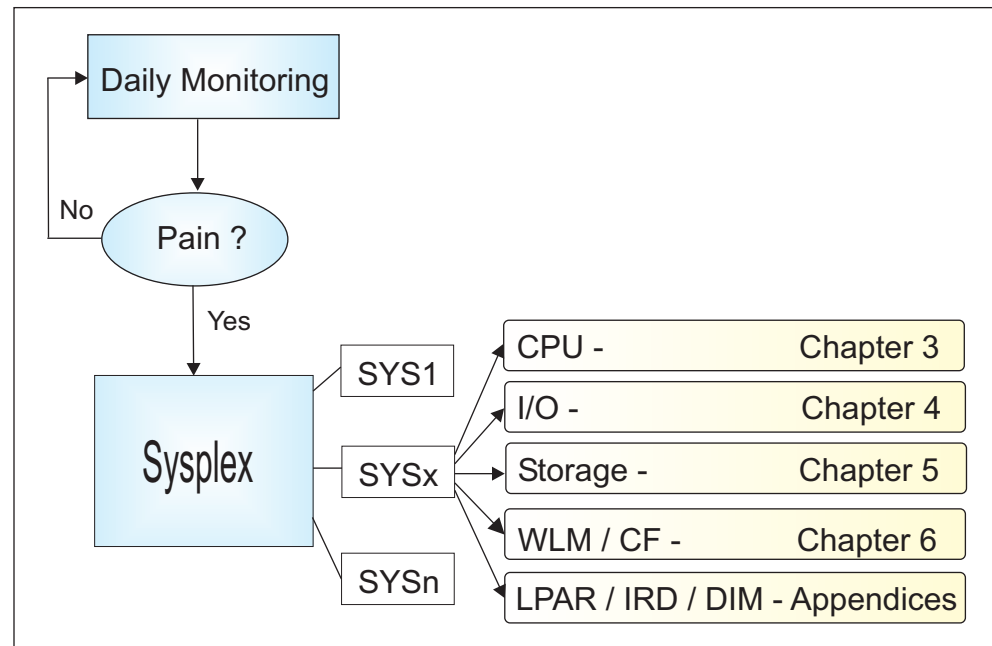


Figure 2-1. Simplified View of Performance Management

This book will take the following top-down approach to investigating and resolving performance problems. Figure 2-1 is a simplified view:

1. Through your daily performance monitoring activities recognize any of the "pain" indicators as being a problem on your sysplex.
2. Discover the system where you can see the most important performance problems.
3. Analyze the data to determine which component of the response time holds the most promise for relief.
4. Go to the appropriate chapter or appendix for more detailed advice.

Daily performance monitoring — what does this mean? If you ask ten people, probably you will get eleven answers. Or vice versa, there is not just one answer to the question: *How should I do daily performance monitoring?* Having in mind customers who want to be satisfied with the service that they receive from the system you are responsible for, the focus should be on observing the service level agreements. If the goals being described there can be attained — then you are providing the service that your customers are expecting. In the past (these are not the good old days but the time when your system was running in compatibility mode — do you remember?), it was not a simple task of monitoring the response time and throughput objectives that are described in the service level agreements. And furthermore, it was not a simple task to adjust all parameters in the Parmlib members IEAIPSxx and IEAICSxx to reach the optimal performance of your system.

But now, it's easy and simple: you just define your goals in the service policy and let the system run. The workload manager is doing its best in managing the workload in your system for achieving all goals — your job is done automatically, be

Performance analysis

happy. STOP — if this would be true we could stop at this point of time. Of course, it's not true because there are many aspects which have to be mentioned with regard to performance management.

Starting with the sysplex view, you get a high-level overview about the performance indicators of your workloads. This will lead you to the most relevant systems in the sysplex. There, you may start with the largest cause of delay, do what you can to address it, go back and address the next largest cause of delay, and so on. Continue to do this until the service objectives are met, or until you reach a point of diminishing returns, where further effort does not pay off.

In short ...

... use the data available from RMF to ensure that your efforts are focused where they can do the most good.

Of course, with any performance problem there are many different approaches you can take to analyze the data. We have selected these two paths:

- **Response time problems.** Follow this path if you have a user or group of users complaining about response time.
- **System indicators.** Follow this path if your ongoing performance monitoring shows signs of a problem, or for a general health check. This path starts on page 2-20.

Where to Start Sysplex Monitoring?

When using RMF, you are interested in getting a performance overview at a glance. You have defined a service policy that contains several workloads, each of them with service classes and report classes that have goals of different types.

Monitor III and the Postprocessor offer you some reports that show how your sysplex is running at different levels of detail.

To start with:

Monitor III Sysplex Summary Report

This report shows (based on your option selection) all or only selected workloads, service and report classes, and periods with their goals and actual performance values.

When you run Monitor III in GO mode, you see the *Performance Status Line* that summarizes the key performance indicators for up to 80 time ranges, showing you the performance history of your sysplex.

To continue with:

Monitor III Response Time Distribution Report

You can use this report to see how several systems of the sysplex contribute in servicing one specific service class. This is the entry point from the sysplex to single-system reports, for example:

GROUP	Group Response Time Report
STOR	Storage Delays Report

DELAY	Delay Report
JOB	Job Delays Report
WFEX	Workflow/Exceptions Report

Monitor III Work Manager Delays Report

Here, RMF provides detailed performance data about the CICS and IMS subsystems. The Work Manager Delays report shows you for CICS and IMS several kinds of delay data about your transactions, being in the begin-to-end or in the execution phase. You get an overview of how the different CICS address spaces (for example, the AOR, TOR, or FOR) provide service to the service classes your transactions belong to.

Postprocessor Workload Activity Report

You can use this report to get performance and resource data for your service classes and workloads in the sysplex. You will find a detailed discussion including report samples in “Understanding Workload Activity Data for IMS or CICS” on page 6-2.

Monitor III Indicators

Sysplex Summary Report

```

RMF V1R2 Sysplex Summary - WTSCPLX1
Line 1 of 72
Command ==>>>> Scroll ==>>>> HALF

WLM Samples: 385 Systems: 3 Date: 04/30/01 Time: 09.30.00 Range: 100 Sec

>>>>>>>XXXXXXXXXXXXXXXXXXXX<<<<<<<<

Service Definition: CICSPOL Installed at: 03/24/01, 11.57.51
Active Policy: CICSMAJ Activated at: 03/24/01, 11.58.16

----- Goals versus Actuals -----
Exec Vel --- Response Time --- Perf Trans
Name T I Goal Act ---Goal--- --Actual-- Indx Ended Rate --Avg. WAIT --Resp. EXECUT --Time- ACTUAL
Time Time Time

BATCH W 12 0.000 0.000 0.000 0.000
BATCHLOW S 5 1 12 0.09 0.000 0.000 0.000 0.000
CICS W N/A 18.86 0.580 1.576 2.156
CICSDFLT S 2 N/A 0.300 AVG 5.079 AVG 16.9 0.111 2.970 2.109 5.079
CICSRGN S 2 70 70 1.00 0.000 0.000 0.000 0.000
CICUSRTX S 2 N/A 0.090 AVG 2.139 AVG 23.8 18.75 0.563 1.576 2.139
SYSTEM W 68 0.000 0.000 0.000 0.000
SYSSTC S N/A 70 N/A 0.000 0.000 0.000 0.000
SYSTEM S N/A 63 N/A 0.000 0.000 0.000 0.000
TSO W 68 0.537 0.006 3.460 3.466

```

Figure 2-2. Monitor III Sysplex Summary Report

You can select what should be part of this report by using the report options:

- *What types should be reported?* These can be everything from workload to service class period, as well as report classes.
- *What performance index should be used as threshold?* This allows to show only the data that have an index high enough for you to want to be informed about it.
- *Is any importance important?* If you want to see only high or medium important work - you can select this.
- *Are you interested in all workload groups you have defined?* Then you can display them - otherwise the report shows only active workload groups and their details.

Performance Status Line

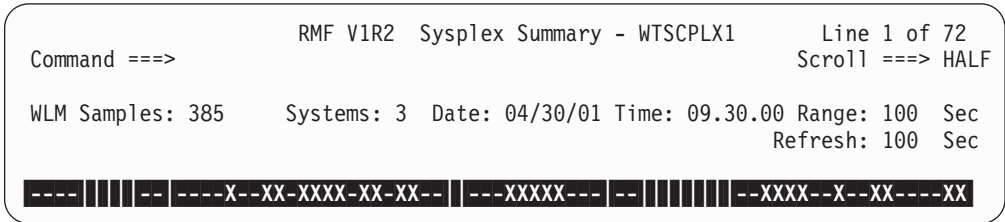


Figure 2-3. Monitor III Sysplex Summary Report - GO Mode

Indicator

Field: -----X--XX-XXXX-XX-XX-

Description: The performance status line gives a performance indication, by its symbols and colors, for each range when the Monitor III reporter session was in GO mode:

Green All goals have been attained for this range

Yellow
Service class periods with low or medium importance have not attained the goal.

Red Service class periods with high importance have not attained the goal.

If you switch from GO mode to STOP mode, the reporter builds no reports for this time, and therefore, no indicator for the status line will be created. When continuing with GO mode, you will see one or several blank fields in the status line.

The status line is updated with each refresh of the report in GO mode. Assuming a range and refresh value of 100 seconds, you will see the *full* status line after 8000 seconds with each interval indicator shifted to the left by one position.

You can take this status line to see at a glance the performance status of your sysplex during the previous minutes or hours.

If green is the dominant color, your sysplex seems to be in good shape, as more yellow or red indicators appear, you might start investigating the sources of possible problems.

Indicator

Field: Perf Indx

Description: The performance index shows how well a performance goal could be achieved and is calculated from the goal and actual performance data.

Guideline: A value of **1** means that the actual value met the goal exactly, a lesser value indicates that the actual value is better than the goal, a higher value could be seen as an indication of a performance problem.

If the goal could not be attained, the lines for the service class period, service class and workload are displayed in red (for high importance) and yellow (for medium and low importance). The same color is also given to the corresponding field in the performance status line.

Problem Area: The red and yellow lines can be indicators of performance problems in the sysplex. If it is a one-time event, you might ignore it. If some lines show red continuously, further investigation is recommended.

Potential Solution: Depending on the type of the workload you want to study, you can proceed with the Response Time Distribution report to get an impression of how this service class performs on the different systems in the sysplex, or you might choose the Work Manager Delays report that shows you more about CICS and IMS delays.

Note: The calculation of the performance index is done with actual values that are averages for the reporting range (could be, for example, 100 seconds for Monitor III, or 30 minutes in the Workload Activity report).

You might distinguish between this value and the performance index that is used by the workload manager internally to manage all service classes. This index is calculated every 10 seconds and you find the values in SMF records type 99. Due to the different ranges it is obvious that a difference will be seen.

Indicator

Field: Avg. Resp. Time

Description: The response time information for all workloads and service classes is given in three fields:

1. ACTUAL Time

The average response time for all ended transactions.

Note that these response times are for ended transactions only. Thus, if there is a problem where transactions are completely locked out, either while queued or running, you can't see the problem on this report until the locked out transactions end.

2. EXECUT Time

For CICS transactions, this includes execution time in AOR and following regions.

For IMS transactions, this includes execution time within the MPR.

For Batch, TSO, etc., this is the average time that transactions spent in execution.

Note: In the Postprocessor Workload Activity report, you see this field as EXECUTION TIME.

3. WAIT Time

This time is calculated as the difference between ACTUAL and EXECUT time, as long as ACTUAL time is the bigger value. However, for subsystem data, it can happen that EXECUT time is more than the ACTUAL time.

For CICS transactions, this includes not only queuing in the TOR and AOR, but also processing time within the TOR.

For IMS transactions, this includes not only queuing for the MPR, but also processing time within the CTL region.

Otherwise, this is the average time that transactions spent waiting on a JES or APPC queue. Note that WAIT time may not always be meaningful, depending on how the customer schedules work. For example, if a customer submits jobs in hold status and leaves them until they are ready to be run, all of the held time counts as queued time.

The "server" service classes are blank in the Avg. Resp. Time and Trans Ended Rate columns, because their "transactions" are address spaces, and response times are available only for ended transactions.

Problem Area / Potential Solution: See chapter "Understanding Workload Activity Data for IMS or CICS" on page 6-2.

Response Time Distribution Report

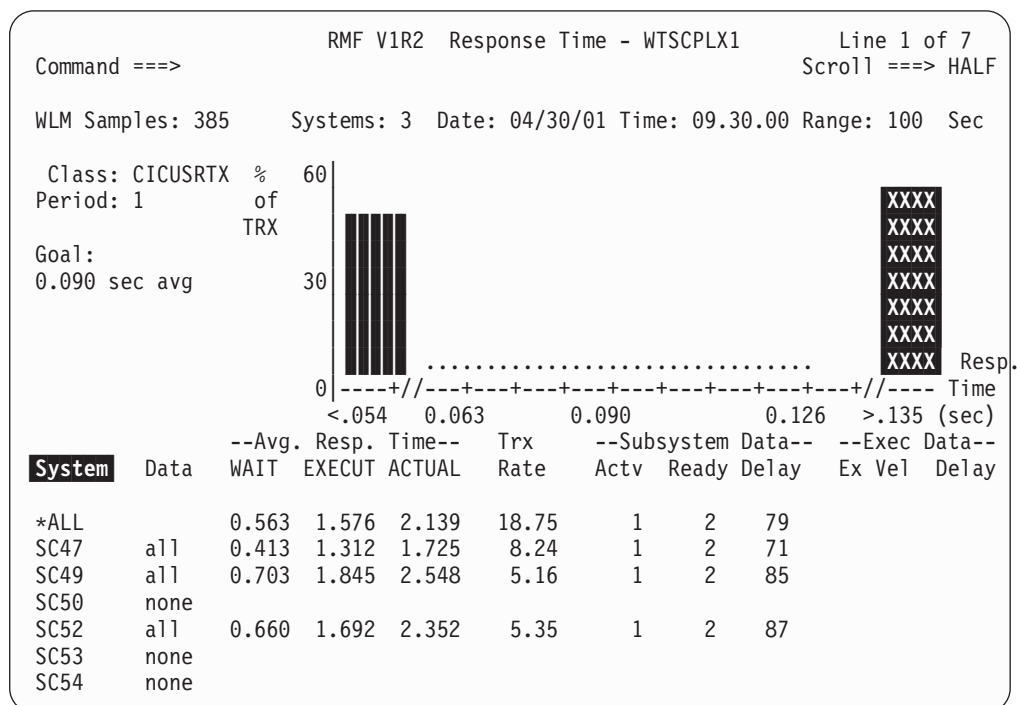


Figure 2-4. Monitor III Response Time Distribution Report

This report enables you to analyze the distribution of a response time to see whether a response time goal was met and, if not, how close it came to failing. The report shows how the response time for a specific service or report class period is distributed. Two levels of detail are shown:

- A character graphic shows the distribution of response time for all systems in a sysplex which have data available in this period.
This graphic is shown only for a periods with a response time goal.
- The details of how each system contributed to the overall response time.

Using cursor-sensitive control, you can navigate from this report to the GROUP report, which provides a detailed analysis of the response time, or to the SYSINFO report.

Indicator

Field: Response Time Distribution Graphic

Description: The horizontal axis shows response time (in seconds) with the response time goal in the middle. The middle section of the graph surrounding the goal shows the distribution of transactions that met between 60% and 150% of the goal.

Guideline: Easy — the more *green* fields you see the better your system is performing.

Problem Area: A big number of transactions on the right of the graphic in *red* indicates a problem.

Potential Solution: There can be different reasons for getting a distribution graphic like the one shown in the sample report:

- If you get this graphic more or less permanently, then probably different types of transactions are classified for the same service class. You can analyze the response time of the transactions by classifying them to different report classes, and then — as the second step — to different service classes to get more meaningful reports.
- The problem can also be either an untuned sysplex, a temporary performance problem, or an unrealistic performance goal. Then you need to investigate further.

Indicator

Field: System

Description: The bottom part of the report shows each system in the sysplex that provides service to the chosen service class.

Guideline: You can use this report to evaluate possible anomalies among the different systems that provide service.

Problem Area: This part of the report shows whether the any system has problems achieving the required goal.

Potential Solution: With cursor-sensitive control you can navigate from this report into the SYSINFO report for the system you are interested in. Then you can continue performance analysis as described in “Using Monitor III Reports” on page 2-14.

Work Manager Delays Report

RMF V1R2 Work Manager Delays - WTSCPLX1														Line 1 of 7			
Command ==>														Scroll ==> HALF			
WLM Samples: 385				Systems: 3		Date: 04/30/01		Time: 09.30.00		Range: 100		Sec					
Class: CICUSRTX				Period: 1		Avg. Resp. time: 2.139 sec for 1805 TRX.											
Goal: 0.090 sec average						Avg. Exec. time: 1.576 sec for 1558 TRX.											
Actual: 2.139 sec average						Abnormally ended: 0 TRX.											
Sub P ----- Response time breakdown (in %) ----- -Switched--																	
Type		Tot		Act		Rdy		Idle		-----Delayed by-----				Time (%)			
										LOCK		I/O		CONV		DIST	
										SESS		TIME		PROD		MISC	
										LOC		SYS		REM			
CICS B		79.0		0.5		1.8		0		2.3		1.3		67.0		0	
CICS X		66.4		0.5		0.4		0		2.8		21.6		0		0	
										40.8		0		0		0.3	
										22		0		0			
----- Address Spaces Serving this Service Class CICUSRTX -----																	
Jobname		M		ASID		System		Serv-Class		Service		Proc-Usg		I/O-Usg		Veloc	
																Capp	
																Quies	
CICSAOR1				46		SC47		SYSSTC		100		.61		4		55	
CICSAOR2				49		SC47		SYSSTC		100		3.7		3		74	
CICSAOR3				50		SC49		SYSSTC		100		4.2		1		43	
CICSAOR4				52		SC52		SYSSTC		100		2.1		2		79	
CICSCMAS				54		SC47		SYSSTC		50		11		8		54	
CICSFOR				39		SC47		CICSRGN		100		14		6		77	
CICSTOR				51		SC47		CICSRGN		100		14		8		63	

Figure 2-5. Monitor III Work Manager Delays Report

Indicator

Field: Response time breakdown (in %)

Description: This part of the report provides performance information for the begin-to-end phase (CICS only) and the execution phase of CICS and IMS.

Guideline: This information is the same as in the Postprocessor Workload Activity report with just the difference in the interval length.

For details, refer to "Understanding Workload Activity Data for IMS or CICS" on page 6-2.

Indicator

Field: Address Spaces Serving this Service Class

Description: You can see in this part of the report what address spaces provide service on different systems in the sysplex.

Guideline: The velocity (Veloc) and the processor service (Proc-Usg) for each address space can be seen as initial indicators to know how well the address spaces are providing service to the service classes of your transactions.

Identifying the Major Delay in a Response Time Problem

You have a response time problem? Want to know where to go next? This section will take you through several methods of analyzing a response time problem to find the major cause. It then points you to the relevant chapter for further diagnosis and problem resolution suggestions.

For a response time problem this means understanding the end-to-end response time components as completely as possible. As shown in Figure 2-6, most transactions can be viewed as having two major response time components:

- *internal* (for example, CPU time, paging, I/O)
- *external* (for example, network delay, server delay from other platforms)

RMF can help you analyze the internal response time components, and that is where this book will focus. The external response time components are beyond the scope of RMF, and will require other monitoring tools such as NetView*.

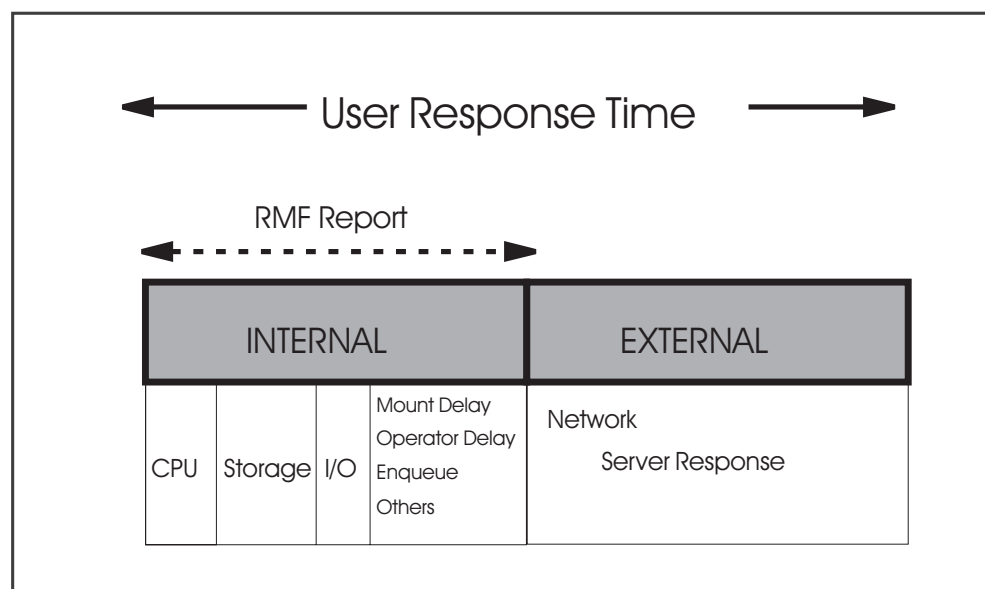


Figure 2-6. End-to-End Response Time Components

Understanding the relative proportions of these components allows you to see where you have the most leverage to improve response times. For example, if 90% of your response time is in I/O, why start with the CPU?

Response time analysis

For response time problems, generally the best place to start is with Monitor III. It reports on contention for resources (both hardware and software) and any associated *delays*.

Start by setting the *range* (or interval) of the data you're looking at to match at least a portion of the time in which the problem occurred. This could be current data in GO mode, or prior data. The choice of the range value must not be too high, which would smooth the peaks, or too low, to have enough samples to provide useful data.

The range should contain at least about 100 cycles. If the cycle is one-second (which is a good value, and is the default in RMF) a 1-5 minute time for the interval will generally fit. 100 seconds is the recommended value. Displayed percentages are then easily converted into elapsed time. If you are unfamiliar with altering these values, see the *RMF User's Guide* for more details.

If your response problem is sporadic, or due to brief spikes, you may need to adjust your range, moving forward or backward in time to find the problem. If you're having trouble, set the range to 100 seconds and move through time to pinpoint a spike.

Do not base your analysis on a single occurrence, as it could be an anomaly. Check over multiple days or times of day, to verify that the problem is real.

Using Monitor III Reports

This section will discuss several reports, showing you how to identify the major cause of delay to a workload. Your starting point might be the GROUP report when you used the cursor sensitivity in the SYSRTD report.

GROUP Report

If you have a response time problem for TSO or batch, go to the Group Response Time report. Look at the Primary Response Time Component field to see the largest component of response time.

RMF V1R2 Group Response Time												
Command ==>												
Samples: 100			System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec	
Class: TSOPROD			Period: 1		Description: TSO Production							
Primary Response Time Component:					Storage delay for local paging							
WFL	Users		Frames	Vector	EXCP	PgIn	TRANS	--- Response Time ---				
%	TOT	ACT	%ACT	UTIL	Rate	Rate	Rate	-- Ended TRANS-(Sec) -				
50	2	1	5	0	3.2	4.1	0.2	WAIT	EXECUT	ACTUAL		
			Total	-AVG USG-	-----Average Delay-----							
				PROC	DEV	PROC	DEV	STOR	SUBS	OPER	ENQ	OTHER
Average Users			0.600	0.10	0.17	0.02	0.03	0.22	0.00	0.00	0.00	0.06
Response Time ACT			3.432	0.57	0.97	0.11	0.17	1.25	0.00	0.00	0.00	0.34
			---STOR Delay---			---OUTR Swap Reason---			---SUBS Delay---			
			Page	Swap	OUTR	TI	TO	LW	XS	JES	HSM	XCF
Average Users			0.19	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Response Time ACT			1.08	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 2-7. Monitor III Group Response Time Report

Report Analysis

This report has two indicators for storage problems:

- Primary Response Time Component: Storage delay for local paging
- Response Time ACT: Average storage delay of 1.25 seconds

For more information, position the cursor on the field you are interested in and press ENTER. For this example, the reporting link will take you to the Storage Delay report, shown in figure 2-8.

Performance analysis with Mon III

STOR Report

RMF V1R2 Storage Delays									
Command ==>					Line 1 of 2 Scroll ==> HALF				
Samples: 100		System: PRD1		Date: 04/07/01	Time: 10.32.00	Range: 100		Sec	
Jobname	C	Service Class	DLY %	COMM	LOCL	VIO	SWAP	OUTR	-- Working Set -- Central Expanded
BAJU	T	TSO	21	0	18	0	3	0	273 5
BHOL	T	TSO	1	1	0	0	0	0	1111 4

Report is for service class TSO only.

Figure 2-8. Monitor III Storage Delays Report

This report shows the address spaces which are affected by storage delays, in this example just for performance group two.

Report Analysis

Address space BAJU is shown with the largest delay.

DELAY Report

If you do not know which group a delayed user belongs to, use the Delay report.

RMF V1R2 Delay Report														Line 1 of 43	
Command ==>														Scroll ==> HALF	
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec					
Name	CX	Service Class	Cr	WFL %	USG %	DLY %	IDL %	UKN %	----- PRC	% Delayed for DEV	STR	SUB	OPR	ENQ	Primary Reason
BHOLEQB	B	BATCH		0	0	51	0	49	0	0	0	0	0	51	SYSDSN
JES2	S	SYSSTC		0	0	2	0	98	0	2	0	0	0	0	SYSPAG
SMF	S	SYSSTC		0	0	1	0	99	0	1	0	0	0	0	SYSPAG
BAJU	T	TSO		29	9	22	67	2	1	0	21	0	0	0	LOCL
RMFGAT	S	SYSSTC		50	1	1	0	98	1	0	0	0	0	0	BAJU
BHOL	T	TSO		78	18	5	73	4	1	3	1	0	0	0	RMFUSR
BHOLPRO2	B	BATCH		93	93	7	0	0	7	0	0	0	0	0	BHOLPRO1

Figure 2-9. Monitor III Delay Report

The report lists all delayed address spaces sorted in ascending order by workflow percentage.

Report Analysis

There are two jobs with significant delays:

- BHOLEQB with 51% enqueue delay
- BAJU with 21% storage delay

Performance analysis with Mon III

We will continue analyzing the storage problem by positioning the cursor at the BAJU address space name for further processing. This leads to the Job Delay report with initial information about possible causes, as shown in figure 2-10.

JOB Report

```

RMF V1R2 Job Delays
Line 1 of 4
Command ==>
Scroll ==> HALF

Samples: 100      System: PRD1  Date: 04/07/01  Time: 10.32.00  Range: 100  Sec

Job: BAJU      Primary delay: Paging of private area storage.

Probable causes: 1) Job may be using excessive central storage.
                  2) Paging configuration may need tuning.
Help panels contain more possible causes.

----- Job Storage Usage Data -----
Average Frames:  300      Working Set:  278      Fixed Frames:  43
Active Frames:   92      Aux Slots:    978      DIV Frames:    0
Idle Frames:    209      Page In Rate: 14.1      ES Move Rate:  0.0

----- Job Performance Summary -----
Service      P WFL -Using%- DLY IDL UKN ----- % Delayed for ----- Primary
CX ASID Class P Cr  %  PRC DEV  %  %  PRC  DEV STR SUB OPR ENQ Reason
T  0027 TSO   *   29  4  5  22  67  2   1   0  21  0  0  0  LOCL
      TSO   1   33  1  1  4  67  2   0   0  4  0  0  0  SWAP
      TSO   2   35  2  4  11  0  0   1   0  10  0  0  0  LOCL
      TSO   3   13  1  0  7  0  0   0   0  7  0  0  0  LOCL

```

Figure 2-10. Monitor III Job Delays Report

Report Analysis

Monitor III has done basic analysis of the status and provides some possible causes. Use these as a starting point, and investigate further to confirm or rule-out these possibilities. In this example, swap trim may also be worth investigating.

In this example you would need to investigate processor storage further. See Chapter 5. Analyzing Processor Storage Activity for details.

Performance analysis with Mon III

WFEX Report

If your help desk uses the Workflow/Exceptions report as a continual system monitor, they would be alerted to exception conditions. These could be your first indicators to a problem. This depends on your having customized the screen to your particular needs and thresholds. See the *RMF Report Analysis* for tailoring information.

Or, you can use this screen as your first diagnosis aid if investigating a user problem.

RMF V1R2 Workflow/Exceptions				Line 1 of 4			
Command ==>				Scroll ==> HALF			
Samples: 100		System: PRD1	Date: 04/07/01	Time: 10.32.00	Range: 100	Sec	
----- Speed (Workflow) -----							
Speed of 100 = Maximum, 0 = Stopped				Average CPU Util: 100 %			
Name	Users	Active	Speed	Name	Users	Active	Speed
*SYSTEM	43	3	72	TSOPROD	2	1	50
ALL TSO	2	1	50	BATCHPRD	6	3	75
ALL STC	35	0	84				
ALL BATCH	6	3	75				
ALL ASCH			Not avail				
*PROC	17	2	93				
*DEV	6	0	21				
----- Exceptions -----							
Name	Reason	Critical val.	Possible cause or action				
ECSA	SECS% > 85	90.6 %	System ECSA usage 91 %.				
*STOR	TSQA0 > 0	784K bytes	SQA overflow into CSA 784K.				
BHOLEQB	ENQ -SYSDSN	51.0 % delay	ENQ.TEST.DAT				
HSM	Not avail		Job HSM is not running.				

Figure 2-11. Monitor III Workflow/Exceptions Report

Speed, or workflow, can be used as a performance indicator either for the total system or for groups of users or resources. It is an indicator of how well a workload is able to get the system resources it wants. 100% means it gets whatever it wants whenever it wants it; 0% means it never gets what it wants. Speed is also used on a resource level (processors or devices) to reflect contention for that resource.

Speed can also be a useful indicator for exception reporting for your workloads. Make note of the workflow values reported when your system is running well. Use these as your own guideline values to set up exception reporting.

Report Analysis

The Speed of 50% for all TSO users might suggest a response time problem, if users are complaining, or if your experience has shown that a higher workflow is required to meet service objectives on your system.

However, your system may function well at a 50% speed. Use your judgment and review related indicators to determine whether or not a low speed is a problem.

DELAY versus USING

So far, we have been concentrating on workload delays. Your workload's dominant state could also be USING. Both cases will be discussed further in the relevant chapters.

Performance problem due to DELAY: If the largest single component of response or delay for the workload you're interested in is:

- PROC (or processor delays), go to Chapter 3. Analyzing Processor Activity for further analysis
- DEV (or device delays), go to Chapter 4. Analyzing I/O Activity for further analysis
- STOR (or storage delays), go to Chapter 5. Analyzing Processor Storage Activity for further analysis

If some other component (ENQ, IDL, SUBS, OPER, UKN) indicates a problem, see Appendix D. Other Delays.

Performance problem due to USING: If there are no delays of any significance (at least 5-10%), look at the USING% values for PROC and DEV in the Job Delay report (other reports also have this information). Select the larger, and go to the corresponding CPU or I/O chapter for some thoughts on reducing the workload's need for that resource or speeding up the processing.

Monitoring Daily Performance: System Indicators

As discussed at the beginning of this chapter, there are different kinds of performance problems. Response time complaints or SLA exceptions are two examples. Potential problems may also be indicated by your daily performance monitoring. This section will discuss some RMF indicators which will be of use in your daily monitoring.

Here are some of the most frequently used global indicators of MVS system health, along with some *rules-of-thumb* (ROTs), on what constitutes potential trouble.

As with any ROTs, these should be looked at as a starting point only. There is no magic single number for any indicator that suggests you have a problem.

The most important thing is that your service levels are being met.

We will highlight the indicators by using RMF reports, with pointers to the appropriate chapter of this book for more details.

As you read these, remember that Monitor III will show you the impact of most of these indicators:

- *WHO* is being delayed?
- For *HOW LONG*?
- And *BY WHOM*?

Use this delay information to help you decide whether a given indicator really means trouble or not.

Summary of Major System Indicators

How do you like this approach?

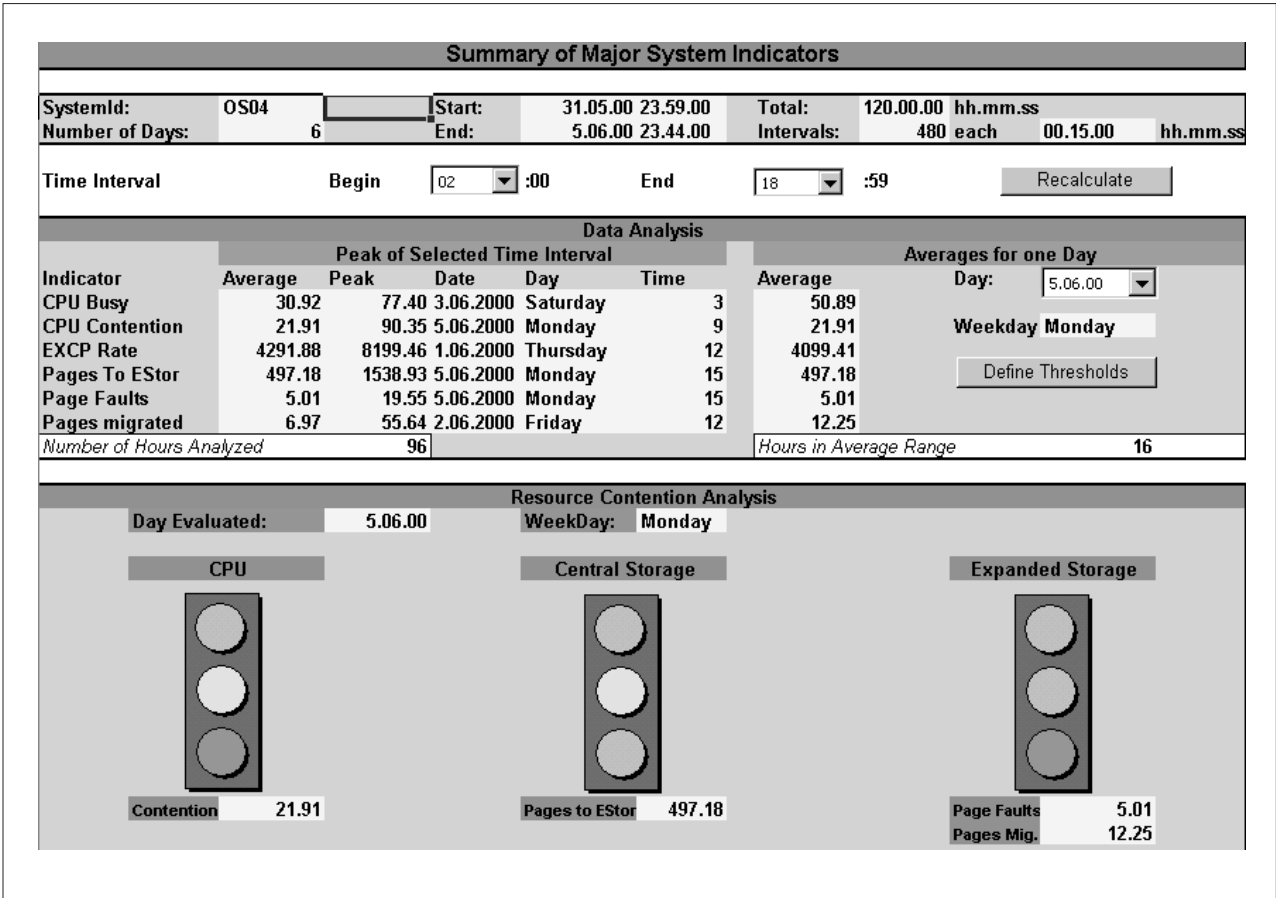


Figure 2-12. Summary of Major System Indicators. Spreadsheet Reporter macro RMFY9OVW.XLS (System Overview Report - Summary)

The Summary report displays key indicators representing the performance of your system. At a glance, you see whether your system experiences processor or storage contention.

A resource contention analysis is done for three indicators:

- CPU Contention** The percent of time with at least one job waiting for the CPU.
- CS Contention** The page movement rate from CS to ES is used as indicator for CS contention.
- ES Contention** The page fault rate and the migration rate are used as indicators for ES contention.

You can specify a time range and a day to perform the contention evaluation. The calculated values will be compared against a set of defined thresholds:

- CPU Contention** 20 - 80
- CS Contention** 200 - 800

System indicators

ES Contention	10 - 50 (page fault rate)
	30 - 80 (migration rate)

You can specify the low and high thresholds which are used to set the traffic light to red or green according to your own experiences. Especially, the ES contention threshold depends on the key workload you are running in your system. If it is an online application (for example CICS or DB2), you should decrease the values to 10 - 30 (page fault rate) and to 20 - 50 (migration rate). On the other hand, a TSO system can run with much higher values, here you might specify 20 - 70 and 50 - 150.

Please keep in mind that the contention analysis should be done with data for a longer interval, the sample report covers prime shift data (8:00am to 3:59pm), therefore, the thresholds are different to other values in this publication, because those will be taken for interval reports of 15 or 30 minutes.

Using Monitor I Reports

CPU Activity Report

C P U A C T I V I T Y															
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996			
				RPT VERSION V1R2 RMF				TIME 09.29.00				CYCLE 1.000 SECONDS			
PAGE 1															
CPU 9672 MODEL Z97															
CPU	ONLINE TIME	LPAR BUSY	MVS BUSY	CPU SERIAL	I/O TOTAL	% I/O INTERRUPTS									
NUMBER	PERCENTAGE	TIME PERC	TIME PERC	NUMBER	INTERRUPT RATE	HANDLED VIA TPI									
0	100.00	76.93	99.15	045104	320.9	0.33									
1	100.00	76.85	99.13	145104	324.0	0.22									
2	100.00	76.86	99.09	245104	321.6	0.22									
3	100.00	76.87	98.99	345104	329.5	0.25									
4	100.00	76.89	99.01	445104	325.9	0.33									
5	100.00	76.87	98.88	545104	328.7	0.36									
6	100.00	76.88	98.86	645104	338.4	0.46									
7	100.00	76.85	98.73	745104	341.1	0.51									
8	100.00	76.82	98.59	845104	335.9	0.67									
TOTAL/AVERAGE		76.87	98.94		2966	0.37									
SYSTEM ADDRESS SPACE ANALYSIS SAMPLES = 898															
TYPE	NUMBER OF ASIDS			DISTRIBUTION OF QUEUE LENGTHS (%)											
	MIN	MAX	AVG	0	1	2	3	4	5	6	7-8	9-10	11-12	13-14	14+
IN READY	5	37	14.8	0.0	0.0	0.0	0.0	0.0	0.2	0.4	2.7	9.7	16.8	22.3	47.5
				0	1-2	3-4	5-6	7-8	9-10	11-15	16-20	21-25	26-30	31-35	35+
IN OUT	161	198	177.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
READY OUT	0	2	0.0	98.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WAIT LOGICAL	161	188	174.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
OUT RDY LOGICAL	0	2	0.0	97.9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT WAIT	50	105	83.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
BATCH	76	85	79.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
STC	218	232	226.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
TSO	87	97	92.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ASCH	0	1	0.0	99.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OMVS	35	43	36.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	37.4

Figure 2-13. Monitor I CPU Activity Report

Rules-of-Thumb

BUSY TIME PERCENTAGE

A value of over 85%, along with the total of the IN READY numbers for the columns 0,1,...N below 80%, implies contention for the CPU.

If your CPU is more than 85% busy, look at the values for the DISTRIBUTION OF QUEUE LENGTHS (%). Add up the IN READY numbers for the columns 0,1,...N, where N is the number of CPs in your system (e.g. for a system with two CPs add up columns 0+1+2). This total is the percent of time that you had enough CPs to handle all the work on the IN READY queue. The remaining time, you had work waiting for CPs. If your total for the columns 0,1,...N was 80%, then 20% of the time you had ready work waiting for a CP.

This is not to say that you cannot run an MVS system at higher utilizations, on up to 100% busy. You can. Just be aware that the busier the CPU, the longer the CPU delay for lower-priority workloads will be. The more low-priority work you have, and the fewer non-CPU bottlenecks you have (for example, responsive I/O), the busier you will be able to drive your CPU and still maintain good response for your high-priority workloads.

If your goal is to run your system to 100% busy, minimize your non-CPU bottlenecks and use the information from the Monitor III Processor Delay report to keep an eye on CPU delay for your low-priority work.

BUSY TIME PERCENTAGE

Conversely, a low CPU busy could indicate that other bottlenecks in the system are preventing work from being dispatched.

A peak-to-average ratio (for example, peak hour busy/prime shift average busy) of less than 1.3-1.4 for a commercial workload could also indicate bottlenecks preventing work from using the CPU.

This ratio is inversely correlated to IN READY users: the numbers of IN READY users go up as the peak-to-average ratio comes down. This is due to latent demand and the inability of the system to dispatch all the ready work.

OUT READY

Number of address spaces swapped out (probably TSO and batch), but ready to execute. If it is greater than 1, and TSO or batch response is an issue, look into this. This could reflect processor storage constraints, and probably a need for updating IPS and OPT parameters.

Report Analysis

- BUSY TIME PERCENTAGE is 98.94%
- Total of IN READY for 0 to 10: 13%

This might point to a problem, because at least 87% of the time one or more address spaces are delayed for CPU. The Monitor III Processor Delay report will tell you which AS were delayed, and for how long.

See Chapter 3. Analyzing Processor Activity and Chapter 5. Analyzing Processor Storage Activity for further analysis.

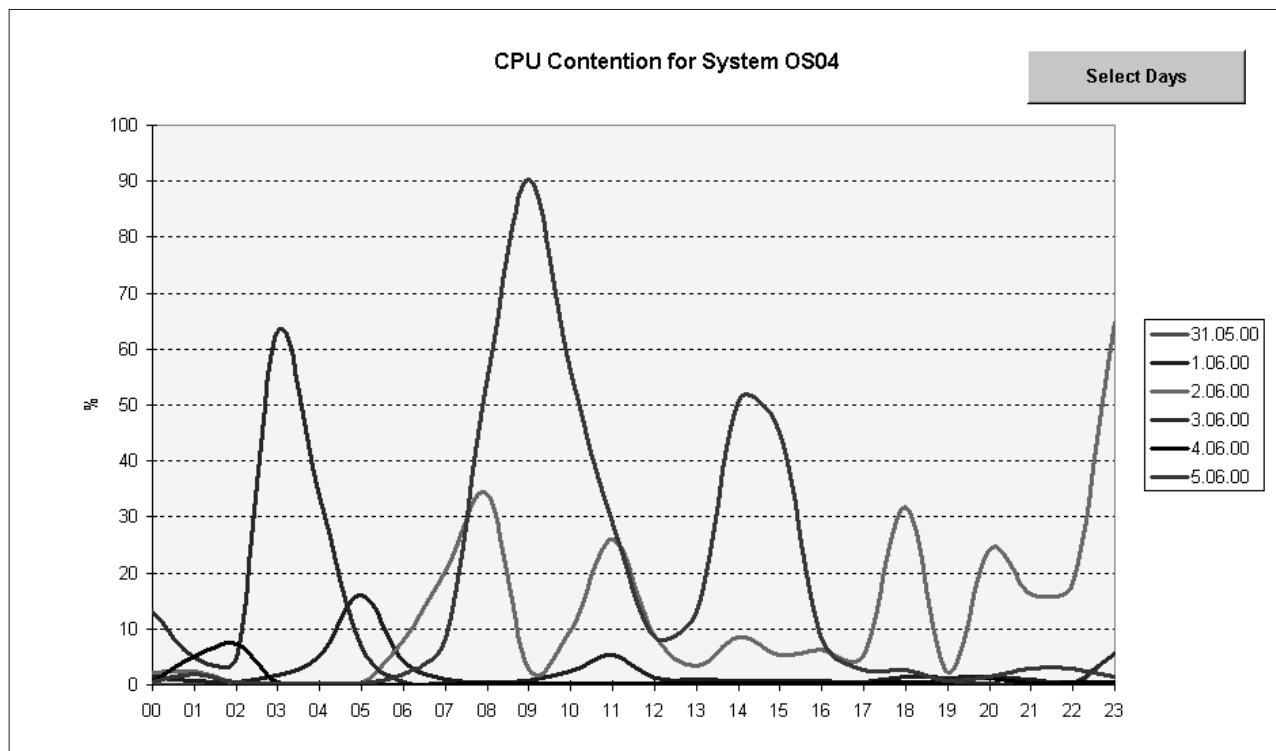


Figure 2-14. CPU Contention. Spreadsheet Reporter macro RMFY9OVW.XLS (System Overview Report - DaysCont)

The CPU Contention report helps you in understanding your processor capacity. It extends the *long-term* indicator in the Summary report (Figure 2-12 on page 2-21) and informs you about the contention of your system in some more detail.

System indicators

Partition Data Report

P A R T I T I O N D A T A R E P O R T																PAGE	2
z/OS V1R2			SYSTEM ID NP1				DATE 04/15/2001				INTERVAL 14.59.678						
			RPT VERSION V1R2 RMF				TIME 09.30.00				CYCLE 1.000 SECONDS						
MVS PARTITION NAME			NP1														
IMAGE CAPACITY			100														
NUMBER OF CONFIGURED PARTITIONS			9														
NUMBER OF PHYSICAL PROCESSORS			9														
CP			9														
ICF			0														
WAIT COMPLETION			NO														
DISPATCH INTERVAL			DYNAMIC														
----- PARTITION DATA ----- -- LOGICAL PARTITION PROCESSOR DATA -- -- AVERAGE PROCESSOR UTILIZATION PERCENTAGES --																	
NAME	S	WGT	DEF	ACT	---MSU---	-CAPPING--	PROCESSOR-	----	DISPATCH	TIME DATA----	LOGICAL PROCESSORS	---	PHYSICAL PROCESSORS	---			
					DEF	WLM%	NUM	TYPE	EFFECTIVE	TOTAL	EFFECTIVE	TOTAL	LPAR MGMT	EFFECTIVE	TOTAL		
NP1	A	20	100	10	NO	62.2	1.2	CP	00.04.29.502	00.04.27.519	25.10	24.92	****	3.33	3.30		
NP2	A	1	0	1	YES	0.0	4	CP	00.00.22.680	00.00.22.083	0.75	0.73	****	0.28	0.27		
NP3	A	10	5	8	NO	3.3	1.0	CP	00.03.37.761	00.03.35.859	24.20	23.99	****	2.69	2.67		
NP4	A	300	95	155	NO	0.0	0.3	CP	01.12.08.405	01.12.06.405	80.18	80.15	****	53.46	53.43		
NP5	A	200	50	52	NO	0.0	4	CP	00.24.13.447	00.24.11.311	40.39	40.33	****	17.95	17.92		
CFC1	A	DED	0	32		0.0	1	CP	00.14.59.611	00.14.59.625	99.99	99.99	0.00	11.11	11.11		
CFC2	A	DED	0	0		0.0	1	CP	00.00.00.000	00.00.00.000	0.00	0.00	0.00	0.00	0.00		
PHYSICAL										00.00.03.603				0.04		0.04	
TOTAL									01.59.51.408	01.59.46.408			0.04	88.81	88.75		
CB88	D																
CB89	D																

Figure 2-15. Monitor I CPU Activity Report - Partition Data Report Section

If your system is showing signs of CPU constraint (see previous report), and you are running as a *logical partition (LP)* in a PR/SM environment, check the Partition Data report to be sure that your LP is correctly configured. You would do this to allocate more CPU resource to a particular LP.

See Appendix A. PR/SM LPAR Considerations for further analysis.

Channel Path Activity Report

CHANNEL PATH ACTIVITY									
z/OS V1R2			SYSTEM ID OS04			DATE 06/05/2001		INTERVAL 14.59.996	
			RPT VERSION V1R2 RMF			TIME 09.29.00		CYCLE 1.000 SECONDS	
IODF = 01	CR-DATE: 07/10/01		CR-TIME: 21.00.01		ACT: POR	MODE: LPAR		CPMF: EXTENDED MODE	
B5 CNC_S Y	25.22	26.16				BD CNC_S Y	22.65	23.48	
B6 CNC_P	OFFLINE					BE CNC_S Y	0.00	0.01	
B7 CNC_S Y	0.01	0.01				BF CTC_S Y	0.40	1.48	
B8 CNC_S Y	0.00	0.00				C0 CNC_S Y	2.11	2.77	
B9 CNC_S Y	0.00	0.00				C1 CNC_S Y	0.00	0.00	
BA CNC_S Y	1.11	1.16				C2 CNC_S Y	0.00	0.00	
BB CNC_S Y	2.55	2.56				C3 CNC_P	OFFLINE		
BC CNC_S Y	4.63	9.21				C4 CNC_S Y	0.00	0.00	
C5 CNC_S Y	0.00	0.00				CD CFS Y	-----	0.00	
C6 CNC_S Y	13.70	14.72				D0 CNC_S Y	2.03	2.68	
C7 CNC_S Y	33.26	33.26				D1 CNC_S Y	0.00	0.00	
C8 CNC_S Y	0.00	0.00				D2 CVC	0.00	0.00	
C9 CNC_S Y	4.40	8.84				D3 CNC_S Y	32.96	32.97	
CA CNC_S Y	0.00	0.00				D4 CNC_S Y	37.13	39.54	
CB CNC_? Y	0.00	0.00				D5 CNC_S Y	1.24	1.27	
CC CFS Y	-----	0.00				D6 CNC_S Y	0.00	0.00	

Figure 2-16. Monitor I Channel Path Activity Report

Note: In the past, it gave rules-of-thumb about channel utilization providing numbers up to 50%. For new channel types, for example, OSA-Express Gigabit Ethernet, you may see values for channel utilization close to 100% without any performance degradation. For more information, please refer to the *OSA-Express Gigabit Ethernet Performance Report*.

Report Analysis

Channel 54 has a partition utilization of 37.13 % and a total utilization of 39.54 %. This may not be a problem.

To find out which *logical control unit (LCU)* is using this channel, look in the I/O Queuing Activity report (see Figure 2-17 on page 2-28). From there, you can go on to check device response times.

See Chapter 4. Analyzing I/O Activity for further analysis.

System indicators

I/O Queuing Activity Report

I/O QUEUING ACTIVITY															
z/OS V1R2			SYSTEM ID SYS1			DATE 03/14/2001			INTERVAL 15.00.036						
			RPT VERSION V1R2 RMF			TIME 16.30.00			CYCLE 1.000 SECONDS						
TOTAL SAMPLES = 900			IODF = 01			CR-DATE: 05/10/2000			CR-TIME: 21.00.01			ACT: POR			
IOP	- INITIATIVE QUEUE -		----- IOP UTILIZATION -----			-- % I/O REQUESTS RETRIED --					----- RETRIES / SSCH -----				
	ACTIVITY RATE	AVG Q LGTH	% IOP BUSY	I/O START RATE	INTERRUPT RATE	ALL	CP BUSY	DP BUSY	CU BUSY	DV BUSY	ALL	CP BUSY	DP BUSY	CU BUSY	DV BUSY
00	1282.40	0.15	54.58	853.56	984.56	67.7	34.0	15.1	11.3	7.3	2.10	1.05	0.47	0.35	0.23
02	1188.30	0.11	51.25	797.23	856.23	63.4	27.5	9.2	18.3	8.4	1.74	0.75	0.25	0.50	0.23
SYS	2470.70	0.13	52.83	1650.79	1840.79	65.8	31.1	12.4	14.5	7.8	1.92	0.91	0.36	0.42	0.23
LCU	CONTROL UNITS	DCM GROUP		CHAN PATHS	CHPID TAKEN	% DP BUSY	% CU BUSY	CONTENTION RATE	DELAY Q LGTH						
		MIN	MAX	DEF											
0056	0100			D4	58.953	42.50	1.22								
				EC	57.117	43.34	0.90								
	0101			45	55.935	44.62	1.14								
				28	67.282	28.32	1.39								
				*	239.29	39.91	1.16	8.596	0.41						
0057	0140			D4	61.322	42.20	0.98								
				EC	60.601	41.87	0.82								
	0141			45	59.820	42.99	1.02								
				28	74.294	24.96	1.15								
				*	256.04	38.20	0.99	8.913	0.22						

Figure 2-17. Monitor I I/O Queuing Activity Report

Report Analysis

Channel path D4 is connected to LCU 0056 - 0059. The corresponding devices can be seen in the Device Activity report.

DASD Activity Report

D I R E C T A C C E S S D E V I C E A C T I V I T Y																				
z/OS V1R2				SYSTEM ID 0S04				DATE 06/05/2001				INTERVAL 14.59.996								
				RPT VERSION V1R2 RMF				TIME 09.29.00				CYCLE 1.000 SECONDS								
TOTAL SAMPLES = 1,807				IODF = 12				CR-DATE: 03/01/01				CR-TIME: 10.23.17								
STORAGE GROUP	DEV NUM	DEVICE TYPE	VOLUME PAV SERIAL	LCU	DEVICE ACTIVITY RATE	AVG RESP TIME	AVG IOSQ	AVG DPB DLY	AVG CUB DLY	AVG DB DLY	AVG PEND TIME	AVG DISC TIME	AVG CONN TIME	% DEV CONN	% DEV UTIL	% DEV RESV	AVG NUMBER ALLOC	% ANY ALLOC	% MT PEND	
SGGDG	0340	33903	IDP386	0056	0.139	18	0	0.0	0.0	0.0	0.6	0.7	17.1	0.24	0.25	0.0	1.3	100.0	0.0	
SGGDG	0341	33903	IDP387	0056	0.001	1	0	0.0	0.0	0.0	0.3	0.0	0.6	0.00	0.00	0.0	0.0	100.0	0.0	
SGGDG	0342	33903	IDP388	0056	3.311	22	0	0.0	0.0	0.2	0.6	0.2	21.5	7.12	7.18	0.0	1.0	100.0	0.0	
SGGDG	0343	33903	IDP389	0056	0.001	1	0	0.0	0.0	0.0	0.3	0.0	0.6	0.00	0.00	0.0	0.0	100.0	0.0	
SGCCBS	0344	33903	CCB178	0056	0.150	13	0	0.0	0.0	0.0	0.5	9.9	2.4	0.04	0.18	0.0	2.0	100.0	0.0	
SGCCBS	0345	33903	CCB179	0056	3.703	23	11	0.0	0.0	0.0	0.3	4.8	7.1	2.63	4.40	0.0	3.7	100.0	0.0	
SGDBSWN	0346	33903	DBSW11	0056	0.959	2	0	0.0	0.0	0.2	0.5	0.0	1.8	0.17	0.17	0.0	11.0	100.0	0.0	
SGDBSWN	0347	33903	DBSW12	0056	0.003	1	0	0.0	0.0	0.0	0.3	0.0	0.6	0.00	0.00	0.0	2.0	100.0	0.0	
SGSW	0348	33903	IDP302	0056	0.003	1	0	0.0	0.0	0.0	0.3	0.0	0.6	0.00	0.00	0.0	0.0	100.0	0.0	
	0349	33903	PLEXP1	0056	0.002	1	0	0.0	0.0	0.0	0.2	0.1	0.4	0.00	0.00	0.0	0.0	100.0	0.0	
:																				
:																				
SGSW	037E	33903	IDP303	0056	0.003	1	0	0.0	0.0	0.0	0.3	0.0	0.5	0.00	0.00	0.0	0.0	100.0	0.0	
SGCRITC	037F	33903	IDP076	0056	0.003	1	0	0.0	0.0	0.0	0.2	0.0	0.6	0.00	0.00	0.0	1.0	100.0	0.0	
			LCU	0056	44.580	13	1	0.0	0.0	0.2	0.7	3.6	8.2	0.57	0.82	0.0	137	100.0	0.0	

Figure 2-18. Monitor I DASD Activity Report

Rules-of-Thumb

AVG RESP TIME

Typical values by DASD device type:

• Uncached 3380	25 ms
• Uncached 3390	20 ms
• Uncached 9345	18 ms
• Cached 3380	12 ms
• Cached 3390	10 ms
• Cached 9345	9 ms

This table seems to have a slightly nostalgic look because most of these device may not be found in any installation. You might take it as a historical view about the development of DASD devices. Today, cached 3390 is the current standard, at least for all those installations which have not started with the migration of their I/O subsystem to the *Enterprise Storage Server* (ESS) which can provide significant better I/O performance. For details, please refer to “Improving I/O Performance with the Enterprise Storage Server” on page 4-5.

If your response times significantly exceed these, for devices with high activity rates and/or important workloads, you should investigate further.

Note that some workloads are prone to higher response times, which may still be quite acceptable (for example, DB2 sequential prefetch, page/swap I/O).

Tape LCU AVG RESP TIME

Look at the ratio of LCU DISC + PEND time to CONN time. When the DISC+PEND exceeds CONN for extended periods of time, this is an indication of channel and/or control unit contention.

Report Analysis

Several devices 340, 342, 344, or 345 have response times that are far above typical values and need further investigation. (Which workloads are using these devices? How much are they being delayed? Are these response times typical for my system?).

See Chapter 4. Analyzing I/O Activity for further analysis.

RMF DASD System Summary						
System Id: OS04		Operating System: OS/390 02.10.00		Report Range(seconds): 899.628		
Reporting Date: 6.05.00		Reporting Time: 09.29.00		Report Range(hh.mm.ss): 14.59.628		
Overall	Total Number of Logical Control Units	116	Installed Capacity Estimation			
	Total Number of DASDs	6588	Types	GB each	Number	Capacity
	Installed Capacity	18458.12 GB	3380D	0.63	0	0
	Total Activity Rate	1990.76 I/O per sec	3380E	1.26	0	0
	Access Density	0.11	3380J	0.63	0	0
Times			3380K	1.89	0	0
	Connect Time	3.11 ms	33901	0.94	0	0
	Disconnect Time	2.63 ms	33902	1.89	0	0
	Service Time	5.74 ms	33903	2.83	6236	17647.88
	Pending Time	0.60 ms	33906	8.44	0	0
	IOS Queue Time	0.55 ms	33909	8.44	96	810.24
	Response Time	6.90 ms	9345	1.50	0	0
			Unknown	NA	256	NA
	Response Time / Service Time	1.20	Additional	NA	NA	0
	Intensities	I/O Intensity	13732.83 ms / s	Total		6588
Service Time Intensity		11426.68 ms / s				
Path Intensity		6188.40 ms / s				
DASD Skew	Average Service Time Intensity	1.73 ms / s				
	Highest Service Time Intensity	838.88 ms / s				
	Ratio: Highest/Average (DASD Skew)	483.65				
	Typical DASD Skew	47.89				
	Typical Range (low / high)	23.70 96.77				

Figure 2-19. DASD Summary. Spreadsheet Reporter macro RMFR9DAS.XLS (DASD Activity Report - System)

In the DASD Summary report, you see at a glance the key data of your DASD subsystem: performance values as well as capacity data. If you feel that you might see some more details, you can have a look on the ten most busy DASD volumes in your system:

System indicators

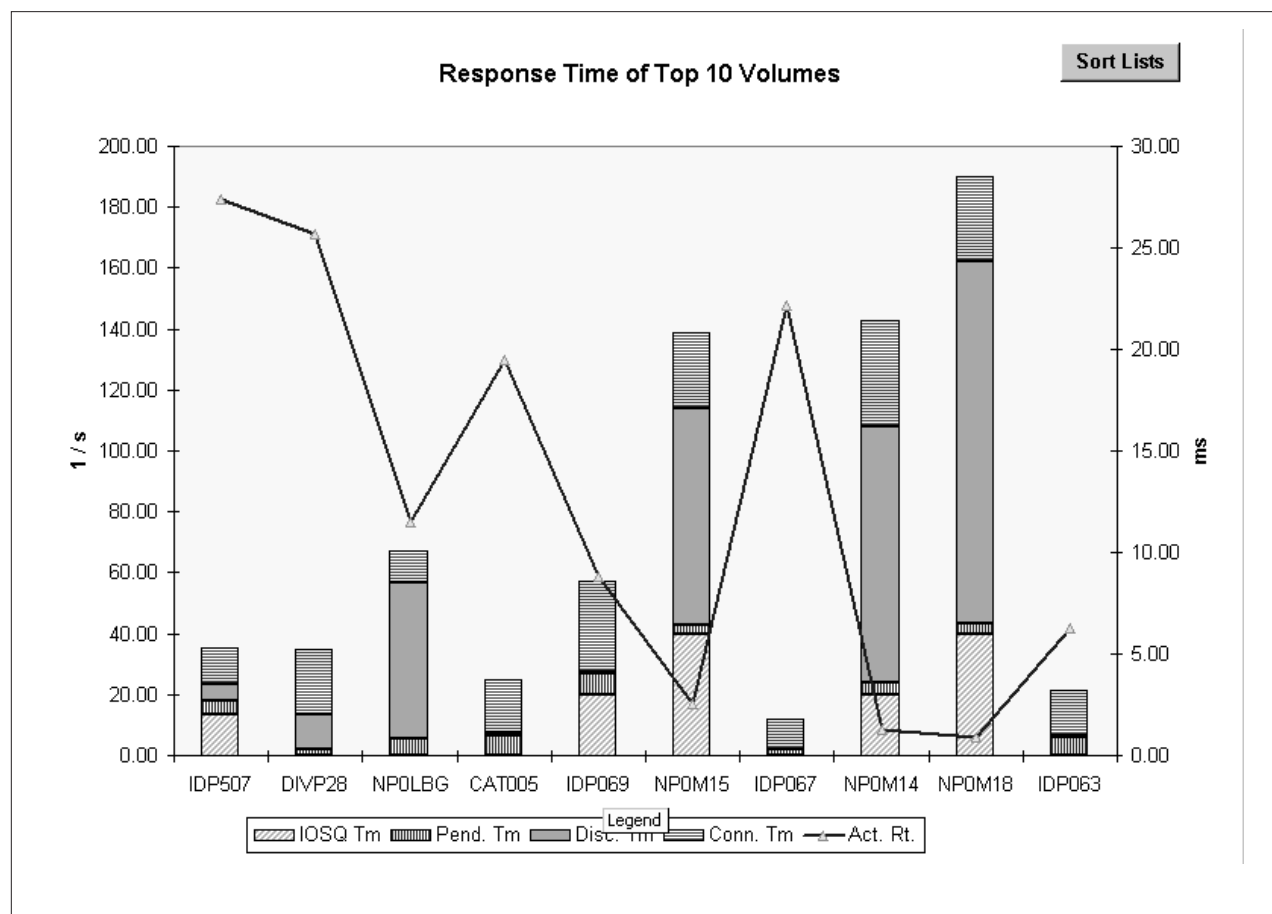


Figure 2-20. Response Time of Top-10 Volumes. Spreadsheet Reporter macro RMFR9DAS.XLS (DASD Activity Report - Top10RT)

Paging Activity Report - Page 3

P A G I N G A C T I V I T Y												
z/OS V1R2			SYSTEM ID OS04			DATE 06/05/2001			INTERVAL 14.59.996			
			RPT VERSION V1R2 RMF			TIME 09.29.00			CYCLE 1.000 SECONDS			
OPT = IEAOPT02 MODE=ESAME			S W A P P L A C E M E N T A C T I V I T Y									
----- AUX STORAGE ----- *---LOGICAL SWAP---* *----- EXPANDED STORAGE -----*												
		TOTAL	AUX STOR TOTAL	AUX STOR DIRECT	AUX STOR VIA TRANSITION	LOG SWAP	LOG SWAP EFFECTIVE	EXP STOR DIRECT	EXP STOR TOTAL	MIGRATED FROM EXP STOR	EXP STOR EFFECTIVE	LOG SWAP /EXP STOR EFFECTIVE
TERMINAL	CT	1,558	0	0	0	1,558	1,535	0	23	0	23	1,558
INPUT/OUTPUT	RT	1.73	0.00	0.00	0.00	1.73	1.71	0.00	0.03	0.00	0.03	1.73
WAIT	%	23.2%	0.0%	0.0%	0.0%	100.0%	98.5%	0.0%	1.5%	0.0%	100.0%	100.0%
LONG	CT	2,081	0	0	0	2,081	2,060	0	21	0	21	2,081
WAIT	RT	2.31	0.00	0.00	0.00	2.31	2.29	0.00	0.02	0.00	0.02	2.31
	%	30.9%	0.0%	0.0%	0.0%	100.0%	99.0%	0.0%	1.0%	0.0%	100.0%	100.0%
DETECTED	CT	2,918	1	0	1	2,918	2,894	0	24	1	23	2,917
WAIT	RT	3.24	0.00	0.00	0.00	3.24	3.22	0.00	0.03	0.00	0.03	3.24
	%	43.4%	0.0%	0.0%	100.0%	100.0%	99.2%	0.0%	0.8%	4.2%	95.8%	100.0%
UNILATERAL	CT	6	0	0	0	6	6	0	0	0	0	6
	RT	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01
	%	0.1%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
EXCHANGE ON	CT	3	0	0	0	3	3	0	0	0	0	3
RECOMMENDA-	RT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TION VALUE	%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
TRANSITION	CT	8	0	0	0	0	0	8	8	0	8	8
TO NON-	RT	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
SWAPPABLE	%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%
OMVS	CT	153	0	0	0	153	150	0	3	0	3	153
INPUT	RT	0.17	0.00	0.00	0.00	0.17	0.17	0.00	0.00	0.00	0.00	0.17
WAIT	%	2.3%	0.0%	0.0%	0.0%	100.0%	98.0%	0.0%	2.0%	0.0%	100.0%	100.0%
TOTAL	CT	6,727	1	0	1	6,719	6,648	8	79	1	78	6,726
	RT	7.48	0.00	0.00	0.00	7.47	7.39	0.01	0.09	0.00	0.09	7.48
	%	100.0%	0.0%	0.0%	100.0%	99.9%	98.9%	0.1%	1.2%	1.3%	98.7%	100.0%
AUXILIARY STORAGE - AVERAGE PAGES PER SWAP OUT -						1	AVERAGE PAGES PER SWAP IN -					
OCCURRENCES OF TERMINAL OUTPUT WAIT -						87	257					

Figure 2-21. Monitor I Paging Activity Report - Page 3

Rule-of-Thumb

LOG SWAP/EXP STOR EFFECTIVE

This is the percentage of all swaps that are satisfied from processor storage. You want the TOTAL value under this column to be a high number (e.g. over 95%) to keep swap delay times low.

The percentage under TERMINAL INPUT/OUTPUT WAIT should also be high, as this is where most TSO swaps are reflected.

System indicators

Report Analysis

The LOG SWAP/EXP STOR EFFECTIVE values for

- TOTAL: 100%
- TERMINAL INPUT/OUTPUT WAIT: 100%

are perfect.

See Chapter 5. Analyzing Processor Storage Activity for further analysis.

Page/Swap Data Set Activity Report

PAGE / SWAP DATASET ACTIVITY														
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996		
				RPT VERSION V1R2 RMF				TIME 09.29.00				CYCLE 1.000 SECONDS		
NUMBER OF SAMPLES = 898				PAGE DATA SET USAGE										

PAGE SPACE TYPE	VOLUME SERIAL	DEV NUM	DEVICE TYPE	SLOTS ALLOC	---- MIN	SLOTS USED MAX	--- AVG	BAD SLOTS	% IN USE	PAGE TRANS TIME	NUMBER IO REQ	PAGES XFER'D	V I O	DATA SET NAME
PLPA	PAGP11	0378	33903	45000	16466	16466	16466	0	0.11	0.200	6	5		PAGE.OS04.APLPA
COMMON	PAGP10	0377	33903	21240	5345	5378	5355	0	0.11	0.027	38	37		PAGE.OS04.ACOMMON
LOCAL	PAGP12	0379	33903	566820	67670	70965	69140	0	2.67	0.004	711	5,697	N	PAGE.OS04.LOCAL01
LOCAL	PAGP13	037A	33903	566820	65887	69007	67190	0	3.01	0.005	771	5,711	N	PAGE.OS04.LOCAL02
LOCAL	PAGP14	037B	33903	566820	66611	69723	67928	0	3.01	0.005	821	5,625	Y	PAGE.OS04.LOCAL03
LOCAL	PAGP15	038D	33903	566820	66296	69563	67618	0	3.23	0.005	726	5,523	Y	PAGE.OS04.LOCAL04
LOCAL	PAGP16	039F	33903	566820	66390	69311	67560	0	3.12	0.005	766	5,548	Y	PAGE.OS04.LOCAL05

Figure 2-22. Monitor I Page/Swap Data Set Activity Report

Rules-of-Thumb

% IN USE

This is really the % busy for the data set. Above 30% you may start to see response times increase. However, you also need to consider other active data sets on the same volume; check the total device utilization on the device activity report.

PAGES XFER'D

The total number of pages transferred to and from a given page/swap dataset. Divide this number by the number of INTERVAL seconds to get the rate in pages/second. Above 30 pages/second for a single data set may mean it is time to add another page pack, dedicate the packs to paging (or better yet, look into more processor storage).

Report Analysis

If we check the two highest values in the report, we get:

- % IN USE: 3.23% - no problem seen
- PAGES XFER'D: 5711 - this is equivalent to 6 pages/second.

See Chapter 5. Analyzing Processor Storage Activity for further analysis.

Workload Activity Report

REPORT BY: POLICY=SPECIAL WORKLOAD=ONLINE SERVICE CLASS=TSO RESOURCE GROUP=*NONE PERIOD=1 IMPORTANCE=2									
TRANSACTIONS	TRANS.-TIME	HHH.MM.SS.TTT	--DASD I/O--	---SERVICE----	--SERVICE RATES--	PAGE-IN RATES	----	STORAGE----	
AVG 1.25	ACTUAL	96	SSCHRT 10.0	IOC 30100	ABSRPTN 1,244	SINGLE 16.72		AVERAGE 124.31	
MPL 0.86	EXECUTION	96	RESP 15.4	CPU 357.3K	TRX SERV 856	BLOCK 6.23		TOTAL 107.44	
ENDED 4,945	QUEUED	0	CONN 2.8	MS0 203.7K	TCB 32.3	SHARED 0.00		CENTRAL 75.66	
END/S 8.21	R/S AFFINITY	0	DISC 2.5	SRB 56334	SRB 5.1	HSP 0.00		EXPAND 31.78	
#SWAPS 4,952	INELIGIBLE	0	Q+PEND 10.2	TOT 647.4K	RCT 0.0	HSP MISS 0.00			
EXCTD 0	CONVERSION	0	IOSQ 0.0	/SEC 1,075	IIT 0.1	EXP SNGL 100		SHARED 0.00	
AVG ENC 0.00	STD DEV	119			HST 0.0	EXP BLK 0.00			
REM ENC 0.00					APPL% 6.2	EXP SHR 0.00			
MS ENC 0.00									
...									
REPORT BY: POLICY=SPECIAL									
TRANSACTIONS	TRANS.-TIME	HHH.MM.SS.TTT	--DASD I/O--	---SERVICE----	--SERVICE RATES--	PAGE-IN RATES	----	STORAGE----	
AVG 60.79	ACTUAL	749	SSCHRT 368.7	IOC 1106K	ABSRPTN 517	SINGLE 0.88		AVERAGE 152.18	
MPL 55.66	EXECUTION	652	RESP 12.4	CPU 5630K	TRX SERV 474	BLOCK 0.48		TOTAL 8,471	
ENDED 14,418	QUEUED	96	CONN 2.4	MS0 9228K	TCB 509.9	SHARED 0.00		CENTRAL 4,904	
END/S 23.95	R/S AFFINITY	0	DISC 2.1	SRB 1380K	SRB 124.9	HSP 0.00		EXPAND 3,568	
#SWAPS 14.8K	INELIGIBLE	0	Q+PEND 7.9	TOT 17343K	RCT 0.2	HSP MISS 0.00			
EXCTD 0	CONVERSION	0	IOSQ 0.0	/SEC 28,819	IIT 1.3	EXP SNGL 9.50		SHARED 0.00	
AVG ENC 0.00	STD DEV	5.769			HST 0.0	EXP BLK 0.46			
REM ENC 0.00					APPL% 105.4	EXP SHR 0.00			
MS ENC 0.00									

Figure 2-23. Workload Activity Report

Rules-of-Thumb

APPL%

This value tells you how much CPU time was captured for the workload in a given service class or performance group. You can use this information for several purposes:

- Compute a *capture ratio (CR)* for your system
- Input to capacity planning
- Check for a single-CP constraint

Remember that the APPL% is given as percent of a single engine, so you will need to divide by the number of engines if your system has more than one.

Most MVS systems today have capture ratios greater than 80%. If yours is below that, you may want to investigate further.

PAGE-IN RATES

For any workload that is sensitive to paging (for example CICS), check the SINGLE and BLOCK paging values to be sure that no paging is taking place. The amount of paging that these workloads can sustain is up to you, but the best answer is probably zero.

Report Analysis

- Calculation of the capture ratio:

$$\text{Capture ratio} = \frac{\text{APPL \%}}{\text{MVS BUSY \%} * \text{\#CP}} = \frac{105.4}{73.88 * 2} = 0.71$$

This value is somewhat low.

If your system is running in an PR/SM environment, the calculation has to be performed using LPAR BUSY and the number of logical processors.

- The paging rates for TSO are

SINGLE 16.72 page-ins per second
BLOCK 6.23 page-ins per second

This may be worth further investigation.

See Chapter 3. Analyzing Processor Activity and Chapter 5. Analyzing Processor Storage Activity for further analysis.

Virtual Storage Report

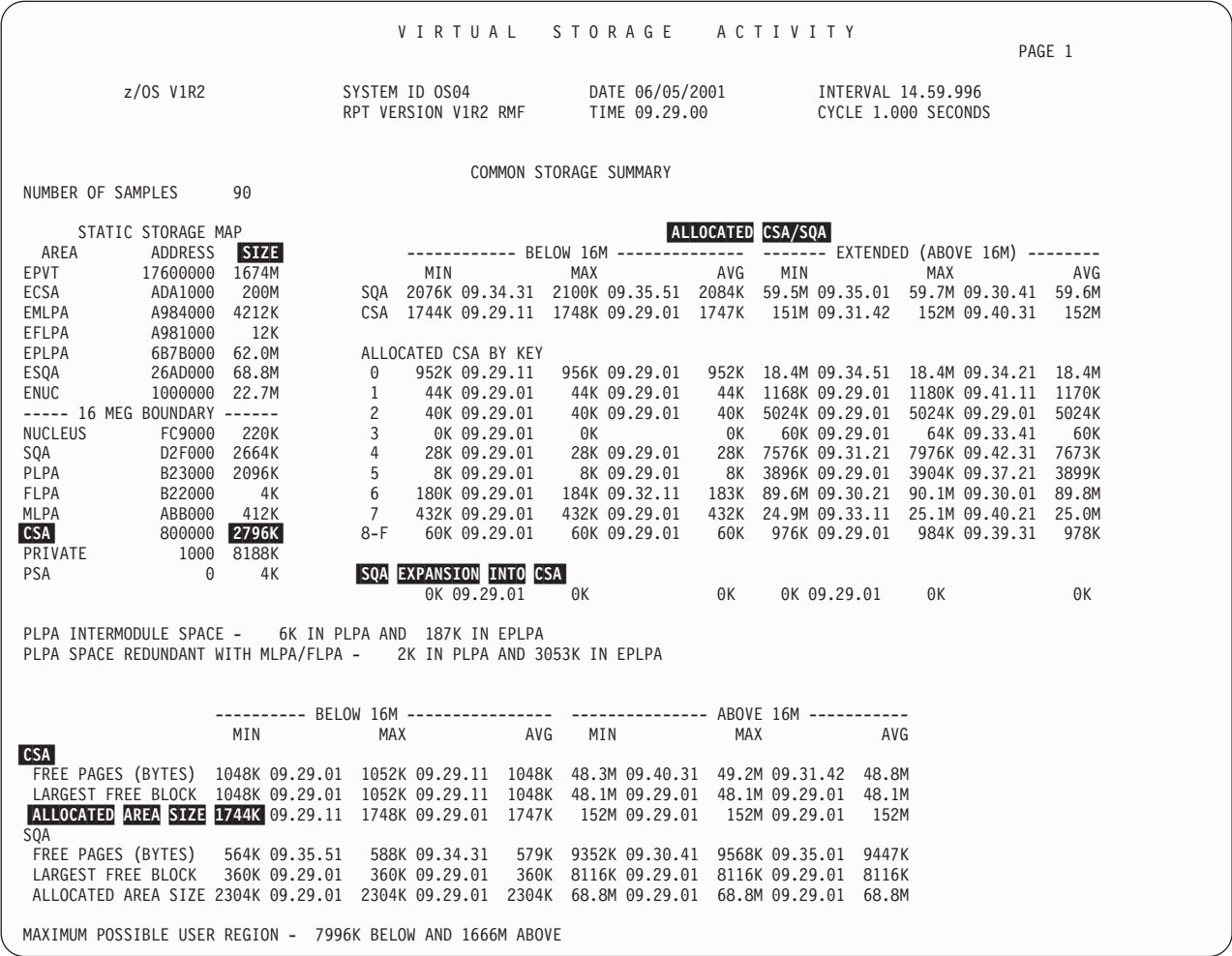


Figure 2-24. Monitor I Virtual Storage Activity Report - Common Storage Summary

Rules-of-Thumb

Maximum Allocated Percent

Calculate this value for the CSA, the ECSA, the SQA, and the ESQA. For example, for the CSA:

$$\text{Maximum Allocated Percent(CSA)} = \frac{\text{CSA ALLOCATED AREA SIZE}}{\text{CSA SIZE}} * 100$$

For CSA and ECSA, this value should be less than 65%.

The virtual storage that is most volatile is the SQA and CSA, both above and below the 16MB line. This is a number that is readily tracked on the Virtual Storage report on either a daily or weekly basis.

RMF calculates the size of this area as the difference between the highest and lowest address occupied by allocated storage, and includes all free blocks that lie between allocated blocks. Significant segmentation causes this number to be much larger than the amount of storage actually used.

If the size allocated for ESQA is too small or is used up, the system attempts to steal pages from the ECSA. When both areas are full, the system allocates space from the SQA and CSA below the 16MB line. SRM will attempt to reduce the demand for resources. If no storage is available, the result is a system failure.

If the size of SQA below 16M is too small, additional data will spill into the CSA below the 16MB line. If no storage is available, the result is a system failure.

- Is CSA/ECSA allocated percent high?
 - Review ECSA, CSA, ESQA, and SQA sizes
 - Increase CSA size: cleanup LPA, split address spaces (MRO for example), use Version/Release products that exploit ESA, or convert applications to exploit ESA (for example to Cobol II)
- Is SQA/ESQA allocated percent low?
 - ESQA or SQA may be too large.
- Is SQA EXPANSION INTO CSA low?
 - SQA size may be too large; you may be able to decrease SQA size and increase CSA size.

Using the Monitor III Common Storage report is a very good way to understand which AS has the storage.

Report Analysis

The maximum allocated percent for the CSA is:

$$\frac{1744K}{2796K} * 100 = 62.4\%$$

That concludes there is no problem in this area.

The SQA EXPANSION INTO CSA is zero, that means the SQA is large enough.

Where Do You Go from Here?

By now you will have found the major cause of your performance problem. The following chapters will go into more detail to help you further.

As you know, performance tuning is an iterative process and bear in mind:

- Take a base measurement as your starting point
- Only change one thing at a time
- Predict how your key measurements will change
- Measure your change against your expectation

System indicators

Chapter 3. Analyzing Processor Activity

Let's Analyze Your Processors

This chapter discusses how to analyze a processor problem. It takes the following approach:

- What RMF values can you look at in a performance problem situation?
- What do these fields mean?
- What can you do to solve the problem?

We make recommendations for two cases:

- An application being *delayed* by higher priority work
- An application *using* excessive CPU, or overall CPU under stress

As you continue through this chapter, bear in mind that tuning the processor is generally a high-effort/low-return activity. Quick fixes are rare. However, we will discuss the tuning activities that can apply.

Do You Have a Processor Problem?

There are many views on what constitutes a processor performance problem. You should conclude that you have a processor performance problem because your:

- Service level objectives are being exceeded.
- Users are complaining about slow response.
- AND, the CPU indicators (discussed in the following section) show signs of stress. Or better still, you see a processor delay directly in Monitor III.

We suggest there are two main ways to approach this problem analysis, depending on how you are alerted:

- If a user or group of users complains about response times then start with Monitor III.
- If your normal daily or weekly performance tracking procedures show a trend or problem developing, then start with Monitor I.

Table 3-1 shows for each monitor, which fields in which RMF reports can detect and resolve a processor performance problem.

Table 3-1. Processor Indicators in Monitor III and Monitor I

	REPORTS	DELAY Fields	USING Fields
Monitor III	GROUP	Avg Delay PROC	AVG USG PROC
	DELAY	%Delayed for PRC	
	WFEX	Speed *PROC	
	PROC	DLY%	USG% App1%
	CPC	WLM Capping %	
Monitor I	CPU Activity		BUSY TIME PERCENTAGE
	Partition Data		PHYSICAL PROCESSOR TOTAL

Monitor III Indicators

This section lists the Monitor III indicators that may be used to alert you to a potential processor problem.

GROUP Report

RMF V1R2 Group Response Time											
Command ==>						Scroll ==> HALF					
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec	
Class: BATCH		Period: 1		Description: Primary Batch							
Primary Response Time Component:				Using the processor							
--- Response Time ---											
WFL		Users		Frames		Vector		EXCP		PgIn	
%		TOT ACT		%ACT		UTIL		Rate		Rate	
60		30 3		25		0		2.1		0.5	
								TRANS		Ended	
								Rate		Rate	
								0.0		830.5	
										152.7	
										983.3	
-----Average Delay-----											
		Total		-AVG USG-		PROC		DEV		STOR	
Average Users		3.270		1.89		0.10		0.74		0.06	
Response Time ACT		152.7		88.3		4.67		34.6		2.80	
								0.47		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
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								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	
								0.00		0.00	

USING Indicator

Field: AVG USG PROC for Response Time ACT

Description: This is a component of average response time, namely the average number of seconds, transactions belonging to the service class were using the CPU during the range period.

Guideline: Check all the service classes and start with that one showing the average largest processor consumption.

Problem Area: This points out processor consumption.

Potential Solution:

- See “Processor USING: Trimming Activities” on page 3-16

DELAY Report

RMF V1R2 Delay Report														Line 1 of 44
Command ==>														Scroll ==> HALF
Samples: 100 System: PRD1 Date: 04/07/01 Time: 10.32.00 Range: 100 Sec														
Name	Service CX Class	WFL Cr	USG %	DLY %	IDL %	UKN %	PRC	% Delayed for					ENQ	Primary Reason
BHOLEQB	B BATCH	0	51	0	49	0	0	0	0	0	0	51	0	SYSDSN
CATALOG	S SYSSTC	0	0	3	0	97	0	0	3	0	0	0	0	LOCL
BAJU	T TSO	14	2	12	85	1	0	0	12	0	0	0	0	LOCL
BHOLNAM4	B BATCH	62	31	19	0	32	18	0	1	0	0	0	0	BHOLPRO2
JES2	S SYSSTC	67	13	7	0	83	1	6	0	0	0	0	0	SYSPAG
BHOLPRO1	B BATCH	72	72	28	0	0	28	0	0	0	0	0	0	BHOLPRO2
BHOLPRO2	B BATCH	74	74	26	0	0	26	0	0	0	0	0	0	BHOLPRO1
RMF	S SYSSTC	75	3	1	0	96	1	0	0	0	0	0	0	BHOLPRO2
MASTER	S SYSTEM	92	23	2	0	76	0	2	0	0	0	0	0	SYSPAG
BHOL	T TSO	97	29	1	67	3	1	0	0	0	0	0	0	CONSOLE
CONSOLE	S SYSSTC	100	2	0	0	98	0	0	0	0	0	0	0	
BHOLST09	B BATCH	100	1	0	99	0	0	0	0	0	0	0	0	
VTMLCL	S SYSSTC	100	1	0	0	99	0	0	0	0	0	0	0	

Figure 3-2. Monitor III Delay Report

This is a good report to look at for a quick snapshot of 'Who is delayed' for CPU and for how long. The report is sorted by workflow percentage (WFL % column) in ascending order. Check this report to see if any priority work is being delayed.

DELAY Indicator

Field: % Delayed for PRC

Description: This gives for each address space (AS), the percentage of the measured time that a transaction running in that AS was delayed by the lack of CPU.

Guideline: Look at the largest %Delayed for PRC value. Compare it with the DLY % value of the same job. If the PRC value is the main part of the delay, look at this job.

You can put the cursor on the line describing the job that may be a problem and press ENTER: a new panel is displayed (see Figure 3-8 on page 3-13) that lists the main cause of the delay and suggests some possible actions to reduce the delay.

Problem Area: This points out a delay for processing.

Potential Solution:

- See “DELAY for Processor: Guidelines for Improvement” on page 3-13
- See “Processor USING: Trimming Activities” on page 3-16

WFEX Report

RMF V1R2 Workflow/Exceptions				Line 1 of 4	
Command ==>				Scroll ==> HALF	
Samples: 100	System: PRD1	Date: 04/07/01	Time: 10.32.00	Range: 100	Sec
----- Speed (Workflow) -----					
Speed of 100 = Maximum, 0 = Stopped			Average CPU Util: 100 %		
Name	Users	Active	Speed	Name	Users Active Speed
*SYSTEM	41	4	63		
ALL TSO	2	0	70		
ALL STC	32	1	79		
ALL BATCH	7	3	59		
*PROC	24	3	73		
*DEV	6	1	33		
MASTER	1	0	92		
----- Exceptions -----					
Name	Reason	Critical val. Possible cause or action			
ECSA	SECS% > 85	90.6 %	System ECSA usage 91 %.		
*STOR	TSQA0 > 0	784K bytes	SQA overflow into CSA 784K.		
BHOLEQB	ENQ -SYSDSN	51.0 % delay	ENQ.TEST.DAT		

Figure 3-3. Monitor III Workflow/Exceptions Report

DELAY Indicator

Field: *PROC Speed (Workflow)

Description: This is a good global indicator for CPU performance. If equal to 100%, no work has been delayed by the CPU. If equal to 50%, this means that half of the attempts to use CPU were denied because the CPU was busy (that is, five out of ten ready AS were being delayed). This field does not deal with how busy the CPU is, but rather the amount of delay that exists.

Guideline: If this value is low (less than 40%), it may be due to CPU delay. If this value is greater than 80%, there is no CPU problem. Between these two values, it depends on the characteristics of the environment.

Problem Area: This points out a delay for processing.

Potential Solution:

- See “DELAY for Processor: Guidelines for Improvement” on page 3-13
- See “Processor USING: Trimming Activities” on page 3-16

PROC Report

RMF V1R2 Processor Delays									
Command ==>					Line 1 of 19 Scroll ==> HALF				
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100	
Jobname	Service CX Class	DLY %	USG %	App1 %	EApp1 %	----- Name	Holding %	Job(s) Name	----- Name
#STONE1	B NRPRIME	41	60	55.1	62.1	18 D10PAV1	15	SAYLEKR	12 DAVEP
SAYLEKR	B NRPRIME	24	21	20.7	20.7	13 DB2MDIST	12	#STONE1	9 CATALOG
SAYLEKQ	B NRPRIME	22	14	14.8	14.8	16 D10PAV1	11	SAYLEKR	8 TREVORJ
RSTSHYS0	B NRPRIME	15	24	18.6	18.6	9 DAVEP	8	#STONE1	7 GRS
CHARLESR	B NRPRIME	15	7	2.9	4.2	8 D10PAV1	6	SAYLEKR	5 DAVEP
LUCKYSMP	B NRPRIME	6	8	4.1	4.1	5 DAVEP	4	STEVEB	2 DSEAGER
DFHSM	S SYSSTC	5	17	13.0	13.0	3 D10PAV1	3	#STONE1	2 *MASTER*
APETER	B NRPRIME	5	5	3.7	3.7	3 DB2MDIST	3	SAYLEK	2 #STONE1
MARYPATM	B NRPRIME	5	2	2.2	3.1	2 GRS	2	DAVEP	2 #STONE1
D10PAV1	T TSOPRIME	4	25	23.5	23.5	2 BKELLER	2	DFHSM	2 RHANSON
DAVEP	T TSOPRIME	4	25	14.9	14.9	3 DB2MDIST	2	DSEAGER	2 LUCKYSMP
HJPB88E	B NRPRIME	4	3	1.1	1.1	3 #STONE1	2	GRS	2 DB2MDIST

Figure 3-4. Monitor III Processor Delays Report

This report displays all AS waiting for or using the processor during the range period. The report is sorted by descending overall delay percentages: the first line is the job you need to look at first.

DELAY Indicator

Field: DLY %

Description: The percentage of time an AS is delayed because of contention for the processor during the range period. For the multitask AS, RMF reports only one delay when several tasks are delayed at the same time.

Guideline: Use the cursor sensitivity: put the cursor on the name of the AS you want to analyze (usually we start with the most delayed job). Hence the Job Delay report (as in Figure 3-8 on page 3-13) is displayed; it allows further investigation as explained later in this chapter.

Problem Area: Points out a processor delay.

Potential Solution:

- Start by identifying the holding jobs that are causing the most delay
- See “Determine CPU 'Holders’” on page 3-13

USING Indicator

Field: USG % and App1%

Description:

- USG %: The percentage of time an AS is using the processor during the range period. This is a sampled single state value.
- App1%: Percentage of CPU time as sum of TCB time, global and local SRB time, and preemptable or client SRB time consumed on behalf of this address space. This is a measured multi-state value: if the address space is using more than one processor, this value can exceed 100%.

Guideline: Start with the AS with the largest App1% value, then look at its USG% value: if the USG% value is large, you have a heavy processor consumer.

Problem Area: Points out processor consumption.

Potential Solution:

- See “Processor USING: Trimming Activities” on page 3-16

Mon I - Processor analysis

Monitor I Indicators

This section describes the Monitor I indicators that may be used to alert you to a potential processor problem.

CPU Activity Report

C P U A C T I V I T Y															
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996			
				RPT VERSION V1R2 RMF				TIME 09.29.00				CYCLE 1.000 SECONDS			
PAGE 1															
CPU 9672 MODEL Z97															
CPU	ONLINE TIME	LPAR BUSY	MVS BUSY	CPU SERIAL	I/O TOTAL	% I/O INTERRUPTS									
NUMBER	PERCENTAGE	TIME PERC	TIME PERC	NUMBER	INTERRUPT RATE	HANDLED VIA TPI									
0	100.00	76.93	99.15	045104	320.9	0.33									
1	100.00	76.85	99.13	145104	324.0	0.22									
2	100.00	76.86	99.09	245104	321.6	0.22									
3	100.00	76.87	98.99	345104	329.5	0.25									
4	100.00	76.89	99.01	445104	325.9	0.33									
5	100.00	76.87	98.88	545104	328.7	0.36									
6	100.00	76.88	98.86	645104	338.4	0.46									
7	100.00	76.85	98.73	745104	341.1	0.51									
8	100.00	76.82	98.59	845104	335.9	0.67									
TOTAL/AVERAGE		76.87	98.94		2966	0.37									
SYSTEM ADDRESS SPACE ANALYSIS															
SAMPLES = 898															
TYPE	NUMBER OF ASIDS			DISTRIBUTION OF QUEUE LENGTHS (%)											
	MIN	MAX	AVG	0	1	2	3	4	5	6	7-8	9-10	11-12	13-14	14+
IN READY	5	37	14.8	0.0	0.0	0.0	0.0	0.0	0.2	0.4	2.7	9.7	16.8	22.3	47.5
				0	1-2	3-4	5-6	7-8	9-10	11-15	16-20	21-25	26-30	31-35	35+
IN	161	198	177.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
OUT															
READY	0	2	0.0	98.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT															
WAIT	161	188	174.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
LOGICAL															
OUT RDY	0	2	0.0	97.9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LOGICAL															
OUT WAIT	50	105	83.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
BATCH	76	85	79.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
STC	218	232	226.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
TSO	87	97	92.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ASCH	0	1	0.0	99.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OMVS	35	43	36.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	37.4

Figure 3-5. Monitor I CPU Activity Report

USING Indicator**Field:** BUSY TIME PERCENTAGE

Description: The percentage of the interval time that the processor was busy executing instructions; it includes the non-captured CPU-Time. The calculation is different depending on whether you are in basic mode or LPAR mode (see *RMF Report Analysis*).

Guideline: If this value is greater than 85% AND the total of IN READY values for the columns 0,1,...N is below 80% (N = the number of CPs in your system), then you have some work with CPU delay.

Note: Depending on your environment, the guidelines may be very different:

- In a batch or scientific environment, a 100% CPU busy is usually not a problem.
- In a transaction environment, user response times usually increase when CPU busy goes over 80%. The type of the application and the number of CPs available to it can influence how high this CPU busy value can go before response time suffers.

Problem Area: Points out processor consumption.

Potential Solution:

- See “Processor USING: Trimming Activities” on page 3-16

Note: BUSY TIME PERCENTAGE by itself is not enough as a CPU indicator. You must remember that the distribution of the arrival rate of work demanding CPU is not constant. So, chances are that even at a low utilization level, a queue will build up. The total of IN READY values for the columns 0,1,...N gives the percentage of time when no contention for CPU was detected, that is the number of AS with a ready process (TCB or SRB) was equal to or less than the number of CPs. For example, if your total is 80%, then 20% of the time (100%-80%) you have work delayed.

This is not to say that you cannot run an MVS system at higher utilizations, on up to 100% busy. You can. Just be aware that the busier the CPU, the longer the CPU delay for lower-priority workloads will be. The more low-priority work you have, and the fewer non-CPU bottlenecks you have (e.g. responsive I/O), the busier you will be able to drive your CPU and still maintain good response for your high-priority workloads.

Mon I - Processor analysis

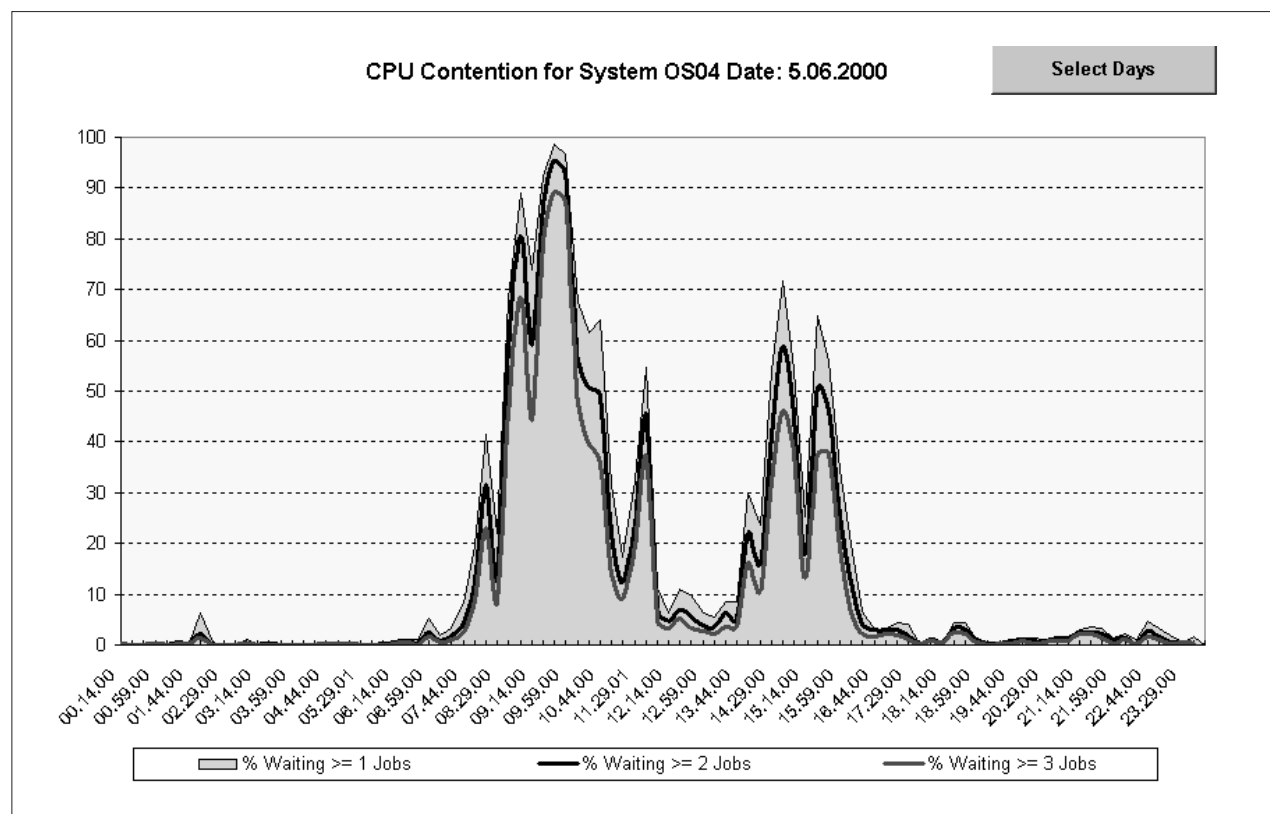


Figure 3-6. CPU Contention Report. Spreadsheet Reporter macro RMFY9SUM.XLS (System Overview Report - OneCpuCont)

This report provides some more detailed data on CPU contention. In addition to the contention value which is given by the percentage of time when at least one job was ready and waiting for the processor, you see here the percentages when at least two or three jobs were waiting.

Partition Data Report

P A R T I T I O N D A T A R E P O R T																PAGE 2			
z/OS V1R2				SYSTEM ID NP1				DATE 04/15/2001				INTERVAL 14.59.678							
				RPT VERSION V1R2 RMF				TIME 09.30.00				CYCLE 1.000 SECONDS							
MVS PARTITION NAME				NP1															
IMAGE CAPACITY				100															
NUMBER OF CONFIGURED PARTITIONS				9															
NUMBER OF PHYSICAL PROCESSORS				9															
CP				9															
ICF				0															
WAIT COMPLETION				NO															
DISPATCH INTERVAL				DYNAMIC															
----- PARTITION DATA -----																-- LOGICAL PARTITION PROCESSOR DATA --		-- AVERAGE PROCESSOR UTILIZATION PERCENTAGES --	
NAME	S	----MSU----			-CAPPING--		PROCESSOR-		----DISPATCH TIME DATA----		LOGICAL PROCESSORS		--- PHYSICAL PROCESSORS ---		TOTAL				
		WGT	DEF	ACT	DEF	WLM%	NUM	TYPE	EFFECTIVE	TOTAL	EFFECTIVE	TOTAL	LPAR MGMT	EFFECTIVE					
NP1	A	20	100	10	NO	62.2	1.2	CP	00.04.29.502	00.04.27.519	25.10	24.92	****	3.33	3.30				
NP2	A	1	0	1	YES	0.0	4	CP	00.00.22.680	00.00.22.083	0.75	0.73	****	0.28	0.27				
NP3	A	10	5	8	NO	3.3	1.0	CP	00.03.37.761	00.03.35.859	24.20	23.99	****	2.69	2.67				
NP4	A	300	95	155	NO	0.0	0.3	CP	01.12.08.405	01.12.06.405	80.18	80.15	****	53.46	53.43				
NP5	A	200	50	52	NO	0.0	4	CP	00.24.13.447	00.24.11.311	40.39	40.33	****	17.95	17.92				
CFC1	A	DED	0	32		0.0	1	CP	00.14.59.611	00.14.59.625	99.99	99.99	0.00	11.11	11.11				
CFC2	A	DED	0	0		0.0	1	CP	00.00.00.000	00.00.00.000	0.00	0.00	0.00	0.00	0.00				
PHYSICAL										00.00.03.603		0.04		0.04					
TOTAL									01.59.51.408	01.59.46.408			0.04	88.81	88.75				
CB88	D																		
CB89	D																		

Figure 3-7. Monitor I CPU Activity Report - Partition Data Report Section

This report provides data about configured partitions in LPAR mode. Only partitions active at the end of the duration interval are reported.

USING Indicator

Field: PHYSICAL PROCESSORS TOTAL

Description: The total amount of time the physical processor resource was assigned to a partition AND to the management of the LPAR itself. The partition identified by the name *PHYSICAL* is not a configured partition: this is a way to report uncaptured time which was used by LPAR but could not be attributed to a specific logical partition.

Guideline: If the total physical processor complex is 100% busy for one partition, this LPAR could be constrained by other LPARs.

Problem Area: Points out processor consumption.

Potential Solution: Check the partition weights, capping, and number of CPs defined, to be sure you are allocating the CP resources the way you intended.

- See Appendix A. PR/SM LPAR Considerations

Processor analysis

Is Your Processor Idle due to Other Bottlenecks?

If your system shows no processor indicators under stress, that does not mean you don't have a potential processor problem: You may have some other bottleneck in the system preventing work from using the processor. If your daily processor-busy peaks start to plateau, before reaching 100%, this could be an indication of such a bottleneck. The major ones are:

- Storage
- I/O
- ENQ
- Operator
- Network

If you think this might be the case, see the other chapters for guidance on finding bottlenecks.

Remember that all CPUs wait at the same speed...

DELAY for Processor: Guidelines for Improvement

We assume in this section that you have found that your application’s primary delay is due to the processor. This means that other workloads are using the processor when your application wanted it. In this section, we will discuss what can be done to decrease processor delay for a workload.

The section “Processor USING: Trimming Activities” on page 3-16 is worth checking when you have a delay problem as well: the delay can be caused by an AS using too much of the processor. Trimming this AS solves the delay problem.

Determine CPU ‘Holders’

Bringing up the Monitor III Processor Delays report (shown in 3-4), use the cursor sensitivity. By positioning the cursor on the line describing the job you want to look at, and pressing ENTER, a new panel is displayed, on which the AS delaying the workload are named, as shown in Figure 3-8.

JOB Report

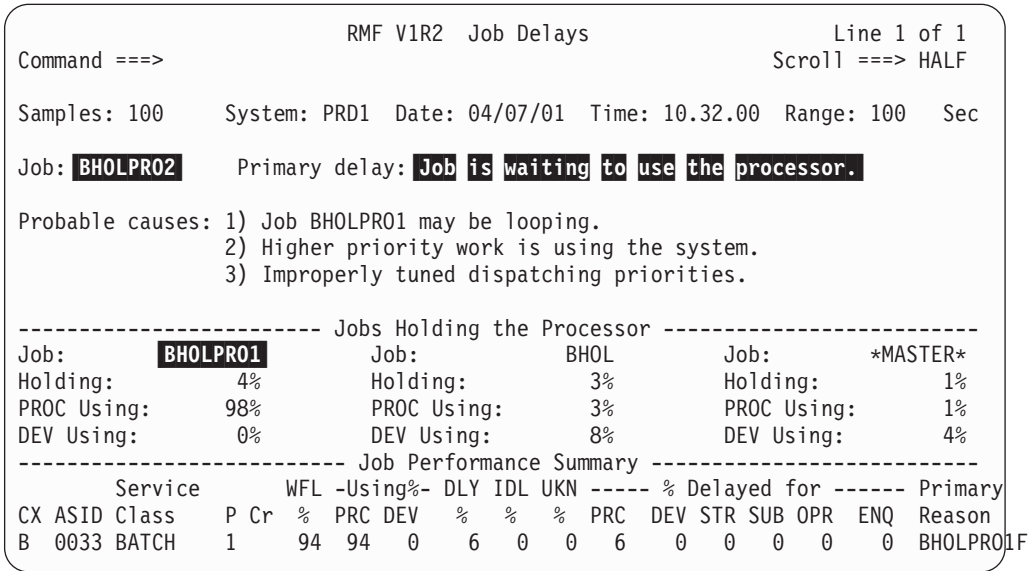


Figure 3-8. Monitor III Job Delays Report

Some probable causes of trouble are mentioned as well. This is the best starting point. See which AS are delaying your workload.

Processor analysis

Review Dispatching Priorities

The *dispatching priority (DP)* of each address space is specified dynamically according to the goals of the respective service class. You should reconsider your service policy definition if the workload delaying your application has higher dispatching priority.

The Monitor II ASD report shows address space dispatching priorities (DP PR).

ASD Report

RMF - ASD Address Space Data Report														Line 1 of 64	
Command ==>														Scroll ==> HALF	
CPU= 67/ 55 UIC=2540 PR= 0														System= SYSF Total	
13:43:53		S	C	R	DP	CS	ESF	CS	TAR	X	PIN	ES	TX	SWAP	WSM
JOBNAME	SRVCLASS	P	L	LS	PR	F		TAR	WSS	M	RT	RT	SC	RV	RV
ANTAS000	STCDEF	1	NS		F1	871									
MASTER*	SYSTEM	1	NS		FF	141			0		0.0	0.0	0	0	
PCAUTH	STCDEF	1	NS		74	26			0	X	0.0	15	0	175	
RASP	STCDEF	1	NS		FF	48			0	X	0.0	15	0	0	
TRACE	STCDEF	1	NS		76	78			0	X	0.0	15	0	0	
GRS	SYSTEM	1	NS		FF	1381			0	X	0.0	15	0	175	
DUMPSRV	SYSTEM	1	NS		FF	31			0		0.0	15	0	175	
CONSOLE	SYSTEM	1	NS		FF	62			0	X	0.0	15	1	0	
ALLOCAS	SYSTEM	1	NS		71	317			0	X	0.0	15	1	0	
LLA	SYSSTC	1	NS		FC	331			0	X	0.0	24	0	0	
VTAM	SYSSTC	1	NS		FD	518			0		0.0	44	0	175	
NETVS	SYSSTC	1	NS		FC	77			0	X	0.0	32	1	175	
NETVIEW	SYSSTC	1	NS		FC	497			0		0.0	30	0	175	
SMF	SYSTEM	1	NS		FF	65			0	X	0.0	15	0	175	
RMF33	SYSSTC	1	NS		FF	128			0		0.0	38	0	175	
DFHSM	SYSTEM	1	NS		7D	674			0		0.0	671	1	175	
AMSAQTS	SYSTEM	1	NS		74	37			0		0.0	50	1	175	
VLF	SYSTEM	1	NS		78	2297			0	X	0.0	22	0	175	
JES2	SYSTEM	1	NS		FE	827			0		0.0	25	0	175	
SMS	SYSTEM	1	NS		79	59			0	X	0.0	24	0	175	
JOEUSER	BTCHPRD	1	WT	TI	FF	764			0	X	0.0	15	0	18 -1000	

Figure 3-9. Monitor II Address Space State Data Report

Check for CPU Delay due to Other LPARs

If you are running as an LPAR sharing CPs with other LPARs, and your MVS system is not 100% busy, you might ask: Are the logical CPs not working more because there is no demand (wait time) or because the LPAR is not getting enough CPU?

One way to check if other LPARs are constraining your system is to do the following: as described in a prior section, add up your total of IN READY values for the columns 0,1,...N (N = the number of CPs in your LPAR) from the Monitor I CPU Activity report. If this total is more than your CPU BUSY PERCENTAGE, then you have another LPAR constraining you (you have CPU delay % > CPU busy %). If this is the case, check the partition weights, capping, and number of CPs defined, to be sure you are allocating the CP resources the way you intended.

Check LPAR Balancing Using the CPC Capacity Report

You can use the Monitor III CPC Capacity report to check whether the capacity being defined for each partition is sufficient to provide the service that all applications are expecting.

RMF V1R2 CPC Capacity Report										Line 1 of 1
Command ==>								Scroll ==> HALF		
Samples: 100		System: PRD1		Date: 10/07/01		Time: 10.32.00		Range: 100		Sec
----- 2064 Model 114 -- Partition Z2 -----										---
CPC Capacity		410		Weight % of Max		74.2		Average		51
Image Capacity		50		WLM Capping %		5.4		Maximum		185
Partition		-- MSU --	Cap	Proc	Logical	Util %	- Physical Util % -			
		Def Act	Def	Num	Effect	Total	LPAR	Effect	Total	
*CP							1.0	10.1	11.1	
TZ1		130 122	NO	4.3	11.2	12.5	0.4	3.4	3.8	
Z1		150 89	NO	5.2	9.3	9.6	0.1	3.5	3.6	
Z2		50 58	NO	2.1	11.5	12.8	0.2	1.7	1.9	
Z3		N/A 0	YES	2.4	8.8	10.6	0.3	1.5	1.8	
PHYSICAL							0.1		0.1	
*ICF total							0.1	7.1	7.1	
CF1		0 29		1	99.9	99.9	0.0	7.1	7.1	
CF2		0 0		1	0.0	0.0	0.0	0.0	0.0	
PHYSICAL							0.1		0.1	

Figure 3-10. Monitor III CPC Capacity Report

The report provides information about processor resource consumption of each partition, and it displays the 4-hours average consumption. If this average is higher than the defined image capacity, WLM will start capping this partition. In the above example, the average (51 MSUs/hour) is higher than the image capacity (50 MSUs/hour). Therefore, partition Z2 will get less processor resources in the following intervals until the average is below the defined capacity. This might result in processor constraints and performance problems. If this is not just a temporary but a permanent problem, one should consider about increasing the image capacity for this partition.

Processor USING: Trimming Activities

This section describes the activities that help decrease the processor consumption. In case of delay, this list of activities can be used to trim the AS that uses too much processor resource.

Check for Loops

PROC Report

RMF V1R2 Processor Delays										Line 1 of 71	
Command ===>										Scroll ===> HALF	
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec	
Jobname	CX	Service Class	DLY %	USG %	App1 %	EApp1 %	%	Name	%	Holding Job(s)	%
BOE1HCP\$	B	BATCH	10	11	9.8	9.8	9	BJPI	8	BTFL	4
BTFL	T	TSO 2	9	91	83.6	83.7	8	BJPI	3	BOE1MGR\$	3
BOE1TBL\$	B	BATCH	9	28	26.7	26.7	8	BTFL	7	BJPI	5
BOE1FIR\$	B	BATCH	9	21	20.5	20.5	8	BTFL	7	BJPI	7
BOE1HCL\$	B	BATCH	7	19	15.3	15.3	7	BJPI	7	BTFL	4
BOE1DEV\$	B	BATCH	7	11	9.7	9.7	6	BJPI	5	BTFL	4
BOE1MGR\$	B	BATCH	6	15	12.7	12.7	6	BJPI	5	BTFL	3
BJPI	T	TSO	4	96	87.9	87.9	4	BTFL	3	JES3	2
BOE1HIT\$	B	BATCH	3	13	10.4	10.4	3	BTFL	3	BJPI	2
BOE1HOM\$	B	BATCH	3	5	3.0	3.0	3	VIBTS	3	BJPI	2
JES3	S	SYSSTC	2	21	22.0	22.0	2	BJPI	1	BTFL	1
BRTV	T	TSO	2	6	4.9	4.9	2	BTFL	2	BJPI	1
BRMC	T	TSO	2	5	5.0	5.0	2	TESTRTX	1	CATALOG	1
XXVTAM	S	SYSSTC	1	22	15.8	15.8	1	JES3	1	BOE1TBL\$	1
TESTRTX	S	SYSSTC	1	13	12.2	12.2	1	ELF	1	GRS	1
VIBTS	S	SYSSTC	1	9	5.5	5.5	1	*MASTER*	1	BTFL	1
BHWG	T	TSO	1	7	4.4	4.4	1	MAT	1	SNALINK	1
BOE1	T	TSO	1	4	2.7	2.7	1	OMEGA	1	BOE1FIR\$	1
BPFX	T	TSO	1	4	2.1	2.1	1	BTFL	1	BJPI	1
BOE1GCR\$	B	BATCH	1	4	2.7	2.7	1	BHWG	1	BJPI	1

Figure 3-11. Monitor III Processor Delays Report

Detect loops by inspecting DLY % and USG % in this report for individual address spaces. If the sum of both is 100%, you could be in an enable loop.

You can check this by moving the cursor to jobname BTFL, and press ENTER. This links to the Job Delays report.

Job Report

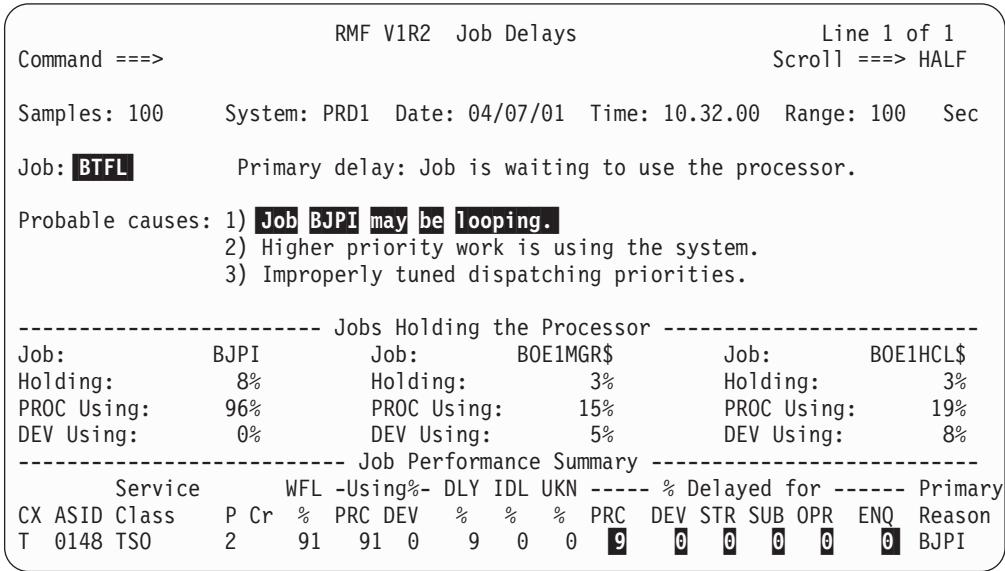


Figure 3-12. Monitor III Job Delays Report

A good indication of a loop is the fact that no other delays than processor delay are shown.

This is also detected by Monitor III which points to another job that might be looping.

Check with the owner of this address space (in this example, it is a TSO user), before deciding how to proceed - don't cancel it too quickly!

Processor analysis

Check for Slip Traps

WFEX Report

RMF V1R2 Workflow/Exceptions				Line 1 of 12											
Command ==>				Scroll ==> HALF											
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec					
----- Speed (Workflow) -----															
Speed of 100 = Maximum, 0 = Stopped						Average CPU Util: 81 %									
Name		Users		Active		Speed		Name		Users		Active		Speed	
*SYSTEM		505		13		54									
ALL TSO		433		10		55									
ALL BATCH		2		0		42									
ALL STC		70		2		55									
ALL ASCH						Not avail									
----- Exceptions -----															
Name		Reason		Critical val.		Possible cause or action									
* SLIP *		SLIP PER TRAP				SLIP ID=SR01 is active.									
BEVK		Rate < 2.0		1.220 /sec		Tx rate is 1.220 /s.									
BSHR		STOR-COMM		23.1 % delay											
CSAHO		JCSA% > 15		18.3 %		Job CSA usage 18 %, system 57 %.									
POK063		DAR > 20		23.22 /sec		I/O rate is 23.22 /s on volume POK063.									
DATAPK		Not avail				Volume DATAPK is not mounted.									

Figure 3-13. Monitor III Workflow/Exceptions Report

Use the workflow/exceptions report to watch for signs of a SLIP PER active trap. *Program Event Recording (PER)* is a function of S/390 architecture that generates program interrupts and uses the CPU unproductively (when not used to analyze a problem).

PER is started by a SLIP trap and has significant overhead. The WFEX report shows any active SLIP traps using PER. Check to see if the trap is still needed.

The * SLIP * exception line, in yellow, is always shown as the first exception. This line cannot be suppressed when the SLIP is active.

Reduce I/O

Rules of Thumb

- 1000 I/Os per second consume about 7.6% of a 9672 Z87 system.
- Every 160 DASD demand pages/sec uses about 1.0% of a 9672 Z87 system.

You can avoid I/O by:

- Using *Data-In-Memory (DIM)* techniques (refer to Appendix C. Data-In-Memory).
- Increasing block sizes
- Exploring SAM/E chain scheduling possibilities
- Moving I/O bound activities to other shifts
- Decreasing the paging

Avoiding I/O may help in saving CPU. Consequently you improve your performance (response and throughput); however chances are that your CPU is going to be busier, productively, because you decrease I/O delay.

Decrease Monitor Overhead

- Check for obsolete operations clists.
- Close down duplicate/redundant monitoring.
- Reduce scope and/or frequency of other monitors.
- Control and decrease SMF records generation.
- Increase RMF cycle, control the use of RMFMON and RMF commands.

Tune System Address Spaces

The system AS that usually consume the most processor are:

- Console AS, due to commands and message traffic in MVS console. Consider message filtering to reduce traffic.
- Catalog AS (CAS). Decrease the use of Stepcat and Jobcat statements in JCL (particularly effective in a batch and TSO environment).
- VTAM AS. Consult a TP specialist.
- Master Scheduler AS, mainly due to paging activities in SRB mode. See Chapter 5. Analyzing Processor Storage Activity for ways to reduce paging.
- JES AS. Decrease batch and some TSO activity (drastic action for small payback).

Tracing

GTF traces can be used to see the use of supervisor code in your TCB time (SVCs and PCs).

Sometimes you may see a lot of GETMAIN, EXCP, or CLOSE activities in your GTF trace. This can be a clue for application redesign.

Calculate Your Capture Ratio

If your prime shift capture ratio is below about 80%, check the following:

- How much CPU am I spending with swapping (non-captured)?
- How much CPU am I spending with paging (some non-captured)?

Redesign Application

Sometimes the only answer may be to redesign an application completely or partly, or change the user's expectations.

Install More CPU Power

When you have done all you can, and the problem does not go away, you can still resort to buying more CPU power.

Summary

To analyze processor problems you should:

- Determine if this is a *DELAY* due to another user or a *high USING* processor consumption.
- Look at the Monitor III Job Delay report first in case of *DELAY*.
- Reduce all the processor overhead that you can: it will usually be a very small amount.

Chapter 4. Analyzing I/O Activity

Let's Analyze Your I/O Subsystem

This chapter discusses how to analyze an I/O problem. We review:

- How to perform an overall health check of your I/O subsystem
- How to improve I/O performance with the Enterprise Storage Server
- How to analyze and solve I/O problems related to
 - Cache
 - DASD
 - Tape

We start by reviewing some of the key concepts, terms, and functions that will be used throughout the chapter.

Do You have an I/O Problem?

You can conclude that you have an I/O problem if:

- Service level objectives are being missed
- Users are complaining about response times
- AND, the I/O indicators discussed in this chapter show signs of stress. Or better still, you see high DEV DLY or USG for an important workload directly in Monitor III reports (for example, SYSINFO, DELAY, DEV, or DEVR).

Here are the primary RMF indicators you can use to assess your I/O subsystem. After listing these indicators, we will go on to discuss each one in more detail, with guidelines on values that may indicate contention and suggestions for further action.

RMF I/O INDICATORS

DASD LCU level	DASD Device level	Tape
I/O rate	I/O rate	I/O rate
Response Time	Response Time	Response Time
• Disconnect • Connect • Queue • Pend	• Disconnect • Connect • Queue • Pend	• Disconnect • Connect • Queue • Pend
Cache Statistics	Utilization Cache Statistics	
• Read hits • DASD fast write hits • Cache Fast write hits • Staging • DFW retries • Bypass • Inhibit • Off • ASYNC	• Read hits • DASD fast write hits • Cache Fast write hits • Staging • DFW retries • Bypass • Inhibit • Off • ASYNC	

Never start any tuning effort simply because one indicator seems to be a problem. Always check other related indicators to build a good understanding of your I/O subsystem (and overall system). Check to see which workloads are delayed, and by how much. Do all this to make sure you have the big picture well in hand, and only then begin to plan your tuning efforts.

As you analyze I/O problems, remember the following:

- **Manage to service level agreements.** No I/O response time, or other indicator, is inherently good or bad. The basic premise of performance management is that you want good I/O response times for important applications. What is "good" response time? The answer, of course, is that it depends. One way you can determine good response is to measure the response times of the volumes and

logical control units (LCUs) when your applications are running well, meeting the formal or informal service level agreements.

- **Keep the balanced systems concept in mind.** Before embarking on I/O subsystem analysis, review the CPU and processor storage resources. Keeping the big picture in mind will help you make better decisions on matters that affect overall system throughput, and on trade-offs such as using additional processor storage to reduce I/O rates.
- **Proceed in a top-down manner.** This implies three things:
 - If you think you see a problem, start with the basic facts. Which workload has the problem? What are the I/O rates and response times? Are service levels really being impacted? A "bad" response time may not be worth spending time on, if the I/O rate is low, or the workload has low priority.
 - Analyze your overall subsystem before trying to tune for specific DASD volumes or tape subsystems.
 - Analyze any response-time problem to see which component is greatest (disconnect, queue, etc.), and address that component first.
- **Optimize DASD data placement.** The best response time is achieved if the I/O never happens. This may be accomplished by a smarter program that avoids the I/O, by buffering, or by data-in-memory techniques where the I/O is resolved somewhere in processor storage. The next best response time is achieved by resolving the I/O directly in a cache control unit, a cache hit. The worst response time occurs when a DASD I/O must be resolved directly from a DASD device. See Appendix C. Data-In-Memory.

I/O Subsystem Health Check

This section describes how to perform an overall health check of your I/O subsystem. Use this section to help you establish a baseline measurement of I/O subsystem performance, set up your performance monitoring process, and provide a base of knowledge from which to begin performance tuning.

Understand your Business Priorities

All devices and workloads do not have the same priority. Before starting any tuning effort, be sure you understand the important business applications and their formal or informal service objectives. Know which volumes serve the important workloads.

Review CPU and Processor Storage

Alleviating an I/O bottleneck will mean that more work will be delivered to the CPU for processing. Keep the 'balanced system' concept in mind, making sure that CPU and processor storage resources are available. Review processor storage to see how much might be available for increased I/O elimination using data-in-memory techniques.

Establish a Baseline Measurement

Establishing a set of measurements for when your system is running well, provides a good base for later comparison. This will tell you what numbers are good for YOUR environment, which is better than simply following any rule of thumb guideline.

Measure the I/O rate, response times, and the cache activity at the LCU and device level. Disconnect time is inversely proportional to cache effectiveness and is the key measurement.

Concentrate on the DASD LCUs and individual devices with the highest load or most critical data, and account for all I/Os being resolved either in CACHE or directly to DASD (this gives you the cache hit ratio). Then explode these two categories CACHE and DASD into their components, to gain further insights into how the cache controller is performing and what options may be available to manage the performance of the data.

Using the Spreadsheet Report, you can display these measurements by shift and by hour for further evaluation.

Using the guidelines and recommendations given in this chapter, analyze these measurements to determine overall DASD subsystem health and to identify areas of further opportunity. See *Cache Performance Management* for further details and examples.

Improving I/O Performance with the Enterprise Storage Server

Introduction

The Enterprise Storage Server (ESS) is the latest IBM storage product to be developed using IBM's Seascope architecture. It provides all the open system functions of the Versatile Storage Server, and it provides all the functions of the 3990 Storage Control too - and a lot more. This chapter describes only features and functions that are relevant in a z/OS environment.

For more information about ESS as well as for z/OS as for open systems, please refer to *IBM Enterprise Storage Server*.

In ESS, there are exciting new features that significantly enhance performance. These features, which together with z/OS software deliver a new world to the S/390 storage environment, are probably the biggest change since disk caching was introduced.

The Enterprise Storage server is the natural successor to the IBM 3990. It provides nearly all the functions that were available on the 3990, including peer-to-peer remote copy (PPRC), extended remote copy (XRC), and concurrent copy. For the many customers who have installed the RAMAC Virtual Array (RVA), with its revolutionary log structure files (LSF) architecture, ESS is protecting their investment in this technology, too.

Many problems with I/O performance being described in this publication will disappear when you migrate from 3390 (or still 3380) to the Enterprise Storage Server, and many *traditional* recommendations about I/O tuning will become obsolete.

RMF has incorporated a number changes to accomodate and report on the advanced ESS functions related to performance, for example, the number of parallel access volumes or information about RAID ranks in the cache subsystem.

Architecture

The Enterprise Storage Server is a high performance, high availability, high capacity storage subsystem. It contains two 4-way RISC processors with 6 GB of cache and 384 MB of non-volatile storage to protect from data loss. It has a maximum capacity of over 11 TB and will be connected to S/390 through up to 32 ESCON channels. The first two models of the Enterprise Storage Server that became available are:

- The IBM 2105-E20 Enterprise Storage Server
This model supports the full complement of 128 disks in two 2105 cages.
- The IBM 2105-E10 Enterprise Storage Server
This model has a limited capacity in terms of disk arrays: only 64 disks can be installed in the base rack. These occupy a single 2105 cage.

Ongoing and frequent ESS performance upgrades can be expected as a direct result of its underlying Seascope architecture. The first example of such upgrades, the ESS Models F10 and F20, incorporates 64-bit RISC processing, higher effective host adapter utilization, more PCI buses, larger cache, and other improvements at the component level. The maximum sequential throughput capability of the ESS Model F20 is approximately double that of the ESS Model E20. The maximal cache size in the new models is 16 GB, and they have 128 drives in the main cabinet and 256 drives in the extension.

I/O analysis

Disks can be installed in the cages in groups of 8. These are called *disk 8-packs*. Each group of 8 disks is configured as a RAID Rank (of either 6 Data + Parity + Spare, or 7 Data + Parity) or JBOD (Just a Bunch Of Disks) with no Parity.

For each 8-pack, you have the choice of three different disks for use:

- 9.1 GB
Use this disk size for the highest performance RAID ranks.
- 18.2 GB
Use this disk size for the high performance and capacity - this is the optimum choice for most applications.
- 36.4 GB
Use this disk size for the high capacity and standard performance.

These guidelines are applicable for most workloads, however, disk performance is most applicable to cache-unfriendly operations that rely on disk performance characteristics for application performance.

A RAID rank is formatted as a set of Logical Volumes (LV). The number of LVs in a rank depends on the capacity of the disks in the array. The LVs are striped across all the data and parity disks in the array.

A non-RAID rank, also called a JBOD rank, is very different, each disk in the group of 8 is a rank in itself. So there are 8 ranks in a JBOD group. Each JBOD disk can be defined as one or more LVs. It is not RAID protected and, should a disk fail, all data on it will be lost.

JBOD or RAID 5? A group of JBODs will normally be used in a situation where you need high random write performance and you do not need RAID protection. With the improvement of ESS, the known disadvantages of the RAID 5 write penalty have been eliminated. It is strongly recommended for virtually all customer environments to use RAID 5, which delivers very high performance, the best data protection and fault tolerance.

z/OS Parallel Sysplex I/O Management

In the z/OS Parallel Sysplex, the Workload Manager (WLM) controls where work is run and optimizes the throughput and performance of the total system. Until now, WLM management of the I/O has been limited. With ESS, there are some exciting new functions that allow WLM to control I/O across the sysplex. These functions include parallel access to both single system and shared volumes and the ability to prioritize the I/O based upon the WLM goals. The combination of these features can significantly improve performance in a wide variety of workload environments.

ESS Performance Features

This chapter covers the performance features of the ESS including PAV, multiple allegiance, and I/O priority queuing.

Concurrent Access Features

z/OS retains device queuing features that were developed to ensure effective serial access to physical devices. These features were developed at a time when physical devices rather than emulated devices were the norm and long before RAID solutions were developed. They ensured that only one channel program could be active to a disk at any time. This ensured that there was no possibility of interference between channel programs.

The traditional queuing method is illustrated in Figure 4-1 which shows that Application B is processing a request for volume 2000. If applications A and C issue I/O requests to the same volume, they will get a device busy or UCB busy response.

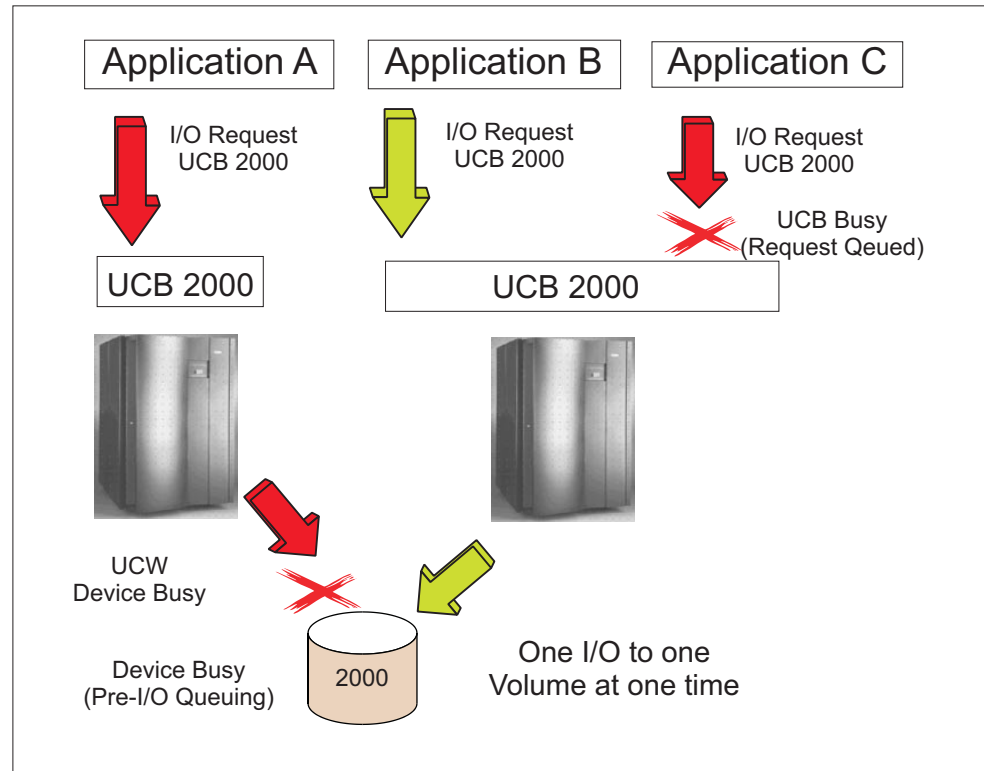


Figure 4-1. z/OS Traditional Device Serialization

z/OS interacting with the ESS relaxes some of these restrictions. Two features are introduced to allow this.

- Multiple allegiance
- Parallel Access Volumes (PAV)

Although there may be a large number of concurrent operations active to a particular logical volume, the ESS ensures that no I/O operations that have the potential to conflict over access to the same data will be scheduled together. Effectively no data can be accessed by one channel program that has the potential to be altered by another active program. Channel programs that are deemed to be incompatible with an active program are queued within the ESS.

Multiple Allegiance

S/390 device architecture has defined that a state of implicit allegiance exists between a device and the channel path group that is accessing it. This allegiance is created in the control unit between the device and a channel path group when an I/O operation is accepted by the device. The allegiance causes the control unit to guarantee access, no busy status presented, to the device for the remainder of the channel program over the set of paths associated with the allegiance. This concept has been expanded to support the ESS with a concept of multiple allegiance.

I/O analysis

ESS's concurrent operations capability supports concurrent accesses to or from the same volume from multiple channel path groups, system images. The ESS's multiple allegiance support allows different hosts to have concurrent implicit allegiances provided that there is no possibility that any of the channel programs can alter any data that another channel program might read or write.

Multiple allegiance requires no additional software or host support, other than to support the ESS. It is not externalized to the operating system or operator. Multiple allegiance will reduce contention reported as PEND time.

Resources that will benefit most from multiple allegiance are:

- Volumes that:
 - Have many concurrent read operations
 - Have a high read to write ratio
- Data sets that:
 - Have a high read to write ratio
 - Have multiple extents on one volume
 - Are concurrently shared by many users

Parallel Access Volumes

z/OS systems queue I/O activity on a unit control block (UCB) that represents the physical device. High parallel I/O activity can adversely effect performance, traditionally because high accesses usually correlated to high levels of mechanical motion and in subsystems with large caches and RAID arrays because the volumes were treated as a single resource, serially reused. This contention is worst for large volumes with numerous small data sets. The symptom displayed is extended IOSQ time. The operating system can not attempt to start more than one I/O operation at a time to the device.

The ESS's concurrent operations capabilities also support concurrent data transfer operations to or from the same volume from the same system. A volume accessed in this way is called a Parallel Access Volume (PAV).

Figure 4-2 illustrates multiple allegiance and PAV allowing concurrent I/O processing.

PAV exploitation requires both software enablement and an optional feature on your ESS. PAV support must be installed on each ESS. It enables the issuing of multiple channel programs to a volume from a single system, and allows simultaneous access to the logical volume by multiple users or jobs. Reads, as well as writes to different extents, can be satisfied simultaneously. The domain of an I/O consists of the specified extents to which the I/O operation applies. Writes to the same domain still have to be serialized to maintain data integrity.

Support is implemented by defining multiple UCBs for volumes. The UCBs are of two types.

Base address

This is the actual unit address of the volume. There is only one base address for any volume.

Alias address

Alias addresses are mapped back to a base device address. I/O scheduled for an alias is physically performed against the base by the ESS. No

physical disk space is associated with an alias address, however, they do occupy storage within z/OS. Alias UCBs are stored above the 16MB line.

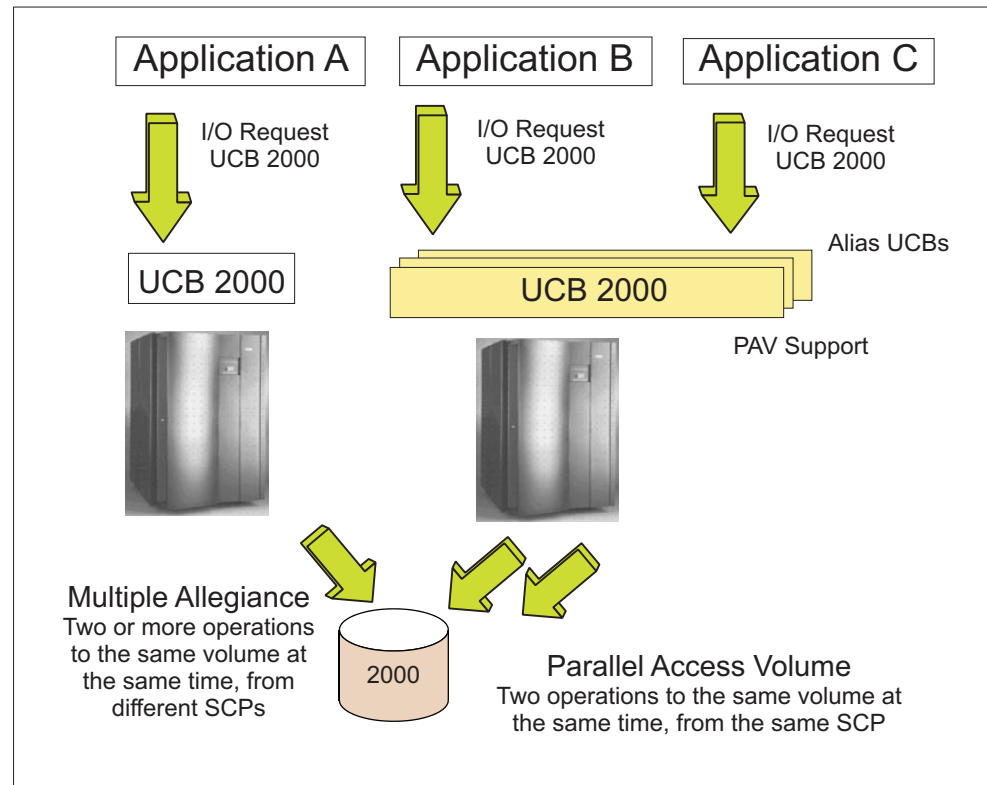


Figure 4-2. Device Queuing in a Parallel Access Volume Environment

The workloads that are most likely to benefit from the PAV function being available include:

- Volumes that have many concurrently open data sets, for example, volumes in a work pool
- Volumes that have high read to write ratio per extent
- Volumes reporting high IOSQ times

Candidate data types are:

- High read to write ratio
- Many extents on one volume
- Concurrently shared by many readers
- Accessed using media manager or allocated as VSAM extended format

PAVs can be assigned to base UCBs either manually or automatically by WLM. PAVs assigned manually are called static, while those movable by WLM are called dynamic. If WLM is used to manage I/O priorities, then you can use WLM dynamic PAV management as well. Otherwise, WLM can only use dynamic PAVs to balance device utilizations, not to directly help work achieve its goal.

I/O Priority Queueing

If I/Os cannot run in parallel, for example, due to extent conflicts, the ESS will internally queue I/Os. This reduces operating system overheads incurred by having to post "device busy" and redriving channel programs. The ESS will queue I/Os in

I/O analysis

the order in which they are received. This helps to reduce problems that occur when one processor can respond to interrupts faster than a sharing one, and so monopolize a device.

You also have the option to enable priority queuing of I/Os to the ESS. WLM sets a priority bit in the CCW when running in goal mode. Priority queuing is within a sysplex and queuing is at a volume level. The ESS queues I/O requests in the order specified by WLM. I/O may be queued in the following situations:

- An extent conflict exists for a write operation.
- To allow servicing of a cache miss, device will reconnect when data has been staged to cache.
- A reserve request is issued and other accesses are current with a different path group ID.

Cache Performance

Below are the CACHE and DASD components which you should measure. They are obtained from the Monitor I Cache Subsystem Activity report. In addition, the Monitor I Device Activity report data should be collected for the same period. You will also need to know which devices are used by your important workloads: you may already know this, or you can get this information from Monitor III DEVR or DEV reports.

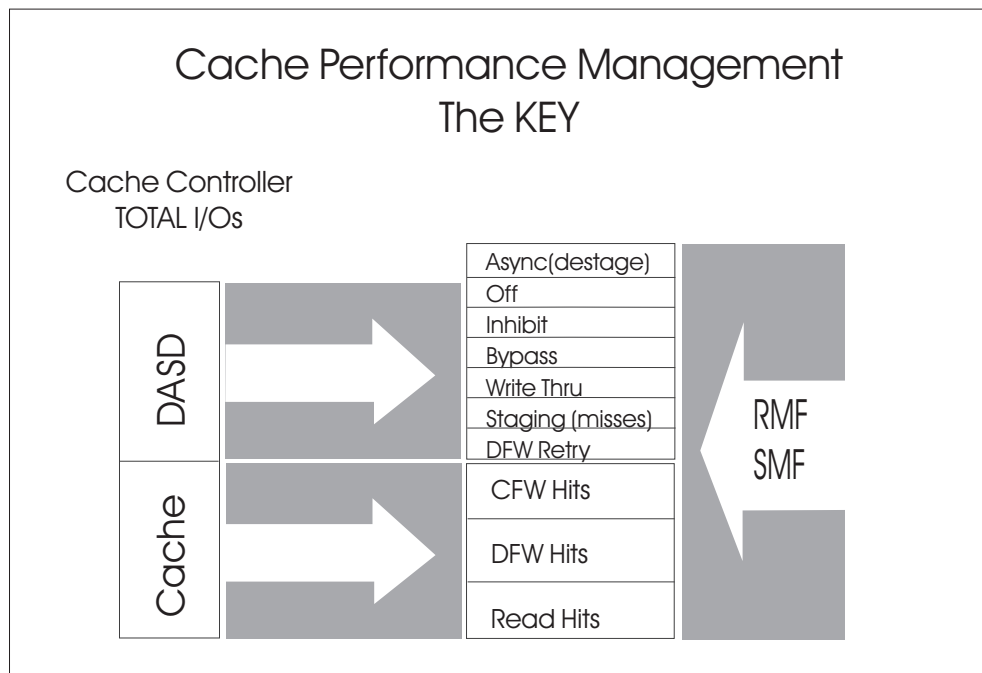


Figure 4-3. Cache Performance Management: The Key

CACHE

RHIT	Normal and sequential read hits
DFWHIT	DASD fast write (DFW) hits
CFWHIT	Cache fast write (CFW) write and read hits

DASD

STAGE	Read misses and DFW misses. The record was not found in the cache. It is read or written, and that record with the rest of the track is staged into the cache. In the ESS, stages no longer occur when data for a DFW request is absent from cache. Instead, this is handled as a write "promote" (and counts as a hit).
DFWRETRY	DASD fast write retry. The record is in cache and is about to result in a cache hit, but non-volatile storage (NVS) is full. The operation is not really retried but written directly to DASD.
THRU	Write 'THRU' to DASD. These are writes to devices behind storage controls that are not enabled for DFW.
BYPASS	The bypass mode was specified in the define extent. The I/O is sent directly to DASD, the track is not promoted and the record is invalidated in cache. The ESS does not actually bypass the cache, but ensures that data which specifies bypass mode is destaged quickly.
INHIBIT	The inhibit mode was specified in the define extent and the record was not in the cache. Examples of inhibit include DFDSS for reads and DFSMS dynamic cache management (DCM or DCME) "maybe cache" and "never cache" storage classes. The I/O will retrieve the record in cache if it is there; if it is not in the cache, the I/O is sent directly to DASD, but no staging of the rest of the track occurs. If inhibit mode was specified and the result was a cache hit, the I/O would fall into one of the cache hit categories.
OFF	Device is turned off for caching.
ASYNCH	Asynchronous destage of records to DASD. This includes anticipatory destage to write new or updated data from cache to DASD if NVS or cache is full. The unit is in tracks per second. All the other values given above are in I/Os per second. Async is not actually part of the I/O rate. It is the consequence of a write hit which must eventually be written to DASD. Counting it in the I/O rate would cause the I/O to be accounted for twice, once on the write hit and again when the track was destaged. Async can offer insight into the DFW.

It should be noted that the causes of bypass and inhibit listed above may not be all inclusive. In particular, you should consult your software vendor to understand which caching mode, if any, they use. The default mode is normal or sequential. However, bypass and inhibit mode can explicitly be set in software on an I/O basis. For example, it is possible for some I/Os to a data set to use inhibit and some normal caching mode, even within the execution of a particular application program. The same is true for DB2. Within DB2, one plan may access a table space in normal caching mode and another plan may optimize to access in prefetch mode, utilizing the bypass mode to accomplish this.

Cache Management with ESS

The ESS provides performance improvements over those provided by raw disk by using caching. Caching algorithms are executed by the storage directors and determine what data occupies cache. Attached hosts can offer information about their data access intentions that the storage directors will use to help select the best algorithm to use for cache management. The following caching features are provided.

Cache performance

Read Caching

Read hits occur when all of the data requested for a data access is located in cache. The ESS improves the performance of read caching by using algorithms to store in cache tracks that have the greatest probability of being accessed by a read operation.

An I/O operation that results in a read hit will not disconnect from the channel and data will be immediately available to the application. If the requested data is not located in cache a write miss occurs and data is read from disk, returned to the program, and loaded to cache. This is called staging. While records are being read from disk the channel program is disconnected allowing other applications to access the channel.

There are three types of staging:

Record staging

Only those records accessed by the channel program are staged into cache

Partial track staging

The required records and the rest of the track are staged to cache. This is the default mode of cache operation

Full track staging

Based on the prediction of sequential I/O processing. This can be predicted either the previous behavior of the application or by the application signalling in the I/O request that sequential access will be used.

Data transferred using inhibit cache load or bypass cache attributes will be loaded into cache but eligible for accelerated destaging.

The ESS offers new capabilities to support the optimization of sequential performance; improved and more sensitive pre-fetching algorithms, and new channel commands that improve overheads and provide increased bandwidth.

Write Caching

Two forms of write caching are supported: DASD Fast Write (DFW) and Cache Fast Write (CFW). Cache fast write is a z/OS function that is intended for data that does not need to be written to disk. CFW is used only when explicitly requested by the application and should only be selected for transient data, data that is not required beyond the end of the current job step and that can more easily be recreated from scratch than recovered from a checkpoint. An example of this type of data is intermediate work files, such as used by a sort program.

DFW is the more usual form of write caching. With DFW the application is told that an I/O operation is complete once data has successfully been written to cache and Non-Volatile Storage (NVS). Data integrity and availability is maintained by retaining two copies of the data until it is hardened to disk, one copy in cache on one cluster and the second in NVS of the other cluster. NVS is protected by battery backup. Normal access to the data is from the copy retained in cache.

Destaging of data that is backed up in NVS from cache to disk is based on a Least Recently Used (LRU) algorithm. Data may be retained in cache after being written to disk based on the cache activity. Destaging from NVS and cache is anticipatory and threshold based. The intention is to always have NVS and cache resources available to accept new data.

Tracks at the top of the cache LRU list are checked for updates in NVS that have not been destaged to disk. The ESS schedules tracks at the top of the NVS LRU for destaging, so that they can be allocated without a delay during destaging.

Write Performance

Caching benefits write performance as almost all writes are at cache speeds. DFW minimizes any potential penalty of RAID 5 generation of parity. This performance benefit is clearly demonstrated by the published results of ESS performance tests. In addition, write performance is enhanced by striping. The ESS automatically stripes logical volumes across all the drives in the RAID array. This provides automatic load balancing across the disk in the array, and an elimination of hot spots. This design should reduce the amount of effort that storage administrators spend, hand placing data, at the same time offering performance improvements.

The ESS RAID 5 implementation gives a minimal RAID 5 write penalty for sequential writes. When writing a sequential 'stripe' across the disks in an array, the ESS generates the parity only once for all the disks. This is sometimes called a RAID 3-like implementation, and it provides high performance in sequential operations.

Cache Subsystem Activity Report

The report provides cache statistics on a subsystem basis as well as on a detailed device-level basis. You may start the analysis of your cache subsystem with the Summary report.

Subsystem Summary

The report allows you a top-down approach to analyze the storage subsystems in your configuration because you can see at a glance the most important data. Looking at this report, the storage subsystems causing problems can be easily identified and analyzed in a second Postprocessor run requesting more details.

C A C H E S U B S Y S T E M S U M M A R Y																			PAGE	1
z/OS V1R2					SYSTEM ID OS04					DATE 06/05/2001					INTERVAL 14.59.996					
					RPT VERSION V1R2 RMF					TIME 09.30.00										
SSID	CU-ID	TYPE	CACHE	NVS	I/O RATE	OFF RATE	--CACHE READ	HIT DFW	RATE- CFW	-----DASD STAGE	I/O RATE- DFWBP	ICL	BYP OTHER	ASYNC RATE	TOTAL H/R	READ H/R	WRITE H/R	% READ		
0600	0600	3990-006	256	64	3.1	0.0	1.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	1.000	1.000	1.000	30.8		
06C0	06E0	3990-006	512	32	38.6	0.0	16.5	22.0	0.0	0.0	0.0	0.0	0.0	1.7	0.999	0.997	1.000	42.9		
0A80	0ABE	3990-006	512	32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A	N/A	N/A		
6801	4000	2105-F20	8192	192	55.3	0.0	0.0	55.2	0.0	0.0	165.5	0.0	0.0	486.2	1.000	1.000	1.000	0.1		
6802	4100	2105-F20	8192	192	49.5	0.0	0.2	49.3	0.0	0.0	145.1	0.0	0.0	500.8	1.000	1.000	1.000	0.4		
6803	4200	2105-F20	8192	192	56.9	0.0	0.2	56.7	0.0	0.0	169.9	0.0	0.0	489.1	1.000	1.000	1.000	0.4		
6804	4300	2105-F20	8192	192	50.7	0.0	0.2	50.5	0.0	0.0	149.0	0.0	0.0	465.6	1.000	1.000	1.000	0.4		
6805	4400	2105-F20	8192	192	53.0	0.0	0.2	52.8	0.0	0.0	158.3	0.0	0.0	467.6	1.000	1.000	1.000	0.4		
6806	4500	2105-F20	8192	192	42.0	0.0	0.3	41.8	0.0	0.0	123.6	0.0	0.0	434.6	1.000	1.000	1.000	0.6		
6807	4600	2105-F20	8192	192	50.3	0.0	0.2	50.0	0.0	0.0	150.2	0.0	0.0	454.1	1.000	1.000	1.000	0.4		

Figure 4-4. Cache Subsystem Activity Report - Summary Report

Top-20 Device Lists

The report consists of two top-20 lists of devices, sorted in descending order by DASD I/O rate and by total I/O rate. These two lists allow you to identify the volumes with the highest I/O rates to the lower interface of a subsystem as well as the volumes with the highest I/O rates in total. Solving a possible problem, one of the listed devices would probably be of most benefit to the overall subsystem.

Cache performance

C A C H E S U B S Y S T E M S U M M A R Y																	
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996					
				RPT VERSION V1R2 RMF				TIME 09.30.00									
*** DEVICE LIST BY DASD I/O RATE ***																	
VOLUME SERIAL	DEV NUM	SSID	% I/O	I/O RATE	---CACHE READ	HIT DFW	RATE-- CFW	-----DASD STAGE	I/O DFWBP	RATE----- ICL	----- BYP	----- OTHER	ASYNC RATE	TOTAL H/R	READ H/R	WRITE H/R	% READ
PRD440	077E	00B1	25.7	53.1	21.3	16.7	0.0	13.9	0.0	1.3	0.0	0.0	1.6	0.714	0.604	1.000	67.9
PPDS14	0220	00CC	6.9	29.1	1.0	15.7	0.0	0.1	0.0	12.4	0.0	0.0	2.0	0.573	0.943	1.000	6.2
PRD437	0214	00CC	4.5	19.0	12.5	2.0	0.0	4.4	0.0	0.0	0.0	0.0	2.0	0.765	0.738	0.998	89.2
PPD026	0B76	00F1	27.4	71.4	65.9	1.1	0.0	4.3	0.0	0.0	0.0	0.0	0.5	0.939	0.939	0.975	98.4
PRD554	06B9	00FE	59.1	32.4	28.9	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.893	0.893	1.000	99.9
PRD339	0231	00CC	2.4	10.3	7.2	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.698	0.698	N/A	0.0
...																	
*** DEVICE LIST BY TOTAL I/O RATE ***																	
VOLUME SERIAL	DEV NUM	SSID	% I/O	I/O RATE	---CACHE READ	HIT DFW	RATE-- CFW	-----DASD STAGE	I/O DFWBP	RATE----- ICL	----- BYP	----- OTHER	ASYNC RATE	TOTAL H/R	READ H/R	WRITE H/R	% READ
PPD026	0B76	00F1	27.4	71.4	65.9	1.1	0.0	4.3	0.0	0.0	0.0	0.0	0.5	0.939	0.939	0.975	98.4
PRD440	077E	00B1	25.7	53.1	21.3	16.7	0.0	13.9	0.0	1.3	0.0	0.0	1.6	0.714	0.604	1.000	67.9
PRD327	0200	00CC	11.8	49.8	3.0	46.8	0.0	0.1	0.0	0.0	0.0	0.0	6.3	0.998	0.973	1.000	6.2
PRD343	0515	00E4	17.5	48.9	24.8	24.0	0.0	0.1	0.0	0.0	0.0	0.0	5.5	0.998	0.996	0.999	50.8
PBV321	022C	00CC	11.2	47.3	47.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.000	1.000	1.000	99.7
PRD307	0507	00E4	15.3	42.8	4.1	38.2	0.0	0.5	0.0	0.0	0.0	0.0	13.0	0.988	0.891	1.000	10.8
...																	

Figure 4-5. Cache Subsystem Activity Report - Top-20 Reports

Based on these reports, you can decide whether further investigation is necessary. The next step could be the creation of reports which show some more details. This can be done on subsystem level as well as on device level.

Subsystem-level Reporting

This generates a report with three sections.

- Cache Subsystem Status
- Cache Subsystem Overview
- Cache Subsystem Device Overview

The subsystem-level report gives an overall view of the storage control, that is the amount of cache storage and non-volatile storage installed, as well as the current status of the cache. In addition, the performance analyst finds the number of I/O requests sent to the control unit and their resolution in the cache (*hits*). The report is completed by a list of all volumes attached to the subsystem, showing their specific utilization of the cache.

Device-level Reporting

This generates, in addition to the above described report, a report with two sections:

- Cache Device Status
- Cache Device Activity

The device-level report provides detailed information for each single device attached to the selected control unit. The report is intended to analyze the cache usage in detail on the basis of the information about the applications that access these volumes.

Based on the data in the Summary report (Figure 4-4), one might decide that the subsystem SSID=00B1 needs further investigation.

Cache Subsystem Overview

C A C H E S U B S Y S T E M A C T I V I T Y												PAGE	1
z/OS V1R2		SYSTEM ID OS04				DATE 06/05/2001		INTERVAL 14.59.996					
		RPT VERSION V1R2 RMF				TIME 09.30.00							
SUBSYSTEM	3990-06	CU-ID	074C	SSID	00B1	CDATE	06/05/2001	CTIME	09.30.03	CINT	15.00		
TYPE-MODEL	9396-001												

C A C H E S U B S Y S T E M S T A T U S													

SUBSYSTEM STORAGE			NON-VOLATILE STORAGE			STATUS							
CONFIGURED	1024.0M		CONFIGURED	32.0M		CACHING		-	ACTIVE				
AVAILABLE	1019.9M		PINNED	0.0		NON-VOLATILE STORAGE		-	ACTIVE				
PINNED	0.0					CACHE FAST WRITE		-	ACTIVE				
OFFLINE	0.0					IML DEVICE AVAILABLE		-	YES				

C A C H E S U B S Y S T E M O V E R V I E W													

TOTAL I/O	186363	CACHE I/O	181922	CACHE OFFLINE	0								
TOTAL H/R	0.865	CACHE H/R	0.886										

CACHE I/O REQUESTS	-----READ I/O REQUESTS-----					-----WRITE I/O REQUESTS-----							
	COUNT	RATE	HITS	RATE	H/R	COUNT	RATE	FAST	RATE	HITS	RATE	H/R	% READ
NORMAL	116003	128.9	95313	105.9	0.822	15150	16.8	15150	16.8	15134	16.8	0.999	88.4
SEQUENTIAL	16655	18.5	16617	18.5	0.998	34114	37.9	34114	37.9	34114	37.9	1.000	32.8
CFW DATA	0	0.0	0	0.0	N/A	0	0.0	0	0.0	0	0.0	N/A	N/A
TOTAL	132658	147.4	111930	124.4	0.844	49264	54.7	49264	54.7	49248	54.7	1.000	72.9

---CACHE MISSES---							---MISC---		-----NON-CACHE I/O-----				
REQUESTS	READ	RATE	WRITE	RATE	TRACKS	RATE		COUNT	RATE		COUNT	RATE	
							DFW BYPASS	289	0.3		ICL	4435	4.9
NORMAL	20690	23.0	16	0.0	12993	14.4	CFW BYPASS	0	0.0		BYPASS	6	0.0
SEQUENTIAL	38	0.0	0	0.0	870	1.0	DFW INHIBIT	0	0.0		TOTAL	4441	4.9
CFW DATA	0	0.0	0	0.0			ASYNC (TRKS)	7239	8.0				
TOTAL	20744	RATE	23.0										
---CKD STATISTICS---													
---RECORD CACHING---													
WRITE	268	READ MISSES	14502										
WRITE HITS	268	WRITE PROM	12938										

Figure 4-6. Cache Subsystem Activity Report - Status and Overview

This section provides, at a glance, all relevant data for one subsystem. It distinguishes between I/O requests to be handled by the cache (*cachable I/Os*) and non-cache I/O requests.

Cachable I/O Requests

These requests are shown in three categories:

NORMAL

Cache will be managed by *least-recently-used (LRU)* algorithm for making cache space available.

SEQUENTIAL

Tracks following the track assigned in the current CCW chain are promoted, they will be transferred from DASD to cache in anticipation of a near-term requirement.

CFW DATA

WRITE and READ-AFTER-WRITE requests are processed in cache. The

Cache performance

data might not be written to DASD. Because CFW does not use the NVS, the application is responsible for restoring the data after a cache or subsystem failure.

Non-Cache I/O Requests

These requests that switched off cache processing, are shown in two categories:

ICL Inhibit cache load — number of I/O requests that inhibited load of data into cache, and the data was not found in the cache.

Note: If the data was in the cache, it has been counted as cache hit. Therefore, this is actually the number of ICL misses.

BYPASS

Number of I/O requests that explicitly bypassed the cache, no matter whether the data is in the cache or not.

I/O Requests

You find the following numbers in the sample report:

Cachable I/O Requests

TOTAL READS	132658		
READ HITS	111930	→	READ HIT RATE (H/R) 0.844
TOTAL WRITES	49264		
WRITE HITS	49248	→	WRITE HIT RATE (H/R) 1.000
TOTAL CACHE I/O	181922		
CACHE HITS	161178	→	CACHE HIT RATE (H/R) 0.886

Non-Cache I/O Requests

ICL	4435
BYPASS	6
TOTAL	4441

Total I/O Requests

The sum of these two groups is shown as total number of I/O requests for cached devices of this subsystem:

CACHE I/O	181922		
NON-CACHE I/O	4441		
TOTAL I/O	186363		
CACHE HITS	161178	→	TOTAL HIT RATE (H/R) 0.865

While hit percentage by itself (CACHE H/R) does not drive the cache performance management process, hit percentage should be derived by dividing the hits by all I/Os (TOTAL H/R).

Hit percents derived by dividing the hits by cachable I/Os are misleading. Cachable I/Os refers to those I/Os that are eligible for caching. At first glance, the distinction between cachable I/Os and all I/Os seems rather insignificant since most I/Os are eligible for caching. However, some software (e.g. DFSMS Dynamic Cache Management and DB2) will selectively disable I/O operations for caching, using inhibit and bypass modes of operations. This could result in high cachable hit percentages but lower hit percentages. In this case the disconnect time would be higher than what you would expect for a high cachable hit percent, but the

Cache performance

disconnect time would be reasonable for a lower hit percent. Where all I/Os are eligible for caching, the hit percent and cachable hit percent will be equal.

You can also get from the report the relationship between READ and WRITE requests as %READ. Sometimes, performance experts work with the READ/WRITE ratio — this value is not shown in the report because of arithmetic problems in case of very less (or zero) WRITE requests, but can be calculated easily, otherwise.

READ/WRITE Ratio

TOTAL CACHE I/O	181922			
TOTAL CACHE READS	132658	→	% READ	72.9
TOTAL CACHE WRITES	49264	→	R/W ratio	2.69

The R/W ratio can also be calculated as

$$\text{R/W ratio} = 72.9 / (100 - 72.9) = 2.69$$

Cache performance

Cache Subsystem Device Overview

C A C H E S U B S Y S T E M A C T I V I T Y																	PAGE	2				
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996										
				RPT VERSION V1R2 RMF				TIME 09.30.00														
SUBSYSTEM	2105-01	CU-ID	4000	SSID 6801				CDATE	06/05/2001				CTIME	09.30.03				CINT	15.00			
TYPE-MODEL	2105-F20																					

C A C H E S U B S Y S T E M D E V I C E O V E R V I E W																						

VOLUME SERIAL	DEV NUM	RRID	% I/O	I/O RATE	---CACHE READ	HIT DFW	RATE-- CFW	-----DASD STAGE	DFWBP	I/O RATE----- ICL	BYP	OTHER	ASYNC RATE	TOTAL H/R	READ H/R	WRITE H/R	% READ					
*ALL			100.0	55.3	0.0	55.2	0.0	0.0	165.5	0.0	0.0	0.0	486.2	1.000	1.000	1.000	0.1					
*CACHE-OFF			0.0	0.0																		
*CACHE			100.0	55.3	0.0	55.2	0.0	0.0	165.5	0.0	0.0	0.0	486.2	1.000	1.000	1.000	0.1					
SR4B00	4000	0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A	N/A	N/A					
SR4B01	4001	0000	17.5	9.7	0.0	9.7	0.0	0.0	29.0	0.0	0.0	0.0	39.1	1.000	N/A	1.000	0.0					
SR4B02	4002	0000	17.9	9.9	0.0	9.9	0.0	0.0	29.7	0.0	0.0	0.0	36.3	1.000	N/A	1.000	0.0					
SR4B03	4003	0000	10.3	5.7	0.0	5.6	0.0	0.0	16.9	0.0	0.0	0.0	16.8	1.000	1.000	1.000	0.9					
SR4B04	4004	0000	17.7	9.8	0.0	9.8	0.0	0.0	29.4	0.0	0.0	0.0	39.2	1.000	N/A	1.000	0.0					
SR4B05	4005	0000	18.1	10.0	0.0	10.0	0.0	0.0	30.0	0.0	0.0	0.0	33.8	1.000	N/A	1.000	0.0					
SR4B06	4006	0000	18.4	10.2	0.0	10.2	0.0	0.0	30.5	0.0	0.0	0.0	34.6	1.000	N/A	1.000	0.0					

Figure 4-7. Cache Subsystem Activity Report - Device Overview

This section of the report provides an overview for one control unit with all attached devices. You can use this report for investigating the cache effectiveness of each volume.

During this analysis, you should use the values I/O RATE and % I/O as indicators to decide whether a volume has an I/O activity that makes it worth for further performance investigation.

If you come to the conclusion that further analysis of a specific volume might be necessary, you should request the report on device level. It has the same structure as the Subsystem Overview report, but provides the details for each volume.

RAID Rank Activity

C A C H E S U B S Y S T E M A C T I V I T Y																PAGE 3	
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996					
				RPT VERSION V1R2 RMF				TIME 09.30.00									
SUBSYSTEM 2105-01		CU-ID 4000		SSID 6801		CDATE 06/05/2001		CTIME 09.30.03		CINT 15.00							
TYPE-MODEL 2105-F20																	

RAID RANK ACTIVITY																	

ID	RAID TYPE	DA	HDD	----- RATE	READ REQ AVG MB	----- MB/S	RTIME	----- RATE	WRITE REQ AVG MB	----- MB/S	RTIME	----- HIGHEST UTILIZED VOLUMES -----					
*ALL			14	265	0.055	14.6	150	243	0.111	27.0	249						
0000	RAID-5	01	7	257	0.055	14.2	150	125	0.089	11.1	266	SR4B06	SR4B05	SR4B02	SR4B04	SR4B01	
0001	RAID-5	01	7	7	0.055	0.4	148	118	0.134	15.9	232						

Figure 4-8. Cache Subsystem Activity Report - RAID Rank Activity

This section of the report provides an overview about the activities of all RAID ranks belonging to the storage server. For each rank, you get the list of those six logical

Cache performance

volumes which have the highest utilization, this might help you in deciding whether the mapping between RAID ranks and logical volumes is well balanced, or whether some changes should be performed.

Cache Device Activity

C A C H E D E V I C E A C T I V I T Y													PAGE 62
z/OS V1R2			SYSTEM ID 0S04			DATE 06/05/2001			INTERVAL 14.59.996				
			RPT VERSION V1R2 RMF			TIME 09.30.00							
SUBSYSTEM	3990-06	CU-ID	074C	SSID	00B1	CDATE	06/05/2001	CTIME	09.30.03	CINT	15.00		
TYPE-MODEL	9396-001												
VOLSER	PRD440	NUM	077E	RRID	N/A								

C A C H E D E V I C E S T A T U S													

C A C H E S T A T U S						D U P L E X P A I R S T A T U S							
CACHING						- ACTIVE		DUPLEX PAIR		- NOT ESTABLISHED			
DASD FAST WRITE						- ACTIVE		STATUS		- N/A			
PINNED DATA						- NONE		DUAL COPY VOLUME		- N/A			

C A C H E D E V I C E A C T I V I T Y													

TOTAL I/O	47833	CACHE I/O	46696	CACHE OFFLINE	N/A								
TOTAL H/R	0.714	CACHE H/R	0.731										
CACHE I/O REQUESTS	COUNT	RATE	HITS	RATE	H/R	COUNT	RATE	FAST	RATE	HITS	RATE	H/R	% READ
NORMAL	31692	35.2	19131	21.3	0.604	487	0.5	487	0.5	487	0.5	1.000	98.5
SEQUENTIAL	0	0.0	0	0.0	N/A	14517	16.1	14517	16.1	14517	16.1	1.000	0.0
CFW DATA	0	0.0	0	0.0	N/A	0	0.0	0	0.0	0	0.0	N/A	N/A
TOTAL	31692	35.2	19131	21.3	0.604	15004	16.7	15004	16.7	15004	16.7	1.000	67.9

---CACHE MISSES---						-----MISC-----				-----NON-CACHE I/O-----			
REQUESTS	READ	RATE	WRITE	RATE	TRACKS	RATE	COUNT		RATE	COUNT		RATE	
NORMAL	12561	14.0	0	0.0	7020	7.8	DFW BYPASS		27	0.0	ICL		1137
SEQUENTIAL	0	0.0	0	0.0	0	0.0	CFW BYPASS		0	0.0	BYPASS		0
CFW DATA	0	0.0	0	0.0			DFW INHIBIT		0	0.0	TOTAL		1137
							ASYNC (TRKS)		1396	1.6			1.3
TOTAL	12561	RATE	14.0										
---CKD STATISTICS---													
---RECORD CACHING---													
WRITE	0	READ MISSES	8825										
WRITE HITS	0	WRITE PROM	6466										

Figure 4-9. Cache Subsystem Activity Report - Device Report

This report shows the statistics for volume PRD440. For example, you might look at this data if users are complaining about the response time of a specific application, and Monitor III reports flag PRD440 as a major cause of delay.

Cache performance

If you prefer to see data for more than one interval, you can create an Overview report with the selection of those data you are interested in. Let us assume that you want to get the following data for volume PRD440 (with SSID=00B1 and address 077E):

Exception	Meaning
CADRT	Total READ I/O rate
CADWT	Total WRITE I/O rate
CADRHRT	Total READ hit ratio
CADWHRT	Total WRITE hit ratio
CADMT	Total staging rate
CADDFWB	Total DFW bypass rate
CADNCICL	Non-cache ICL rate

You find a listing of all conditions in the *RMF User's Guide*.

You get the Overview report by specifying the following Postprocessor options:

```
OVERVIEW(REPORT)
OVW(READRATE(CADRT(SSID(00B1),DEVN(077E))))
OVW(WRTRATE(CADWT(SSID(00B1),DEVN(077E))))
OVW(READHR(CADRHRT(SSID(00B1),DEVN(077E))))
OVW(WRTHR(CADWHRT(SSID(00B1),DEVN(077E))))
OVW(STGRT(CADMT(SSID(00B1),DEVN(077E))))
OVW(DFWBPRT(CADDFWB(SSID(00B1),DEVN(077E))))
OVW(ICLRT(CADNCICL(SSID(00B1),DEVN(077E))))
```

This creates the following report:

RMF OVERVIEW REPORT										PAGE 001
z/OS V1R2			SYSTEM ID OS04			DATE 06/05/2001		INTERVAL 14.59.996		
			RPT VERSION V1R2 RMF			TIME 09.30.00		CYCLE 1.000 SECONDS		
NUMBER OF INTERVALS 5			TOTAL LENGTH OF INTERVALS 01.14.57							
DATE	TIME	INT	READRATE	WRTRATE	READHR	WRTHR	STGRT	DFWBPRT	ICLRT	
MM/DD	HH.MM.SS	MM.SS								
06/05	10.44.00	15.00	35.213	16.671	0.604	1.000	13.957	0.030	1.263	
06/05	10.59.00	14.59	2.799	12.444	0.514	1.000	1.359	0.089	0.021	
06/05	11.14.00	15.00	2.769	0.159	0.318	1.000	1.889	0.000	0.063	
06/05	11.29.00	14.59	3.692	0.225	0.377	1.000	2.301	0.001	0.034	
06/05	11.44.00	14.59	0.535	0.261	0.696	0.996	0.164	0.003	0.022	

Figure 4-10. Overview Report for Cached DASD Device

In this report, you see that the volume was very active just in one interval, this means that further investigation is required to highlight the critical volumes of this Cache subsystem.

Using the Spreadsheet Reporter, you can create reports with key performance data you are interested in.

If you would like to see all SSIDs at glance, you can create the Cache Subsystem Report which displays all important cache characteristics. To get all details about cache rates for a longer period of time, you would use the Cache Trend Report.

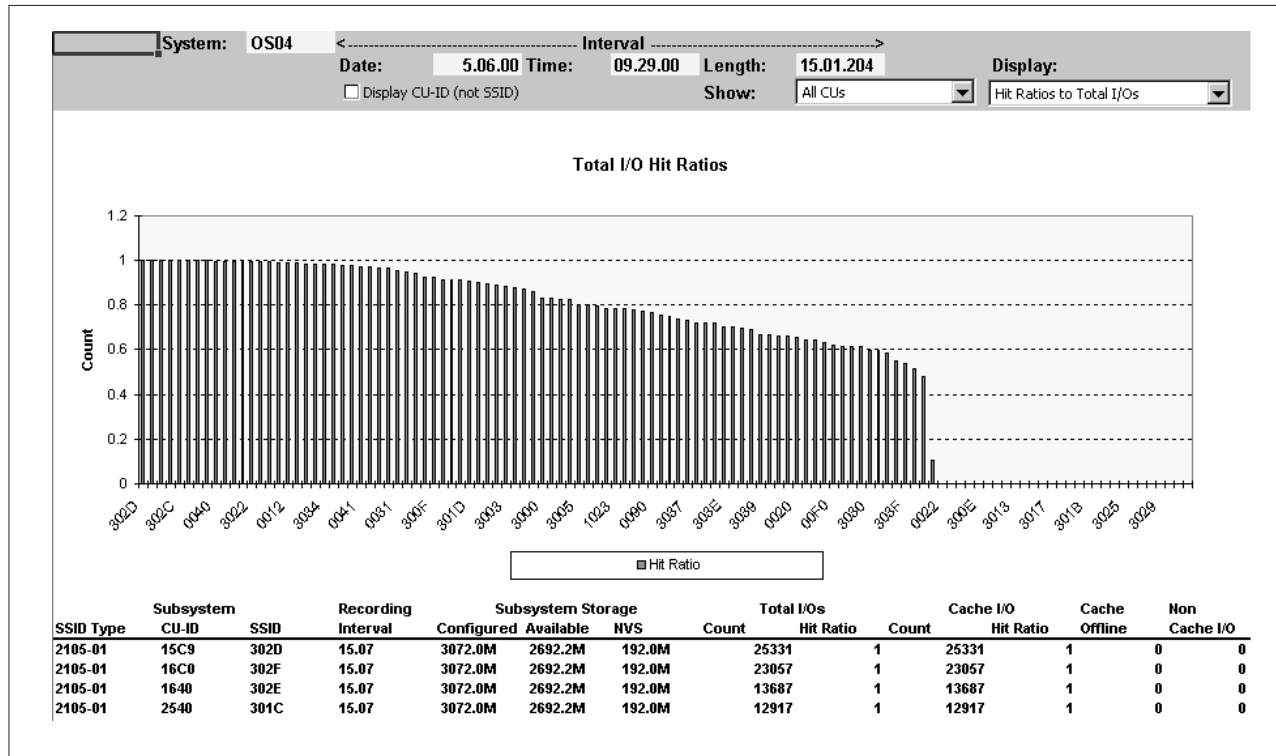


Figure 4-11. Cache Hits Overview Report. Spreadsheet Reporter macro RMFR9CAC.XLS (Cache Subsystem Report - SSIDovw)

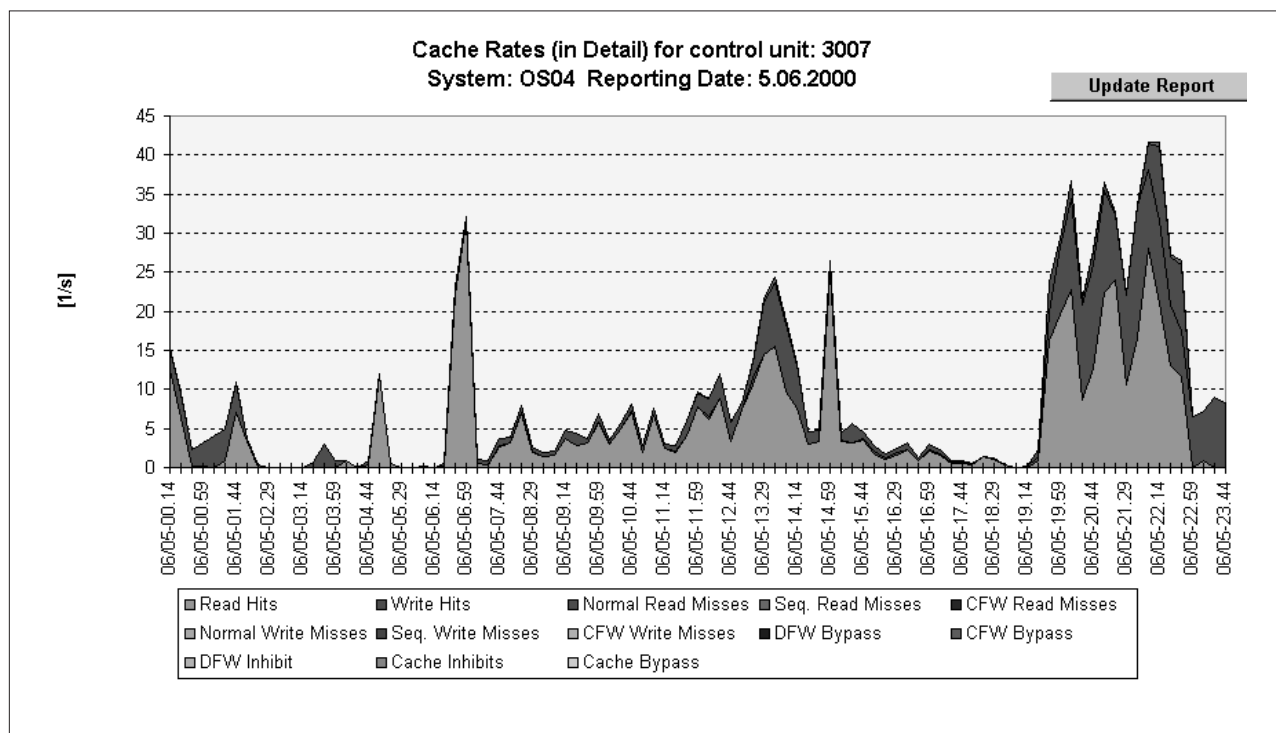


Figure 4-12. Cache Trend Report. Spreadsheet Reporter macro RMFX9CAC.XLS (Cache Trend Report - Summary)

Cache performance

Notes:

1. Cache controller information is collected by individual device addresses without segregation by issuing system. Therefore, the Monitor I Data Gatherer automatically collects the total for each device behind the storage controller. There is no way to differentiate the I/Os by each sharing system. Thus, data gathering is only required to be activated on one of the sharing systems.
2. The report uses cache storage subsystem ID (SSID) numbers to identify control units. The Monitor I DASD Activity report uses logical control unit (LCU) numbers to report on these same control units. LCU and SSID often will not be the same value, even when referring to the same control unit. You may need to compare the address range of devices on a given controller to match LCU to SSID.
3. Also, I/O rates shown in the Cache Subsystem Activity report may not exactly match I/O rates given in Shared Device Activity report (the sum of device activity from all sharing systems). This is because the storage controller counts each locate in a multiple locate CCW chain, whereas RMF only counts one I/O to start the CCW. An example of a CCW with multiple locates is DB2 list prefetch. Conversely, control unit commands, such as standalone RESERVEs, would get counted for the DASD Activity report but not for the Cache Subsystem Activity report.

Indicator

Field: Use the following fields:

- TOTAL H/R - CACHE H/R in the Subsystem Overview report and Device Activity report.
- TOTAL H/R - READ H/R - WRITE H/R in the Device Overview report

Guideline: Check whether all volumes (pay special attention to those that do a lot of I/O) are experiencing a good hit ratio (80% or higher). If this is the case, further analysis is not necessary. Note that the occurrence of a low hit ratio for one or more devices cannot be interpreted as a sure sign of the need for more cache (other analytical tools, such as the IBM Cache Analysis Aid, will be required for more thorough cache sizing). The low hit ratio may be caused by data sets which do not cache well, bypass cache, etc.

Problem Area: Low cache hit ratios will mean higher DISC times for that device. Also, devices with low cache hit ratios may use cache storage that other devices could have used more profitably.

Potential Solution: If you have DFSMS/MVS and its *Dynamic Cache Management Extended (DCME)* capability, DCME will dynamically manage cache for those data sets you specify (via storage class). Thus no manual cache tuning should be required on your part.

If your data is not SMS-managed, you may wish to identify volumes which are not achieving a good cache hit ratio, and are doing a significant amount of staging, and turn them off for caching. This will improve the use of cache for volumes that benefit more from cache. A trial and error approach will be needed here; you will need to make a judgment call on whether to cache devices that are benefitting marginally from cache (maybe 30-80 % hit ratios).

Using Monitor III Cache Reporting

Monitor III offers two reports which can assist you in monitoring online the performance of your Cache subsystem:

CACHSUM Cache Summary report

CACHDET Cache Detail report

Both reports provide similar information as you can find in the Postprocessor Cache reports. Therefore, the performance indicators are the same, and you might refer to the description of the Postprocessor reports for further evaluation.

Cache Summary Report

The report provides an overview about the activities in the cache subsystem for all SSIDs. You might take this as starting point when analyzing I/O performance to get a first impression about the I/O processing.

If you feel that further analysis is required, you may continue with the Cache Detail report.

RMF V1R2 Cache Summary - SYSPLEX													
Line 1 of 21													
Command ==> _													
Scroll ==> HALF													
Samples: 120 Systems: 5 Date: 04/15/01 Time: 08.25.00 Range: 120 Sec													
CDate: 04/15/01 CTime: 08.24.55 CRange: 120 Sec													
SSID	CUID	Type-Mod	Size	I/O Rate	Hit %	Hit Rate	-- Miss Total	--- Stage	Read %	Seq Rate	Async Rate	Off Rate	
0010	071D	9396-001	1024M	99.8	98.8	98.6	1.2	1.2	99.2	1.6	0.1	0.0	
0011	0520	9396-001	1024M	5.4	100	5.4	0.0	0.0	100	0.0	0.0	0.0	
0030	0269	3990-006	256M	90.6	99.8	90.4	0.2	0.2	100	0.0	0.0	0.0	
0040	0401	9393-002	1536M	142.0	100	141.9	0.0	0.0	97.7	0.0	0.3	0.0	
0041	0460	9393-002	1536M	1.1	100	1.1	0.0	0.0	68.2	0.0	0.2	0.0	
0042	05AA	9393-002	1536M	0.9	100	0.9	0.0	0.0	70.4	0.0	0.1	0.0	
0043	05C6	9393-002	1536M	42.9	99.5	42.7	0.2	0.2	72.2	0.6	1.8	0.0	
0044	0200	3990-006	64M	129.7	99.5	129.0	0.7	0.7	98.2	0.2	0.0	0.0	
0060	0627	9393-002	1536M	9.2	29.3	2.7	0.0	0.0	40.3	0.0	0.4	0.0	
0061	0654	9393-002	1536M	4.3	99.8	4.3	0.0	0.0	64.6	0.3	0.4	0.0	
0062	06B0	9393-002	1536M	7.4	30.9	2.3	0.1	0.1	17.5	0.0	0.6	0.0	
0063	06CE	9393-002	1536M	0.3	100	0.3	0.0	0.0	88.9	0.0	0.0	0.0	

Figure 4-13. CACHSUM Report

Cache performance

Cache Detail Report

The CACHDET report provides detailed information about the activities of one cache subsystem.

RMF V1R2 Cache Detail - SYSPLEX												Line 1 of 199	
Command ==> _												Scroll ==> HALF	
Samples: 120			Systems: 5			Date: 04/15/01		Time: 08.25.00		Range: 120		Sec	
						CDate: 04/15/01		CTime: 08.24.55		CRange: 120		Sec	
Volume	/Num	SSID	I/O %	I/O Rate	Hit %	Cache Read	Hit DFW	Rate CFW	- DASD Total	I/O - Stage	Seq Rate	Async Rate	
*ALL			100	42.9	99.5	30.8	11.9	0.0	0.2	0.2	0.6	1.8	
*NOCAC			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
*CACHE			100	42.9	99.5	30.8	11.9	0.0	0.2	0.2	0.6	1.8	
SYSPXC	05CB	0043	27.9	12.0	100	10.4	1.6	0.0	0.0	0.0	0.0	0.0	
SYSSM3	05C3	0043	11.6	5.0	100	3.9	1.1	0.0	0.0	0.0	0.3	0.4	
SYSAXC	05CA	0043	11.2	4.8	100	3.2	1.6	0.0	0.0	0.0	0.0	0.0	
SYSSM6	05C6	0043	10.8	4.6	98.9	3.7	0.9	0.0	0.1	0.1	0.0	0.3	
SYSSMS	05C0	0043	9.7	4.2	97.6	0.4	3.7	0.0	0.1	0.1	0.0	0.0	
SYSSM8	05C8	0043	6.8	2.9	100	1.6	1.4	0.0	0.0	0.0	0.1	0.1	
SYSSM5	05C5	0043	5.4	2.3	100	2.3	0.1	0.0	0.0	0.0	0.0	0.2	
SYSSM2	05C2	0043	3.7	1.6	100	0.6	1.0	0.0	0.0	0.0	0.0	0.5	
SYSSMB	05DA	0043	3.6	1.6	100	1.4	0.1	0.0	0.0	0.0	0.1	0.0	
SYSSMA	05CD	0043	3.6	1.5	99.5	1.5	0.0	0.0	0.0	0.0	0.1	0.0	
SYSSM7	05C7	0043	3.3	1.4	98.2	1.2	0.2	0.0	0.0	0.0	0.0	0.1	
SYSOPE	05CC	0043	1.6	0.7	97.5	0.6	0.1	0.0	0.0	0.0	0.0	0.0	
SYSSM4	05C4	0043	0.6	0.3	96.9	0.0	0.2	0.0	0.0	0.0	0.0	0.0	
SYSSM9	05C9	0043	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SYSSM1	05C1	0043	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SYSSMC	05DB	0043	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
MVSWR1	05FF	0043	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Figure 4-14. CACHDET Report

DASD Indicators and Guidelines

Response Time Components

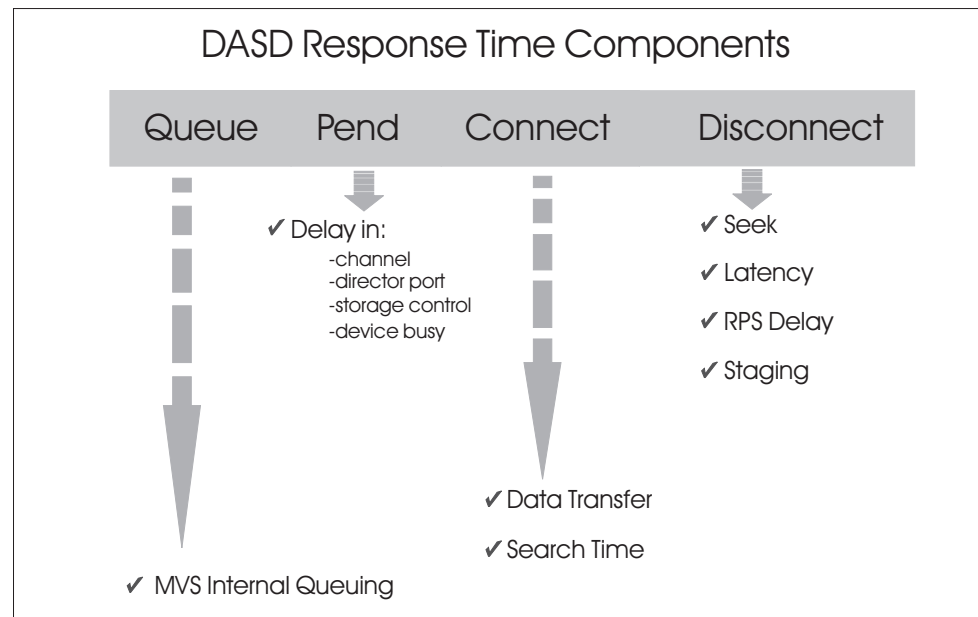


Figure 4-15. DASD Response Time Components

Response time is a key measure of how well your I/O is performing, and a key indicator of what can be done to speed up the I/O. It is important to understand the components of this response time, and what they mean. DASD response time is the sum of queue, pend, connect and disconnect time. The following lists the response time components and what causes them:

- Connect** The part of the I/O during which data is actually transferred, protocol, search and data transfer time.
- Disconnect** Time that an I/O request spends freed from the channel. This is the time that the I/O positions for the data that has been requested. It includes
- SEEK and SET SECTOR*
 - Moving the device to the requested cylinder and track
 - Latency*
 - Waiting for the record to rotate under the head
 - Rotational Position Sensing (RPS)*
 - Rotational delay, as the device waits to reconnect to the channel. The term "RPS delay" traditionally means waiting for an extra disk rotation because a transfer could not occur when the data was under the head. Delays of this type are now obsolete with the ESS.
- Pend** Time that the I/O is delayed in the path to the device. Pend time may be attributable to the channel, control unit, or wait for director (director port delay time), although it is often caused by shared DASD.

DASD performance

IOS Queue Represents the average time that an I/O waits because the device is already in use by another task on this system, signified by the device's UCBBUSY bit being on.

For most customers, reporting is based on one or both of the following measurements:

Service Time Connect time plus disconnect time

Response Time Connect time plus disconnect time plus pend time plus IOSQ time

Spreadsheet Reports

In "Chapter 2. Diagnosing a Problem: The First Steps" on page 2-1, you could see the DASD Summary report (Figure 2-19 on page 2-31) to be used for first steps in understanding the DASD performance of your system. If you feel that further investigation is required, you can create additional reports.

You might start with a second Summary report that provides data on the most heavily used LCUs and DASD devices:

RMF DASD System Summary													
System Id:		OS04	Operating System:		OS/390 02.10.00	Report Range(seconds):		899.628		Sort Lists			
Reporting Date:		6.05.00	Reporting Time:		09.29.00	Report Range(hh.mm.ss):		14.59.628					
System Summary													
#of LCUs	# of DASD	I/O Intens.	ST Intens.	Path Int.	Act. Rt.	Resp. Tm	Serv. Tm	IOSQ Tm	Pend. Tm	Disc. Tm	Conn. Tm	RT/ST	
116	6588	13732.83	11426.68	6188.40	1990.76	6.90	5.74	0.55	0.60	2.63	3.11	1.20	
LCU Summary													
Top 5	LCU	I/O Intens.	ST Intens.	Path Int.	Act. Rt.	Resp. Tm	Serv. Tm	IOSQ Tm	Pend. Tm	Disc. Tm	Conn. Tm	RT/ST	
	0057	1536.20	844.91	665.69	256.03	6.10	3.30	2.00	0.80	0.70	2.60	1.06	
	005D	1127.20	1014.48	601.17	187.87	5.70	5.40	0.00	0.30	2.20	3.20	1.85	
	012B	1067.62	843.42	261.57	53.38	19.30	15.80	3.00	0.50	10.90	4.90	1.22	
	0056	957.13	669.99	622.14	239.28	3.90	2.80	0.00	1.10	0.20	2.60	1.39	
	011D	949.83	846.21	155.43	86.35	10.60	9.80	0.00	0.80	8.00	1.80	1.08	
sorted by I/O Intensity													
Device Summary Top 10													
LCU	VolSer	I/O Intens.	ST Intens.	Path Int.	Act. Rt.	Resp. Tm	Serv. Tm	IOSQ Tm	Pend. Tm	Disc. Tm	Conn. Tm	RT/ST	
0057	IDP507	913.50	475.02	328.86	182.70	5.30	2.60	2.00	0.70	0.80	1.80	2.04	
005D	DIVP28	856.00	838.88	547.84	171.20	5.20	4.90	0.00	0.30	1.70	3.20	1.06	
011D	NP0LBG	766.73	713.06	122.68	76.67	10.10	9.30	0.00	0.80	7.70	1.60	1.09	
0056	CAT005	519.98	350.98	337.98	129.99	3.70	2.70	0.00	1.00	0.10	2.60	1.37	
0057	IDP069	470.02	270.26	264.39	58.75	8.60	4.60	3.00	1.00	0.10	4.50	1.87	
012B	NP0M15	341.60	245.95	63.20	17.08	20.80	14.40	6.00	0.40	10.70	3.70	1.44	
00AC	IDP067	295.41	221.56	221.56	147.71	1.80	1.50	0.00	0.30	0.00	1.50	1.20	
012B	NP0M14	179.95	152.53	44.56	8.57	21.40	17.80	3.00	0.60	12.60	5.20	1.20	
012B	NP0M18	171.33	129.98	24.81	5.91	28.50	22.00	6.00	0.50	17.80	4.20	1.30	
0056	IDP063	166.50	95.74	91.58	41.63	3.20	2.30	0.00	0.90	0.10	2.20	1.39	
sorted by I/O Intensity													
Averages													
		I/O Intens.	ST Intens.	Path Int.	Act. Rt.	Resp. Tm	Serv. Tm	IOSQ Tm	Pend. Tm	Disc. Tm	Conn. Tm	RT/ST	

Figure 4-16. DASD Summary Report. Spreadsheet Reporter macro RMFR9DAS.XLS (DASD Activity Report - Summary)

If you have seen some average data for most active volumes, you might be interested in getting some more details:

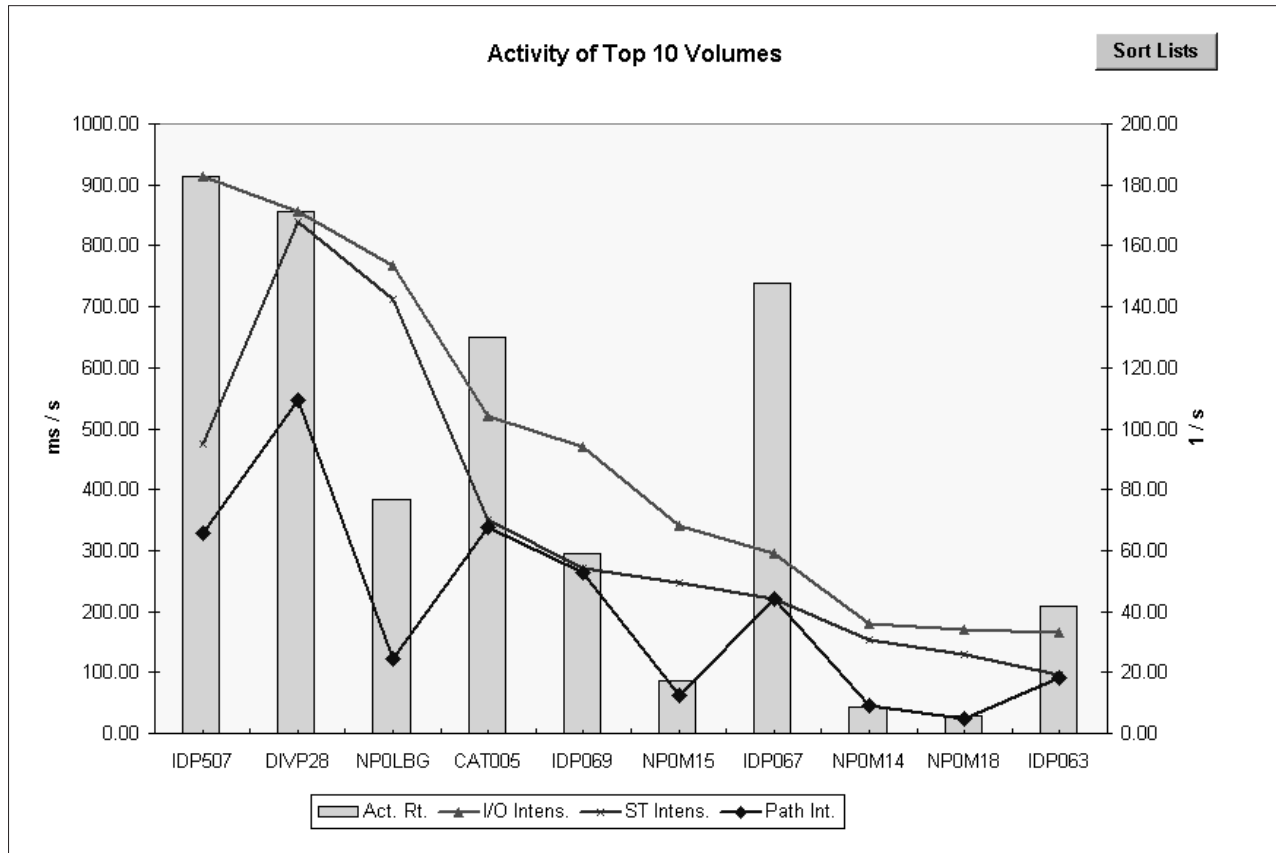


Figure 4-17. Activity of Top-10 Volumes. Spreadsheet Reporter macro RMFR9DAS.XLS (DASD Activity Report - Top10Act)

The report shows four values: in addition to the activity rate, you get the values for the I/O Intensity, the Service Time Intensity, and the Path Intensity.

I/O Intensity is the product of response time multiplied with the activity rate. The unit of measurement is ms/s.

It allows you to examine how many milliseconds per second applications waited for the device. The value can exceed 1000, which is an indicator that the device experiences a very heavy load and requires a long time to satisfy the requests. The value also includes the IOS Queue Time. If the activity rate is very low (e.g. less than 1 SIO/s) and the IOS Queue Time is high, the value is not very meaningful. You should use this measurement for devices with a considerable load (more than 2 IOs/s).

I/O Intensity is not a common name in the literature. Other references may use the same measurement with a different name, for example

Response Time Volume

DASD MPL (typically divided by 1000)

If you are interested in getting some details about the response times of the top-10 volumes, you can get this report:

DASD performance

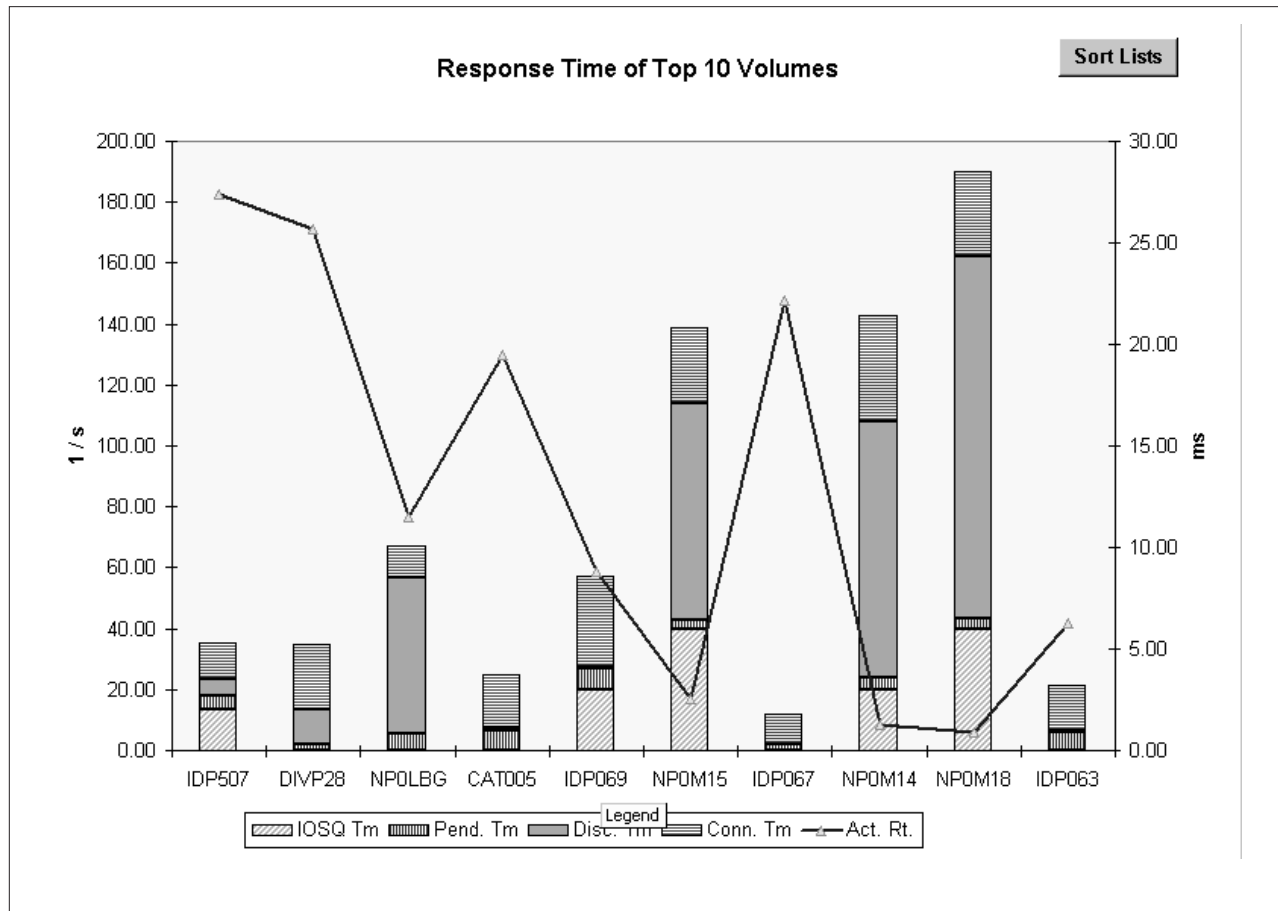


Figure 4-18. Response Time of Top-10 Volumes. Spreadsheet Reporter macro RMFR9DAS.XLS (DASD Activity Report - Top10Rt)

General DASD Guidelines

Following are some guidelines for expected values for typical DASD volumes. There are two practical ways to monitor DASD activities with RMF:

- The Monitor I DASD Activity report
- The Monitor III DEV and DEVR reports

The most common procedure is to analyze the Monitor I DASD Activity report.

Note: With any RMF reports, the I/O information reported is from one MVS system only. If you are sharing I/O across multiple systems, you will need to review RMF reports from each of the sharing systems in order to see the complete I/O activity to the LCUs and devices (this is not true for the Cache RMF Reporter, however; since CRR data is obtained from the control unit, it does include I/O activity from all sharing systems). Contention from a sharing system will generally be seen as increased pend and disconnect times.

DASD Activity Report

D I R E C T A C C E S S D E V I C E A C T I V I T Y																				PAGE 1	
z/OS V1R2				SYSTEM ID 0S04				DATE 06/05/2001				INTERVAL 14.59.996									
				RPT VERSION V1R2 RMF				TIME 09.30.00				CYCLE 1.000 SECONDS									
TOTAL SAMPLES = 1,800 IODF = 12 CR-DATE: 03/01/01 CR-TIME: 10.23.17																					
STORAGE GROUP	DEV NUM	DEVICE TYPE	VOLUME SERIAL	PAV	LCU	DEVICE ACTIVITY RATE	AVG RESP TIME	AVG IOSQ TIME	AVG DPB DLY	AVG CUB DLY	AVG DB DLY	AVG PEND TIME	AVG DISC TIME	AVG CONN TIME	% DEV CONN	% DEV UTIL	% DEV RESV	AVG NUMBER ALLOC	% ANY ALLOC	% MT PEND	
	0800	3390	FRE800		0045	0.000	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	100.0	0.0	
	0801	3390	DATA24		0045	2.092	18	0	0.0	0.0	0.0	0.2	14.9	3.0	0.63	3.75	0.0	1.3	100.0	0.0	
	0802	3390	DATA25		0045	0.376	14	0	0.0	0.0	0.0	0.2	10.0	4.3	0.16	0.59	0.1	7.9	100.0	0.0	
	0803	3390	SLB002		0045	0.003	11	0	0.0	0.0	0.0	0.2	9.0	2.3	0.00	0.00	0.0	1.7	100.0	0.0	
	0810	3390	DATA26		0045	0.112	15	0	0.0	0.0	0.0	0.2	12.2	2.6	0.03	0.17	0.1	8.5	100.0	0.0	
	0811	3390	DATA33		0045	0.051	15	0	0.0	0.0	0.0	0.2	12.5	2.4	0.01	0.13	0.1	0.0	100.0	0.0	
	0812	3390	DATA34		0045	0.057	16	0	0.0	0.0	0.0	0.2	13.4	2.7	0.02	0.09	0.1	2.6	100.0	0.0	
	0813	3390	DATA35		0045	0.046	16	0	0.0	0.0	0.0	0.2	13.4	2.3	0.01	0.07	0.0	8.0	100.0	0.0	
			LCU		0045	2.736	17	0	0.0	0.0	0.0	0.2	14.0	3.1	0.11	0.60	0.0	30.1	100.0	0.0	

Figure 4-19. Monitor I DASD Activity Report

In this report, the fields of most interest are:

- DEVICE ACTIVITY RATE
- AVG RESP TIME
- AVG IOSQ TIME
- AVG PEND TIME
- AVG DISC TIME
- AVG CONN TIME
- % DEV UTIL

Indicator

Field: AVG RESP TIME

Description: The average response time, in milliseconds, for an I/O to this device or LCU.

Related Fields: DEVICE ACTIVITY RATE, AVG PEND TIME, AVG DISC TIME, AVG CONN TIME, AVG IOSQ TIME

Guideline: For most situations, this measurement is the best way to quickly determine how well a device is performing.

AVG RESPONSE TIME can be considered as the overall measure of the health of a device's operation.

It is the sum of the AVG IOSQ TIME, AVG PEND TIME, AVG DISCONNECT TIME, and AVG CONNECT TIME. If response time is too high, then you can look further at these response time components and take remedial action.

What is too high? If your service level objectives are being met, then your response time is OK. If not, analyze what job is being delayed, and for how long (see prior section). Check the I/O rate to the device: if the I/O rate is insignificant, why bother tuning for response time?

Problem Area: I/O response time is a component of user response time; often it is the dominant component. High I/O response can delay user jobs and increase response times to unacceptable levels.

Potential Solution: Determine the dominant response time component, and see "Improving Your DASD Performance" on page 4-45 for suggestions.

Indicator

Field: AVG IOSQ TIME

Description: This is the time measured when a request is being delayed in the MVS system.

Related Fields: DEVICE ACTIVITY RATE, AVG RESP TIME

Guideline: If IOSQ is greater than 1/2 times *service time* (where service time is DISC + CONN) then it warrants a closer look. In practice, there should be little queue time (less than 5 ms).

Problem Area: High IOSQ times contribute to high AVG RESP TIME. Combined with high I/O rates for important workloads, this could become a user response time problem.

Potential Solution: If your problem is high IOSQ time then you have the following options. Traditionally IOSQ problems are usually resolved by data movement either by separating active data sets or by moving active data to faster storage, for example, a coupling facility structure.

On an ESS subsystem, you have additional options.

- If PAV is not enabled for the device, enable it.
- If you are using static PAVs, assign more aliases to the device.
- If you are using dynamic PAV, then increase the number of PAVs associated in the pool for the subsystem.
- Check to ensure that all PAVs that should be bound to the device are online and operational. You can use the DEVSERV QP and DS QP,xxxx,UNBOX commands to do this.

Indicator

Field: AVG PEND TIME

Description: This value represents the average time (ms) an I/O request waits in the hardware (channel subsystem).

Related Fields: AVG RESP TIME, DEVICE ACTIVITY RATE

Guideline: A high PEND time suggests that the channel subsystem is having trouble initiating the I/O operation. There is a blockage somewhere in the path to the device. That might be due to:

- AVG DPB DELAY. Delay due to ESCON director ports being busy.
- AVG CUB DELAY. Delay due to the DASD control unit being busy, due to I/O from another sharing MVS system.
- AVG DB DELAY. Delay due to the device being busy, due to I/O from another sharing MVS system.
- Channel path wait. Whatever PEND time is not accounted for by the above three measures is due to delay for channel paths. This is the measure of channel delay that matters - not channel busy. If you think your channels are too busy, track this component of response time, for volumes that serve important work, to see if it is really a problem.

If you think shared DASD causes the problem, look at the DASD Activity report from the other system, taken at the same time. PEND time should generally be less than 4 ms.

Problem Area: High PEND times contribute to high AVG RESP TIME. Combined with high I/O rates for important workload, this could become a user response time problem.

Potential Solution: High PEND times are usually caused by shared DASD contention or high channel path utilization.

On an ESS subsystem, multiple allegiance should reduce PEND times. If problems with PEND times exist you have the following options.

- Change the mix of data on the volume to reduce contention. If you can identify one data set that is contributing to most of the problem this may be eligible to be moved to a custom volume or moved into storage.
- Check channel utilization, especially if not using eight-path path groups. Changes have been made to CCWs to reduce channel overheads for the ESS. This will tend to lower channel utilization and increase throughput, however, using multiple allegiance and PAV successfully will cause increases in channel utilization.

Indicator

Field: AVG DISC TIME

Description: For cache controllers, DISC includes the time waiting while staging completes for the previous I/O to this particular device or until one of the four lower interfaces frees up from either transferring, staging or destaging data for other devices.

DISC can also be caused by a device which seeks to the correct location on the disk to read or write the data.

Related Fields: AVG RESP TIME, DEVICE ACTIVITY RATE

Guideline: Generally, DISC time should be less than 17 ms. If the data is cached with reasonable hit ratios there should be little DISC time (3-5 ms).

Once your DISC time gets above 12 ms (about the amount of time you would expect for latency and typical seek times), you are probably experiencing RPS misses due to path contention.

Problem Area: High DISC times contribute to high AVG RESP TIME. Combined with significant I/O rates for important workloads, this could become a user response time problem.

Potential Solution: If the major cause of delay is disconnect time then you will need to do some further research to find the cause. You might use the *ESS Expert* for creating more detailed reports. The most probable cause of high disconnect time is having to read or write data from disks rather than cache. You need to check for the following conditions.

- High DISK to CACHE transfer rate, check the ESS Expert Disk to Cache Transport report and use the drill-down functions of the ESS Expert to identify the logical volumes that are experiencing response time problems.
- High disk utilization, check the ESS Expert Disk Utilization report, if the problem is limited to one physical disk, or array the best solution is to move data to balance performance across the subsystem. The other option is to move data to another subsystem, or to another storage medium, for example data in memory, or to change the way that the application uses this data.
- Low CACHE hit ratio — seen in the Cache Subsystem Device Overview report. If you are suffering from poor cache hit ratios there is little that you can do, you should look at the ESS as a whole, using ESS Expert and check that activity is balanced across both clusters of the ESS.
- NVS full condition, if the NVS is overcommitted you will see an increase in the values reported in the DFW BYPASS field of the Cache Subsystem Overview report. If this is a persistent performance indicator you may want to spread activity across more ESS subsystems.

Indicator

Field: AVG CONN TIME

Description: This is time as measured by the channel subsystem during which the device is actually connected to the CPU through the path (channel, control unit, DASD) and transferring data. This time is considered good in most cases, because it is transferring data.

Related Fields: AVG RESP TIME, DEVICE ACTIVITY RATE

Guideline: Connect time is a function of block size and channel speed. Typical connect times often fall in the 2-6 ms range.

Problem Area: There are times when doing large searches in catalogs, VTOC, and PDS directories causes the connect time to become excessive. This results in connect time being considered "expensive" time in that no real data is transferred during this activity. Also during connect time, all parts related to an I/O operation (the entire path) must be available for use by that I/O. So no other user can do I/O to or from a device while that device is in connect mode.

One word of caution here - chained scheduling and seldom ending channel programs may generate high connect time which is not indicative of a performance problem.

Potential Solution: If you see devices with poor performance and high connect times then the cause is probably application related, high connect times are associated with large data transfers, either due to the use of large blocksizes or to activities like DB2 prefetch that schedule large I/O transfers. If the application is not reporting poor response and other users of the volume are not impacted, then no further work is required. High connect time is an indication of large amounts of data being transferred. An application, such as DB2, transfers large I/Os for maximum efficiency.

Indicator

Field: % DEV UTIL

Description: This is the percentage of time the UCB is "busy" (see IOSQ time). This includes both the time when the device was involved in an I/O operation (CONN and DISC) as well as any time it was reserved but not involved in an I/O operation.

Related Field: AVG IOSQ TIME

Guideline: A device overload condition is not always easy to detect. The device utilization as reported by RMF is not a measure of goodness or badness. If there is only one active data set on the device, and presuming that this data set cannot be made resident in processor storage, there is nothing wrong with a very high device utilization.

However, if multiple online users are all trying to get to data sets on the same device, they can be delayed due to the device being busy (from the other users). This will show up as increased IOSQ time.

If the utilization rises above 35%, response times may start to suffer, due to increased queuing for the device. If you have online response-sensitive data on a non-cached volume, you may want to investigate if utilization rises above the 25-30% range.

Problem Area: High device utilization can lead to increased IOSQ time, if users are delayed while the device is in use by others.

Potential Solution: Potential ways to decrease device utilization include:

- Caching the device (if not already cached). With a good hit ratio service time may be reduced significantly, which will reduce device utilization dramatically.
- Distribute heavily used data sets onto different volumes.
- Remove poor cache users. Turn off caching for data sets or volumes that do not achieve good hit ratios. As discussed before, this frees up cache for users that benefit more.

DASD performance

Indicator

Field: Multiply DEVICE ACTIVITY RATE by AVG CONN TIME

Description: Utilization (% busy) of the paths to DASD devices.

Related Fields: AVG PEND TIME, AVG DISC TIME

Guideline: The maximum allowable utilization is not a fixed number, but it can be higher as the overall hit ratio increases. In an average 4-path system (DLSE), cached or non-cached, a general guideline is not to exceed 50%, if the goal is to maintain good response for interactive users.

If the workload using these paths is not response-time sensitive, you may not care about high path utilization. For example, if you have only four jobs accessing four paths, then there is no delay and high path utilization is desired.

Since the storage path utilization is not directly reported, an estimate can be made using the RMF reported LCU I/O rate and the average LCU connect time. This amounts to a simple calculation, which you should execute for each system that accesses devices attached to the storage control unit:

1. Multiply I/O rate by average connect time
2. Divide the result by four (a 3990 has four storage paths)
3. Divide by 10 to convert to a percentage (because I/O rate is given in I/O per second, while connect time is reported in millisecond time units)

Problem Area: Higher utilizations will be an issue if they are causing delay to important work. This delay will show up as increased pend and disconnect times for volumes sharing these paths.

Potential Solution: If your storage path utilization is above 50% and causing delay to important work, a potential solution is to balance activity across control units by moving data sets.

Indicator

Field: AVG DISC TIME, ASYNC and STAGE rates

Description: These fields give you an indication of "lower interface" contention. The lower interfaces are the connections between the DASD devices and the DASD control unit.

Related Fields: LCU cache hit ratio

Guideline: Direct measure of lower interface utilization is not available from any reporting tool, but normally you should not have to worry about the lower interfaces. If the utilization of the storage paths and the hit ratios are within acceptable limits, the lower interface utilization should be fine.

The lower interfaces can be overloaded on cache controllers, however, if the hit ratio for the storage control unit falls below about 70% and a high subsystem throughput is imposed.

Problem Area: Problems here would be reflected in increased DISC times. If you suspect a problem, check your STAGE and ASYNC rates from the Cache RMF Reporter. Correlate both STAGE and ASYNC rates to your DISC times (for example, plot DISC time vs. STAGE + ASYNC rates).

Potential Solution: If you see a significant correlation between STAGE + ASYNC and DISC, investigate cache tuning or workload movement to reduce cache overload.

DASD performance

DASD Performance in the Sysplex

The Shared Device Activity report is a sysplex report that is available for DASD and tape devices. In this context we will discuss the DASD version of this report.

Note: The report requires matching device numbers (the physical device must have the same device number on all systems), or self-defining devices to give meaningful results.

Shared DASD Activity Report

S H A R E D D I R E C T A C C E S S D E V I C E A C T I V I T Y																		
z/OS V1R2				SYSPLEX RMFPLEX1				DATE 04/10/2001				PAGE 1						
				RPT VERSION V1R2 RMF				TIME 16.30.00				INTERVAL 014.59.946						
												CYCLE 1.000 SECONDS						
TOTAL SAMPLES(AVG) = 900.0 (MAX) = 900.0 (MIN) = 900.0																		
DEV	DEVICE	VOLUME	PAV	SMF	IODF	LCU	DEVICE	AVG	AVG	AVG	AVG	AVG	AVG	AVG	%	%	%	AVG
NUM	TYPE	SERIAL		SYS	SUFF		ACTIVITY	RESP	IOSQ	DPB	CUB	DB	PEND	DISC	CONN	DEV	DEV	DEV
				ID			RATE	TIME	TIME	DLY	DLY	DLY	TIME	TIME	TIME	CONN	UTIL	RESV
06AA	3380E	DPVOL1		*ALL			14.589	4	0	0.0	0.0	0.2	0.4	0.6	2.5	3.63	4.45	0.1
				MVS1	01	0043	4.550	5	0	0.0	0.0	0.0	0.2	0.5	4.1	1.86	2.10	0.0
				MVS2	02	0143	5.489	3	0	0.0	0.0	0.3	0.8	0.6	1.7	0.91	1.24	0.1
				MVS3	03	0043	4.550	4	1	0.0	0.0	0.2	0.3	0.6	1.9	0.86	1.11	0.0
077A	3380E	ERBDAT		*ALL			15.186	9	1	0.0	0.0	0.2	1.2	5.2	2.4	3.62	11.48	0.4
077A				MVS1	01	0043	4.069	5	2	0.0	0.0	0.8	1.1	0.4	1.7	0.68	0.84	0.0
0872				MVS2	02	0143	6.438	15	0	0.0	0.0	0.0	1.0	10.2	3.1	2.00	8.58	0.0
077A				MVS3	03	0052	4.679	8	2	0.0	0.0	0.1	1.6	2.4	2.0	0.94	2.06	0.4

Figure 4-20. Shared DASD Activity Report

This example reports about a sysplex consisting of three systems (MVS1, MVS2, and MVS3). Only two devices are shown.

The second device does not have the same device number on all three systems.

Indicator

Field: *ALL

Description: The system line shows the device activity contributed by all systems in the sysplex.

Guideline: The report gives you an overall performance picture of DASD devices that are shared between MVS systems in a sysplex.

For each shared DASD device the report contains one line for each system that has access to it.

The summary line allows you to identify a bottleneck caused by device delay in the sysplex. Furthermore, it allows you to see each systems share in the bottleneck.

The summary device activity rate and the device utilization show the total load on the device. The single-system values show the share of each system.

Analyzing Specific DASD Problems

This section will focus on how to analyze specific DASD problems. It is assumed that you have a good overall knowledge of your DASD subsystem (as discussed in “I/O Subsystem Health Check” on page 4-4) before proceeding.

One approach to investigating I/O problems can be summarized:

1. Is there a problem?
2. Who's got it?
3. Do I care?
4. What can be done about it?

Is there a problem? The Monitor III SYSINFO report shows whether there is any device delay. It also measures the size of the problem by the number of users affected.

SYSINFO Report

RMF V1R2 System Information										Line 1 of 27				
Command ==>										Scroll ==> HALF				
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec				
----- 9672 Model RX4 -----										Policy: STANDARD				
Average CPU Util%:		73		Appl% / EAppl%:		63/ 65		Date:		11/20/01				
Avg. MVS CPU Util%:		84		Partition Name:		MVS1		Time:		08.00.11				
Group	T	WFL	--Users--	RESP	TRANS	-AVG	USG-	-Average Number Delayed For -						
		%	TOT ACT	Time	/SEC	PROC	DEV	PROC	DEV	STOR	SUBS	OPER	ENQ	
*SYSTEM		34	664	26	13.95	5.1	5.0	1.9	4.1	7.0	2.6	2.0	2.0	
*TSO		50	534	8	13.95	2.6	2.1	0.4	1.5	2.0	0.8	0.0	0.0	
*BATCH		26	11	10	0.00	1.5	1.4	1.4	1.7	0.5	1.8	1.0	2.0	
*STC		27	115	8	0.00	1.1	1.5	0.1	1.0	4.5	0.1	1.0	0.0	
*ASCH			3	0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
*OMVS			2	0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
*ENCLAVE		5	4	N/A	N/A	0.2	N/A	3.7	N/A	0.0	N/A	N/A	N/A	
PRIMEBAT	W	26	11	10	46.0	0.06	1.5	1.4	1.4	1.7	0.5	1.8	1.0	2.0
NRPRIME	S	26	11	10	46.0	0.06	1.5	1.4	1.4	1.7	0.5	1.8	1.0	2.0
	1	23	9	9	27.9	0.06	0.9	1.4	0.8	1.6	0.5	1.8	1.0	2.0
	2	29	0	0	54.2	0.02	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0
	3	59	1	1	.000	0.00	0.6	0.0	0.4	0.0	0.0	0.0	0.0	0.0
PRIMETSO	W	50	527	8	.759	13.98	2.6	2.1	0.4	1.5	2.0	0.8	0.0	0.0
TSOPRIME	S	50	527	8	.759	13.98	2.6	2.1	0.4	1.5	2.0	0.8	0.0	0.0
	1	48	526	8	.403	13.98	2.1	1.9	0.3	1.3	2.0	0.8	0.0	0.0
	2	75	1	1	30.6	0.08	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
	3	75	0	0	126	0.02	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 4-21. Monitor III System Information Report

Who's got it? Look at the Delay report shown in 4-22. Who (which address space) has a device delay problem? This is more important than the number of users affected. Remember, I/O service is not democratic. One important job or transaction being delayed can be much more significant than several other transactions or jobs. The Delay report shows where delays exist by specific resource for specific users. This aids in the assessment of performance impact: “Who will be helped? How much?”

DASD performance

DELAY Report

RMF V1R2 Delay Report														Line 21 of 49	
Command ==>														Scroll ==> HALF	
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec					
Name	CX	Service Class	WFL Cr	USG %	DLY %	IDL %	UKN %	----- PRC	% Delayed for -----					Primary Reason	
MISTYDFS	B	NRPRIME		0	0	100	0	0	0	0	0	0	100	0	Message
BHOLEQB	B	NRPRIME		0	0	49	0	0	0	0	0	0	0	49	SYSDSN
BHOLWT01	B	NRPRIME		0	0	33	0	1	0	0	0	0	33	0	Message
BRHI	T	TSOPRIME		0	0	4	0	0	0	0	4	0	0	0	COMM
CONSOLE	S	SYSSTC		0	0	3	0	97	0	0	3	0	0	0	LOCL
VTMLCL	S	SYSSTC		0	0	2	0	98	0	0	2	0	0	0	LOCL
STARTING	T	TSOPRIME		0	0	2	0	7	0	0	2	0	0	0	COMM
CATALOG	S	SYSSTC		0	0	1	0	99	0	0	1	0	0	0	LOCL
INIT	S	SYSSTC		0	0	1	49	0	0	0	1	0	0	0	LOCL
BHOLDEV3	B	NRPRIME	20	20	80	0	0	1	79	0	0	0	0	0	BBVOL1
BTEUDASD	B	NRPRIME	22	22	77	0	1	1	76	0	0	0	0	0	BBVOL1
BAJU	T	TSOPRIME	24	24	75	0	1	0	75	0	0	0	0	0	BBVOL1
KLSPRINT	B	NRPRIME	25	25	75	0	0	0	75	0	0	0	0	0	BBVOL1
BHIM	T	TSOPRIME	31	11	25	64	0	2	18	5	0	0	0	0	BBVOL1
BHOLPRO1	B	NRPRIME	52	13	12	0	0	12	0	0	0	0	0	0	BHOLPRO2

Figure 4-22. Monitor III Delay Report

Do I care? Who is being delayed, and how much, often determines whether any action is necessary. Very important work requires immediate attention. Less important work? Small delays? Well, maybe you can look at it tomorrow.

What can be done about it? To identify the solution to an I/O problem, you must identify where the I/O pain is.

Remember, Monitor III can direct you to any device that is causing delays. This point of view is important; just because a device might have a high activity rate or a high response time, it MAY NOT be causing significant delays, or it may be delaying work you do not care about.

The reports that are useful here include:

DEV Report

RMF V1R2 Device Delays										Line 1 of 9				
Command ==>										Scroll ==> HALF				
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec				
Jobname	C	DMN	PG	DLY %	USG %	CON %	----- % VOLSER		Main Delay %	VOLSER	Volume(s) %	VOLSER	----- % VOLSER	
BHOLDEV3	B	NRPRIME		79	15	4	72	BBVOL1						
BTEUDASD	B	NRPRIME		76	20	4	75	BBVOL1						
KLSPRINT	B	NRPRIME		75	23	4	75	BBVOL1						
BAJU	T	TSOPRIME		75	19	1	71	BBVOL1						
BHIM	T	TSOPRIME		18	6	1	16	BBVOL1	1	430D13				
BHOL	T	TSOPRIME		4	11	6	9	BBVOL1						
JES2	S	SYSSTC		4	3	0	6	SYSPAG						
BHOLNAM4	B	NRPRIME		1	0	0	1	BBVOL1						

Figure 4-23. Monitor III Device Delays Report

The Device Delays report shows jobs in your system that are delayed due to device contention.

Jobnames (address space names) are listed in descending order in delay percentages. For each jobname, the names of up to 4 device volumes are listed indicating which volumes are causing the delay. If a job is being delayed, you can immediately see which volume is causing the most delay.

DASD performance

DEVR Report

RMF V1R2 Device Resource Delays										Line 1 of 16 Scroll ==> HALF			
Command ==>													
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec			
Volume S/ /Num PAV	Act Rate	Resp Time	ACT %	CON %	DSC %	PND Reasons	%	DEV/CU Type	Jobname	Service C Class	USG %	DLV %	
BBVOL1 0222	41.8	.099	88	21	66	PND	1	3380K 3990-2	KLSPRINT	B	NRPRIME	6	92
									BHOLDEV3	B	NRPRIME	2	92
									BTEUDASD	B	NRPRIME	5	91
									BAJU	T	TSOPRIME	3	91
									BHIM	T	NRPRIME	1	22
									BHOL	T	TSOPRIME	3	10
									RMFGAT	S	SYSSTC	0	1
									BHOLNAM4	B	NRPRIME	0	1
SYSPAG 0225 430D13 0220	10.9	.028	19	6	13	PND	0	3380K 3990-2	BVAU	T	TSOPRIME	6	14
									JES2	S	SYSSTC	0	7
									BENK	T	TSOPRIME	0	1
									BHIM	T	TSOPRIME	0	1
SYSCAT 0221	0.3	.017	0	0	0	PND	0	3380K 3990-2	BHOL	T	TSOPRIME	2	0
									INIT	S	SYSSTC	0	1

Figure 4-24. Monitor III Device Resource Delays Report

The DEVR report is used to evaluate the performance of each volume. It differs from the DEV report in that it lists a volume and all of the jobs that are being delayed for that volume. Thus, if you find a volume that RMF suggests is performing poorly, you can use Monitor III to determine which jobs it is affecting and how badly it is affecting any particular job.

You can get similar information from the Monitor I DASD Activity report.

Report Analysis

- In this case, from the SYSINFO report (shown in 4-21) we know that 1.7 jobs in service class NRPRIME are delayed because of a device.
- From the Delay report (shown in 4-22) we know the jobs in NRPRIME are waiting for volume BBVOL1.
- From the DEVR report (shown in 4-24) we identify that BBVOL1 is a 3380K that is not cached.

Replacing this disk by a faster device would be appropriate.

Performance Analysis on Data Set Level

The following sample reports do not show specific problems but can illustrate how performance analysis can be done on data set level.

If you need further analysis for a specific volume that you see in the DEVR report, you can navigate through cursor-sensitive control to some reports which provide information on data set level.

RMF V1R2 Device Resource Delays												Line 1 of 19	
Command ==> _												Scroll ==> HALF	
Samples: 76			System: D3		Date: 05/03/01		Time: 12.39.00		Range: 120		Sec		
Volume /Num	S	Act Rate	Resp Time	ACT %	CON %	DSC %	PND % Reasons	DEV/CU Type	Jobname	Service C Class	USG %	DLY %	
COUPLB 9191	S	2.4	.115	21	9	0	PND 12 DB 8 DPB 3	33903 3990-3	XCFAS	S SYSSTC	16	7	
COUPLP 91CD	S	0.8	.224	18	1	0	PND 17 DB 15	33903 3990-3	XCFAS	S SYSSTC	22	5	
SGT103 9182	S	0.7	.056	3	0	1	PND 2 DPB 1	33903 3990-3	U015074	T TSOSLOW	1	1	
									IXGLOGR	S SYSTEM	1	1	
									CATALOG	S SYSTEM	0	1	
									U015041	T TSOSLOW	0	1	
CMNAF8 BAF8	S	0.5	.105	5	0	0	PND 5 DB 5	33903 3990-6	CATALOG	S SYSTEM	0	4	
HDCAT 910E	S	2.3	.009	0	0	0	PND 0	33903 3990-3	RMFGAT	S SYSSTC	1	1	
									CATALOG	S SYSTEM	1	1	
									MASTER	S SYSTEM	1	0	

Figure 4-25. Monitor III - Device Resource Delays Report

If you select volume SGT103 and click on Enter, you get this report:

DSNV Report

RMF V1R2 Data Set Delays - Volume										Line 1 of 5	
Command ==> _										Scroll ==> HALF	
Samples: 76		System: D3		Date: 05/03/01		Time: 12.39.00		Range: 120		Sec	
----- Volume SGT103 Device Data -----											
Number: 9182		Active: 3%		Pending: 2%		Average Users					
Device: 33903		Connect: 0%		Delay DB: 0%		Delayed					
Shared: Yes		Disconnect: 1%		Delay CU: 0%		0.1					
				Delay DP: 1%							
----- Data Set Name -----						Jobname	ASID	DUSG%	DDL%		
IXGLOGR.ATR.UTCPLEXHD.RM.DATA.A0000010.DATA						IXGLOGR	0021	1	1		
U015074.CALENDAR.DATA						U015074	0110	0	1		
U015041.COURSEIN.DATA						U015041	0125	0	1		
SYS1.VVDS.VSGT103						CATALOG	0051	0	1		
SYS1.VTOCIX.VSGT103						U015074	0110	1	0		

Figure 4-26. Monitor III - Data Set Delays by Volume

In addition to general information about this volume, you see a list with all data sets which are currently used. Selecting a specific job, you navigate to the next report.

DASD performance

The Device Resource Delays report (DEVR) provides USG and DLY values for jobs that are using devices or are waiting for them. This data is gathered in a multistate fashion, this means that there may be several wait records for the same job for the same device. The reporter changes to "pseudo multistate", this can result in one USG counter and one DLY counter in parallel within a cycle, but does not take multiple wait records into account.

Data gathering for the Data Set Delays reports (DSND, DSNJ, and DSNV) is different. Here, several wait records referring to the same device are not treated as being the same and counted only once because they may refer to different data set names, and have to be counted individually.

As a result, the sum of the USG and DLY percentage values in these reports can be different to the USG and DLY percentage values in the DEVR report. Therefore, the three reports contain the headings DUSG% and DDLY% instead of USG% and DLY% to indicate a potential difference to the related values in the DEVR report.

It might happen that -- **N/A** -- is provided instead of a data set name. This happens if only those I/O instructions have been detected for which no data set information is provided by the SMS subsystem, like

- I/Os to system data sets (like paging or spooling)
- I/Os to any data set which was opened prior to SMS subsystem initialization
- I/Os like SENSE or RELEASE
- System I/Os not done by an access method

DSNJ Report

RMF V1R2 Data Set Delays - Job				Line 1 of 2	
Command ==> _				Scroll ==> HALF	
Samples: 76	System: D3	Date: 05/03/01	Time: 12.39.00	Range: 120	Sec
Jobname: U015074	EXCP Rate	0.1	Connect:	0%	
ASID	-----	Data Set Name	-----	Volume	Num DUSG% DDLY%
0110		U015074.CALENDAR.DATA		SGT103	9182 0 1
		SYS1.VT0CIX.VSGT103		SGT103	9182 1 0

Figure 4-27. Monitor III - Data Set Delays by Job

This report shows all active data sets for a specific job. If you now are interested to know whether some other job is working with this data set, again, you can navigate to the corresponding report.

DSND Report

RMF V1R2 Data Set Delays				Line 1 of 1	
Command ==> _				Scroll ==> HALF	
Samples: 76	System: D3	Date: 05/03/01	Time: 12.39.00	Range: 120	Sec
Input Data Set Name: SYS1.VTOCIX.VSGT103					
----- Data Set Name -----		Volume	Jobname	ASID	DUSG% DDLY%
SYS1.VTOCIX.VSGT103		SGT103	U015074	0110	1 0

Figure 4-28. Monitor III - Data Set Delays by Data Set

In this sample, no other job than U015074 is using the data set.

Improving Your DASD Performance

This section will suggest actions you may want to consider, to improve the performance of your DASD.

- Obviously, the best response time is achieved if the DASD I/O never happens. Eliminate I/O using buffering or data-in-memory techniques wherever possible (see Appendix C. Data-In-Memory).
- Next best is resolving the I/O in cache.
- Last is an I/O to DASD itself.

Also remember ways to increase the "parallelism" of your I/O processing.

- This could include the Data Striping capability of DFSMS, where sequential data is distributed across multiple I/O devices to allow concurrent I/O.
- As a last resort, parallelism could also mean manually splitting data across volumes, or duplicating data on multiple volumes.

In addition, here are actions to consider to address the following symptoms:

High DISC time

- Cache the volume, if it is a suitable cache candidate.
- Un-cache the volume, if it is a poor cache candidate.
- Tune cache.
 - Best to use DCME to dynamically manage cache for you.
 - If necessary, manually tune cache by turning off poor cache users.
- Review blocksize. Increase where applicable.
- Add paths (if not already 4-path).
- Use faster device.
- Move or copy data sets to other volumes to reduce contention.
- Reduce arm movement via data set placement (seek analysis required).

High IOSQ time

- Cache the volume, if it is a suitable cache candidate.
- Tune cache.
 - Best to use DCME to dynamically manage cache for you.
 - If necessary, manually tune cache by turning off poor cache users.
- Decrease DISC, CONN, PEND times. Decreasing the other response time components will also decrease IOSQ time proportionally.
- Use I/O priority queuing (IOQ=PRTY in IEAIPsxx).

DASD performance

- Move or copy data sets to other volumes to reduce contention.
- Run requests sequentially to reduce contention.

High CONN time

- Cache the volume, if it is a suitable cache candidate.
- Use indexed VTOCs.
- In a cached environment, use faster channels.
- Use PDSEs if you suspect directory search time is a problem.

High PEND time

- Address the biggest subcomponent of PEND time (see page 4-32).
 - Use faster channels, or add more channels (if not already 4-path).
 - Move data sets to avoid contention from sharing systems.

Tape Indicators and Guidelines

This section discusses guidelines for analyzing and resolving tape performance issues for the 3480 and 3490 families of tape devices.

From a performance perspective, you can think of tape as being like DASD with long connect times. All of the things we used to do for single path DASD are true for tape: short strings, many control units and channels. If the subsystem is configured with one channel per control unit function, the only reason to add channels or cross communication of control units is availability, not performance.

Identifying Tape-bound Jobs

An indication of a tape-bound job is when a large proportion of the total time for the job is spent in tape activity and a small amount in CPU (or other) activity. The job termination messages, NUMBER OF MOUNTS and AVG MOUNT TIME from the Magnetic Tape Device Activity report can help determine if a job is tape-bound.

Look at the job termination messages for the ratio of CPU time to the total elapsed time as indication for tape-bound jobs. You can also use the Monitor III Delay report, to verify that no other (non-I/O) significant delays exist for the job in question and that tape delay is dominant.

Once a job is identified as tape-bound then further evaluation and measurements may be justified.

RMF Measurements

Options for Tape Monitoring

The options required to measure and monitor the tape subsystems may not be the default options used in most user environments. The reason is that the jobs and applications using tape are normally batch tasks, more concerned with throughput than response time.

Some RMF options that must be enabled to have meaningful RMF data for tape subsystem measurements are discussed. These options may be modified in the ERBRMF00 parmlib member or may be modified online for current sessions:

Monitor I Session Options

INTERVAL	This value needs to be small (preferably no more than 15 minutes) if the details of the tape subsystem performance are to be evaluated.
DEVICE	TAPE must be one of the device types specified.
IOQ	To request I/O queuing activity for tape LCUs, IOQ(TAPE) must be specified.
CHAN	This option specifies that the channel activity is to be measured. The channel utilization may be of interest in evaluating multiple control units on the same channel, or for evaluating the requirement for additional channel paths.

Tape performance

Magnetic Tape Device Activity Report:

M A G N E T I C T A P E D E V I C E A C T I V I T Y																			PAGE 1	
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996								
				RPT VERSION V1R2 RMF				TIME 09.30.00				CYCLE 1.000 SECONDS								
TOTAL SAMPLES =		900	IODF = A3		CR-DATE: 03/01/01				CR-TIME: 07.42.20				ACT: POR							
DEV NUM	DEVICE TYPE	VOLUME SERIAL	LCU	DEVICE ACTIVITY RATE	AVG RESP TIME	AVG IOSQ TIME	AVG DPB DLY	AVG CUB DLY	AVG DB DLY	AVG PEND TIME	AVG DISC TIME	AVG CONN TIME	% DEV CONN	% DEV UTIL	% DEV RESV	NUMBER OF MOUNTS	AVG MOUNT TIME	TIME DEVICE ALLOC		
05B0	3490		0046	0.027	3155	0	0.0	0.2	0.0	1411	1736	8.0	0.02	4.65	0.0	1	20	1:47		
05B1	3490		0046	0.000	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0	0	0		
05B2	3490		0046	0.023	860	0	0.0	0.1	0.0	362	494	4.0	0.01	1.16	0.0	1	30	55		
05B3	3490		0046	0.023	2158	95	0.0	0.2	0.0	891	1169	2.9	0.01	2.74	0.0	1	29	1:31		
05B4	3490		0046	0.032	2241	0	0.0	0.1	0.0	1365	874	2.9	0.01	2.82	0.0	1	32	1:41		
05B5	3490	H3158	0046	0.000	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0	0	0		
05B6	3490		0046	0.000	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0	0	0		
05B7	3490		0046	0.975	81	0	0.0	0.0	0.0	53.9	20.8	6.4	0.62	2.66	0.0	1	59	3:21		
05B8	3490		0046	0.109	388	0	0.0	0.0	0.0	230	154	4.8	0.05	1.72	0.0	1	50	2:00		
05B9	3490		0046	1.993	24	0	0.0	0.0	0.0	9.0	9.3	5.5	1.09	2.94	0.0	1	33	2:05		
05BA	3490		0046	0.023	1461	0	0.0	0.3	0.0	621	833	7.3	0.02	1.96	0.0	1	46	1:36		
05BB	3490		0046	0.023	3990	0	0.0	0.2	0.0	1453	2529	8.1	0.02	5.92	0.0	1	1:09	2:39		
05BC	3490		0046	OFFLINE																
05BD	3490		0046	OFFLINE																
05BE	3490		0046	OFFLINE																
05BF	3490		0046	OFFLINE																
LCU			0046	3.229	162	1	0.0	0.0	0.0	78.9	76.6	5.7	0.15	2.21	0.0	9	41	1:28		

Figure 4-29. Monitor I Magnetic Tape Device Activity Report

Response Time Components

Response time is a key measure of how well your I/O is performing, and a key indicator of what can be done to speed up the I/O. It is important to understand the components of this response and what they mean. Tape response time is the sum of queue, pend, connect and disconnect time (see page 4-30). The following lists the response time components and what causes them:

Queue Time

AVG IOSQ TIME is a measure of an I/O request waiting in software for the device to become available to service the request. For tape this usually means a REWIND/UNLOAD is in progress.

Pend Time

AVG PEND TIME reflects the time an I/O spends waiting to get a path to the control unit. This is the time spent waiting for an available channel path.

Disconnect Time

AVG DISC TIME is one of the more significant measures of a heavily loaded tape subsystem. Disconnect time is that time spent waiting for the buffer in the control unit to become available to transfer data; it includes the tape rewind time. One example of a disconnected I/O operation is a buffer-full condition.

Connect Time

AVG CONN TIME is predominantly time spent transferring data between the control unit and the processor. Connect time is directly related to data block size, and to the amount of data transferred for each I/O.

General Tape Indicators

Indicator

Field: AVG DISC TIME (LCU), AVG PEND TIME (LCU), AVG CONN TIME (LCU)

Description: Ratio of DISC + PEND time to CONN time. Lower ratios indicate less contention for channels and control units.

Related Fields: DEVICE ACTIVITY RATE. If the I/O rate to the controller is negligible, don't bother with any further analysis.

Guideline: Percent channel busy is not a good indicator of tape performance. Instead look at the ratio of LCU DISC + PEND time to CONN time. If the ratio exceeds 2 to 1 for extended periods of time (with an I/O rate high enough to be of interest), this is an indication of channel and/or control unit contention.

Problem Area: This is an indicator that response times are increasing (increased DISC and PEND) due to an overloaded control unit or channels.

Potential Solution: If you have significant DISC time and little PEND time, add more or faster control units. If you have significant DISC **and** PEND times, add more/faster control units and more/faster channels. As a guideline, you probably want to configure no more than four active drives per control unit. Beyond four **concurrently active** drives behind a single control unit function, data throughput for the additional drives drops off dramatically.

Indicator

Field: AVG CONN TIME (LCU)

Description: Predominantly, data transfer time between the control unit and the CPU.

Related Fields: AVG RESP TIME, DEVICE ACTIVITY RATE

Guideline: CONN times in the 20-40 ms range are typical. If your CONN time is significantly lower (for example, 4-5 ms), you may have smaller than optimal block sizes, resulting in more I/Os required to transfer the data.

Problem Area: This could mean delay to the application, if a high number of I/Os are being generated to transfer the data. Decreasing the I/O rate by increasing the amount of data transferred per I/O will speed up the application run-time.

Potential Solution: Increase blocksize and/or the number of host buffers where applicable.

Tape performance

Improving Your Tape Performance

This section will suggest actions you may want to consider to improve tape performance.

The key to good performance is to maximize data transfer, minimize control unit communication and command processing, and minimize PEND and DISC times. This can be accomplished by using large blocksizes, allocating no more than four concurrently active drives per control unit and not cross-coupling control units.

As a checklist, review the following:

- Review blocksize. Increase where applicable.
- Allocate data sets to DASD. TMM (tape mount management) is a method to accomplish this and significantly reduce tape mount requirements.
- Increase host buffers for priority jobs. Increase buffers from default of 5, to as high as 20 (but no more than 20).
- Use VIO for temporary data sets.
- Use faster channels.
- Add channels (if not already one channel per control unit function).
- Reduce mount delay.
 - use ACLs/ICLs (cartridge loaders) for nonspecific mounts
 - use an automated tape library for specific mounts
 - review physical logistics for manual mount efficiencies (e.g. are tapes stored near the operators, and near the drives?)
- Add control unit functions (probably want no more than 4 concurrently active drives per control unit).
- Use enhanced-capacity cartridges and tape drives.
- Restructure for more parallelism (for example, to allow application to use multiple drives).
- Use the *Improved Data Recording Capability (IDRC)* to reduce the amount of data transfer required.

Summary

Typically, I/O processing is the largest single component of transaction response time. So, while I/O performance management can be complicated and time consuming, the return in terms of response time and throughput can be significant.

Look for ways to avoid I/O altogether: Through optimized use of buffers, newer data-in-memory techniques, and eliminating unnecessary I/O.

Cache the I/O that will benefit from cache, and keep cache "tuned" to the extent that poor cache users are not allowed to get in the way of better cache users.

As with all performance management you need to:

- Understand the overall system picture (CPU, processor storage) and the overall I/O subsystem picture before tuning.
- Measure the delay to important workloads.
- Review "related fields" before tuning. For example, if response time for a device seems high, also check the I/O rate, type of workload using the device, and % DLY to users, before deciding what (if any) action to take.
- Determine where your leverage for improvement exists. Start by seeing which component of response time (DISC, CONN, etc.) is dominant, and take further action accordingly.

I/O Performance - Summary

Chapter 5. Analyzing Processor Storage Activity

Let's Analyze Your Storage

This chapter discusses how to analyze a processor storage problem. Topics include:

- What are the indicators in RMF to review, to verify there is a problem?
- Some examples of common problems that RMF can help you resolve.
- Potential tuning actions.

Simply put, resolving processor storage problems generally means prioritizing which workloads get access to processor storage, finding ways to move fewer pages, or speeding up the movement of pages.

Do You Have a Processor Storage Problem?

Here are the primary RMF indicators you may wish to use in assessing your processor storage configuration. After listing these indicators, we will then discuss each one in more detail, with guidelines for each value that may indicate contention and suggestions for further action.

We will refer to the components of storage as *central storage (CS)* and *auxiliary storage (AUX)*.

Never start any tuning effort simply because one indicator seems to be a problem. Always check other related indicators to build a good understanding of your overall processor storage situation (and overall system situation, for that matter) and only then begin to plan your tuning efforts. For example, if your UIC is low, also look at demand paging from auxiliary storage and storage delays in Monitor III.

Table 5-1 shows for each monitor, which fields in which report can most often help detect and solve a processor storage problem.

Table 5-1. Processor Storage Indicators in Monitor III and Monitor I

MONITOR	REPORT	FIELDS
Monitor III	SYSINFO	Average Number Delayed for STOR
	DELAY	%Delayed for STR
	STOR	DLY%
Monitor I	Paging Activity	PAGE MOVEMENT WITHIN CENTRAL STORAGE PAGE-IN EVENTS AVG HIGH UIC TOTAL FRAMES AVAILABLE
	Page/Swap Activity	SLOTS ALLOC SLOTS USED % IN USE
	DASD Activity	AVG RESP TIME

Monitor III Indicators

This section reviews the most frequently used processor storage indicators in the Monitor III reports. We will start by looking at SYSINFO and DELAY reports, which can lead you to the STOR report.

SYSINFO Report

RMF V1R2 System Information										Line 1 of 23				
Command ==>										Scroll ==> HALF				
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec				
----- 2064 Model 110 -----										Policy: STANDARD				
Average CPU Util%:		73		Appl% / EAppl%:		63/ 65		Date:		11/20/01				
Avg. MVS CPU Util%:		84		Partition Name:		MVS1		Time:		08.00.11				
Group	T	WFL	--Users--	RESP	TRANS	-AVG	USG-	-Average	Number	Delayed	For	-		
		%	TOT	ACT	Time	/SEC	PROC	DEV	PROC	DEV	STOR	SUBS	OPER	ENQ
*SYSTEM		34	664	26		13.95	5.1	5.0	1.9	4.1	7.0	2.6	2.0	2.0
*TSO		50	534	8		13.95	2.6	2.1	0.4	1.5	2.0	0.8	0.0	0.0
*BATCH		26	11	10		0.00	1.5	1.4	1.4	1.7	0.5	1.8	1.0	2.0
*STC		27	115	8		0.00	1.1	1.5	0.1	1.0	4.5	0.1	1.0	0.0
*ASCH			3	0		0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
*OMVS			2	0		0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
*ENCLAVE		5	4	N/A		N/A	0.2	N/A	3.7	N/A	0.0	N/A	N/A	N/A
PRIMEAPP	W		3	0	.000	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APPPRIME	S		3	0	.000	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1		2	0	.000	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2		1	0	.000	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRIMEBAT	W	26	11	10	46.0	0.06	1.5	1.4	1.4	1.7	0.5	1.8	1.0	2.0
NRPRIME	S	26	11	10	46.0	0.06	1.5	1.4	1.4	1.7	0.5	1.8	1.0	2.0
	1	23	9	9	27.9	0.06	0.9	1.4	0.8	1.6	0.5	1.8	1.0	2.0
	2	29	0	0	54.2	0.02	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0
	3	59	1	1	.000	0.00	0.6	0.0	0.4	0.0	0.0	0.0	0.0	0.0

Figure 5-1. Monitor III System Information Report

Storage analysis

Indicator

Field: Average Number Delayed For STOR

Description: This shows you the average number of AS delayed for reasons related to processor storage.

Guideline: Look at the value for the user community you are trying to help (for example, a specific service class, all TSO, or overall SYSTEM). If the STOR delay is larger than the other delays listed, you probably have some leverage here. If the STOR delay is zero or near zero, then your leverage is elsewhere (for example, I/O or CPU).

Problem Area: This points out delays for paging, swapping, VIO, and out-ready.

Potential Solution: See the Storage Delays report to find out which AS are delayed, and the type of storage delay they are having. You can get there by positioning the cursor on the storage value you are interested in, and pressing ENTER.

DELAY Report

RMF V1R2 Delay Report														Line 1 of 43
Command ==>														Scroll ==> HALF
Samples: 100 System: PRD1 Date: 04/07/01 Time: 10.32.00 Range: 100 Sec														
Name	Service CX Class	Cr	WFL %	USG %	DLY %	IDL %	UKN %	----- PRC	% Delayed for -----					Primary Reason
									DEV	STR	SUB	OPR	ENQ	
BHOLEQB	B BATCH		0	0	51	0	49	0	0	0	0	0	51	SYSDSN
JES2	S SYSSTC		0	0	2	0	98	0	2	0	0	0	0	SYPAG
SMF	S SYSSTC		0	0	1	0	99	0	1	0	0	0	0	SYPAG
BAJU	T TSO		29	9	22	67	2	1	0	21	0	0	0	LOCL
RMFGAT	S SYSSTC		50	1	1	0	98	1	0	0	0	0	0	BAJU
BHOL	T TSO		78	18	5	73	4	1	3	1	0	0	0	RMFUSR
BHOLPRO2	B BATCH		93	93	7	0	0	7	0	0	0	0	0	BHOLPRO1
BHOLPRO1	B BATCH		95	95	5	0	0	5	0	0	0	0	0	BHOLPRO2
MASTER	S SYSTEM		96	24	1	0	76	0	1	0	0	0	0	SYPAG
CATALOG	S SYSSTC		100	2	0	0	98	0	0	0	0	0	0	
BHOLSTOA	B BATCH		100	1	0	99	0	0	0	0	0	0	0	
PCAUTH	S SYSSTC			0	0	0	100	0	0	0	0	0	0	

Figure 5-2. Monitor III Delay Report

Indicator

Field: % Delayed for STR

Description: This will give you the percentage of time the job was delayed for processor storage related reasons.

Guideline: See if the STR delay is larger than the others, and is significant (over 10%). If so, go to the Storage Delays panel (enter STOR at the command line) and see the guidelines described there.

Problem Area: Delays due to paging, swapping, VIO, and out-ready.

Potential Solution: See the "STOR Report" on page 5-6 section of this chapter.

Storage analysis

STOR Report

RMF V1R2 Storage Delays										Line 1 of 44	
Command ==>										Scroll ==> HALF	
Samples: 100		System: PRD1		Date: 04/07/01		Time: 10.32.00		Range: 100		Sec	
Jobname	C	Service Class	DLY %	----- % Delayed for -----					-- Working Set --		
				COMM	LOCL	VIO	SWAP	OUTR	Central	Expanded	
BAJU	T	TSO	21	0	18	0	3	0	273	5	
BHOL	T	TSO	1	1	0	0	0	0	1111	4	
MASTER	S	SYSTEM	0	0	0	0	0	0	73	7	
PCAUTH	S	SYSSTC	0	0	0	0	0	0	30	3	
RASP	S	SYSSTC	0	0	0	0	0	0	60	3	
TRACE	S	SYSSTC	0	0	0	0	0	0	35	2	
XCFAS	S	SYSSTC	0	0	0	0	0	0	173	71	
GRS	S	SYSSTC	0	0	0	0	0	0	68	66	
SMXC	S	SYSSTC	0	0	0	0	0	0	20	2	
SYSBMAS	S	SYSSTC	0	0	0	0	0	0	21	1	
DUMPSRV	S	SYSSTC	0	0	0	0	0	0	33	6	
CONSOLE	S	SYSSTC	0	0	0	0	0	0	74	6	
ALLOCAS	S	SYSSTC	0	0	0	0	0	0	26	3	
SMF	S	SYSSTC	0	0	0	0	0	0	47	4	
LLA	S	SYSSTC	0	0	0	0	0	0	213	4	
BHOLST09	B	BATCH	0	0	0	0	0	0	0	0	

Figure 5-3. Monitor III Storage Delays Report

Indicator

Field: Check DLY % first, then find biggest component (e.g. COMM, LOCL...).

Description: This report shows AS in descending order of delay.

Guideline: See if the DLY % field is significant (over 10%) before proceeding further. The DLY % fields in Monitor III give you a good estimate of how much you can reduce response time by eliminating delay. 10% delay implies that if you are able to eliminate that delay entirely, you could improve response time by about 10%.

Problem Area: Paging, swapping, VIO, etc.

Potential Solution:

- COMM
 - See “Prioritize Access to Processor Storage” on page 5-14 - consider storage isolation using CVSS and CPGRT parameters from IEAIPSxx
 - See “Decrease Storage Demand” on page 5-14
 - See “Auxiliary Storage Tuning” on page 5-14
- LOCL
 - See “Prioritize Access to Processor Storage” on page 5-14 - storage isolation and criteria age
 - See “Decrease Storage Demand” on page 5-14
 - See “Auxiliary Storage Tuning” on page 5-14
 - If swappable, consider swap set size tuning
- VIO
 - See “Prioritize Access to Processor Storage” on page 5-14 - storage isolation and criteria age
 - See “Decrease Storage Demand” on page 5-14
 - See “Auxiliary Storage Tuning” on page 5-14
- SWAP
 - See “Prioritize Access to Processor Storage” on page 5-14 - storage isolation and criteria age
 - See “Auxiliary Storage Tuning” on page 5-14
 - Swap set size tuning
- OUTR
 - Check RTO setting
 - See “Decrease Storage Demand” on page 5-14

Storage analysis

Monitor I Indicators

This section will review the most frequently used processor storage indicators in the Monitor I reports.

Paging Activity Report - Page 1

PAGING ACTIVITY									
z/OS V1R2		SYSTEM ID OS04		DATE 06/05/2001		PAGE 1			
		RPT VERSION V1R2 RMF		TIME 09.29.00		INTERVAL 14.59.996			
						CYCLE 1.000 SECONDS			
OPT = IEAOPT02 MODE=ESAME CENTRAL STORAGE PAGING RATES - IN PAGES PER SECOND									

CATEGORY	PAGE IN					PAGE OUT			
	SWAP	NON SWAP, BLOCK	NON SWAP, NON BLOCK	TOTAL RATE	% OF TOTL SUM	SWAP	NON SWAP	TOTAL RATE	% OF TOTL SUM
PAGEABLE SYSTEM AREAS (NON VIO)									
LPA		0.00	0.01	0.01	0				
CSA		0.00	0.04	0.04	0		0.00	0.00	0
SUM		0.00	0.05	0.05	0		0.00	0.00	0
ADDRESS SPACES									
HIPERSPACE		0.06		0.06	1		0.00	0.00	0
VIO		0.00		0.00	0		0.00	0.00	0
NON VIO	0.28	7.01	2.01	9.30	99	0.00	0.01	0.01	100
SUM	0.28	7.07	2.01	9.37	100	0.00	0.01	0.01	100
TOTAL SYSTEM									
HIPERSPACE		0.06		0.06	1		0.00	0.00	0
VIO		0.00		0.00	0		0.00	0.00	0
NON VIO	0.28	7.01	2.06	9.35	99	0.00	0.01	0.01	100
SUM	0.28	7.07	2.06	9.41	100	0.00	0.01	0.01	100
SHARED			0.00	0.00			0.00	0.00	
PAGE MOVEMENT WITHIN CENTRAL STORAGE				20.84	PAGE MOVEMENT TIME % 0.0				
AVERAGE NUMBER OF PAGES PER BLOCK				5.6					
BLOCKS PER SECOND				1.26					
PAGE-IN EVENTS (PAGE FAULT RATE)				3.31					

Figure 5-4. Monitor I Paging Activity Report - Page 1

Indicator

Field: PAGE MOVEMENT WITHIN CENTRAL STORAGE

Description: Rate of page movement above and below 16MB in CS. For example, to keep long term fixed pages out of reconfigurable storage.

Guideline: This is rarely a problem. If you see large numbers here (maybe over 100/sec), it may be worth looking at.

Problem Area: Some CPU time is required to move these pages. Generally not enough to worry about.

Potential Solution: Review the setting of your RSU parameter for reconfigurable storage. Reduce if possible (but not at the expense of your disaster recovery planning).

Indicator

Field: PAGE-IN EVENTS (PAGE FAULT RATE)

Description: This is the rate of demand paging in from auxiliary storage. The AS waits while these pages are obtained.

Guideline: No overall system guideline for this number would make much sense. More important than the single-number here, is the amount of paging delay to important work (see Monitor III Storage Delays report). You may wish to track this one over time, or turn to this for specific MPL tuning.

Problem Area: Problems here would show up as paging delay to important work.

Potential Solution: Paging problems are probably best addressed by analyzing which workloads are paging, then addressing the problem for those workloads specifically (see Monitor III Storage Delays report). Use Monitor III to get to the AS level, or the Workload Activity report to get to the service class. There, the following solutions could apply:

- Isolate storage
- Adjust swap set size
- Adjust the criteria age value
- As a last resort, see “Auxiliary Storage Tuning” on page 5-14 for ways to speed up the paging.

For overall system paging reduction, most of the items in “General Storage Recommendations” on page 5-14 could apply.

Storage analysis

Paging Activity Report - Page 2

P A G I N G A C T I V I T Y									
PAGE 2									
z/OS V1R2			SYSTEM ID OS04		DATE 06/05/2001		INTERVAL 14.59.996		
			RPT VERSION V1R2 RMF		TIME 09.29.00		CYCLE 1.000 SECONDS		
OPT = IEAOPT02 MODE = ESAME			CENTRAL STORAGE MOVEMENT RATES - IN PAGES PER SECOND						

HIGH UIC (AVG) = 2498.3			(MAX) = 2540		(MIN) = 2133				
		WRITTEN TO	READ FROM	*--- CENTRAL STORAGE FRAME COUNTS ---*					
		CENTRAL STOR	CENTRAL STOR	MIN	MAX	AVG			
HIPERSPACE	RT	0.02	0.00	67	140	112			
PAGES									
VIO	RT	2.93	1.96	18	1,832	169			
PAGES									

FRAME AND SLOT COUNTS									

CENTRAL STORAGE				EXPANDED STORAGE			LOCAL PAGE DATA SET SLOT COUNTS		
(90 SAMPLES)	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG
AVAILABLE	1	6,697	1,765				AVAILABLE SLOTS	2,485,531	2,501,203
SQA	16,860	17,348	17,070				VIO SLOTS	30	30
LPA	3,902	4,134	3,961				NON-VIO SLOTS	332,867	348,539
CSA	22,983	24,966	24,101				BAD SLOTS	0	0
LSQA	32,169	34,632	33,304				TOTAL SLOTS	2,834,100	2,834,100
REGIONS+SWA	434,175	440,857	438,221						
TOTAL FRAMES	524,288	524,288	524,288						
FIXED FRAMES				SHARED FRAMES AND SLOTS					
NUCLEUS	5,862	5,862	5,862	CENTRAL STORAGE					
SQA	15,632	15,777	15,685					264	643
LPA	88	89	88						424
CSA	11,108	11,203	11,119				FIXED TOTAL	0	0
LSQA	21,916	23,626	22,930				FIXED BELOW 16 M	0	0
REGIONS+SWA	21,201	22,181	21,629				AUXILIARY SLOTS	1,651	1,701
BELOW 16 MEG	843	916	880				TOTAL	1,915	2,344
BETWEEN 16M-2G	N/A	N/A	N/A						2,079
TOTAL FRAMES	76,292	78,574	77,314						

Figure 5-5. Monitor I Paging Activity Report - Page 2

Indicator

Field: HIGH UIC (AVG)

Description: Amount of time a page remains in central storage without being referenced. This indicates stress on central storage and ranges from a low of 0 to a high of 2540.

Guideline: Small values might indicate storage constraints, however, some systems have run perfectly well at low UICs.

Problem Area: Problems here would show up as delays caused by demand paging or swapping, or increased CPU overhead due to page movement. Also throughput of the system could drop, due to MPL adjustment.

Potential Solution: See “Decrease Storage Demand” on page 5-14.

Page/Swap Data Set Activity Report

PAGE / SWAP DATASET ACTIVITY														PAGE 1	
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996			
				RPT VERSION V1R2 RMF				TIME 09.29.00				CYCLE 1.000 SECONDS			
NUMBER OF SAMPLES = 898				PAGE DATA SET USAGE											

PAGE SPACE TYPE	VOLUME SERIAL	DEV NUM	DEVICE TYPE	SLOTS ALLOC	---- MIN	SLOTS USED MAX	--- AVG	BAD SLOTS	% IN USE	PAGE TRANS TIME	NUMBER IO REQ	PAGES XFER'D	V I O	DATA SET NAME	
PLPA	PAGP11	0378	33903	45000	16466	16466	16466	0	0.11	0.200	6	5		PAGE.OS04.APLPA	
COMMON	PAGP10	0377	33903	21240	5345	5378	5355	0	0.11	0.027	38	37		PAGE.OS04.ACOMMON	
LOCAL	PAGP12	0379	33903	566820	67670	70965	69140	0	2.67	0.004	711	5,697	N	PAGE.OS04.LOCAL01	
LOCAL	PAGP13	037A	33903	566820	65887	69007	67190	0	3.01	0.005	771	5,711	N	PAGE.OS04.LOCAL02	
LOCAL	PAGP14	037B	33903	566820	66611	69723	67928	0	3.01	0.005	821	5,625	Y	PAGE.OS04.LOCAL03	
LOCAL	PAGP15	038D	33903	566820	66296	69563	67618	0	3.23	0.005	726	5,523	Y	PAGE.OS04.LOCAL04	
LOCAL	PAGP16	039F	33903	566820	66390	69311	67560	0	3.12	0.005	766	5,548	Y	PAGE.OS04.LOCAL05	

Figure 5-6. Monitor I Page/Swap Data Set Activity Report

Note: Starting with OS/390 2.10, swap data sets are no longer supported. Therefore, the report contains information only about page data sets.

Storage analysis

Indicator

Field: SLOTS ALLOC and AVG SLOTS USED

Description: This tells you how much of your auxiliary storage space is used.

Guideline: Keep the percent of space used to around 30% (always below 50%) of the space allocated.

Indicator

Field: % IN USE

Description: This is the busy percentage for the data set.

Guideline: For page data sets, you may see response time increase if this number rises above 30%. If you have swap data sets defined, you may see response time increases if they are above 15%.

Problem Area: Increased time to satisfy a page request from DASD.

Potential Solution: See “Auxiliary Storage Tuning” on page 5-14

DASD Activity Report

D I R E C T A C C E S S D E V I C E A C T I V I T Y																				PAGE 1	
z/OS V1R2				SYSTEM ID OS04				DATE 06/05/2001				INTERVAL 14.59.996									
				RPT VERSION V1R2 RMF				TIME 09.29.00				CYCLE 1.000 SECONDS									
TOTAL SAMPLES =		1,807		IODF =		12		CR-DATE: 03/01/01				CR-TIME: 10.23.17									
STORAGE GROUP	DEV NUM	DEVICE TYPE	VOLUME SERIAL	PAV	LCU	DEVICE ACTIVITY RATE	AVG RESP TIME	AVG IOSQ TIME	AVG DPB DLY	AVG CUB DLY	AVG DB DLY	AVG PEND TIME	AVG DISC TIME	AVG CONN TIME	% DEV CONN	% DEV UTIL	% DEV RESV	AVG NUMBER ALLOC	% ANY ALLOC	% MT PEND	
	0377	33903	PAGP10		005F	0.044	20	0	0.0	0.0	0.0	1.9	16.5	1.8	0.01	0.08	0.0	1.0	100.0	0.0	
	0378	33903	PAGP11		005F	0.011	25	0	0.0	0.0	0.0	0.2	22.7	2.0	0.00	0.03	0.0	1.0	100.0	0.0	
	0379	33903	PAGP12		005F	0.805	32	0	0.0	0.0	0.0	1.7	17.9	12.5	1.01	2.45	0.0	1.0	100.0	0.0	
	037A	33903	PAGP13		005F	0.863	32	0	0.0	0.0	0.0	1.4	18.2	12.2	1.05	2.62	0.0	1.0	100.0	0.0	
	037B	33903	PAGP14		005F	0.915	31	0	0.0	0.0	0.0	1.4	17.9	11.3	1.04	2.68	0.0	1.0	100.0	0.0	
	038D	33903	PAGP15		0060	0.819	33	0	0.0	0.0	0.0	1.6	18.8	13.0	1.07	2.60	0.0	1.0	100.0	0.0	
	039F	33903	PAGP16		0060	0.854	33	0	0.0	0.0	0.0	1.8	19.7	11.9	1.02	2.70	0.0	1.0	100.0	0.0	

Figure 5-7. Monitor I DASD Activity Report

Indicator

Only DASD volumes used for paging and swapping are of interest in this section. See Chapter 4. Analyzing I/O Activity for analysis of other I/O.

Field: AVG RESP TIME

Description: This will show overall response time (ms) for these volumes.

Related Field: DEVICE ACTIVITY RATE, Monitor III page/swap delay % values.

Guideline: Typical response times for page/swap volumes are in the 30-40 ms range. If your response times are significantly higher you may want to investigate.

Problem Area: Problems here would add page or swap delay to your important workloads.

Potential Solution: See “Auxiliary Storage Tuning” on page 5-14

General Storage Recommendations

This section gives actions you may want to consider to improve your processor storage performance. Before you start, bear in mind the following;

- The first priority of tuning is to make the best use of your resources.
- After this, prioritizing workload is even more critical as you will be stealing from one workload to give to another.

Decrease Storage Demand

- Reduce AS buffer sizes and use hiperspace buffering. Consider:
 - VSAM
 - DB2 hiperpools
 - PDSE with low MSR values specified
- Reduce MPL
 - Activate RCCPTRT values in IEAOPTxx
 - Decrease number of initiators
- Decrease the number of active AS by trimming CICS AS, IMS MPRs. Maybe reducing MAXUSERS keyword at IPL.
- Use IEFUSI to limit the use of AS private area (region).
- Decrease other work (for example, monitors).

Increase Storage

- Take central storage from another partition, or install more.

Auxiliary Storage Tuning

- Reduce paging (see above).
- Dedicate volumes to page data sets.
- Distribute page data sets among channel paths and control units.
- Limit use of VIO=YES.
- Add more LOCALs. Make the sum of all the page space 2 to 4 times the number of slots used.
- Use faster devices.

Prioritize Access to Processor Storage

- Make better use of the PLPA by removing unused modules and verify that concatenated libraries are needed (LPALSTxx).
- Decrease the page fixing level. RMF tells you the cause of the problem at PRIV-FF in the ARD Monitor II report.
- Adjust criteria age values via IEAOPTxx, this can be used to direct pages from CS to AUX.
- Use the storage protection specification in the service policy.

Tune DASD

- Tuning 'normal' DASD I/O reduces storage requirements. Transactions will complete faster, needing less virtual and processor storage.

Summary

To analyze storage problems you should:

- View the system as a whole and not rely on individual guidelines.

As we have said before the main thing is: Are your SLA targets being met? If not, and storage is the problem then:

- Ensure the storage is being used fully and start looking at prioritizing access.
- Use the recommendation checklist with the *z/OS MVS Initialization and Tuning Reference*.
- Only change one value at a time and monitor its effect before making any other change.

Storage analysis

Chapter 6. Analyzing Sysplex Activity

Let's Analyze Your Sysplex

This chapter discusses some special performance aspects in a sysplex:

- How to understand CICS and IMS workload reports
- Analyzing coupling facility activities

Understanding Workload Activity Data for IMS or CICS

This chapter provides an explanation of some Workload Activity report data for work managers. RMF provides data for the subsystem work managers that support workload management. In z/OS MVS, these are IMS and CICS. You find these values either in the Monitor III Work Manager Delays report or in the Postprocessor Workload Activity report. The following examples will describe the Workload Activity report.

This section provides some sample reports for CICS and IMS, followed by some potential problem data and explanations. Based on the explanations, you may decide to alter your service class definitions. In some cases, there may be some actions that you can take. In those cases, you can follow the suggestion. In other cases, the explanations are provided only to help you better understand the data.

Interpreting the Workload Activity Report

CICS Service Class Accessing DBCTL

Figure 6-1 shows an example of the work manager state section for a service class representing CICS transactions accessing Database Control (DBCTL). The paragraphs below explain the data.

REPORT BY: POLICY=HPTSPOL1																		WORKLOAD=PRODWKLD				SERVICE CLASS=CICSHR				RESOURCE GROUP=*NONE				PERIOD=1				IMPORTANCE=HIGH									
-TRANSACTIONS--																		TRANSACTION TIME				HHH.MM.SS.TTT																					
AVG		0.00		ACTUAL		000.00.00.114																																					
MPL		0.00		QUEUED		000.00.00.036																																					
ENDED		216		EXECUTION		000.00.00.078																																					
END/SEC		0.24		STANDARD DEVIATION		000.00.00.270																																					
#SWAPS		0																																									
EXECUTD		216																																									
-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																																											
SUB		P		TOTAL		ACTIVE		READY		IDLE		-----WAITING FOR-----												-----STATE-----																			
TYPE												LOCK		I/O		CONV		DIST		LOCAL		SYSPL		REMO		TIMER		PROD		MISC		SWITCHED TIME (%)											
CICS		BTE		93.4		10.2		0.0		0.0		0.0		0.0		83.3		0.0		0.0		0.0		0.0		0.0		0.0		83.3		0.0		0.0									
CICS		EXE		67.0		13.2		7.1		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		46.7		0.0		0.0		0.0		0.0									

Figure 6-1. Hotel Reservations Service Class

The fields in this report describe the CICSHR service class. CICS transactions have two phases:

- The *begin-to-end phase* (CICS BTE) takes place in the first CICS region to begin processing a transaction. Usually this is the terminal owning region (TOR). The TOR is responsible for starting and ending the transaction.
 - The ENDED field shows that 216 hotel reservation transactions completed.
 - The ACTUAL time shows that the 216 transactions completed in an average response time of 0.114 seconds.
- The *execution phase* (CICS EXE) can take place in an application owning region (AOR) and a file owning region (FOR). In this example, the 216 transactions were routed by a TOR to an AOR.
 - The EXECUTD field shows that the AORs completed 216 transactions in the interval.
 - The EXECUTION time shows that on average it took 0.078 seconds for the AORs to execute the 216 transactions. The EXECUTION time applies only to the EXECUTD transactions.

While executing these transactions, the CICS subsystem records the states the transactions are experiencing. RMF reports the states in the RESPONSE TIME BREAKDOWN IN PERCENTAGE section of the report. Because there is a CICS BTE and a CICS EXE field, you can assume that the time spent in the TOR represents the BTE phase, and the time spent in the AOR represents the EXE phase. There is one EXE phase summarizing all the time spent in one or more AORs. Figure 6-2 shows the response time break down of the CICS service class.

Response Time = 0.114 = 100%

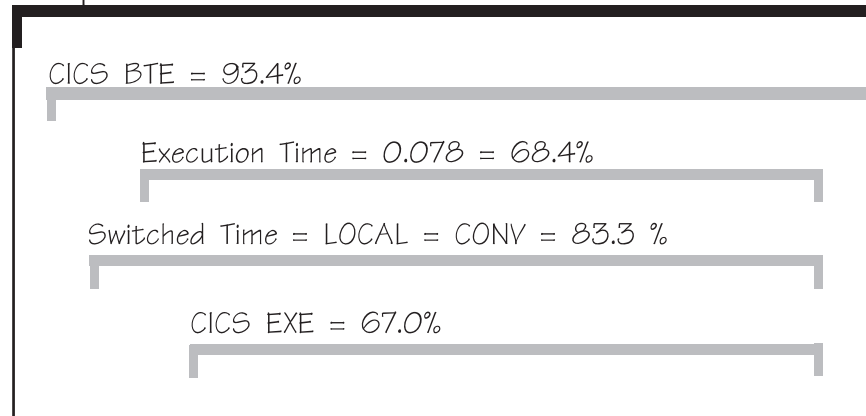


Figure 6-2. Response Time Breakdown of CICS service class accessing DBCTL

The CICS BTE field shows that the TORs have information covering 93.4% of the response time. RMF does not have information covering 100% of the response time because it takes some time for the system to recognize and assign incoming work to a service class before it can collect information about it.

For most of the 93.4% of the time, the transactions were not being run in the TOR, but had been routed locally, to an AOR on the same MVS image. You can see this by the SWITCHED TIME % LOCAL field, which is 83.3 %. This value is close, if not equal, to the WAITING FOR CONV field, which indicates that there is no delay in the TOR once the AOR has returned the transactions.

The total execution time is some percentage of the total response time. It is the EXECUTION transaction time (0.078) divided by the ACTUAL transaction time (0.114) which is 68.4%. The CICS execution phase (CICS EXE field) covers 67% of the response time. Some of that time the work is active in the AOR, sometimes it is waiting behind another task in the region, but 46.7% (PROD field) of the response time is spent outside of the CICS subsystem, waiting for another product to provide some service to these transactions. Based on the configuration of the system, the transactions are accessing DBCTL.

The WAITING FOR LOCAL, SYSPL, and REMOT states percentages show the percentage of the response time the service class was delayed when CICS was waiting to establish a session. The STATE percentages LOCAL, SYSPL, and REMOT show the percentage of the response time during which transactions were routed via MRO, MRO/XCP, or VTAM connections.

CICS Service Class Accessing DBCTL with IMS V5

Figure 6-3 shows an example of a Workload Activity report for a CICS service class representing point-of-sale transactions (CICSPS). This example builds on the

Understanding WLM

example in Figure 6-1 on page 6-2. It shows how the RMF report changes when IMS is upgraded to Version 5.

REPORT BY: POLICY=WSTPOL02		WORKLOAD=CICS		SERVICE CLASS=CICSPS												
RESOURCE GROUP=*NONE		PERIOD=1		IMPORTANCE=HIGH												
-TRANSACTIONS--		TRANSACTION TIME		HHH.MM.SS.TTT												
AVG	0.00	ACTUAL		000.00.00.503												
MPL	0.00	QUEUED		000.00.00.104												
ENDED	579	EXECUTION		000.00.00.399												
END/SEC	0.95	STANDARD DEVIATION		000.00.00.847												
#SWAPS	0															
EXECUTD	559															

-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																
		-----WAITING FOR-----												-----STATE-----		
SUB	P	TOTAL	ACTIVE	READY	IDLE	LOCK	I/O	CONV	DIST	LOCAL	SYSPL	REMOT	TIMER	PROD	MISC	SWITCHED TIME (%)
CICS	BTE	96.6	2.4	0.1	0.0	0.0	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.2 0.0 0.0
CICS	EXE	29.2	14.2	4.1	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.0 0.0 0.0
IMS	EXE	43.7	40.3	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 0.0 0.0

Figure 6-3. Point-of-Sale Service Class

The ENDED field shows that 579 point-of-sale transactions completed. The ACTUAL time shows that those transactions completed in an average response time of 0.503 seconds.

The EXECUTD field shows that the AORs completed 559 transactions in the interval. This is less than the ENDED value because a TOR may not always route all transactions to an AOR. Those non-routed transaction are not counted as EXECUTD. The EXECUTION field shows that on average it took the AORs 0.399 seconds to execute the 559 transactions.

While executing these transactions, the CICS subsystem reports the states the transactions are experiencing. Figure 6-4 shows the response time breakdown of the CICSPS service class.

Response Time = 0.503 = 100%

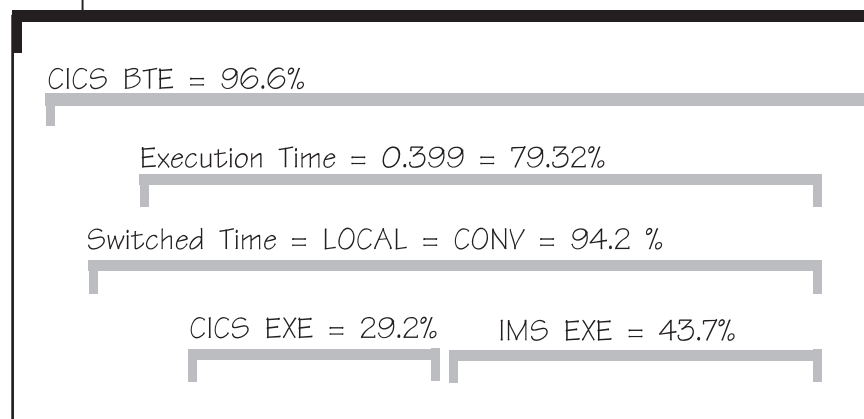


Figure 6-4. Response Time Breakdown of CICSPS accessing DBCTL with IMS V5

The report shows that there is CICS BTE information. This means that the TORs have information covering 96.6% of the response time. Most of that time, the

transactions were in fact not being run in the TOR, but had been routed locally, to an AOR on the same MVS image. You can see this by the SWITCHED TIME % LOCAL field, which is 94.2 %.

The EXECUTION transaction time (0.399) divided by the ACTUAL transaction time (0.503) is 79.32%. There are two execution phases shown: a CICS EXE, and an IMS EXE. The CICS execution phase covers only 29.2% of the response time. That is lower than in the previous example, because now IMS is providing information. The IMS EXE row shows the 43.7% of the response time for which it is responsible.

CICS Accessing Data via FORs

Figure 6-5 shows an example of a Workload Activity report for some CICS user transactions which have data accessed via file owning regions.

REPORT BY: POLICY=EQUALIMP WORKLOAD=CICS SERVICE CLASS=CICUSRTX																		
RESOURCE GROUP=*NONE PERIOD=1 IMPORTANCE=HIGH																		
-TRANSACTIONS-- TRANSACTION TIME HHH.MM.SS.TTT																		
AVG		0.00	ACTUAL		000.00.00.093													
MPL		0.00	QUEUED		000.00.00.024													
ENDED		14119	EXECUTION		000.00.00.069													
END/SEC		47.17	STANDARD DEVIATION		000.00.00.063													
#SWAPS		0																
EXECUTD		13067																
-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																		
-----WAITING FOR-----																		
SUB	P	TOTAL	ACTIVE	READY	IDLE	LOCK	I/O	CONV	DIST	LOCAL	SYSPL	REMO	TIMER	PROD	MISC	STATE		
																SWITCHED TIME (%)		
TYPE																LOCAL	SYSPL	REMO
CICS	BTE	90.5	2.7	3.5	0.2	0.0	3.6	80.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.6 0.0 0.0		
CICS	EXE	67.2	4.7	2.6	0.0	0.1	59.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.9 0.0 0.0		

Figure 6-5. CICS User Transactions Service Class

In this example 14,119 transactions completed with a response time of 0.093 seconds. Only 13,067 were executed by AORs in the interval. Others ran completely in the TOR.

The CICS execution phase contains information about the transactions while they were running in either the AOR or FOR. This shows that 59.8% of the response time for these transactions was spent waiting for I/O completion. It is not possible to describe whether this time was for I/O initiated by the FOR, or for I/O initiated within the AOR. However, the SWITCHED value in the CICS EXE field says that for 40.9% of the response time, one of those regions was waiting for the other region to complete some processing for the transaction before the original region could proceed.

Understanding WLM

Problem: Very Large Percentages in the Response Time Breakdown

Figure 6-6 shows an example of a work manager state section for the CICSPROD service class. In the RESPONSE TIME BREAKDOWN IN PERCENTAGE section of the report, both the CICS EXE and the CICS BTE rows show excessively inflated percentages: 78.8K, 183, 1946 and so on.

REPORT BY: POLICY=HPTSPOL1 WORKLOAD=PRODWKLD SERVICE CLASS=CICSPROD																	
RESOURCE GROUP=*NONE PERIOD=1 IMPORTANCE=HIGH																	
-TRANSACTIONS--		TRANSACTION TIME		HHH.MM.SS.TTT													
AVG	0.00	ACTUAL	000.00.00.111														
MPL	0.00	QUEUED	000.00.00.000														
ENDED	1648	EXECUTION	000.00.00.123														
END/SEC	1.83	STANDARD DEVIATION	000.00.00.351														
#SWAPS	0																
EXECUTD	1009																
-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																	
-----WAITING FOR-----																	
		TOTAL	ACTIVE	READY	IDLE	LOCK	I/O	CONV	DIST	LOCAL	SYSPL	REMO	TIMER	PROD	MISC	-----STATE-----	
SUB	P															SWITCHED TIME (%)	
TYPE																LOCAL	SYSPL
CICS	BTE	78.8K	183	265	1946	0.0	0.0	235	0.0	0.0	0.0	0.0	0.0	0.0	76.2K	229	0.0
CICS	EXE	140	91.8	3.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	45.4	0.0	19.6K	0.0

Figure 6-6. Response Time Percentages Greater than 100

Possible Explanations

Long-running Transactions: The report above shows how long-running transactions can inflate the response time percentages. While the following example does not explain the exact values in the figure, it explains why this is possible.

Suppose 100 transactions have ended within 1 second, and one transaction has been running for 5 minutes and is still executing when the RMF interval expires. The ACTUAL transaction time shows an average response time of 1 second, and RMF shows the response time breakdown into the states recorded by CICS or IMS. The subsystem, however, recorded a total of 6 minutes and 40 seconds (5 minutes plus 100 seconds) worth of data. That is an average of 4 seconds worth of data for each completed transaction — which is 4 times the 1 second response time. The response time percentage breakdown shows information representing 400% of the response time.

Also, when the one long-running transaction completes, it could easily distort the average response time during that interval. The RMF standard deviation and distribution of response times emphasizes when this occurs.

The long-running transactions could be either routed or non-routed transactions. Routed transactions are transactions that are routed from a TOR to any AOR. Long-running routed transactions could result in many samples of WAITING FOR CONV (waiting for a conversation) in the CICS BTE phase, as well as states recorded from the AOR in the execution phase.

Long-running non-routed transactions execute completely in a TOR, and have no CICS EXE phase data, and could inflate any of the state data for the CICS BTE phase.

Never-ending Transactions: Never-ending transactions differ from long-running transactions in that they persist for the life of a region. For CICS, these could include the IBM reserved transactions such as CSNC and CSSY, or customer defined transactions. Never ending transactions are reported similarly to

long-running transactions explained in “Long-running Transactions” on page 6-6. However, for never-ending CICS transactions, RMF might report large percentages in the IDLE, WAITING FOR TIMER, or the WAITING FOR MISC (miscellaneous) fields.

Conversational Transactions: Conversational transactions are considered long-running transactions. CICS marks the state of a conversational transaction as IDLE when the transaction is waiting for terminal input. Terminal input often includes long end-user response time, so you might see very large values in the IDLE state as a percent of response time for completed transactions.

Service Class Includes Dissimilar Work: A service class that mixes customer and IBM transactions, short and long or never-ending transactions, routed and non-routed transactions, or conversational and non-conversational transactions can expect to have RMF reports showing that the total states sampled account for more than the average response time. This could be true for both IMS and CICS, and can be expected if the service class is the subsystem default service class. The default is defined in the classification rules as the service class to be assigned to all work in a subsystem not otherwise assigned a service class.

Possible Actions

Group Similar Work into Service Classes: Make sure your service classes represent a group of similar work. This could require creating additional service classes. For the sake of simplicity, you can have only a small number of service classes for CICS or IMS work. If there are transactions for which you want the RMF response time breakdown data, consider including them in their own service class.

Do Nothing: For service classes representing dissimilar work such as the subsystem default service class, understand that the response time breakdown could include long-running or never-ending transactions. RMF data for such service classes may not make immediate sense.

Understanding WLM

Problem: Response Time Breakdown Data is All Zero

Figure 6-7 shows an example of a work manager state section for the CICSLONG service class. All fields show a 0.0 value.

REPORT BY: POLICY=HPTSPOL1 WORKLOAD=PRODWKLD SERVICE CLASS=CICSLONG																		
RESOURCE GROUP=*NONE PERIOD=1 IMPORTANCE=HIGH																		
CICS Long Running Internal Trxs																		
-TRANSACTIONS-- TRANSACTION TIME HHH.MM.SS.TTT																		
AVG		0.00	ACTUAL		000.00.00.000													
MPL		0.00	QUEUED		000.00.00.000													
ENDED		0	EXECUTION		000.00.00.000													
END/SEC		0.00	STANDARD DEVIATION		000.00.00.000													
#SWAPS		0																
EXECUTD		0																
-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																		
SUB		P	TOTAL	ACTIVE	READY	IDLE	-----WAITING FOR-----									-----STATE-----		
TYPE							LOCK	I/O	CONV	DIST	LOCAL	SYSPL	REMO	TIMER	PROD	MISC	SWITCHED TIME (%)	
CICS		BTE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 0.0 0.0	

Figure 6-7. Response Time Breakdown Percentages all Zero

Possible Explanations

No Transactions Completed: While a long-running or never-ending transaction is being processed, RMF stores the service class state samples in SMF 72.3 records. But when no transactions have completed, the average response time is 0. Then the calculations for the response-time breakdown result in 0.

RMF did not Receive Data from all Systems in the Sysplex: The Postprocessor may have been given SMF records from only a subset of the systems running in the sysplex. The report may represent only a single MVS image. If that MVS image has no TOR, its AORs receive CICS transactions routed from another MVS image or from outside the sysplex. Since the response time for the transactions is reported by the TOR, there is no transaction response time for the work, nor are there any ended transactions, on this MVS image.

Possible Actions

Do Nothing: You may have created this service class to prevent the state samples of long-running transactions from distorting data for your production work.

Combine all SMF Records for the Sysplex: When a single MVS image that does not have TORs is combined with another MVS image that does, the states from the first image will be combined by RMF with the response times from the second so that the response time distribution data will no longer be reported as zero.

Problem: More Executed Transactions Than Ended Transactions

In an IMS TM environment, the control region counts the number of ended transactions, and provides the actual response time information. The message processing program (MPP) counts the number of executed transactions, and provides the execution time. IMS provides only EXE phase information. There is no BTE phase information for IMS work.

Figure 6-8 shows an example of a work manager data section for the IMSTRX service class. The EXECUTD field shows that 5312 transactions have finished executing while the ENDED field shows that only 5212 have been ended by the CTL region.

REPORT BY: POLICY=WSTPOL01		WORKLOAD=IMS		SERVICE CLASS=IMSTRX														
-TRANSACTIONS--		TRANSACTION TIME		HHH.MM.SS.TTT														
AVG	0.00	ACTUAL		000.00.00.133														
MPL	0.00	QUEUED		000.00.00.026														
ENDED	5212	EXECUTION		000.00.00.107														
END/SEC	5.79	STANDARD DEVIATION		000.00.00.512														
#SWAPS	0																	
EXECUTD	5312																	
-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																		
		-----WAITING FOR-----										-----STATE-----						
SUB	P	TOTAL	ACTIVE	READY	IDLE	LOCK	I/O	CONV	DIST	LOCAL	SYSPL	REMO	TIMER	PROD	MISC	SWITCHED TIME (%)		
TYPE																LOCAL	SYSPL	REMO
IMS	EXE	82.4	80.8	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 6-8. Executed Transactions greater than Ended Transactions

Possible Explanations

IMS Program-to-Program Switches: When an IMS transaction makes a program-to-program switch, the switched work can be considered either a new transaction, or a continuation of the originating transaction. The system checks the classification rules for the service class to be associated with the switched work.

If the service class is the same as the originating transaction, it is processed in the MPP, and it is counted as an executed transaction (EXECUTD). When the response is sent back to the network, RMF shows two executed transactions: the originating and the switched work, but only a single ended transaction (ENDED). Here, the number of executed transactions exceeds the number of ended transactions.

If the service class is different from the original transaction, then RMF counts it as a new transaction with its own EXECUTD and END. Here, the executed transaction value and ended value agree.

RMF Processed only Part of the Entire Sysplex Data: It is possible to invoke the Postprocessor, giving it SMF records from just part of a sysplex — for example a single MVS image. Suppose that MVS image has no TOR, but its AORs just receive CICS transactions routed from another MVS image. Since the transaction ends in the TOR, but is executed in the AOR, there will be no ended transactions for the CICS service class from this MVS image.

Snapshot Data is not always Complete: The Workload Activity report contains "snapshot data", which is data collected over a defined interval. For IMS, in a given interval, several transactions may have already executed in an MPP, but the control region may not have reported their completion yet. Similarly for CICS, the AOR

Understanding WLM

could have finished executing a transaction, but the TOR may not have completed processing and reporting the completion. Thus, RMF may show more executed transactions than completions.

Possible Actions

Classify IMS Transactions Uniquely: When an IMS transaction makes a program-to-program switch, the system checks the classification rules for the service class to be associated with the transaction. You can classify the switched transactions to a service class different from the service class of the originating transaction. RMF then counts a new transaction, with its own execution and end.

This way, the execution and ended values agree, and the RMF data is consistent with the data reported in the IMS Performance Analysis and Reporting System (IMSPARS). IMSPARS includes transaction timings, analysis reports, and detailed reports tracing individual transaction and database change activity. Classifying the program-to-program switched transaction to a unique service class might be useful for asynchronous program-to-program switches.

Combine all SMF Records for the Sysplex: When a single MVS image that doesn't have TORs is combined with another MVS image that does, the executed transactions from the first image will be combined by RMF with the ended transactions from the second so that the sysplex-wide report is consistent.

Problem: Execution Time is Greater Than Response Time

Figure 6-9 shows an example of a work manager state section for the CICSPROD service class. In the example, there is a response time of .091 seconds, but an execution time of .113 seconds. The example also shows 1731 ENDED transactions, yet the EXECUTD field shows that only 1086 have been executed.

```
REPORT BY: POLICY=HPTSPOL1  WORKLOAD=PRODWKLD  SERVICE CLASS=CICSPROD
RESOURCE GROUP=*NONE        PERIOD=1  IMPORTANCE=HIGH
                                CICS Trans not classified singly

-TRANSACTIONS-- TRANSACTION TIME  HHH.MM.SS.TTT
AVG          0.00  ACTUAL          000.00.00.091
MPL          0.00  QUEUED          000.00.00.000
ENDED       1731  EXECUTION        000.00.00.113
END/SEC      1.92  STANDARD DEVIATION 000.00.00.092
#SWAPS        0
EXECUTD      1086
```

Figure 6-9. Execution Time Greater than Response Time

Possible Explanation

Mixing Routed and Non-routed CICS Transactions: The AORs may have recorded states which account for more time than the average response time of all the transactions. The response time breakdown shown by RMF for the execution phase of processing can again show percentages exceeding 100% of the response time. The non-routed transactions do not show up in the EXE phase. In addition, most non-routed transactions end very quickly, and decrease the actual response time. The response time (ACTUAL field) shows 0.091 seconds as the average of all 1731 transactions, while the AORs can only describe the execution of the 1086 they participated in. The response time breakdown may also show very inflated percentages, as the actual response time is distorted by the fast non-routed transactions.

Possible Actions

Classify Routed and Non-routed Transactions to different Service Classes: This would keep the numbers consistent with the expectation.

Understanding WLM

Problem: Large SWITCH Time in CICS Execution Phase

Figure 6-10 shows a work manager state data section for a CICSPROD service class. The SWITCH LOCAL time in the response time breakdown section shows a value of 6645.

REPORT BY: POLICY=HPTSPOL1 WORKLOAD=PRODWKLD SERVICE CLASS=CICSPROD																	
RESOURCE GROUP=*NONE PERIOD=1 IMPORTANCE=HIGH																	
-TRANSACTIONS--		TRANSACTION TIME		HHH.MM.SS.TTT													
AVG	0.00	ACTUAL	000.00.00.150														
MPL	0.00	QUEUED	000.00.00.016														
ENDED	3599	EXECUTION	000.00.00.134														
END/SEC	4.00	STANDARD DEVIATION	000.00.00.446														
#SWAPS	0																
EXECUTD	2961																
-----RESPONSE TIME BREAKDOWN IN PERCENTAGE-----																	
		-----WAITING FOR-----												-----STATE-----			
SUB	P	TOTAL	ACTIVE	READY	IDLE	LOCK	I/O	CONV	DIST	LOCAL	SYSPL	REMO	TIMER	PROD	MISC	LOCAL	SYSPL
TYPE																REMO	
CICS	BTE	26.8K	75.1	98.4	659	0.0	0.3	154	0.0	0.0	0.0	0.0	0.0	0.0	25.8K	149	0.0
CICS	EXE	93.7	38.6	5.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	49.4	0.0	6645	0.0

Figure 6-10. High SWITCH time in a CICS Execution Environment

Possible Explanations

Distributed Transaction Processing: If a program initiates Distributed Transaction Processing to multiple back-end sessions, there can be many AORs all associated with the original transaction. Each of these multiple back-end regions can indicate they are switching control back to the front-end region (SWITCH to another region on the LOCAL MVS image, or to a region on another MVS image in the sysplex). Thus, with a one-to-many mapping like this, there are many samples of the execution phase of requests switched — long enough to exceed 100% of the response time of other work completing in the service class.

Distributed Program Link (DPL): The distributed program link function from CICS/ESA 3.3 builds on the distributed transaction functions available in CICS by enabling a CICS program (the client program) to call another program (the server program) in another CICS region.

While the server program is running, the client program will reflect it is switched to another CICS region.

Possible Actions

None:

Problem: Decreased Number of Ended Transaction with Increased Response Times

The Workload Activity report shows increased response times, and a decrease in the number of ended transactions over a few days.

Possible Explanation

Conversion from ISC Link to MRO: When two CICS regions are connected via a VTAM inter-system communication (ISC) link, they behave differently than when they are connected via multi-region (MRO) option. One key difference is that, with ISC, both the TOR and the AOR are receiving a request from VTAM, so each believes it is starting and ending a given transaction.

So for a given user request routed from the TOR via ISC to an AOR, there would be 2 completed transactions. Let us assume they have response times of 1 second and .75 seconds for an average of .875 seconds.

When the TOR routes via MRO, the TOR will describe a single completed transaction taking 1 second, and the AOR will report its .75 seconds as execution time. Therefore, converting from an ISC link to an MRO connection, for the same workload, as shown in this example, could result in half the number of ended transactions and an increase in the response time reported by RMF. The difference could be much more significant if the AOR to FOR link was converted.

Migration of an AOR to CICS 4.1: CICS 4.1 has extended the information it passes between regions involved in processing a given transaction. If all the regions are at the 4.1 level, this allows RMF to report the number of ended transactions as just those that have completed in the TOR. But if there is a mixture of release levels involved, this is not guaranteed.

Let us assume that the TOR and FOR have been upgraded to release 4.1, but the AOR has not yet been upgraded. When the TOR receives a transaction, it will determine the service class. Then when it calls the AOR, it will pass that service class information.

But since the AOR is not yet at a 4.1 level, the AOR has no code that passes this service class along to the FOR. So when the FOR is invoked, it believes it is starting a new transaction and must classify the request to a service class. When the FOR finishes processing, it states that it has completed the transaction. Later the TOR also states that it has completed the transaction. This results in RMF showing multiple completions for a given end-user transaction (one completion from the TOR, and one completion for each invocation of the FOR), with an average response time less than the value the TOR alone is reporting.

When the AOR is migrated to CICS 4.1, it will pass the service class to the FOR. The FOR recognizes that it is participating in executing some portion of the original end-user transaction. When the FOR returns to the AOR, and the AOR returns to the TOR, there will be just one ended transaction recorded for RMF. Its response time will be the time from reception in the TOR until the TOR has completed.

So RMF data will show a reduced number of transactions executed and a larger response time after the AOR is migrated to CICS 4.1 — even when the end-user request is processed in exactly the same elapsed time.

Understanding WLM

Possible Action

Increase CICS Transaction Goals: Do this prior to your conversion to an MRO connection, or prior to migrating your AOR to CICS 4.1, if the FOR transactions are classified to the same service class as your end-user transactions.

Analyzing Coupling Facility Activity

Using the Postprocessor Report

This chapter gives guidelines for some indicators when monitoring the coupling facility.

Usage Summary Section

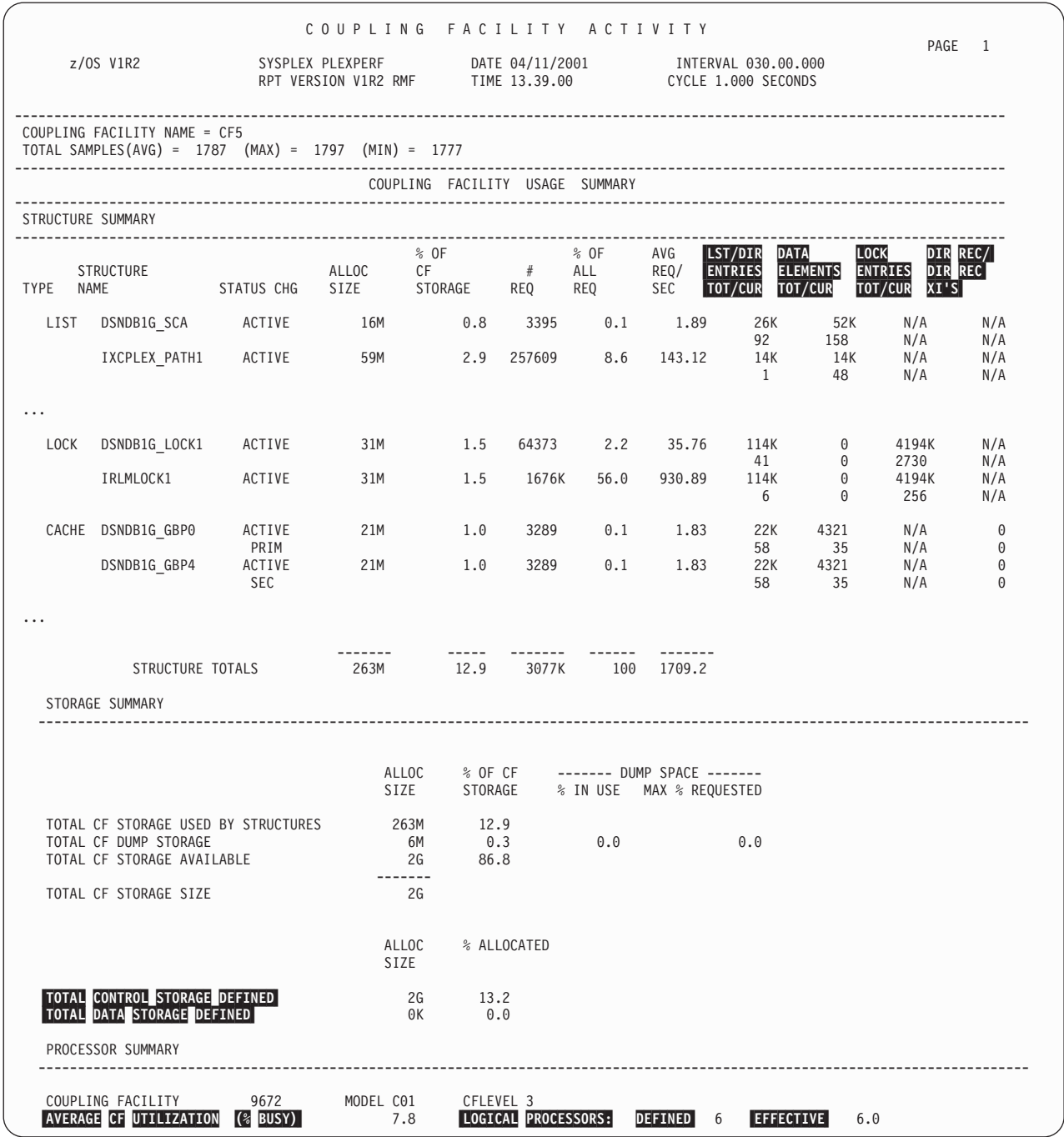


Figure 6-11. Coupling Facility Activity Report - Usage Summary

Coupling facility performance

The Usage Summary part of the report gives summary data for the structures, the storage and the processors.

Indicator

Fields:

LST/DIR	DATA	LOCK
ENTRIES	ELEMENTS	ENTRIES
TOT/CUR	TOT/CUR	TOT/CUR

Description: The first column reports on list entries defined and in use OR directory entries defined and in use, dependent on the type of structure. Similarly, the second column reports on the data elements defined and in use in the structure. The third column reports on lock entries.

The information presented on this report can be used to validate the size of various types of structures. In most cases, some knowledge of the structure is required to interpret the data.

- Cache structures

The CUR in-use values will indicate if the structure is overlarge (if it never fills up) or misproportioned in terms of entry to element ratio (one never fills up but the other does). It will not help in knowing if the structure is too small (i.e. 100% full is normal). To know if the structure is too small you have to look at reclaiming and perhaps hit ratios.

- List structures

Some list structures, like the JES2 checkpoint structure, are very static in size if not content/ static data. For these structures, the TOT can be only slightly larger than CUR. Other functions, like the MVS logger, offload data as the structure fills up. The threshold which triggers the offload is based on parameters associated with the function. The ratio of CUR to TOT should not be higher than this threshold. Other list structures, such as the XCF structure and the VTAM Generic Resource structure, must handle large peaks of data. For these structures, the TOT should be much larger than the CUR in-use to prevent backups of signals during spikes.

- Lock structures

Lock structures, like the IRLM lock structures, are divided in two parts: The actual lock table contains the number of entries in the LOCK ENTRIES TOT column. The number of LOCK ENTRIES CUR is a sampled value of the number in use at the end of the interval. The best way to evaluate the size of this table is to look at the FALSE CONTENTION data for the lock structure on the Coupling Facility Structure Activity report, as described later in this document.

The second part of the lock structure contains RECORD DATA entries. The number of these entries is reported in the LIST ENTRIES column. If there are not enough of these entries, you will not be able to obtain locks, and transactions will start failing at that point.

IRLM provides no external means of apportioning the structure storage between record data and locks; you can only obtain adequate entries for both parts by judiciously choosing the size of the lock structure. The easiest way to do this is to use the lookup tables in INFOSYS Q662530.

Indicator**Field:** DIR RECLAIMS - DIR RECLAIMS XI'S

Description: All cache structures have directory entries and may or may not have data entries (for example, IMS OSAM and VSAM cache structures have only directory entries; while RACF and DB2 cache structures have both directory and data entries.). N/A, for not applicable, will be displayed in the directory reclaim column for list and lock structures.

A cache structure can be over committed by the data base managers. This occurs when the total number of unique entities cached by the data base managers exceeds the number of directory entries in the cache structure. Whenever a shortage of directory entries occurs, the coupling facility will reclaim in-use directory entries associated with unchanged data. These reclaimed items will be used to satisfy new requests for directory entries by the data base manager. (Directory entries are used by the data base manager to ensure data validity). For the coupling facility to reclaim a directory entry, all users of the data item represented by the directory entry must be notified their copy of the data item is invalid. As a consequence, when the data base manager needs access to the now invalidated data item, the item must be re-read from DASD and registered with the coupling facility. When there are insufficient directory entries, the directory reclaim activity can lead to "thrashing". (The situation is analogous to real storage shortages and page stealing in MVS.) Directory reclaim activity can result in the following:

- Increased read I/O activity to the data base to re-acquire a referenced data item.
- Increased CPU utilization caused by registered interest in data items having to be re-acquired.
- Elongated transaction response times whenever a read miss occurs in the local buffer pool.

Directory reclaim activity can be managed by increasing the number of directory entries for a particular structure. This can be accomplished by:

- Increasing the size of the structure. For directory only structures, only the number of directory entries is affected (i.e. IMS OSAM and VSAM structures). For structures with data elements and directory entries, both will increase in the ratio specified by the structure user (i.e. RACF structures).
- Changing the proportion of the structure space used for directory entries and data elements. This action is dependent on the structure users' implementation. Some cache structure exploiters allow the installation to specify the ratio of directory entries to data entries, which it internally maps to a ratio of directory entries to data elements (a data entry may be composed of multiple data elements). DB2 provides this capability. On the other hand, RACF is hard coded to organize the structure in a 1:1 ratio of directory entries to data elements.

If the cache structure directory to data element ratio is installation specifiable AND there are ample data elements, then one can increase the number of directory entries at the expense of data elements without a performance impact, and without increasing the structure size. Determining the impact of decreasing the number of data items is at best an inexact science. Unless the Structure Summary report indicates a consistent difference between the total and current number of data elements, it is difficult to estimate the impact of changing the

Coupling facility performance

directory entry to data element ratio. The CUR value reported by RMF is not a highwater value or average value during the interval, it is the number in use at the end of the interval.

The usual causes for directory reclaim activity are:

1. Initial structure size is insufficient to support the amount of local buffering.
2. Increasing the size of the local buffer pools without an accompanying increase in structure size.
3. Increasing the number of users of the structure without an accompanying increase in structure size.

The advice here is to monitor trends. If directory reclaims are increasing and response time is impacted, take appropriate action.

The second value in this column is the number of reclaims that caused an XI (see page 6-25). A high value is an indicator for a performance problem in this structure.

Indicator

Field: STRUCTURE SUMMARY - TOTAL CONTROL/DATA STORAGE DEFINED

Description: The amount of coupling facility storage that is allowed to be occupied by control information (CONTROL STORAGE) or data (DATA STORAGE).

Guideline: Each structure plus the dump area is allocated some control storage and some data storage. The coupling facility defines an area called control storage; structure control information is restricted to that area. The remaining storage is called data storage and is used for structure data. If the data storage area becomes full, structure data can then be allocated from the control storage area. If TOTAL DATA STORAGE DEFINED is zero, it means control information can reside anywhere on the coupling facility and there are no allocation restrictions.

If % ALLOC field for control storage shows a percentage approaching 100, it means the control storage is close to being completely allocated even though the CF SPACE AVAILABLE field may still show an amount of total free space. Possible actions include:

- Changing structure preference lists in the coupling facility policy specification to direct some structures away from this facility
- Adding another coupling facility to the sysplex

Indicator

Fields: AVERAGE CF UTILIZATION (%BUSY) LOGICAL PROCESSORS DEFINED / EFFECTIVE

Description: These fields report on the average CPU utilization of the CPs supporting the coupling facility partition, and in addition, on the number of logical processors assigned to the partition and the effective number of logical processors active during the RMF interval.

Coupling facility performance

For example, if a CEC contains six CPs, and a test coupling facility LPAR has two logical CPs, but is capped at 5% of the CEC, then the LOGICAL PROCESSORS DEFINED will be 2 and the EFFECTIVE LOGICAL PROCESSORS number will be 0.3 (if the partition is uncapped the EFFECTIVE LOGICAL PROCESSORS number will be 2).

CFCC does not enter a wait state when there are no commands to be processed. CFCC continues to search for work until LPAR management removes processor resources or work is found (the "active wait" phenomenon).

Note: The above statement is true for LPARs providing real coupling facility functionality. It is NOT true for LPARs providing integrated coupling facility (ICMF) function. LPAR and CFCC have been enhanced to allow an ICMF LPAR with nothing to do to give up its CP resources. In this environment, use the Monitor I Partition Data Report, rather than the Coupling Facility Usage Summary report, to determine the utilization of the ICMF LPAR.

Guideline: These fields will assist you in diagnosing the following types of problems which have occurred in customer environments.

- "High" coupling facility processor utilization and excessively high service times when only one CP out of six in the CEC was assigned to the coupling facility LPAR.
- "High" coupling facility processor utilization and excessively high service times caused by two LPARs in the same CEC with active CFs. (Production coupling facility weight of 80, test coupling facility LPAR weight of 50, all CPs shared). The test coupling facility consumed 5/13 of the available CP resources even though it was unused.

Coupling facility processor utilization does influence structure access service times and thus the responsiveness and CPU utilization of the coupling facility exploiter.

Please, see "Factors Affecting Coupling Facility Performance" on page 6-32 for additional information.

Coupling facility performance

Structure Activity Section

COUPLING FACILITY ACTIVITY															PAGE 3	
z/OS V1R2			SYSPLEX PLEXPERF			DATE 04/11/2001			INTERVAL 030.00.000							
			RPT VERSION V1R2 RMF			TIME 13.39.00			CYCLE 1.000 SECONDS							

COUPLING FACILITY NAME = CF5																

COUPLING FACILITY STRUCTURE ACTIVITY																

STRUCTURE NAME = COUPLE_CKPT1 TYPE = LIST STATUS = ACTIVE																
# REQ REQUESTS DELAYED REQUESTS																
SYSTEM	TOTAL	#	% OF	-SERV	TIME(MIC)	REASON	#	% OF	AVG	TIME(MIC)	EXTERNAL REQUEST					
NAME	AVG/SEC	REQ	ALL	AVG	STD_DEV		REQ	REQ	/DEL	STD_DEV	/ALL	CONTENTIONS				
J80	8463	SYNC 2927	5.8	306.6	127.8	NO SCH	1240	22.4	508.4	597.7	113.9	REQ TOTAL	8339			
	4.70	ASYN 5535	11.0	1502.1	1263.2	PR WT	0	0.0	0.0	0.0	0.0	REQ DEFERRED	123			
		CHNGD 1	0.0	INCLUDED	IN ASYN	PR CMP	0	0.0	0.0	0.0	0.0					
						DUMP	0	0.0	0.0	0.0	0.0					
...																

TOTAL	50370	SYNC 17K	34.3	342.2	124.5	NO SCH	8797	26.6	1047	1245	278.4	REQ TOTAL	50K			
	27.98	ASYN 33K	65.5	557551G	0.0	PR WT	0	0.0	0.0	0.0	0.0	REQ DEFERRED	497			
		CHNGD 69	0.1			PR CMP	0	0.0	0.0	0.0	0.0					
						DUMP	0	0.0	0.0	0.0	0.0					
...																
STRUCTURE NAME = IRLMLOCK1 TYPE = LOCK STATUS = ACTIVE																
# REQ REQUESTS DELAYED REQUESTS																
SYSTEM	TOTAL	#	% OF	-SERV	TIME(MIC)	REASON	#	% OF	AVG	TIME(MIC)	EXTERNAL REQUEST					
NAME	AVG/SEC	REQ	ALL	AVG	STD_DEV		REQ	REQ	/DEL	STD_DEV	/ALL	CONTENTIONS				
JF0	128K	SYNC 128K	7.7	221.9	37.5	NO SCH	0	0.0	0.0	0.0	0.0	REQ TOTAL	128K			
	71.26	ASYN 0	0.0	0.0	0.0	PR WT	0	0.0	0.0	0.0	0.0	REQ DEFERRED	80			
		CHNGD 0	0.0	INCLUDED	IN ASYN	PR CMP	0	0.0	0.0	0.0	0.0	-CONT	80			
						DUMP	0	0.0	0.0	0.0	0.0	-FALSE CONT	25			
...																

TOTAL	1676K	SYNC 1676K	100	198.1	44.7	NO SCH	0	0.0	0.0	0.0	0.0	REQ TOTAL	1674K			
	930.9	ASYN 0	0.0	0.0	0.0	PR WT	0	0.0	0.0	0.0	0.0	REQ DEFERRED	906			
		CHNGD 0	0.0			PR CMP	0	0.0	0.0	0.0	0.0	-CONT	906			
						DUMP	0	0.0	0.0	0.0	0.0	-FALSE CONT	225			
...																
STRUCTURE NAME = DSNDBIG_GBP3 TYPE = CACHE STATUS = ACTIVE PRIMARY																
# REQ REQUESTS DELAYED REQUESTS																
SYSTEM	TOTAL	#	% OF	-SERV	TIME(MIC)	REASON	#	% OF	AVG	TIME(MIC)	EXTERNAL REQUEST					
NAME	AVG/SEC	REQ	ALL	AVG	STD_DEV		REQ	REQ	/DEL	STD_DEV	/ALL	CONTENTIONS				
JA0	1032	SYNC 1025	19.1	448.8	84.3	NO SCH	7	100	2060	1671	2060					
	0.57	ASYN 0	0.0	4508.9	1409.1	PR WT	0	0.0	0.0	0.0	0.0					
		CHNGD 7	0.1	INCLUDED	IN ASYN	PR CMP	0	0.0	0.0	0.0	0.0					
						DUMP	0	0.0	0.0	0.0	0.0					
...																

TOTAL	5356	SYNC 5342	100	432.8	89.0	NO SCH	14	100	1510	1374	1510	-- DATA ACCESS --				
	2.98	ASYN 0	0.0	3685.2	1634.2	PR WT	0	0.0	0.0	0.0	0.0	READS	1331			
		CHNGD 14	0.3			PR CMP	0	0.0	0.0	0.0	0.0	WRITES	1709			
						DUMP	0	0.0	0.0	0.0	0.0	CASTOUTS	44			
												XI'S	1296			

Figure 6-12. Coupling Facility Activity Report - Structure Activity

This section of the report provides detailed information on the frequency of structure operations and the associated service/queue times.

Indicator**Fields:**

```

----- DELAYED REQUESTS -----
REASON    #    % OF    --- AVG TIME(MIC) ---
          REQ  REQ    /DEL   STD_DEV   /ALL

```

Coupling Facility exploiters make structure manipulating requests through the APIs provided by Cross-system extended services (XES). In some instances, the API requests can specify that the operation be performed synchronously or asynchronously relative to requesting task. XES will execute the API request through some number of commands to the Coupling Facility. The coupling facility commands are in turn executed synchronously or asynchronously, based on the type of operation and the API specification. RMF reports on the operations to the coupling facility and the structures within. The only data on API requests is reported in CONTENTION data for lock and serialized list structures.

For an operation to be initiated against a coupling facility structure, one of the subchannels associated with the Coupling Facility must be available. When no subchannel is available, XES must either queue the operation for later scheduling, or "spin" waiting for a subchannel to become available. XES takes one action or the other, depending on the type of structure and operation.

Most SYNC operations which cannot be started due to unavailable subchannels are changed to ASYNC operations (RMF reports them as CHNGD). Certain SYNC operations are not changed from SYNC to ASYNC when no subchannels are available. Most notably, lock requests are not changed to ASYNC. For these operations, the processor "spins" until a subchannel becomes available.

RMF reports on ASYNC operations to a structure which are delayed due to subchannel unavailability. RMF does NOT report on SYNCH operations to a structure which are delayed ("spinning") due to subchannel unavailability. The amount of delay for SYNC operations must be estimated from the subchannel activity report.

Subchannel unavailable condition will manifest itself in one of the following ways:

1. A non-zero percentage of CHNGD requests relative to the total number of ASYNC requests.
2. A non-zero percentage of delayed ASYNC requests.

Depending on the structure either one or both of the above phenomena may be observed, not necessarily both.

In evaluating response times for ASYNC requests, the following should be noted:

- ASYNC command processing is performed primarily by the I/O processor (IOP or SAP).
- ASYNC requests generally take longer (elapsed time) than SYNC requests.
- The reported service time (not shown in the above example, but present on the ASYNC line) does not include delay time. To determine the average elapsed time for an ASYNC operation add the average service time to the average amortized delay time (/ALL column) for all ASYNC operations during the interval.

Coupling facility performance

- ASYNC delay times (/DEL column) can be an indication of inadequate processing capacity in the coupling facility as well as insufficient number of subchannels.

In evaluating response times for SYNC requests, the following should be noted:

- SYNC command processing is performed by the CP.
- The reported service time (not shown in the above example, but present on the SYNC line) does not include the delay spent "spinning" awaiting subchannel busy if OW12415 is installed.
- A SYNC request delayed due to unavailable subchannel is using CPU resources.

Subchannel unavailability has the following negative consequences:

- ASYNC requests will be queued, resulting in delayed access to a coupling facility structure and corresponding diminished responsiveness by the exploiter.
- Non-immediate SYNC requests will be transformed to ASYNC requests, resulting in delayed access to a coupling facility structure and corresponding diminished responsiveness by the exploiter.
- Immediate SYNC requests will "spin" waiting for an available subchannel, resulting in increased CPU usage, delayed access to a coupling facility structure and corresponding diminished responsiveness by the exploiter.

Normally, none of these effects are desirable. The following activities can minimize the detrimental effects:

- Make certain CPU resource is sufficient in the coupling facility LPAR.
- Redistribute structures among the CFs to minimize the delay.
- Add additional coupling facility links between the MVS processor and the coupling facility. Each path will contribute two subchannels.
- Influence the coupling facility activity rates (downward) of coupling facility exploiters if possible. For example, you can reduce the number of XCF signals by reducing lock contention or tuning XCF to eliminate signals related the expansion of transport classes sizes.

Indicator

Fields:

EXTERNAL REQUEST CONTENTIONS	EXTERNAL REQUEST CONTENTIONS
REQ TOTAL REQ DEFERRED	REQ TOTAL REQ DEFERRED -CONT -FALSE CONT

Description: These fields provide information on serialized list contention.

A serialized list structure is a list structure which has an associated lock structure within. For example, JES2 and VTAM structures are serialized list structures; the XCF structure is simply a list structure. A serialized list structure can provide the structure user with increased control (exclusive usage) over the entire structure, a portion of the entries or even a single list entry. The use of the lock structure to control access is completely under the control of the exploiter.

Coupling facility performance

There are a number of operations against a serialized list structure. Some operations against a serialized list structure will succeed if the designated lock entry is not held by any other user. Additionally, these requests will be queued for FIFO processing by XES whenever the command cannot be processed due to lock contention. (Specifically these are UNCONDITIONAL SET and NOTHELD requests). XES will queue the request in a sysplex-wide FIFO queue until the lock is available. Whenever the lock is released, the first queued request will be re-started on the appropriate processor. XES is providing multi-system FIFO queuing on behalf of the users to the serialized list structure.

RMF will report on the number of accesses to the serialized list structure and the number of accesses deferred due to lock contention. This value is reported from the perspective of the indicated connector, the value is not a "global" value across all connectors to the structure. Note: A serialized list structure will not incur false contention due to the manner in which XES manages the contention.

Having XES queue and manage deferred requests requires some amount of CPU usage and XCF signalling usage. Excess contention is most likely a reflection on the usage of the structure itself by the exploiter or poor tuning specifications by the installation. For example, consider JES2s use of a checkpoint structure. Each JES2 member of the MAS will acquire and hold the checkpoint for some period of time (HOLD) and restrain itself from attempting to acquire control for some period of time upon release (DORMANCY). If all members of the MAS specify short dormancy values, then each member (except the current owner) will attempt to acquire the checkpoint lock. XES will happily manage this queue of requestors in a FIFO manner at some cost. It may be worth the effort to adjust these values so members of the MAS receive the necessary service without the overhead of XES managing the queue of requestors.

The average time a serialized list request with lock contention is queued by XES is not tracked and thus not reported by RMF. APAR OW11789 corrected a reporting problem which added the queue time into the AYSNC service time. This resulted in inflated and widely varying service times being reported.

Indicator

Fields:

```
-- DATA ACCESS ---  
READS  
WRITES  
CASTOUTS  
XI'S
```

Description: These fields provide information on cache structure accesses.

Data access counts for a cache structure have been added to the report. Prior to describing what READS, WRITES, etc. counts actually count, the following should be noted:

- The information is acquired from counters in the coupling facility and is global in nature. The information cannot be broken down to give an individual connection contributions to this global count. Thus, the information is reported in the "TOTAL section" of the RMF report.
- Depending on the cache structure implementation one or more of these counter values may be zero.

Coupling facility performance

- Most importantly, only the cache structure user (i.e. data base manager) knows how efficiently the local buffers and cache structure are being used. If the data base manager does not provide usage information, then tuning is a best guess proposition.

The coupling facility maintains a number of structure level counters accessible to RMF. RMF reports on a subset of these counters (to be described momentarily) and stores all the counters in the SMF74 subtype 4 records.

Additional information on these counters can be obtained in *z/OS MVS Programming: Sysplex Services Guide* in the section labeled IXLCACHE REQUEST=READ_STGSTATS.

RMF provides four cache structure usage counters.

READS

This is a count of the number of times the coupling facility returned data on a read request by any connector.

Directory only caches will always have a zero value reported since the structure contains no "data".

WRITES

This is a count of the number of times a connector placed changed or unchanged data into the coupling facility structure. (Changed/unchanged is an attribute assigned to the data when written by the connector. From a performance/capacity view point, the importance of the attribute is: changed data cannot be reclaimed from the structure should directory or data elements become scarce.)

Just as directory only cache structures always have READS counts of zero, they have WRITES counts of zero as the structure contains no "data".

The condition to be concerned with is a large number of WRITES and a small number of READS. This condition may indicate:

- Insufficient structure space allocated, and data entries (and perhaps directory entries) are being discarded by the coupling facility space management routines.
- Inappropriate allocation of the ratio of directory entry to data elements is causing the data entries to be discarded by the coupling facility space management routines.

Directory entry reclaim activity is reported by RMF as discussed earlier; however, data element reclaim activity is not reported.

CASTOUTS

This is a count of the number of times a connector retrieved a changed data entry, wrote the data to DASD (discarded it, whatever), and caused the changed attribute to be reset to unchanged. This process is known as casting out changed data from the structure.

This counter is of interest for store-in cache structures (i.e. DB2 global buffer pool structures) in determining the volume of changed data being removed from the structure. This counter is not an indicator of the number times castout processing was performed during the RMF interval.

A large amount of castout activity on a single structure may warrant additional cache structures and redirecting locally buffered data to different cache structure. Castout processing by the connectors must keep pace with

Coupling facility performance

the rate at which changed data is placed in the structure. When all directory or data elements are associated with changed data, no new data items can be registered or written to the structure. This condition is not desirable and will adversely effect the data base manager and/or the user of the data base manager.

XI'S This is the number of times a data item residing in a local buffer pool was marked invalid by the coupling facility during the RMF interval. To the cache structure user, this means the data item must be re-acquired from DASD or perhaps the coupling facility structure, and interest in the item must be re-registered in the coupling facility structure.

There are several "XI counts" obtained from the coupling facility which are consolidated into this value. They are:

- XI for Directory Reclaim
- XI for Write
- XI for Name Invalidation
- XI for Complement Invalidation
- XI for Local Cache Vector Entry Replacement

Consult section IXLCACHE REQUEST=READ_STGSTATS in the *z/OS MVS Programming: Sysplex Services Guide* for additional information on these XI categories.

It is important to understand what the XI'S counter really counts. This is most easily explained by example. Suppose there are 5 connectors (i.e. #1, #2, #3, #4, and #5). to a cache structure. Further suppose data item "A" is locally cached in connectors #1, #2, #4, and #5 and registered in the coupling facility structure. Now suppose connector number #5, changes data item "A" and issues the command to the coupling facility to have all other copies invalidated (i.e. XI for complement invalidation). In response to the command, the coupling facility would cause the copies of data item "A" in the local buffer pools of connectors #1, #2 and #4 to be marked invalid. At the completion of the XI operation, the XI'S count value would be incremented by 3!

XI'S count values are seen for directory, store-in and store-thru caches. This count reflects both the amount of data sharing among the users of the cache and the amount of write/update activity against the data bases.

Coupling facility performance

Subchannel Activity Section

COUPLING FACILITY ACTIVITY															PAGE 6	
z/OS V1R2			SYSPLEX PLEXPERF			DATE 04/11/2001			INTERVAL 030.00.000							
			RPT VERSION V1R2 RMF			TIME 13.39.00			CYCLE 1.000 SECONDS							

COUPLING FACILITY NAME = CF1																

SUBCHANNEL ACTIVITY																

SYSTEM NAME	# REQ TOTAL AVG/SEC	-- CF TYPE	LINKS GEN	-- PTH USE	BUSY	REQUESTS			DELATED		REQUESTS					
						# REQ	-SERVICE AVG	TIME(MIC)- STD_DEV	# REQ	% OF REQ	AVG /DEL	TIME(MIC) STD_DEV	ALL			
*W04	30740	ICP	3	3	0	SYNC	957	26.8	95.5	LIST/CACHE	2	0.0	174.0	50.9	348.0	
	51.2	SUBCH	42	21		ASYN	22791	736.7	2811	LOCK	0	0.0	0.0	0.0	0.0	
						CHANGED	0	INCLUDED	IN ASYN	TOTAL	2	0.0				
						UNSUCC	0	0.0	0.0							
*W05	9793	CFS	2	2	354	SYNC	790	43.3	116.5	LIST/CACHE	1537	19.1	1797	5626	2761K	
	9.6	SUBCH	4	4		ASYN	8100	937.8	3543	LOCK	4	0.5	69.5	15.6	278.0	
						CHANGED	1	INCLUDED	IN ASYN	TOTAL	1541	17.3				
						UNSUCC	0	0.0	0.0							

Figure 6-13. Coupling Facility Activity Report - Subchannel Activity

The following fields can be used as a quick way of determining which systems are generating the most activity for a given facility, which in turn indicates where to focus tuning or load balancing efforts.

Indicator

Field: CF LINKS

Description: The subchannel configuration is described by these fields:

TYPE This column describes the channel path type.

GEN USE The number of subchannels that are defined, and that MVS is currently using for coupling facility requests.

The description of the channel path type can help in better analyzing the performance of the different channel path types. There are differences between two types of coupling facility channels:

CFS /CFR - CBS /CBR - ICS / ICR

Two subchannels per path.

CFP - CBP - ICP

Seven subchannels per path.

Indicator

Field: PTH BUSY

Description: Path busy - the number of times a coupling facility request was rejected because all paths to the coupling facility were busy.

Guideline: A high count combined with lengthy service times for requests indicates a capacity constraint in the coupling facility. If coupling facility channels are being shared among PR/SM partitions, the contention could be coming from a remote partition.

Identifying path contention: There can be path contention even when the path busy count is low. In fact, in a non-PR/SM environment where the subchannels are properly configured, # DELAYED REQUESTS, not PTH BUSY, is the indicator for path contention. If PTH BUSY is low but # DELAYED REQUESTS is high, it means MVS is delaying the coupling facility requests and in effect gating the workload before it reaches the physical paths.

PR/SM environment only: If coupling facility channels are being shared among PR/SM partitions, PTH BUSY behaves differently. You potentially have many MVS subchannels mapped to only a few coupling facility command buffers. You could have a case where the subchannels were properly configured (or even underconfigured), subchannel busy is low, but path busy is high. This means the contention is due to activity from a remote partition.

If a coupling facility capacity constraint is suspected, the first action to consider is adding more paths. If the coupling facility is already fully configured for paths, you need to determine whether some structures can be offloaded to another coupling facility or whether another coupling facility should be added to the configuration. Use the Coupling Facility Usage Summary reports to balance workloads across coupling facilities based on activity rates and storage usage.

In a PR/SM environment, you may need to increase or adjust the configuration of shared coupling facility channels to reduce path contention.

Coupling facility performance

Indicator

Fields:

```
----- DELAYED REQUESTS -----
#      % OF  -----AVG TIME(MIC)-----
REQ    REQ   /DEL  STD_DEV  /ALL

LIST/CACHE
LOCK
TOTAL
```

Description: Field TOTAL # DELAYED REQUESTS is the same as BUSY COUNT - SCH that was shown in previous versions of this report. It is the number of times an immediate request was delayed because subchannel resources were not available.

Immediate requests (such as locking operations) could not be completed because all the subchannels were busy. These requests are not queued. They are processed before the non-immediate requests which are reported in the Structure Activity report under QUEUED requests. To get a complete picture of subchannel activity, look at both fields.

Guideline: If this count is high, you should ensure that sufficient subchannels are defined.

See PTH BUSY above for suggested actions to relieve a coupling facility path constraint.

In a data sharing environment, lock structure requests account for a large percentage of coupling facility accesses. By estimating the amortized delay for SYNC operations on lock structure accesses, one can determine the time delay due to subchannel unavailable on lock structure operations and the impact on CPU busy.

Note: Requests which are delayed because a structure was being dumped were removed from this report because they are not related to subchannel contention.

CF to CF Activity Section

COUPLING FACILITY ACTIVITY													
z/OS V1R2		SYSPLEX PLEXPERF			DATE 04/11/2001			INTERVAL 030.00.000			PAGE 6		
		RPT VERSION V1R2 RMF			TIME 13.39.00			CYCLE 1.000 SECONDS					

COUPLING FACILITY NAME = CF1													

CF TO CF ACTIVITY													

PEER CF	# REQ	-- CF LINKS --	--		----- REQUESTS -----			----- DELAYED REQUESTS -----					
	TOTAL				#	-SERVICE	TIME(MIC)-	#	% OF	----	AVG TIME(MIC)	---	
	AVG/SEC	TYPE	USE		REQ	AVG	STD_DEV	REQ	REQ	/DEL	STD_DEV	/ALL	
CF2	86830	CBP	1	SYNC	86830	53.0	33.8	SYNC	19	0.2%	14.5	2.7	0.0
	86.2	ICP	1										

Figure 6-14. Coupling Facility Activity Report - CF to CF Activity

Coupling facility performance

This section of the Coupling Facility Activity report provides information about the activities between coupling facilities.

Indicator Fields:

----- DELAYED REQUESTS -----
% OF -----AVG TIME(MIC)-----
REQ REQ /DEL STD_DEV /ALL

Description: Field # DELAYED REQUESTS is the number of signals of all types which have experienced a delay in being sent from the subject CF to this remote CF. It is an contention indicator for the peer-to-peer communication between both coupling facilities.

Spreadsheet Report

If you are interested to display the data of the Coupling Facility Activity report graphically, you can use the Spreadsheet Reporter with an interval report as input. One of the several charts that you can get is the following one:

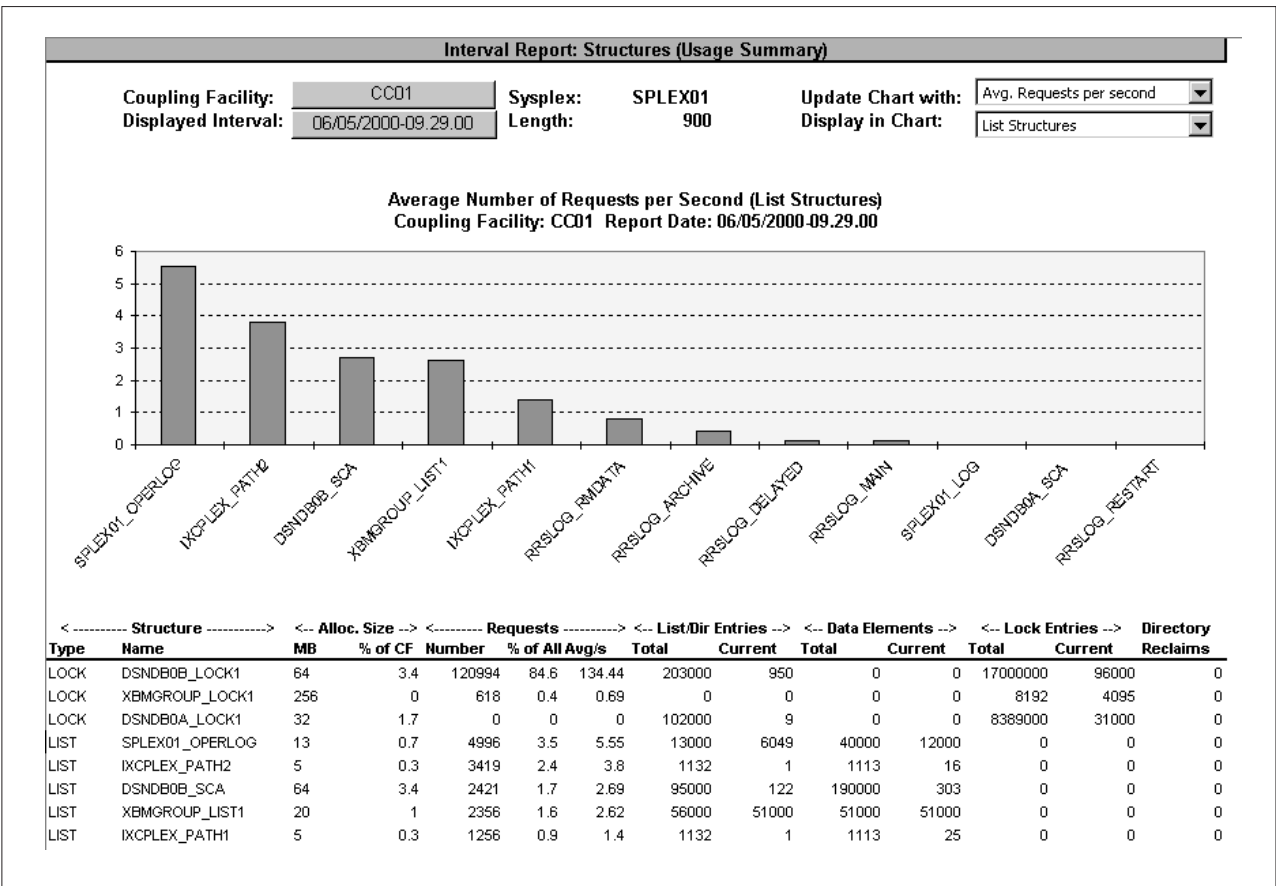


Figure 6-15. Coupling Facility Structure Activity. Spreadsheet Reporter macro RMFR9CF.XLS (CF Report)

The graphic shows the total number of requests for structure ISGLOCK, and you can modify the graphic by selecting a specific type of data in the drop-down list.

Coupling facility performance

Using the Monitor III Online Reports

Three new Monitor III reports enable you to analyze bottlenecks or problems in the coupling facility area that might result in a performance degradation in the parallel sysplex. To avoid critical situations for production data bases and transaction processing systems, customers can see the immediate state of the coupling facility and the structures, and they have all relevant data at a glance in a granularity they can choose. In addition, they can see the results of tuning actions in this area, for example after having removed a coupling structure from an overloaded coupling facility to another one.

The Coupling Facility Overview Report - CFOVER

The Coupling Facility Overview report (CFOVER) gives you information about all coupling facilities which are connected to the sysplex.

Command ==>>				RMF V1R2 CF Overview		- UTCPLXHD		Line 1 of 2	
								Scroll ==> HALF	
Samples: 120		Systems: 3		Date: 05/04/01		Time: 11.27.00		Range: 120 Sec	
---- Coupling Facility ----				---- Processor ----		Request		-- Storage --	
Name	Type	Model	Level	Util%	Defined	Effect	Rate	Size	Avail
CF5B	9674	C01	5	12.4	3	3.0	232.3	1008M	679M
CF6B	9674	C01	5	44.2	3	3.0	4572	1008M	651M

Figure 6-16. CFOVER Report

The Coupling Facility Activity Report - CFACT

The Coupling Facility Activity report (CFACT) gives you information about the activities in each structure.

Coupling facility performance

Command ==>		RMF V1R2	CF Activity	- UTCPLXHD		Line 13 of 76 Scroll ==> HALF			
Samples: 120	Systems: 3	Date: 05/04/01	Time: 11.27.00	Range: 120	Sec				
CF: ALL	Type	ST	System	--- Sync ---		----- Async -----			
Structure Name				Rate	Avg Serv	Rate	Avg Serv	Chng %	Del %
IRRXCFO0_B001	CACHE		*ALL	0.1	372	0.0	0	0.0	0.0
			D0	0.0	0	0.0	0	0.0	0.0
			D1	0.0	0	0.0	0	0.0	0.0
			D2	0.1	372	0.0	0	0.0	0.0
IRRXCFO0_P001	CACHE		*ALL	0.5	378	0.0	0	0.0	0.0
			D0	0.2	353	0.0	0	0.0	0.0
			D1	0.2	401	0.0	0	0.0	0.0
			D2	0.2	378	0.0	0	0.0	0.0
ISGLOCK	LOCK		*ALL	14.5	266	0.0	0	0.0	0.0
			D0	1.1	235	0.0	0	0.0	0.0
			D1	7.2	293	0.0	0	0.0	0.0
			D2	6.1	241	0.0	0	0.0	0.0
ISTGENERIC	LIST		*ALL	1.7	363	0+	8393	50.0	150
			D0	0.8	382	0.0	0	0.0	0.0
			D1	0.4	353	0+	8393	50.0	150
			D2	0.5	341	0.0	0	0.0	0.0
IXCplex_PATH1	LIST		*ALL	0.0	0	248.6	2553	0.0	26.0
			D0	0.0	0	129.4	2107	0.0	39.2
			D1	0.0	0	26.6	3981	0.0	34.0
			D2	0.0	0	92.6	2767	0.0	5.2
IXCplex_PATH2	LIST		*ALL	0.0	0	182.5	3092	0.0	3.3
			D0	0.0	0	82.6	2730	0.0	2.9
			D1	0.0	0	25.5	4833	0.0	10.7
			D2	0.0	0	0.0	0	0.0	0.0

Figure 6-17. CFACT Report

The Coupling Facility Systems Report - CFSYS

The Coupling Facility Systems report (CFSYS) gives you information about the distribution of coupling facility requests among the systems and about the activities in the subchannels and paths attached to the coupling facilities in the sysplex.

Coupling facility performance

Command ==>		RMF V1R2	CF Systems		- UTCPLXHD		Line 1 of 6 Scroll ==> HALF			
Samples: 120		Systems: 3	Date: 05/04/01		Time: 11.27.00		Range: 120	Sec		
CF Name	System	Subch Delay %	-- Paths -- Avail Delay %	-- Sync --- Rate Avg Serv	Rate	Avg Serv	Rate	Avg Serv	Chng %	Del %
CF5B	D0	0.0	2	2.6	5.1	344	91.0	2890	0.1	7.6
	D1	0.2	2	7.3	10.6	315	33.8	4903	0.4	22.1
	D2	0.0	2	3.3	9.3	300	82.2	3042	0.0	7.2
CF6B	D0	5.1	1	2.2	2131	242	252.2	1974	31.0	39.3
	D1	1.1	1	34.1	0.9	548	30.9	3884	0.0	42.6
	D2	0.0	2	0.7	1895	267	144.8	2865	2.8	7.7

Figure 6-18. CFSYS Report

Factors Affecting Coupling Facility Performance

This section is intended to assist one in detecting and assessing processing delays which will impact applications utilizing the coupling facility. Processing delays may manifest themselves as increased in CPU time, increased in elapsed time due to waiting, or some combination of both. There are several approaches to achieving better application or system performance:

- Perform "work" as quickly as possible.
- Don't make additional "work".
- Don't do unnecessary work.

Perform "Work" as Quickly as Possible

Conditions elongating coupling facility request response (service + delay) times include the following:

- Insufficient processor power allocated to the coupling facility LPAR.

The most common cause of this condition is the sharing of CPs among coupling facility LPARs. The changes to RMF and CFCC will allow the installation to accurately determine the amount of available processing power being used.

Elongation of SYNC service times against directory only cache structures is a good indicator of this condition. Alternatively, use the lock structure SYNC service times after removing the no subchannel delay component.

- Insufficient number of paths between the CECs containing multiple MVS images and a coupling facility

RMF does not report on the length of the delay due to path busy conditions, only the number of requests encountering the condition are reported. Requests encountering path delay will have elongated service times.

The most common condition to cause path busy condition is EMIFing the sender ISC links among the MVS LPARs. The current rule of thumb is that the number of requests delayed for path busy (as reported on the Subchannel Activity report in the PTH field under the BUSY COUNTS column) should be less than 10% of total requests (on the same report under the # REQ TOTAL column).

Note: In the case of EMIFed ISC links, be certain to take into account all the MVS LPARS utilizing a common physical connection(s).

Coupling facility performance

The solution to reducing the incidence of path busy conditions is to add ISC links between the processors or refrain from using EMIF, which will probably require additional links as well.

- Insufficient number of subchannels between the MVS image and the coupling facility

RMF reports on delay times and service times at the structure level and the coupling facility level (as previously discussed). Consequences of insufficient subchannels are:

- Increased MVS CPU consumption when the SYNC operation cannot be converted to an ASYNC operation.
- Increased service time for the SYNC operation which cannot be converted to an ASYNC operation.
- Requests being converted from SYNC to ASYNC.
- Increased queue time for ASYNC requests.

The effect of the last two items is difficult to quantify. The effect depends on what the exploiter can do while a request is queued (i.e. was the delay anticipated and the request made asynchronously). Either of these two events will result in an elapsed time increase for some function. Whether this affects only one "user" or many users is dependent on the exploiter and its use of the structure. For example, if all cache structure castout operations are delayed, then it is possible for the cache to become full of changed data and is not a desirable condition.

There are two indicators to be monitored.

1. Increased SYNC operation service times (particularly against the lock structure) and the amount of "spin time" associated with the service time.
2. The percentage of operations delayed.

Use the same rules and values previously discussed.

The only way to increase the number of subchannels is to add more physical paths (i.e. ISC links). There are two subchannels per ISC link. Additional ISC links will help alleviate path busy conditions in an EMIF environment as well.

- Insufficient IOP/SAP capacity on the CEC MVS image and the coupling facility
The IOP/SAP on the CEC housing the MVS image handles IO to DASD, CTC traffic and ASYNC operations. As the number of ASYNC operations increases, the workload on the IOP/SAP increases. If the IOP/SAP becomes overloaded, the service time for ASYNC operations will elongate. ASYNC operations can be quite long and have a large standard deviation, thus changes are somewhat difficult to detect. Perhaps the easiest indicator to track is the Avg Q Length on the I/O Queuing Activity Report; if this value gets large it is an indicator that ASYNC requests as well as I/O requests are being delayed in IOP/SAP processing.

- Hardware problems causing ISC link degradation.

Monitor the hardware incidents in LOGREC and relevant console messages. Get the problem fixed.

Don't Make Additional "Work".

XES and the coupling facility must work within the constraints imposed by the people that setup the parallel sysplex. When structures are not of sufficient size, XES, the coupling facility, and the exploiter will cope as best they can.

Coupling facility performance

For example if a directory only cache structure is being utilized and insufficient structure space is defined, directory entries will be reclaimed according to a least recently used algorithm. This will result in locally cached data items being marked invalid. Whenever these locally cached, but invalid, items are referenced, they will have to be read from DASD and registered with the coupling facility. In essence, unnecessary work has been created due to an improper definition. CPU cycles are required to perform the I/O and to register the data item with the coupling facility. Furthermore, the entity accessing the data item was delayed (elapsed time increased) while these two events occurred.

RMF now provides information allowing the installation to detect, and perhaps alleviate, these conditions on a structure by structure basis.

- Lock Structures

Lock structure request service times should be short. Lock contention should be avoided, as contention must be resolved with the assistance of XES lock services requiring time and CPU cycles. Lock contention also generates additional XCF signalling. False lock contention should be avoided, it is expensive to resolve and is avoidable. RMF reports on the number of lock requests, the number delayed due to contention and the number delayed due to false contention.

False lock contention can be alleviated by increasing the size of the lock table. To reduce true lock contention may require a change to the application, the data base, or the workload mix during the period of time the conflict occurs. One should attempt to manage true contention to less than 1.0 percent and false contention to less than 0.1 percent of the requests.

- Cache Structures

Cache structures are not meant to replace local caches, they are intended to augment their use by:

1. Providing a mechanism for local buffer coherency
2. Providing additional high speed caching for frequently changed data.

Use of the cache structure should not negatively impact the use of local cache.

Prevent invalidation of a local cache entity unless the entity has been changed. This means avoid doing directory entry reclaims. This activity may be avoided by specifying a larger structure. RMF now reports on this activity to assist the installation in verifying the cache structure contains sufficient directory entries to keep track of locally cached data.

If the cache structure user keeps data in the structure, attempt to keep frequently referenced data in the structure. Caching data in the coupling facility is only a performance boost when the data resides in the structure. It is important to have the structure sufficiently large and of the correct entry/data item configuration to support coupling facility caching of data without hindering performance.

The RMF changes discussed previously will assist the installation in tracking anomalies or changes in data access patterns. RMF data is not sufficient in determining optimal read hit ratios.

Don't Do Unnecessary Work

This activity is difficult to assess. The servers using coupling facility structures for message passing, locking, caching, state saving, etc. normally do very little coupling facility accesses unless prompted by some user of the server. Normally applications are causing the servers to perform some task involving coupling facility accesses.

Coupling facility performance

In extensive data sharing environments, the data base manager and the lock manager together will account for over half of accesses to the coupling facility. The applications using the data base manager are normally high profile and critical to the business. Thus the first two activities are most often pursued.

When all coupling facility tuning efforts have failed to meet the applications response time objectives, be it CPU time and/or elapsed time, examination of the application is in order. Unfortunately, this involves real work among different organizations. The causes of contention, excessive locking, cache disruption, etc. must be determined and reduced. This reduction will involve some type of application change. This is obviously not a popular option and is presented last as it is most begrudgingly done.

Coupling facility performance

Appendix A. PR/SM LPAR Considerations

Considerations in PR/SM Environments

This appendix presents performance considerations for systems running in LPAR mode, including:

- Interpretation of RMF reports
- Tuning of an LPAR configuration

Understanding the Partition Data Report

Using the Postprocessor report option `REPORTS(CPU)`, you get the CPU Activity report. This report is divided into these sections:

CPU ACTIVITY — Information about processors and address spaces

PARTITION DATA REPORT — Information about all configured partitions

LPAR CLUSTER REPORT — Information about LPAR clusters

Although this is an inconsistency, the first section is typically referred to as CPU Activity report, too. The third section is new, it is available with the Intelligent Resource Director (IRD) of the zSeries processors and is described in Appendix B. The Intelligent Resource Director.

C P U A C T I V I T Y										PAGE	1
z/OS V1R2		SYSTEM ID NP1			DATE 04/15/2001		INTERVAL 14.59.678				
		RPT VERSION V1R2 RMF			TIME 09.30.00		CYCLE 1.000 SECONDS				
CPU 2064 MODEL 109											
CPU	ONLINE TIME	LPAR BUSY	MVS BUSY	CPU SERIAL	I/O TOTAL	% I/O INTERRUPTS					
NUMBER	PERCENTAGE	TIME PERC	TIME PERC	NUMBER	INTERRUPT RATE	HANDLED VIA TPI					
2	19.33	16.77	100.0	211551	0.00	0.00					
3	100.00	26.49	99.88	311551	7.98	2.48					
TOTAL/AVERAGE		24.92	99.90		7.98	2.48					

Figure A-1. CPU Activity Report

The first part of the CPU Activity report provides information about the processors assigned to that partition which is gathering the data.

Report Analysis

- ONLINE TIME PERCENTAGE

The total online time percentage for all processors is 119.33% which is equivalent to 1.2 processors. This value is shown in the Partition Data report in the field `PROCESSORS NUM`.

- LPAR BUSY TIME PERC

The average utilization of the processors is 24.92%, this value can be found in the Partition Data report in the field `LOGICAL PROCESSORS TOTAL` for partition NP1. The LPAR BUSY time is (with Wait Completion = NO) the dispatch time of the processors that are assigned to the partition, and the percentage is based on their online time.

- MVS BUSY TIME PERC

This field shows the MVS view of the CPU utilization. The MVS BUSY time is the difference between online time and wait time. If the MVS system is busy when the partition is losing control, it will stay in busy mode until the partition will be dispatched again, then the current task can continue, and wait state will be reached later. Therefore, the MVS BUSY time can be higher than the LPAR BUSY time, and the difference between both values is an indicator for CPU constraints in the system.

The Partition Data report shows measurement data for all configured partitions. In addition, it has a line *PHYSICAL* for reporting purposes, this does not reflect a real partition.

PHYSICAL PROCESSORS TOTAL								
DISPATCH TIME DATA TOTAL (Partition 1)			...	DISPATCH TIME DATA TOTAL (Partition n)			...	*PHYSICAL*
DISPATCH TIME DATA EFFECTIVE			...	DISPATCH TIME DATA EFFECTIVE			...	
MVS Captured Time	MVS Uncaptured Time	Partition LPAR Mgmt Time	...	MVS Captured Time	MVS Uncaptured Time	Partition LPAR Mgmt Time	...	LPAR Time not attributed

PARTITION DATA REPORT																
z/OS V1R2			SYSTEM ID NP1				DATE 04/15/2001				INTERVAL 14.59.678					
			RPT VERSION V1R2 RMF				TIME 09.30.00				CYCLE 1.000 SECONDS					
MVS PARTITION NAME			NP1													
IMAGE CAPACITY			100													
NUMBER OF CONFIGURED PARTITIONS			9													
NUMBER OF PHYSICAL PROCESSORS			9													
CP			9													
ICF			0													
WAIT COMPLETION			NO													
DISPATCH INTERVAL			DYNAMIC													
----- PARTITION DATA ----- -- LOGICAL PARTITION PROCESSOR DATA -- -- AVERAGE PROCESSOR UTILIZATION PERCENTAGES --																
NAME	S	WGT	----MSU----		-CAPPING--		PROCESSOR-		----DISPATCH TIME DATA----		LOGICAL PROCESSORS		--- PHYSICAL PROCESSORS ---			
			DEF	ACT	DEF	WLM%	NUM	TYPE	EFFECTIVE	TOTAL	EFFECTIVE	TOTAL	LPAR	MGMT	EFFECTIVE	TOTAL
NP1	A	20	100	10	NO	62.2	1.2	CP	00.04.29.502	00.04.27.519	25.10	24.92	****		3.33	3.30
NP2	A	1	0	1	YES	0.0	4	CP	00.00.22.680	00.00.22.083	0.75	0.73	****		0.28	0.27
NP3	A	10	5	8	NO	3.3	1.0	CP	00.03.37.761	00.03.35.859	24.20	23.99	****		2.69	2.67
NP4	A	300	95	155	NO	0.0	0.3	CP	01.12.08.405	01.12.06.405	80.18	80.15	****		53.46	53.43
NP5	A	200	50	52	NO	0.0	4	CP	00.24.13.447	00.24.11.311	40.39	40.33	****		17.95	17.92
CFC1	A	DED	0	32		0.0	1	ICF	00.14.59.611	00.14.59.625	99.99	99.99	0.00		11.11	11.11
CFC2	A	DED	0	0		0.0	1	ICF	00.00.00.000	00.00.00.000	0.00	0.00	0.00		0.00	0.00
PHYSICAL													0.04		0.04	
TOTAL									01.59.51.408	01.59.46.408			0.04		88.81	88.75
CB88	D															
CB89	D															

Figure A-2. Partition Data Report

Report Analysis

- PROCESSOR NUM

The number of online processors for partition NP1 is 1.2, this reflects the online time percentages of 19.33% + 100% = 119.33% in the CPU report.

- LOGICAL PROCESSORS - TOTAL DISPATCH TIME

DISPATCH TIME 4.27.519 = 268 sec
 ONLINE TIME 119.33% of 14.59.678 = 1074 sec
 LP TOTAL UTIL (268/1074)*100 = 24.9%

The value of 24.9% is shown as LPAR BUSY TIME PERC in the CPU report.

Report Analysis

- PHYSICAL PROCESSORS - TOTAL DISPATCH TIME

DISPATCH TIME 4.27.519 = 268 sec
INTERVAL TIME (9 CPSs) 9 * 14.59.678 = 8097 sec
LP TOTAL UTIL (268/8097)*100 = 3.3%

Partition NP1 has a processor utilization of 3.3% of the total 2064-109 system.

- PHYSICAL PROCESSORS - LPAR MGMT

Each partition's CPU consumption for LPAR management is calculated as the difference between total and effective dispatch time.

It is possible that the total dispatch time is smaller than the effective dispatch time. This situation occurs when partitions get "overruns" in their dispatch intervals caused by machine delays. The most typical form of this is caused by an MVS partition trying to talk to a coupling facility but getting significant delays or time-outs. It is sometimes symptomatic of recovery problems on the machine. In this case, field LPAR MGMT is filled with '****'.

- *PHYSICAL*

The *Physical Management Time* is collected and reported by RMF in this line. The partition named *PHYSICAL* does not exist, this line is created for reporting purposes.

Report Analysis

- LOGICAL PROCESSORS - UTILIZATION ICF PARTITION

PARTITION CF1 99.99% UTILIZATION

CF partitions are actually always busy 100% of the time. For purposes of reporting CF utilization, the CPU time is accumulated in two buckets: *busy* and *idle*. *Idle* is the CPU time spent looking for work (the polling loop), *busy* is all other time (time spent processing a command or background work). From these times, the CF Utilization reported in the Coupling Facility Activity report is $100 * \text{busy} / (\text{busy} + \text{idle})$.

Defining Logical Processors

Obviously, there is a cost to operate in LPAR Mode. One of the key aspects for defining an LPAR configuration is the number of logical partitions.

Defining more logical partitions than are required to handle a partition's workload affects LPAR management time. Define as few LPARs as are needed to support your business needs.

Rule-of-Thumb

Number of Logical Processors

Number of Logical Processors $\leq 2 * \text{Number of Physical Processors}$

The following example demonstrates the impact of the definition of logical processors on the total utilization of a system. In this sample, the processor is an 8-way system.

For a system with 8 physical processors, 9 partitions have been defined with a total of 70 logical processors which is far away from the rule-of-thumb that has been mentioned above.

LPAR #	LPAR Name	# LP	Weights
1	PROD1	8	80
2	PROD2	8	50
3	PROD3	8	40
4	PROD4	6	12
5	PROD5	8	50
6	TEST	8	7
7	PROD6	8	106
8	PROD7	8	40
9	PROD8	8	5

With this configuration, the LPAR management time percentage was 22.83% which is nearly the capacity of 2 processors in this 8-way system. Due to significant performance problems, the configuration has been changed with defining 20 LPs for the same number of partitions, which is close to the 2:1 rule. The weighting factor was taken to estimate the number of LPs for each partition.

LPAR #	LPAR Name	# LP	Weights
1	PROD1	4	80
2	PROD2	2	50
3	PROD3	1	40
4	PROD4	2	12
5	PROD5	3	50
6	TEST	1	7
7	PROD6	4	126
8	PROD7	2	40
9	PROD8	1	5

By changing the number of LPs from 70 to 20, the LPAR management time percentage could be reduced by 20% of the total capacity (from 22.83% to 2.87%) for an 8-way processor which is equivalent to the capacity of 1.6 processors.

Intelligent Resource Director

Considerations about the number of logical processors are relevant and required only for partitions which are not under control of WLM LPAR management. This is a function of the Intelligent Resource Director which is available on z900 servers, and it is described in the following chapter.

PR/SM environment

Appendix B. The Intelligent Resource Director

Learning about the Intelligent Resource Director

This appendix describes the functions of the Intelligent Resource Director and its reporting in RMF, including:

- Dynamic Channel Path Management
- Channel Subsystem Priority Queuing
- LPAR CPU Management

In addition, the reporting of the IBM License Manager is described.

Overview

The Intelligent Resource Director (IRD) is a functional enhancement exclusive to IBM's zSeries family. It is provided in z900 servers and is an extension of IBM's industry leading clustering architecture, the Parallel Sysplex. IRD uses LPAR clusters (see "LPAR Cluster" on page B-5 for a description) that will efficiently balance processor and I/O resources between multiple applications based on quality of service goals defined by the customer. These enhancements will ensure that the unpredictable needs of new e-transaction processing workloads can be managed dynamically according to business requirements.

The current implementation addresses three separate but mutually supportive functions:

- **Dynamic Channel Path Management (DCM)**
This feature enables customers to have channel paths that dynamically and automatically move to those I/O devices that have a need for additional bandwidth. The benefits are enhanced by the use of goal mode and clustered LPARS.
- **Channel Subsystem Priority Queuing**
Channel subsystem priority queuing on the z900 allows the priority queuing of I/O requests within the channel subsystem and the specification of relative priority among LPARs.
- **LPAR CPU Management**
WLM dynamically adjusts the number of logical processors online to an LPAR and the processor weight based on the WLM policy. The ability to move the CPU resources across an LPAR cluster provides processing power to where it is most needed based on WLM goal mode policy.

Dynamic Channel Path Management

Introduction to Dynamic Channel Path Management

There is no typical workload. The requirements for processor capacity, I/O capacity and other resources vary throughout the day, week, month and year. Traditional methods of monitoring and tuning result in configurations that attempt to address the majority of your workload characteristics, leaving resources under or over utilized at various times. Even a well tuned DASD subsystem can quickly become inappropriately configured as data is migrated to and from different subsystems. A better approach would involve tuning decisions being made more responsively, using the capabilities of the operating system to self-monitor and self-adjust.

DCM provides the ability to have the system automatically manage the number of paths available to disk subsystems. By making additional paths available where they are needed, this increases the effectiveness of your installed channels, and potentially reduces the number of channels required to deliver a given level of service. DCM also provides availability benefits by attempting to ensure that the paths it adds to a control unit have as few points of failure in common with existing paths as possible, and configuration management benefits by removing unused paths from over-configured control units. Where paths can be shared by Multiple Image Facility (MIF), DCM will co-ordinate its activities within an LPAR cluster.

Where several channels are attached from a central processor complex (CPC) to a switch, the channels can be considered as a resource pool for accessing any of the control units attached to the same switch. To achieve this without DCM would

require deactivating paths, performing a dynamic I/O reconfiguration and activating new paths. DCM achieves the equivalent process automatically, using those same mechanisms.

Channels managed by DCM will be referred to here as *managed* channels.

With HCD, it has to be defined how many channel paths of a control unit are to be managed. At least one channel path must be defined as static.

Value of Dynamic Channel Path Management

- **Improved system performance**

Improved system performance is achieved by automatic path balancing and service policy. Reassignment is done in real-time or on WLM adjustment interval. A customer may reassign once a year, WLM does it every few seconds.

- **More effective utilization of installed hardware**

Channels will be automatically balanced, providing opportunities to use fewer I/O paths to service the same workload.

- **Simplified I/O definition**

The connection between managed channels and control units does not have to be explicitly defined, but at least one static path is required for each control unit.

- **Reduced skills required to manage z/OS**

Managed channels and control units are automatically monitored, balanced, tuned and reconfigured.

Reporting of Dynamic Channel Path Management

All RMF reports about channel activities and I/O queuing activities provide information about DCM. The following examples show Monitor III reports.

Channel Activity Report

RMF V1R2 Channel Path Activity							Line 1 of 12		
Command ==>							Scroll ==> HALF		
Samples: 100		System: SYS1		Date: 07/22/01		Time: 15.55.00		Range: 120 Sec	
Channel Path			Utilization(%)			Read(MB/Sec)		Write(MB/Sec)	
ID No	Type	SHR	Part	Total	Bus	Part	Total	Part	Total
8	*FC_SM		21.76	38.97	40.20	10.23	23.87	11.02	18.39
12	*FCV_M		13.69	26.86	33.39	8.98	16.43	6.55	12.01
1	*CNC_M		17.23	34.45					
80	FC	Y	22.00	43.90	44.01	11.34	24.40	10.66	19.50
81	FC_SM	Y	21.76	38.97	40.20	10.23	23.87	11.02	18.39
82	FCV	Y	14.70	28.50	31.17	8.22	17.34	6.48	11.16
83	FCV_M	Y	13.69	26.86	33.39	8.98	16.43	6.55	12.01
85	CTC_S	Y	0.10	3.95					
89	CNC_S		0.75	5.82					
8C	CNC	Y	1.79	13.50					
8D	CNC_S	Y	1.87	13.78					
DA	CNC_M	Y	17.23	34.45					

Figure B-1. CHANNEL Report

For all channels that are managed by DCM, additional information is available. These channels are not assigned to a specific control unit permanently, but belong to a pool of channels. Based on workload requirements in the system, these

Intelligent Resource Director

channels will be assigned dynamically by DCM. On top of the report, there is a consolidated data section for managed channel paths displaying the total number of channel paths for each type and the average activity data. The character **M** as suffix of the acronym for the channel path type is an indicator that the channel is managed by DCM.

I/O Queuing Activity Report

RMF V1R2 I/O Queuing Activity										Line 1 of 54		
Command ==>										Scroll ==> HALF		
Samples:		100		System: MVS1		Date: 11/20/01		Time: 08.53.20		Range: 100 Sec		
Path	DCM	CTL	Units	DCM Group			Cont	Del	Q	CHPID	%DP	%CU
				MIN	MAX	DEF	LCU	Rate	Lngh	Taken	Busy	Busy
DA			400A				0150			0.89	0.00	0.00
BA	Y		400A				0150			0.68	19.00	0.00
E3			400B				0150			0.86	0.00	0.00
E5	Y		400B				0150			0.78	18.26	0.00
				2	2	4	0150			1.46	18.63	0.00
							0150	0.0	0.00	3.21	9.41	0.00
DA			440A				0151			0.01	0.00	0.00
BA			440A				0151			0.02	33.33	0.00
E3			440B				0151			0.02	0.00	0.00
E5			440B				0151			0.03	25.00	0.00
							0151	0.0	0.00	0.07	20.00	0.00

Figure B-2. IOQUEUE Report

The values in columns MIN MAX report the minimum and maximum number of DCM managed channels for one LCU (in this interval). DEF is the maximum number of managed channels for each LCU as it has been defined with HCD.

The line with these values is available only for LCUs with DCM managed channels. It also contains the I/O activity rate, director port contention, and control unit contention of all DCM managed channels. These values may include also measurements of managed channels which were partially online.

Channel Subsystem Priority Queuing

Introduction to Channel Subsystem Priority Queuing

Channel subsystem (CSS) priority queuing is a new function available on z900 processors either in basic or LPAR mode that allows the operating system to specify a priority value when starting an I/O request. When there is contention causing queuing in the channel subsystem, the request will be prioritized by this value.

z/OS will set the priority based on a goal mode WLM policy. This will complement the goal mode priority management that sets I/O priority for IOS UCB queues, and for queuing in the 2105 ESS DASD subsystem.

CSS priority queuing uses different priorities calculated in a different way than the I/O priorities used for UCB and control unit queuing.

Value of Channel Subsystem Priority Queuing

- **Improved performance**

I/O from work that is not meeting its goals may be prioritized ahead of I/O from work that is meeting its goals, providing the Workload Manager with an additional method of adjusting I/O performance. Channel subsystem priority queuing is complementary to UCB priority queuing and control unit priority queuing, each addressing a different mechanism that may affect I/O performance.

- **More effective use of providing I/O bandwidth**

Because interference from other I/O is reduced, the total I/O bandwidth required to meet the goals of high importance work may possibly be reduced. Previously, bandwidth had to be acquired to service the whole workload in order to meet the performance requirements of important work.

- **Reduced skills required to manage z/OS**

Monitoring and tuning requirements are reduced because of the self tuning abilities of the channel subsystem.

Reporting of Channel Subsystem Priority Queuing

There is no specific reporting of this function in RMF, but you may see a reduced number of I/O delay samples in the Workload Activity report.

LPAR CPU Management

Introduction to LPAR CPU Management

LPAR CPU management allows WLM working in goal mode to manage the processor weighting and number of logical processors across an LPAR cluster. CPU resources are automatically moved toward LPARs with the most need, by adjusting the partition's weight. The sum of the weights for the participants of an LPAR cluster is viewed as a pooled resource which can be apportioned among the participants to meet the goal mode policy. The installation can place limits on the processor weight range.

WLM will also manage the available processors by varying unneeded CPs offline (more logical CPs implies more parallelism, and less weight per CP). LPAR overheads will be decreased by reducing the number of logical processors.

LPAR Cluster

An LPAR cluster is a group of logical partitions that are resident on the same physical server and in the same sysplex.

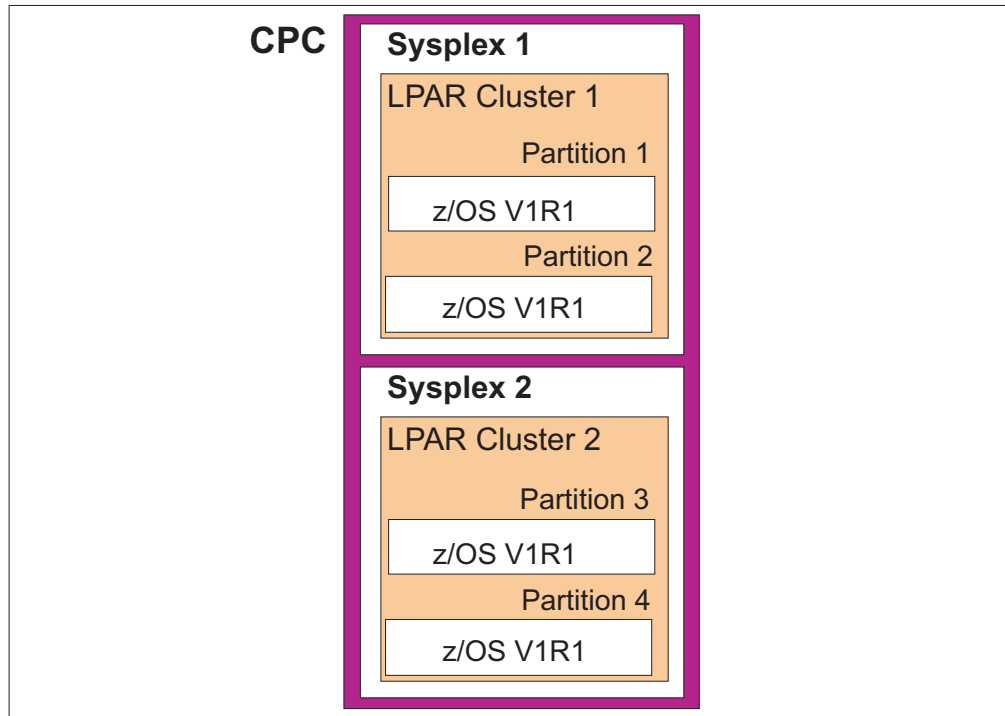


Figure B-3. LPAR Cluster - Example 1

The next figure is a more complex configuration, with four LPAR clusters grouped into two sysplexes across two CPCs:

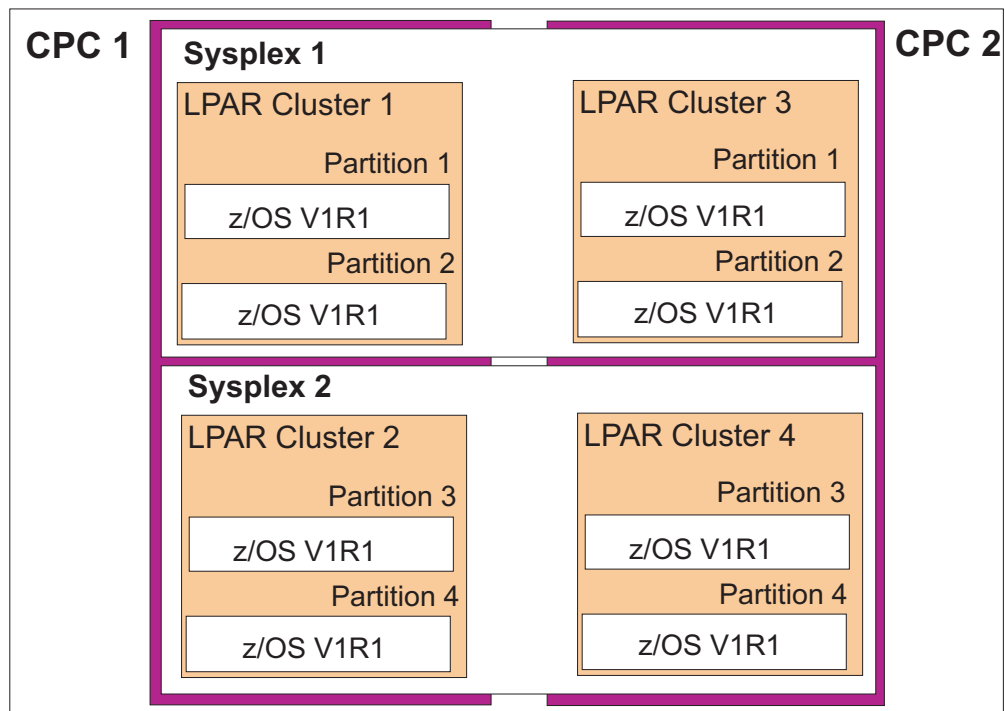


Figure B-4. LPAR Cluster - Example 2

Value of LPAR CPU Management

- **Logical CPs are performing at the fastest uniprocessor speed available.**

This results in the number of logical CPs tuned to the number of physical CPs of service being delivered by the LPARs current weight. If the LPAR is getting 4 equivalent physical CPs of service and has 8 logical CPs online to z/OS, then each logical CP only gets half of an equivalent physical CP. For example, if a CP delivers 200 MIPS, half of it will deliver 100 MIPS. This occurs because each logical CP gets fewer time slices.

- **Reduces LPAR overhead.**

There is an LPAR overhead for managing a logical CP. The higher the number of logical CPs in relation to the number of physical CPs, the higher the LPAR overhead. This is because LPAR has to do more processing to manage the number of logical CPs which exceeds the number of physical CPs.

- **Gives z/OS more control over how CP resources are distributed.**

z/OS is able to change the assigned CP resources (LPAR weights) and place them where they are required for the work. Making both of these adjustments is simple from an operator perspective, but what is difficult is identifying when the changes are required and whether the changes have had a positive effect.

LPAR CPU management

- identifies what changes are needed and when
- projects the likely results on both the work it is trying to help and the work that it will be taking the resources from
- performs the changes
- analyzes the results to ensure the changes have been effective.

LPAR CPU Management Decision Controls

There are two parts of LPAR CPU management:

- WLM LPAR Weight Management
- WLM LPAR Vary CPU Management

WLM LPAR Weight Management

WLM LPAR weight management involves extending the receiver/donor logic for CPU delays to CP resource being used by other LPARs in the LPAR cluster. Until now, WLM could only move CP resource from one service class period to another on the same system by adjusting the dispatching priority of the receiver and/or the donor. When using WLM LPAR weight management, WLM can now alter the weights of LPARs in the LPAR cluster, effectively moving CP resource from one LPAR to another.

In the past, an operator was required to change LPAR current weights manually. However, an operator would first have to determine that there was a CPU delay and then choose which other LPAR the weight units should be taken from. This approach was not practical.

WLM LPAR Vary CPU Management

WLM LPAR vary CPU management does not look at service class periods when making adjustments. It ensures the number of online logical CPs is approximately equal to the number of physical CPs required to do the work. It is more like a tuning action for the CP resources available to the system. Prior to LPAR CPU management, there was no function in WLM to tune the available CP resources in relation to the physical CP resources being used by the system. Once again if this

Intelligent Resource Director

function is to be performed manually, an operator first needs to identify this is a problem before adjusting the number of logical CPs.

LPAR CPU Management Controls

The IBM z900 CPC and CPU management introduce new terms for LPAR weights. The following are used when discussing LPAR weights.

- Initial processing weight
This weight becomes the LPAR's actual weight immediately following an IPL.
- Minimum and maximum processing weight
This is the minimum and maximum weight that WLM LPAR weight management will assign as an LPAR's actual weight.
- Actual weight
An LPAR's weight at a point in time when the systems is running. This is the weight that WLM LPAR weight management and WLM LPAR vary CPU management use when performing their primary functions.
- Enable work load management must be checked to enable LPAR CPU management.
Recommended usage is to use large (2 or 3 digits) values for CPU weights to allow WLM better granularity to work within.

Reporting of LPAR CPU Management

The Postprocessor CPU Activity report has been extended by a new section called LPAR Cluster report.

LPAR Cluster Report

LPAR CLUSTER REPORT															PAGE	3						
z/OS V1R2			SYSTEM ID NP1						DATE 04/15/2001		INTERVAL 14.59.678											
			RPT VERSION V1R2 RMF						TIME 09.30.00		CYCLE 1.000 SECONDS											
----- WEIGHTING STATISTICS -----															----- PROCESSOR STATISTICS -----				----- STORAGE STATISTICS -----			
CLUSTER	PARTITION	SYSTEM	--- DEFINED ---			---- ACTUAL ----			--- NUMBER ---		-- TOTAL% --		--- CENTRAL ---		-- EXPANDED --							
			INIT	MIN	MAX	AVG	MIN %	MAX %	DEFINED	ACTUAL	LBUSY	PBUSY										
SVPLEX1	NP1	NP1	20	20	40	20	100	0.0	4	1.2	24.92	3.30		1024		N/A						
	NP2	NP2	1			1			4	4	0.73	0.27		1024		N/A						
	NP3	NP3	10	10	50	10	100	0.0	4	1.0	23.99	2.67		1024		N/A						
	TOTAL		31						12		49.64	6.24		3072		N/A						
SVPLEX2	NP4	NP4	300	100	500	300	0.0	0.0	6	4.2	80.15	53.43		1024		N/A						
	NP5	NP5	200			200			4	4	40.33	17.92		1024		N/A						
	TOTAL		500						10		120.5	71.36		2048		N/A						

Figure B-5. LPAR Cluster Report

This new report, as well as the Partition Data report (also part of the CPU Activity report), provides information about LPAR CPU management.

Report Analysis

- CLUSTER PARTITION

The three partitions NP1, NP2, and NP3 belong to the LPAR cluster SVPLEX1, but only NP1 and NP3 are under control of LPAR CPU management.

- DEFINED INIT MIN MAX

NP1 has an initial weight of 20 which also is the defined minimum, and it has a defined maximum weight of 40.

- ACTUAL AVG

The average actual weight in the interval for NP1 is 20.

- ACTUAL MIN % MAX %

These values provide the percentage of the interval when the partition's weight was within 10% of the defined minimum or maximum weight. NP1 was within 10% of the specified minimum (20) for the entire interval (MIN%=100).

- NUMBER DEFINED ACTUAL

NP1 has been defined with 4 logical processors. In the current interval, WLM LPAR CPU management has assigned 1.2 processors to this partition in average. This value can be seen also in the Partition Data report (PROCESSOR NUM) and reflects the total ONLINE TIME PERCENTAGE in the CPU Activity report.

- TOTAL% LBUSY PBUSY

These values give the utilization of the logical processors assigned to the partition (based on its online time) and of all physical processors of the CPC (based on the interval time). They are also shown in the Partition Data report.

- STORAGE STATISTICS

The amount of central and expanded storage assigned to each partition is given in these columns.

Intelligent Resource Director

Partition Data Report

P A R T I T I O N D A T A R E P O R T																PAGE 2			
z/OS V1R2				SYSTEM ID NP1				DATE 04/15/2001				INTERVAL 14.59.678							
				RPT VERSION V1R2 RMF				TIME 09.30.00				CYCLE 1.000 SECONDS							
MVS PARTITION NAME				NP1															
IMAGE CAPACITY				100															
NUMBER OF CONFIGURED PARTITIONS				9															
NUMBER OF PHYSICAL PROCESSORS				9															
CP				9															
ICF				0															
WAIT COMPLETION				NO															
DISPATCH INTERVAL				DYNAMIC															
----- PARTITION DATA -----																-- LOGICAL PARTITION PROCESSOR DATA --		-- AVERAGE PROCESSOR UTILIZATION PERCENTAGES --	
NAME	S	WGT	DEF	ACT	DEF	WLM%	PROCESSOR- NUM	TYPE	DISPATCH TIME DATA		LOGICAL PROCESSORS		PHYSICAL PROCESSORS						
									EFFECTIVE	TOTAL	EFFECTIVE	TOTAL	LPAR MGMT	EFFECTIVE	TOTAL				
NP1	A	20	100	10	NO	62.2	1.2	CP	00.04.29.502	00.04.27.519	25.10	24.92	****	3.33	3.30				
NP2	A	1	0	1	YES	0.0	4	CP	00.00.22.680	00.00.22.083	0.75	0.73	****	0.28	0.27				
NP3	A	10	5	8	NO	3.3	1.0	CP	00.03.37.761	00.03.35.859	24.20	23.99	****	2.69	2.67				
NP4	A	300	95	155	NO	0.0	0.3	CP	01.12.08.405	01.12.06.405	80.18	80.15	****	53.46	53.43				
NP5	A	200	50	52	NO	0.0	4	CP	00.24.13.447	00.24.11.311	40.39	40.33	****	17.95	17.92				
CFC1	A	DED	0	32		0.0	1	ICF	00.14.59.611	00.14.59.625	99.99	99.99	0.00	11.11	11.11				
CFC2	A	DED	0	0		0.0	1	ICF	00.00.00.000	00.00.00.000	0.00	0.00	0.00	0.00	0.00				
PHYSICAL										00.00.03.603		0.04		0.04					
TOTAL									01.59.51.408	01.59.46.408			0.04	88.81	88.75				
CB88	D																		
CB89	D																		

Figure B-6. Partition Data Report

The Partition Data report contains in the fields WGT and PROCESSOR NUM the actual values for weighting and number of logical processors, either as dynamically assigned by LPAR CPU management (for example, NP1 or NP3) or as statically defined by the customer (for example, NP2).

IBM License Manager

The IBM License Manager is the base for a new software pricing model. It allows vendors to enable their products for licensed software management by customers and is the basic tool IBM will use to implement the Workload License Charges pricing model on z900 servers.

When using the License Manager, the customer can specify a capacity limit as part of the definition of an LPAR partition.

Report Analysis

The following values in the report are related to the License Manager:

- **IMAGE CAPACITY**

A new value IMAGE CAPACITY in this report gives information about the CPU capacity which is available to the partition. It is measured in MSUs (millions of CPU service units) per hour. There are these alternatives:

- The partition's defined capacity set via the Hardware Management Console, if any. The report shows that NP1 has a defined capacity of 100 MSUs.
- The capacity based on logical processors defined for the partition, if the partition is uncapped and has no defined capacity.

Example:

MSU of CPC	290
# physical processors	9
# logical processors	4
Image capacity	$(4/9) * 290 = 129$

- The capacity at the partition's weight, if the partition is capped via the Hardware Management Console.

- **MSU DEF ACT**

For each partition, the defined and actual MSU values are given. For the partition which is gathering the data, here partition NP1, DEF MSU (100) is identical to IMAGE CAPACITY while the actual MSU consumption in the interval is 10 MSUs (calculated as MSUs per hour). A value of zero in field DEF indicates there is no defined capacity set for this partition.

ACT MSU contains the actual consumption of service units in MSUs per hour. This value does not correlate to the value of service units given in the Workload Activity report.

- **Service Units in Workload Activity Report**

In the Service Policy page you find for each processor the value SU/SEC. This value is based on the number of logical processors assigned to the partition. If you have 4 logical processors in a z900 server, then this value relates to a 2064-104 (with 148 MSUs).

1 LP	= 10289 SU/SEC
4 LPs	= 41156 SU/SEC = 148 MSU/H

- **Service Units in Partition Data Report**

Service unit consumption in a License Manager context is based on the number of physical processors in the CPC. In a 9-way z900 server 2064-109 with 290 MSUs, this value is taken:

1 CP	= 8964 SU/SEC
9 CPs	= 80676 SU/SEC = 290 MSU/H

- **CAPPING WLM%**

The concept of the License Manager is to allow a partition a limited resource consumption - the defined capacity limit. If the partition is using more service units than defined, WLM will cap this partition. This is not done directly on the current consumption but it is based on a long-term average. So peaks exceeding the defined limit are possible. The field CAPPING WLM% shows the percentage of the reporting interval when a partition has been capped by WLM.

Appendix C. Data-In-Memory

Exploiting Your Storage

This appendix concentrates on Data-In-Memory techniques. The key topics are:

- Benefits of these techniques
- Evaluation before the implementation
- Different functions or products that implement DIM

The chapter concludes with a roadmap on how to proceed with your applications.

Introduction

Data-In-Memory (DIM) techniques enable individual jobs (or a group of chained jobs) to run faster by reducing the I/O component of the elapsed time for the job. The reduction is achieved by reading the data from (or in some cases writing to) a buffer in processor storage instead of tape or DASD. There are several benefits of these techniques:

- I/Os are reduced, and therefore their component of elapsed time is reduced in proportion to the reduction in I/Os.
- The remaining I/Os are done to a less busy I/O subsystem, which gives the remaining I/Os a faster response.
- The CPU is no longer used for driving I/Os.
- The CPU is no longer used for pre-processing CLISTS or LOAD modules.
- Some CPU cycles are saved as a result of less contention and a shorter transaction residency time.

On the other hand, sufficient storage and CPU resources need to be available to sustain the new load:

- Data is moved to central storage: if there is not enough storage, the paging activity may rise and become a new bottleneck.
- More work will be available sooner: the processor must be able to execute this new load without stopping the old.
- There is some processor overhead associated with the movement of pages between central and expanded storage.

The net of the CPU savings and the CPU overhead is generally fairly small, usually less than 5%. However for most transactions, waiting for I/O is the largest single component of the response time: any significant reduction in I/O rates can make a large difference in the response time.

To evaluate the benefits of the DIM techniques implementation, the following steps must be performed:

1. Understand the current processor storage situation, assessing the current storage requirements.
2. Perform a study of DIM exploiters, assessing the additional storage requirements for DIM exploitation.
3. Reduce DASD response time, assessing the degree to which remaining I/Os can be expedited and determining the new steps to do this.
4. Implement all the changes.
5. Monitor the results.

In steps 1 and 5, RMF is a good starting tool. Some other tools can help with the assessment of benefits; refer to the documentation related to the different functions or products mentioned below.

Current Implementations

The following sections briefly describe the different functions or products that implement the DIM techniques, in a batch and in an OLTP environment.

Batch LSR Subsystem

The *Batch LSR Subsystem (BLSR)* extends the benefits of *VSAM Local Shared Resources (LSR)* to applications written to use *VSAM Non-Shared Resources (NSR)*, typically programs written in high-level languages. VSAM LSR allows a program processing a VSAM data set to buffer frequently-used data in processor storage, eliminating read I/Os and reducing the elapsed time of an individual job. VSAM NSR does not provide this kind of buffering.

BLSR is implemented as an MVS address space (in particular, a subsystem). Specified VSAM NSR data set OPENs are routed to the BLSR subsystem, which converts them to VSAM LSR OPENs. It also allocates the buffer pools specified either as portions of its own virtual storage or as hiperspaces that it owns. Hence, there is no effect on the job's virtual storage usage.

Eligibility

The Batch LSR Subsystem supports the following VSAM data set organizations and alternate indexes (some restrictions may apply):

- Key Sequenced (KSDS)
- Relative Record (RRDS)
- Entry Sequenced (ESDS)

DFSORT Hipersorting

Many large sorts (particularly the larger ones in the batch window) require work space to hold intermediate data. Typically this is held on DASD (although tape and VIO are also supported). As much as 20% of a large sort's elapsed time might be spent performing I/O to work data sets. DFSORT hipersorting allows part or all of the sort work space to be allocated in a hiperspace residing in expanded storage. This approach leads to a reduction or elimination of sort work I/O and a consequent reduction in elapsed time for the sort.

Hipersorting uses the standard type of hiperspace so there may be an increase in paging and page data set usage because of overcommittal of expanded storage.

Eligibility

Any sort performing I/O to work data sets is eligible for hipersorting. The amount of expanded storage available when the sort begins determines the degree to which hipersorting takes place. Storage availability is measured in terms of the system impact of giving expanded storage to DFSORT rather than the number of free expanded storage frames.

DFSORT does not use hipersorting for sorts using tape work space. These sorts should use DASD work space (or all hiperspace) as tape is not recommended for sort work space.

Implementation

Hipersorting can be enabled at the system level as a default. To do this, code the HIPRMAX keyword on the ICEMAC macro as a system-level option. It can also be enabled at sort invocation by coding the HIPRMAX run-time option.

DIM techniques

Hiperbatch

Frequently, some data sets are read sequentially several times during a batch window. These data sets may be written during the batch window and then subsequently read. Typically, installations have found that these multiply-accessed data sets produce performance bottlenecks because of DASD contention.

Traditional methods of reducing this effect have been to:

- Duplicate the data set over several DASD volumes or even controllers.
- Schedule each of the jobs and jobsteps so that they access the data at different times.
- Copy the data set (if it is small) to a VIO data set (using paging I/O instead of traditional I/O).

Hiperbatch provides a set of services that can provide greater benefits than these techniques and without many of their associated problems. It uses the Data Lookaside Facility (DLF) component of MVS to keep copies of portions of sequentially processed data sets in hiperspaces in expanded storage.

Eligibility

Hiperbatch supports access methods VSAM Non-Shared Resources and QSAM.

A VSAM data set (KSDS, ESDS, or RRDS) is supported if:

- The data set is not accessed as VSAM LSR or GSR.
- The data set is not accessed with shareoptions 3 or 4.
- The control interval size is 4 KB or a multiple thereof.
- The data set is not a catalog.
- The data set is not accessed with CI processing.

A data set processed by QSAM is supported if:

- It resides on DASD.
- It is a physical sequential data set.
- It is not a partitioned data set or a member thereof.

Implementation

Implementing hiperbatch consists of two activities:

1. Finding the right data sets to buffer
2. Turning on hiperbatch for these candidates

Having implemented hiperbatch, its effectiveness and use of resources has to be monitored and tuned (particularly in its usage of expanded storage).

VIO to Expanded Storage

VIO to expanded storage allows temporary data sets to be buffered in expanded storage for the life of the job. This technique eliminates all the I/O to the data set and can reduce the elapsed time of a job significantly. It is an extension to traditional VIO, which uses page data sets to hold temporary data sets. With DFSMS, implementation can be such that the application developer is unaware that the temporary data sets are not on DASD but are using VIO to expanded storage. In this and many other ways, DFSMS enables easier and more effective implementation and control of VIO to expanded storage.

Eligibility

All access methods are eligible for VIO with the exception of VSAM, ISAM, and PDSE.

Implementation

Implementation should be performed cautiously as VIO to expanded storage can consume large amounts of storage if not properly managed. It consists of two main elements:

- Enabling VIO for the system.
- Making individual data sets eligible.

VSAM Large Buffer Pools

VSAM Local Shared Resources (VSAM LSR) allows users accessing VSAM data sets to be buffered using pools of buffers in processor storage. This approach avoids the repeated reading of the same data from DASD and hence reduces the I/O component of elapsed time.

Virtual Lookaside Facility

The *Virtual Lookaside Facility (VLF)* is a component of z/OS MVS designed to improve performance by retrieving frequently-used objects from virtual storage rather than performing I/O operations from DASD.

VLF can save I/Os in several ways; for example:

- Keeping modules in virtual storage.
- Keeping the directories of frequently accessed PDSs in virtual storage.
- Keeping processed CLISTS in virtual storage.

More information on VLF can be found in the *z/OS MVS Initialization and Tuning Guide*.

DB2 Buffer Pool

DB2 Version 3 extends the bufferspace to hiperspace, providing a new facility to keep a large amount of DB2 data in the expanded storage.

This ability to allocate the majority of DB2's bufferpool requirements in expanded storage means that more central storage may now be made available to other subsystems while maintaining the same bufferpool requirements in DB2.

Furthermore, in a hiperpool configuration, DB2 itself manages the page movement to and from expanded storage using the hardware feature *Asynchronous Data Mover Facility (ADMF)*, resulting in the elimination of the MVS-managed paging.

Configurations currently constrained by high MVS paging rates may find hiperpools provide an effective means of reducing MVS paging activity in the system. MVS paging avoidance or elimination in DB2 may translate into system wide response time improvements and throughput improvements from MVS paging reductions in other subsystems as well.

CICS Shared Data Tables

A shared data table is an in-storage copy of some or all of the records from a data set. CICS automatically stores the records in the data table when the corresponding file is opened. Data table records are stored in a z/OS MVS data space.

In actual measurements, the use of CICS shared data tables has shown improvements of over 50% in response time, with up to 95% improvement in the file access times alone. CPU times are also reduced by eliminating the need to process interrupts, and manage the VSAM interface.

DIM techniques

Virtual Fetch

Virtual fetch (VF) is an MVS function that sends storage pages to expanded storage when the migration age is greater than the criteria age. This is specified as an IEAOPTxx parameter: the ESCTVF parameter specifies the criteria age at which a virtual page will be sent to expanded storage.

Methodology Roadmap

The following roadmap provides an example on how to start a DIM study in a batch environment.

Data-In-Memory Roadmap

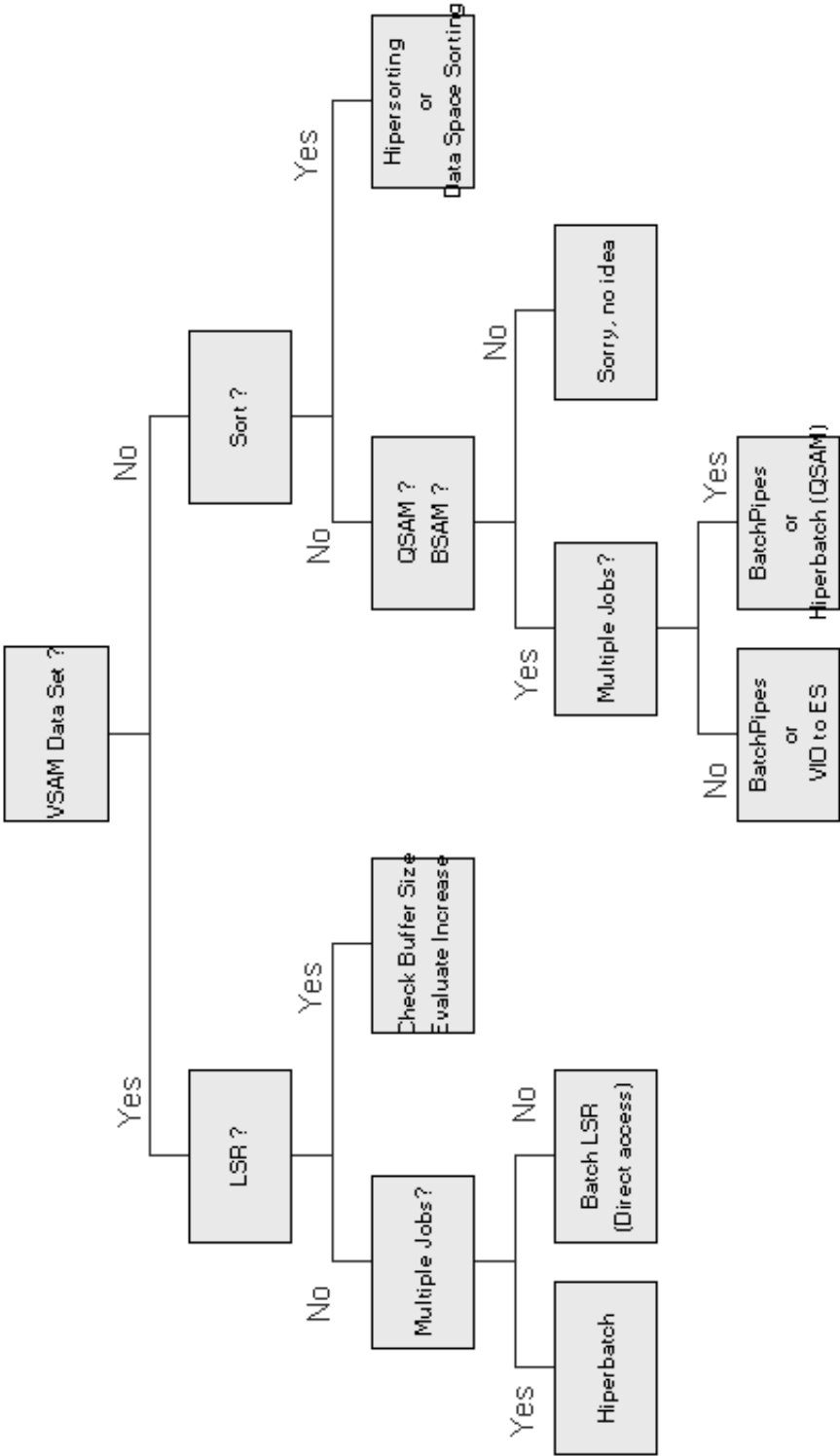


Figure C-1. Data-In-Memory Roadmap

DIM techniques

Appendix D. Other Delays

Some Other Delays

This last appendix discusses the delays shown by Monitor III that have not been covered yet:

- Enqueue delays
- HSM delays
- JES delays
- OPER delays
- Unknown delays

Enqueue Delays

Here is an approach to investigating ENQ delays using Monitor III.

ENQ Report

RMF V1R2 ENQ Delays									
Command ==>					Line 1 of 2 Scroll ==> HALF				
Samples: 100	System: PRD1		Date: 04/07/01	Time: 10.32.00	Range: 100	Sec			
Jobname	DLY	%	%	STAT	Resource Waiting			---- Holding ----	
					Major/Minor Names (Scope)			% Name/SYS	STAT
BHOLEQB	49	49	EW		SYSDSN			49	BTEUPRT
					SYS3.BB.DATA				

Figure D-1. Monitor III Enqueue Delays Report

Look at the ENQ report for the user or user group.

Use the cursor to select the resource name with most delay and press ENTER to get the ENQR report:

- Use this report to view all the contentions.
- What is the major name contributing to most of the delay?
- Find the largest "holding" user for this resource, then go through the dialog with this jobname.

The HELP function (PF1) on the ENQJ report provides description of some different MAJOR/MINOR names. Also check the *Debugging Handbook - Volume 1* for a description of the MAJOR/MINOR names.

If the name does not exist there, it may be a local name. Knowing the resource or the application provides a greater understanding of this problem.

Major Names

SYSDSN Enqueue, look for the following:

- Submitted job needs a data set that the TSO user has
- Jobs actually have to run sequentially

SYSIGGV2 / SYSCTLG Enqueue, look for the following:

- Large LISTCATs running concurrently with a DELETE or HDELETE
- Massive deletes occurring from another address space
- Allocating and deleting but not using the ISPF log data set

Try to find out what the largest "holder" of SYSIGGV2 was doing at the time of the problem. If this is not possible, and the user is a TSO user, he may have been doing massive deletes or a LISTCAT.

If the problem occurred while exiting from ISPF, the delete of the Log data set could have caused the catalog access. If so, consider making the primary and secondary allocation of the log data set zero. This causes the log data set never to be allocated when entering ISPF.

SYSVTOC Enqueue, look for the following:

Try to determine who is allocating space and why it is taking so long. Possibly a job or user is frequently acquiring and freeing the space. If this is the case, acquire it once and do not free it. If the space is for a temporary data set, try using VIO instead.

SYSZRACF Enqueue

SYSZRACF is enqueued exclusively when updating the RACF data set. Find out why it is taking so long and reduce the time.

SYSIEFSD Enqueue

SYSIEFSD has several minor names: CHNGDEVS, DDRTPUR, ALLOCTP, DDRDA, Q4, Q6, QIO, RPL, STCQUE, VARYDEV, and TSOQUE.

If the minor name is CHNGDEVS, look for a large DEVICE USING or DEVICE DELAY for the HOLDING address space. For example DEVICE DELAY may be near 100%. Obtain the dominant volid involved. If the time duration spans several intervals look at the volids for each interval within the problem time range. Browse the SYSLOG for mount or vary activity at or about this time. Determine if anything can be done to prevent this in the future.

HSM Delays

HSM Report

RMF V1R2 HSM Delays				Line 1 of 1	
Command ==>				Scroll ==> HALF	
Samples: 100	System: PRD1	Date: 04/07/01	Time: 10.32.00	Range: 100	Sec
	DLY	----- Main Delay Reason -----			
Jobname	%	%	F-Code	Explanation	
DLOSHIN	7	7	3	Dataset recall from auxiliary storage.	

Figure D-2. Monitor III HSM Delays Report

Here are some general problems to look for:

- HSM is down
- HSM is partially down (HSM device not responding)
- HSM backed up because:
 - Not enough primary space
 - Not enough level one space
 - HSM doing housekeeping

Display the HSM address space with the DELAYJ command. Is the HSM data normal? Ask yourself why, when HSM data is unusual. You can compare this data to times when HSM delays were considered acceptable. Typical things to look for are:

- PROC TCB + SRB at 0.0% (HSM may be dead)
- PROC DELAY very high (HSM may have a poor dispatching queue position)
- DEVICE DELAY or DEVICE USING excessive (see DEVR report and determine why)
- A non-typical volume is in heavy use (modules being fetched?)
- Excessive ENQ DELAY time because of CATALOG or VTOC contention

Do a HLIST PVOL TERMINAL for volumes under HSM or ISMF control. The AGE column under SPACE-MGMT is the number of days a data set on this volume must be inactive before it is eligible for the type of space management indicated under TYPE. Different volumes may have different ages. MIN AGE shows the inactive age of the data set that most recently migrated from the volume.

Pick the one of the following that seems to be most probable:

- Something is broken (HSM in loop, HSM in infinite wait, control unit down, HSM address space terminated, STOR LOCL is 100%).
- HSM address space is running slowly because of contention with others (high PROC DELAY, high STOR LOCL, high DEVICE DELAY, high ENQ DELAY).
- HSM is in house cleaning mode (HSM is reorganizing data sets to reclaim space. There will be a high amount of PROC TCB + SRB and DEVICE USING for the amount of work in progress).
- There is a shortage of primary or level-one space (for example migration age less than 7 days).

- There is excessive traffic (migration age greater than 7 but many recall requests outstanding).

JES Delays

Here are some general problems to look for:

- JES is down
- JES is partially down (JES device not responding)
- JES backed up

Check the SYSLOG for more information. Look for excessive amount of I/O in the JES address space.

OPER Delays

In RMF terms, the operator is another resource hence can appear as a delay.

The Monitor III Delay report has a field of OPER%. This means the job is delayed by a mount request or is waiting for a reply to a WTOR message.

Where practicable, batch jobs or applications should not issue WTORs. The use of WTORs is probably historical and the time spent in recoding may well be recouped by future run time improvements.

Unknown Delays

The Monitor III Delay report has a field of UKN%. RMF considers jobs that are not delayed for a monitored resource, or not in an idling state to be in an unknown state.

Examples of unknown state delays are:

- AS waiting for I/O other than DASD or tape
- Idle address spaces which use an unmonitored mechanism for determining when they are active. Most STCs show as unknown when they are idle.
- AS waiting for a request from another AS to be satisfied.

Other delays

Glossary

A

AS. address space

auxiliary storage (AUX). All addressable storage, other than main storage, that can be accessed by means of an I/O channel; for example storage on direct access devices.

B

balanced systems. To avoid bottlenecks, the system resources (CP, I/O, storage) need to be balanced.

basic mode. A central processor mode that does not use logical partitioning. Contrast with *logically partitioned (LPAR) mode*.

bottleneck. A system resource that is unable to process work at the rate it comes in, thus creating a queue.

BLSR. Batch LSR Subsystem. See also *LSR*

C

cache fast write. A storage control capability in which the data is written directly to cache without using nonvolatile storage. This 3990 Model 3 Storage Control extended function should be used for data of a temporary nature, or data which is readily recreated, such as the sort work files created by DFSORT. Contrast with *DASD fast write*.

cache hit. Finding a record already in the storage (cache) of the DASD control unit (3990).

capture ratio. The ratio of reported CPU time to total used CPU time.

captured storage. See shared page group.

central processor (CP). The part of the computer that contains the sequencing and processing facilities for instruction execution, initial program load, and other machine operations.

central processor complex (CPC). A physical collection of hardware that consists of central storage, one or more central processors, timers, and channels.

CFWHIT. Cache fast write and read hits

channel path. The channel path is the physical interface that connect control units and devices to the CPU.

CICS. Customer Information Control System

compatibility mode. The implicit state of an MVS system when no workload manager service policies are in effect. Contrast with *goal mode*.

contention. Two or more incompatible requests for the same resource. For example, contention occurs if a user requests a resource and specifies exclusive use, and another user requests the same resource, but specifies shared use.

CP. Central processor Synonymous with *CP (central processor)*.

criteria. Performance criteria set in the WFEX report options. You can set criteria for all report classes (PROC, SYSTEM, TSO, and so on).

CRR. Cache RMF Reporter

CS. Central storage

CPU speed. Measurement of how much work your CPU can do in a certain amount of time.

Customer Information Control System (CICS). An IBM licensed program that enables transactions entered at remote terminals to be processed concurrently by user-written application programs. It includes facilities for building, using, and maintaining data bases.

cycle. The time at the end of which one sample is taken. Varies between 50 ms and 9999 ms. See also *sample*

D

DASD fast write. An extended function of the 3990 Model 3 Storage Control in which data is written concurrently to cache and nonvolatile storage and automatically scheduled for destaging to DASD. Both copies are retained in the storage control until the data is completely written to the DASD, providing data integrity equivalent to writing directly to the DASD. Use of DASD fast write for system-managed data sets is controlled by storage class attributes to improve performance. Contrast with *cache fast write*.

data sample. See *sample*

DCM. See *Dynamic Channel Path Management*

DCME. Dynamic cache management extended

delay. The delay of an address space represents a job that needs one or more resources but that must wait because it is contending for the resource(s) with other users in the system.

DFWHIT. DASD fast write hit

DFWRETRY. DASD fast write retry

DIM. Data-In-Memory

direct access storage device (DASD). A device in which the access time is effectively independent of the location of the data.

DLY. Delay

DP. Dispatching priority

dynamic channel path management. Dynamic channel path management provides the capability to dynamically assign channels to control units in order to respond to peaks in demand for I/O channel bandwidth. This is possible by allowing you to define pools of so-called floating channels that are not related to a specific control unit. With the help of the Workload Manager, channels can float between control units to best service the work according to their goals and their importance.

E

EMIF. ESCON multiple image facility

enclave. An enclave is a group of associated dispatchable units. More specifically, an enclave is a group of SRB routines that are to be managed and reported on as an entity.

EPDM. Enterprise Performance Data Manager/MVS, new name of the product is Performance Manager for MVS

execution velocity. A measure of how fast work should run when ready, without being delayed for processor or storage access.

ES. Expanded storage

ESCON multiple image facility (EMIF). A facility that allows channels to be shared among PR/SM logical partitions in an ESCON environment.

ETR. External throughput rate, see also ITR

exception reporting. So that you don't have to watch your monitor all the time to find out if there is a performance problem, you can define performance criteria. RMF will then send a report when the criteria are not being met (an exception has occurred).

expanded storage (ES). (1) An extension of processor storage. (2) Optional high-speed storage that transfers 4KB pages to and from central storage.

G

generalized trace facility (GTF). An optional OS/VS service program that records significant system events,

such as supervisor calls and start I/O operations, for the purpose of problem determination.

GO mode. In this mode, the screen is updated with the interval you specified in your session options. The terminal cannot be used for anything else when it is in GO mode. See also *mode*.

goal mode. The implicit mode of an MVS system that has active service policies and performance goals defined by the workload manager. Contrast with *compatibility mode*.

GTF. generalized trace facility

H

high-speed buffer (HSB). A cache or a set of logically partitioned blocks that provides significantly faster access to instructions and data than provided by central storage.

HS. hiperspace

HSB. High-speed buffer

I

IMS. Information Management System

Information Management System (IMS). A database/data communication (DB/DC) system that can manage complex databases and networks. Synonymous with IMS/VS.

installation performance specification (IPS). In MVS, a set of installation-supplied control information used by the system workload manager. An IPS includes performance group definitions, performance objectives, and coefficients used to establish the service rate. See also service rate.

Intelligent Resource Director (IRD). The Intelligent Resource Director (IRD) is a functional enhancement exclusive to IBM's zSeries family that can continuously and automatically reallocate resources throughout the system in response to user requirements and is based on a customer's business priorities.

ITR. Internal throughput rate, see also *ETR*.

L

Latency. The time waiting for a particular record on a track to rotate to the read/write head. This usually averages one half the rotation time.

LCU. Logical control unit

License Manager. The IBM License Manager is the base for a new software pricing model. It allows vendors

to enable their products for licensed software management by customers and is the basic tool IBM will use to implement the Workload License Charges pricing model on z900 servers.

local shared resources. An option for sharing I/O buffers, I/O-related control blocks, and channel programs among VSAM data sets in a resource pool that serves one partition or address space.

logically partitioned (LPAR) mode. A central processor mode that is available on the Configuration frame when using the PR/SM feature. It allows an operator to allocate processor unit hardware resources among logical partitions. Contrast with *basic mode*.

logical partition (LP). A subset of the processor hardware that is defined to support an operating system. See also *logically partitioned (LPAR) mode*.

LP. Logical partition.

LPAR. Logically partitioned (mode).

LPAR cluster. An LPAR cluster is the subset of the systems that are running as LPARs on the same CEC. Based on business goals, WLM can direct PR/SM to enable or disable CP capacity for an LPAR, without human intervention.

LSPR methodology. Recommended methodology for assessing processor power.

LSR. Local shared resources

LUE. Low utilization effect

M

migration rate. The rate (pages/second) of pages being moved from expanded storage through central storage to auxiliary storage.

mintime. The smallest unit of sampling in Monitor III. Specifies a time interval during which the system is sampled. The data gatherer combines all samples gathered into a set of samples. The set of samples can be summarized and reported by the reporter.

mode. Monitor III can run in various modes: The GO mode displays a chosen report, and updates it according to the interval you have chosen, the STOP mode, which is the default mode. The GRAPHIC mode presents the reports in graphic format using the GDDM* product. You can also use TABULAR mode by setting GRAPHIC OFF.

MPL. Multiprogramming level

MTW. Mean time to wait

N

NVS. Nonvolatile storage

nonvolatile storage (NVS). Additional random access electronic storage with a backup battery power source, available with a 3990 Model 3/6 Storage Control, used to retain data during a power failure. Nonvolatile storage, accessible from all storage directors, stores data during DASD fast write and dual copy operations.

P

partitioned data set (PDS). A data set in direct access storage that is divided into partitions, called members, each of which can contain a program, part of a program, or data. Synonymous with program library.

PDS. partitioned data set

peak-to-average ratio. The ratio between the highest CPU utilization and the average utilization (peak hour busy/prime shift average busy).

PER. Program event recording

performance management. (1) The activity which monitors and allocates data processing resources to applications according to goals defined in a service level agreement or other objectives. (2) The discipline that encompasses collection of performance data and tuning of resources.

performance group. Group of work with the same performance objectives managed by the SRM.

PG. Performance group

PGN. Performance group number

PR/SM. Processor Resource/Systems Manager.

Processor Resource/Systems Manager (PR/SM). The feature that allows the processor to run several operating systems environments simultaneously and provides logical partitioning capability. See also *LPAR*.

program event recording (PER). A hardware feature used to assist in debugging programs by detecting and recording program events.

R

range. The time interval you choose for your report.

RMA. The 3990 RPS miss avoidance feature.

RHIT. Read hit

S

sample. Once in every cycle, the number of jobs waiting for a resource, and what job is using the resource at that moment, are gathered for all resources of a system by Monitor III. These numbers constitute one sample.

SCP. System control program

seek. The DASD arm movement to a cylinder. A seek can range from the minimum to the maximum seek time of a device. In addition, some I/O operations involve multiple imbedded seeks where the total seek time can be more than the maximum device seek time.

service level agreement (SLA). A written agreement of the information systems (I/S) service to be provided to the users of a computing installation.

Service Level Reporter (SLR). An IBM licensed program that provides the user with a coordinated set of tools and techniques and consistent information to help manage the data processing installation. For example, SLR extracts information from SMF, IMS, and CICS logs, formats selected information into tabular or graphic reports, and gives assistance in maintaining database tables.

service rate. In the system resources manager, a measure of the rate at which system resources (services) are provided to individual jobs. It is used by the installation to specify performance objectives, and used by the workload manager to track the progress of individual jobs. Service is a linear combination of processing unit, I/O, and main storage measures that can be adjusted by the installation.

shared page groups. An address space can decide to share its storage with other address spaces using a function of RSM. As soon as other address spaces use these storage areas, they can no longer be tied to only one address space. These storage areas then reside as *shared page groups* in the system. The pages of shared page groups can reside in central, expanded, or auxiliary storage.

SLA. service level agreement

SLIP. serviceability level indication processing

SLR. Service Level Reporter

SMF. System management facility

speed. See *workflow*

SRB. Service request block

SRM. System resource manager

SSCH. Start subchannel

sysplex. A complex consisting of a number of coupled MVS systems.

system control program (SCP). Programming that is fundamental to the operation of the system. SCPs include MVS, VM, and VSE operating systems and any other programming that is used to operate and maintain the system. Synonymous with *operating system*.

T

TCB. Task control block

threshold. The exception criteria defined on the report options screen.

throughput. A measure of the amount of work performed by a computer system over a period of time, for example, number of jobs per day.

THRU. These are DASD writes to devices behind 3990s that are not enabled for DFW.

TP. Teleprocessing

TPNS. Teleprocessing network simulator

TSO. Time Sharing Option, see *Time Sharing Option/Extensions*

Time Sharing Option Extensions (TSO/E). In MVS, a time-sharing system accessed from a terminal that allows user access to MVS system services and interactive facilities.

U

UIC. Unreferenced interval count

uncaptured time. CPU time not allocated to a specific address space.

using. Jobs getting service from hardware resources (PROC or DEV) are *using* these resources.

V

velocity. A measure of how fast work should run when ready, without being delayed for processor or storage access. See also *execution velocity*.

VLF. Virtual Lookaside Facility

VTOC. Volume table of contents

W

WLM. Workload Manager

workflow. (1) The workflow of an address space represents how a job uses system resources and the

speed at which the jobs moves through the system in relation to the maximum average speed at which the job could move through the system. (2) The workflow of resources indicates how efficiently users are being served.

workload. A logical group of work to be tracked, managed, and reported as a unit. Also, a logical group of service classes.

WSM. Working Set Manager

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Index

A

- access to processor storage, prioritize 5-14
- analyzing workload characteristics 1-9
- APPL%, rule-of-thumb 2-36
- AUX 5-2
- auxiliary storage 5-2
- auxiliary storage space 5-12
- auxiliary storage tuning 5-14
- AVG CONN TIME, rule-of-thumb 4-34
- AVG DISC TIME, rule-of-thumb 4-33
- AVG HIGH UIC, rule-of-thumb 5-11
- AVG IOSQ TIME, rule-of-thumb 4-31
- AVG PEND TIME, rule-of-thumb 4-32
- AVG RESP TIME, rule-of-thumb 2-30, 4-30, 5-13
- AVG SLOTS ALLOCATED, rule-of-thumb 5-12
- AVG SLOTS USED, rule-of-thumb 5-12

B

- balanced systems 1-3
- batch 2-15
- Batch LSR subsystem C-3
- BLSR C-3
- BUSY TIME PERCENTAGE, rule-of-thumb 2-24, 3-9
- BYPASS mode 4-11

C

- CACHE, what to measure 4-10
- cache hit ratio, rule-of-thumb 4-22
- Cache Subsystem Activity report 4-18, 4-19
- capacity planning
 - approaches for 1-4
 - benefits 1-3
 - common mistakes 1-3
 - definition 1-3
 - input to 2-36
 - questions to ask 1-3
 - resources 1-3
- capture ratio
 - computing 2-36
 - definition 1-13
- central storage 5-2
- CF (coupling facility activity) 6-15
 - description 6-15
 - XES structure activity 6-15
- CFWHIT 4-10
- Channel Path Activity report, Monitor I 2-27
- Channel Subsystem Priority Queuing B-4
- CICS 2-36
 - workload activity 6-2
- collection, long term data 1-5
- collection, short term data 1-5
- components of response time 1-7
- computing CPU time per workload type 1-14
- constraint, single-CP 2-36

- contention
 - device, report 4-41
 - for resources, Monitor III report 2-14
- continuous monitoring of system status 1-5
- control unit, logical 2-27
- coupling facility activity report 6-15
 - description 6-15
 - XES structure activity 6-15

CPU

- Activity report, Monitor I 2-24
- decreasing delay 3-13
- idle due to bottleneck 3-12
- indication of bottleneck 3-12
- indicators of problem 3-2
- measuring utilization 1-13
- Monitor I indicators of problem 3-8
- problem, delay for 3-13
- problem with 3-1
- speed, calculating 1-20
- time, calculating 1-20
- time per transaction 1-15
- time per workload type, computing 1-14
- CPU Activity report, Monitor I 3-9
- CPU Activity report, partition data, Monitor I 3-11, 3-19
- CR 2-36
- CS 5-2
- cycle, sampling 1-6

D

- daily monitoring, system indicators 2-20
- DASD
 - guidelines, general 4-28
 - response time components 4-25
 - subsystem health check 4-4
 - system resource indicator 2-2
 - typical values by device type 2-30
 - what to measure 4-11
- DASD Activity report, Monitor I 5-13
- DASD guidelines 4-28
- data collection, long term 1-5
- data collection, short term 1-5
- Data-in-memory C-1
- DB2 2-30
- DCM B-2
- DCME 4-22
- decrease storage demand 5-14
- delay
 - causes of 1-8
 - enqueue D-2
 - finding major 2-13
 - HSM D-4
 - JES D-5
 - OPER D-5
 - report, Monitor III 2-16
 - tuning approach 2-4
 - unknown D-5
 - using Monitor III to find 2-14

- delay due to paging 5-9
- delay for CPU, problem 3-13
- Delay report, Monitor III 3-4
- demand, latent 1-3
- DEV 2-19
- device contention, report 4-41
- device type, typical values by DASD 2-30
- DEVICE UTILIZATION, %, rule-of-thumb 4-35
- DFWHIT 4-10
- DFWRETRY 4-11
- diagnosing a problem 2-1
- DIM 3-18, C-1, C-6
- dispatching priority 3-14
- distributing uncaptured time 1-15
- DLY %, rule-of-thumb 5-7
- DP 3-14
- Dynamic Cache Management Extended 4-22
- Dynamic Channel Path Management B-2

E

- ENQ 3-12
- enqueue delay D-2
- ESS (Enterprise Storage Server) 4-5
- exception reporting 2-18
 - guideline values 2-18
 - speed 2-18
- Workflow/Exceptions report, Monitor III 3-6

G

- GO mode 2-14
- Group Response Time report, Monitor III 2-15
- GTF 3-19

H

- hiperbatch C-6
- hit ratio, low, cache 4-22
- HSM delay D-4

I

- I/O
 - I/O Queuing Activity report, Monitor I 2-28
 - indicators for contention 4-2
 - rate of workload 1-16
 - resolving specific problems 4-39
- IMS
 - workload activity 6-2
- indicator
 - sysplex monitoring, Monitor III 2-6
- indicators of problems
 - CPU problem 3-2
 - for storage problems 2-15
 - of overcommitted tape buffers 2-30
 - processor storage, Monitor I 5-2
 - processor storage, Monitor III 5-2, 5-3
 - speed 2-18
 - swap 2-33

- indicators of problems *(continued)*
 - workflow 2-18
- INHIBIT mode 4-11
- Intelligent Resource Director
 - Channel Subsystem Priority Queuing B-4
 - Dynamic Channel Path Management B-1
 - LPAR CPU Management B-5
 - Overview B-1
- interval 2-14
 - reporting 1-6
- IRD (Intelligent Resource Director) B-1
- ITR 1-21

J

- JES delay D-5
- Job Delays report, Monitor III 2-17, 5-5

L

- latent demand 1-3
- LCU 2-27
- LCU AVG RESP TIME, rule-of-thumb 2-30
- License Manager B-10
- LOG SWAP/EXP STOR EFFECTIVE,
 - rule-of-thumb 2-33
- logical control unit 2-27
- logical partition 2-26
- long term data collection 1-5
- loops 3-16
- low hit ratio, cache 4-22
- LP 2-26
- LPAR 2-26
 - constraints, what to do 3-15
 - CPU constraints 2-26
 - Monitor I Channel Path Activity report 2-27
- LPAR Cluster B-5
- LPAR CPU Management B-5

M

- measuring
 - CPU utilization 1-13
 - online 1-5
 - resource consumption 1-11
- MFLOPS 1-21
- MIPS 1-20
- Monitor III processor storage indicators 5-3
- Monitor I reports
 - Channel Path Activity report 2-27
 - CPU Activity report 2-24, 3-9
 - CPU Activity report, partition data 2-26, 3-11, 3-19
 - DASD Activity report 2-30, 4-29, 5-13
 - I/O Queuing Activity report 2-28
 - Magnetic Tape Device Activity report 4-48
 - Page/Swap Data Set Activity report 2-34, 5-12
 - Paging Activity report 2-33, 5-9, 5-11
- Monitor II reports
 - Address Space State Data report 3-14
- Monitor III reports
 - Delay report 2-16, 3-4, 4-40

- Monitor III reports (*continued*)
 - Device Delays report 4-41
 - Device Resource Delays report 4-42
 - Group Response Time report 2-15, 3-3
 - Job Delays report 2-17, 3-13, 3-17, 5-5
 - Processor Delays report 3-6, 3-16
 - Storage Delays report 2-16, 5-7
 - System Information report 4-39, 5-4
 - Workflow/Exceptions report 2-18, 3-6, 3-18
- monitoring of system status, continuous 1-5

O

- online measurements 1-5
- OPER delay D-5
- OUT READY, rule-of-thumb 2-24
- out-ready delay, indicator 5-4

P

- PAGE-IN EVENTS, rule-of-thumb 5-9
- PAGE-IN RATES, rule-of-thumb 2-36
- PAGE MOVEMENT WITHIN CENTRAL STORAGE, rule-of-thumb 5-9
- page/swap 5-13
- Page/Swap Data Set Activity report, Monitor I 2-34, 5-12
- PAGES XFER'D, rule-of-thumb 2-34
- paging 2-36
- paging activity 1-19
- Paging Activity report, Monitor I 2-33, 5-9, 5-11
- paging delay 5-4, 5-9
- partition, logical 2-26
- partition data report section, Monitor I CPU Activity report 2-26
- peak-to-average ratio 1-3, 2-24
- PER 3-18
- performance management
 - approaches for 1-4
 - definition 1-2
- performance problem
 - auxiliary storage tuning 5-14
 - CPU 3-1
 - decrease storage demand 5-14
 - definition 2-2
 - delay for CPU 3-13
 - diagnosing 2-1
 - finding major delay 2-13
 - I/O, resolving specific problems 4-39
 - indicators of CPU problem 3-2
 - investigating 2-3
 - Monitor I indicators of CPU problem 3-8
 - processor storage 5-1
 - resolving 2-3
- PR/SM LPAR considerations A-1
- prioritize access to processor storage 5-14
- problem indicators
 - CPU problem 3-2
 - for storage problems 2-15
 - of overcommitted tape buffers 2-30
 - processor storage, Monitor I 5-2

- problem indicators (*continued*)
 - processor storage, Monitor III 5-2, 5-3
 - speed 2-18
 - swap 2-33
 - workflow 2-18
- PROC 2-19
- Processor Delays report, Monitor III 3-6
- processor storage
 - indicators of 5-1
 - Monitor I 5-2, 5-8
 - Monitor III 5-2, 5-3
 - prioritizing access to 5-14
 - problem 5-1
 - use by workload 1-18
- Program Event Recording 3-18

Q

- QSAM C-6

R

- range 2-14
- rate, SSCH 1-17
- ratio
 - capture 1-13
 - capture, computing 2-36
- ratio, low hit, cache 4-22
- ratio, peak-to-average 1-3
- recommendations 5-14
- reconfigurable storage 5-9
- Relative Processor Power 1-21
- report on device contention 4-41
- reporting interval 1-6
- reports, using Monitor III 2-14
- resolving specific I/O problems 4-39
- resource consumption, measuring 1-11
- response time
 - batch 2-15
 - components of 1-7
 - computing 1-7
 - domain 2-15
 - end-to-end 2-13
 - external response time 2-13
 - finding major delay 2-13
 - internal response time 2-13
 - Monitor I Workload Activity report 1-7
 - Monitor III Group Response Time report 1-7
 - performance group 2-15
 - TSO 2-15
 - where to start 2-14
- Response Time Distribution report
 - description 2-4
- RHIT 4-10
- RMF
 - monitors 1-5
 - tasks 1-5
- RPP 1-21
- RSU 5-9
- rule-of-thumb
 - % Delayed for STR 5-5

rule-of-thumb *(continued)*

- % IN USE 2-34, 5-12
- APPL% 2-36
- AVG CONN TIME 4-34
- AVG DISC TIME 4-33
- AVG HIGH UIC 5-11
- AVG IOSQ TIME 4-31
- AVG PEND TIME 4-32
- AVG RESP TIME 2-30, 4-30, 5-13
- AVG SLOTS ALLOCATED 5-12
- AVG SLOTS USED 5-12
- BUSY TIME PERCENTAGE 2-24
- BUSY TIME PERCENTAGE, CPU 3-9
- cache hit ratio 4-22
- DASD guidelines 4-28
- DEVICE UTILIZATION, % 4-35
- DLY % 5-7
- LCU AVG RESP TIME 2-30
- LOG SWAP/EXP STOR EFFECTIVE 2-33
- OUT READY 2-24
- PAGE-IN EVENTS 5-9
- PAGE-IN RATES 2-36
- PAGE MOVEMENT WITHIN CENTRAL STORAGE 5-9
- PAGES XFER'D 2-34
- STOR 5-4
- TCB+SRB 2-36

S

- sampling cycle 1-6
- service level agreement
 - contents of 1-2
 - definition 1-2
- Service Level Agreement 1-2
- short term data collection 1-5
- single-CP constraint 2-36
- SLA 1-2, 2-20
- SLIP 3-18
- slip trap 3-18
- space, auxiliary storage 5-12
- speed 2-18
- SRB 2-36
- SRB+TCB, rule-of-thumb 2-36
- SSCH rate 1-17
- STAGE 4-11
- STOR 2-19
- STOR, rule-of-thumb 5-4
- storage
 - auxiliary 5-2
 - central 5-2
 - decrease demand 5-14
 - delay report, Monitor III 5-7
 - reconfigurable 5-9
 - space, auxiliary 5-12
 - tuning, auxiliary 5-14
- Storage Delays report, Monitor III 2-16
- storage problem
 - indicators for 2-15
 - processor 5-1
- storage use by workload, processor 1-18

- swapping delay, indicator 5-4
- swaps, TSO 2-33
- Sysplex Summary report
 - description 2-4
- system indicators 2-4
- system indicators, daily monitoring 2-20
- System Information report, Monitor III 5-4
- system status, continuous monitoring of 1-5
- systems, balanced 1-3

T

- TCB 2-36, 3-19
- TCB+SRB, rule-of-thumb 2-36
- throughput
 - external throughput rate 1-21
 - internal throughput rate 1-21
- THRU 4-11
- time, distributing uncaptured 1-15
- time per transaction, CPU 1-15
- tracing 3-19
- transaction
 - computing CPU time 1-15
 - definition 1-2
 - response time, components of 1-7
- TSO 2-15
- TSO swaps 2-33
- tuning 2-2
 - top-down approach 2-3
 - where to begin 1-5
- types of workload 1-9
- typical values by DASD device type 2-30

U

- uncaptured time, distributing 1-15
- unknown delay D-5
- use by workload, processor storage 1-18
- using Monitor III reports 2-14
- utilization, measuring CPU 1-13

V

- VIO, delay, indicator 5-4
- virtual fetch C-6
- VSAM C-6
- VSAM LSR C-6

W

- workflow 2-18
- Workflow/Exceptions report, Monitor III 2-18, 3-6
- workload
 - analyzing 1-9
 - computing CPU time per type 1-14
 - grouping of 1-9
 - I/O rate of 1-16
 - measuring CPU utilization 1-13
 - measuring resource utilization 1-10
 - paging rate of 1-19

workload (*continued*)
 processor storage use by 1-18
 types of 1-9
Workload Activity report 2-5, 2-35
workload type, compute CPU time per 1-14

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