z/OS Workload Manager (WLM)

- A contract between the installation and the z/OS operating system

  - Installation
    - Classifies work running on z/OS in distinct Service Classes
    - Defines goals that express the expectation of how work should perform

  - WLM
    - Uses goal definitions to manage work across all systems of a sysplex through distribution of resources
Service definition hierarchy

Parallel Sysplex plus WLM
Service definition structure

Service Definition

CLASSIFICATION RULES

APPCC I WEB
CICS LDAP
IMS CB
JES DB2
STC DDF
TSO OMVS

Service Policy NORMAL

SERVICE CLASSES

Service Policy TEST1

SERVICE CLASSES

Service definition workload types

identify your workload(s) and categorize them

WORKLOAD

interactive TSO users
zEnterprise PPM work
started tasks
Comm Server zIIP enabled
IPSec
forked and spawned USS programs
NetView, system automation tasks
MQSeries Workflow operations
WebSphere App Server Trans
CICS transaction programs
Sysplex parallel DB2 requests
DB2 DDF requests
IMS transaction programs
HTTP server requests
JES2, JES3 batch jobs

ASCH
CB
CICS
DB2
DDF
IMS
IWEB
JES
LDAP
STC
TCP
OMVS
NETV
MQ
WORKLOAD

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Classification rules

- IMS
- CICS
- TSO
- Unix
- Batch
- APPC
- DB2
- WebSphere

Filters or qualifiers

Service Class:
- TSOPRD

Description:
- Normal TSO Work

Workload:
- TSO

Service Goal:
- Performance Period: 1
- Response Time: 80% AT 1.0s
- Importance: 3
- Duration: 800

Performance Period: 2
- Discretionary

Example of a service class
The WLM Original ISPF application

The WLM welcome screen
Choose service definition

Choose Service Definition

Select one of the following options.
1. Read saved definition
2. Extract definition from WLM couple data set
3. Create new definition

ENTER to continue

Service definition menu

Definition data set : SYSADM1.WLMSRVC.DEFPDS
Definition name : myfirst1 (Required)
Description : The very first definition

Select one of the following options....
1. Policies
2. Workloads
3. Resource Groups
4. Service Classes
5. Classification Groups
6. Classification Rules
7. Report Classes
8. Service Coefficients/Options
9. Application Environments
10. Scheduling Environments

F1=Help F2=Split F3=Exit F9=Swap F10=Menu Bar F12=Cancel
IBM z/OSMF Management Facility

- z/OS Management Facility is a Web 2.0 application on z/OS
  - Manages z/OS from z/OS
  - Browser communicates with z/OSMF via secure connection, anywhere, anytime

Workload Management Task Overview

- Manage Service Definitions: Create, modify, import, export, print, install service definitions
- Manage Service Policies for Sysplex: Activate or view the service policies in the service definition that is currently installed in the WLM couple data set
- Manage Settings: Specify history length, codepage, user preferences
- View Status for Sysplex: Displays information about the service definition installed in the WLM couple data set and the service policy active in the sysplex.
Editing Service Definitions

- Simplified creation, modification and review of service definitions
  - Policy elements are presented in tables
  - Tables can be filtered and sorted
  - Direct editing of policy elements within tables
  - Best-practice hints are displayed automatically while specifying policy elements
  - Several service definitions can be opened simultaneously
  - Cut, Copy, Paste of policy elements between service definitions

WLM Component Environment Overview
The structure of a service class

A service class is built from the following characteristics:

• Performance Period

• Duration

• Goal Type and Setting
  – Average Response Time
  – Response Time and Percentile
  – Velocity
  – Discretionary

• Importance

What is a WLM transaction?

• A WLM transaction represents a WLM "unit of work"
  – Basic workload entity for which WLM collects a resource usage value
  – Foundation for statistics presented in workload activity report
  – Represents a single subsystem "work request"

• Subsystems can implement one of three transaction types
  – Address Space:
    • WLM transaction measures all resource used by a subsystem request in a single address space
    • Used by JES (a batch job), TSO (a TSO command), OMVS (a process), STC (a started task) and ASCH (single APPC program)
  – Enclave:
    • Enclave created and destroyed by subsystem for each work request
    • WLM transaction measures resources used by a single subsystem request across multiple address spaces and systems
    • Exploited by "new workload" subsystems - Component Broker (WebSphere), DB2, DDF, IWEB, MQ (Workflow), LDAP, NETV, TCP
  – CICS/IMS Transactions
    • Neither address space or enclave oriented - special type
    • WLM transaction measures resource used by a single CICS/IMS transaction program request
Response time goals

- **Average Response Time Goal**
  - Defines the average transaction response time for all ended transactions
  - Example: Average response time = 1 second

\[
\text{Average Response Time} = \frac{\text{Sum of elapsed time for ended transactions}^*}{\text{Number of ended transactions}^*}
\]

- **Percentile Response Time Goal**
  - Defines the number of transactions ending with a response time lower than or equal to the time value
  - Example: Goal = 90% < 1 sec

\[
\text{Percentile Response Time} = \frac{\text{No. of transactions ended with time} \leq \text{goal}^*}{\text{Number of ended transactions}^*}
\]

*Measured in a given interval

Velocity goals

- **Transaction Flow**
  - CPU Using + I/O Using + WLM Delay

\[
\text{Velocity} = \frac{(\text{CPU Using} + \text{I/O Using}) \times 100}{\text{CPU Using} + \text{I/O Using} + \text{WLM Delay}^*}
\]

- Delayed I/O requests queued by goal achievement, not DP
- I/O Using
  - Includes non-paging DASD I/O only
  - Device connect
- I/O Delay
  - IOS queue
  - Subchannel pending
  - CU queue

\[
\frac{11 \times 100}{11 + 4} = 73\%
\]

*Delay = CPU Delay + I/O Delay + Paging Delay + MPL Delay + A/S Delay

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Goal type: Discretionary

WLM-defined Goal Type to run the work and apply resources only when there are resources left over.

- Discretionary Workload receives resources from:
  - Higher importance work
  - Overachieving its goal if giving resources will not cause goals to be missed

- Runs in lowest MTTW dispatching priority

- Always last period in a service class

Multiple periods and velocity goals

- The DURation value defines period length in service units
- Each period can use different goals, goal types, and importance
- Not supported for CICS and IMS transactions
Importance

- Importance is relevant when system is overloaded
- WLM uses it to decide which workload goals are most important to satisfy
- Generally importance decreases across multiple periods

<table>
<thead>
<tr>
<th>Workload Importance</th>
<th>PERIOD 1</th>
<th>PERIOD 2</th>
<th>PERIOD 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUR=800</td>
<td>DUR=3K</td>
<td>Discretionary</td>
<td></td>
</tr>
<tr>
<td>R/T=0.5 sec</td>
<td>R/T=4 sec</td>
<td>IMP=1</td>
<td>IMP=3</td>
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</table>

System goals and dispatching priority

WLM-defined Goal Types that are automatically assigned to certain types of workload recognized by WLM.

- **SYSTEM**
  - z/OS system address spaces created at IPL.
  - Highest dispatching priority.
- **SYSSTC**
  - You assign important STCs
  - Second highest dispatching priority.
- **SYSOTHER**
  - Catcher for forgotten subsystem definitions.
  - Same as discretionary. Lowest dispatching priority.

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Goals: System-wide view

Typical goals (1 of 3)
## Typical goals (2 of 3)

<table>
<thead>
<tr>
<th>Workload</th>
<th>Service Class</th>
<th>Goal</th>
<th>Period</th>
<th>Duration</th>
<th>Importance</th>
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<tbody>
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<td>CICS</td>
<td>CICSNOR</td>
<td>90% within 0.2 second</td>
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<td>CICSLOW</td>
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<td>IMS</td>
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<td>IMSHOT</td>
<td>80% within 0.2 secs</td>
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<td>IMSLOW</td>
<td>Average 5 seconds</td>
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<td>DDF</td>
<td>DB1A</td>
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<td>DB1B</td>
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<td>APPC</td>
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<td>VEL=20</td>
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## Typical goals (3 of 3)

<table>
<thead>
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<th>Workload</th>
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<th>Goal</th>
<th>Period</th>
<th>Duration</th>
<th>Importance</th>
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The classification process

Getting to the classification rules

File Utilities Notes Options Help
--------------------------------------------------------------
Definitions Menu
Definition data set . . : 'SYSADM.WLMSRVC.DEFPDS'
Definition name . . . . . myfirst1 Required)
Description . . . . . . My first service definition

Select one of the following options . . __
1. Policies
2. Workloads
3. Resource Groups
4. Service Classes
5. Classification Rules
6. Classification Groups
7. Report Classes
8. Service Coefficients
9. Application Environments
10. Scheduling Environments

Command ===> _____________________________________________
F1=Help F2=Split F3=Exit F9=Swap F10=Menu Bar __ F12=Cancel

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Subsystems follow one of three transaction type models.
Need to understand how this affects the value of figures shown in workload activity report.

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<th>Transaction Type</th>
<th>Allowable Goal Types</th>
<th>Allowable # Periods</th>
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<td>CICS/IMS</td>
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Workload qualifiers supported by WLM (1 of 2)

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<th>DFSF</th>
<th>IWEB</th>
<th>JES</th>
<th>LSF M</th>
<th>MQ</th>
<th>NETV</th>
<th>OMS V</th>
<th>SOTC</th>
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### Workload qualifiers supported by WLM (2 of 2)

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<th>DFS</th>
<th>IMS</th>
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</table>

### Example of batch classification rules

**Subsystem Type**: JES

**Description**: Batch classification rules

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<thead>
<tr>
<th>Qualifier</th>
<th>Name</th>
<th>Service</th>
<th>Report</th>
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<tr>
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<td>SYSPROG1</td>
<td>BATCHHI</td>
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</table>
When Do the "OMVS" Classification Rules Apply?

A. TSO/STC/Batch
   - "dub"
   - syscall
   - UNIX kernel
   Not Here

B. Any A/S
   - fork
   - spawn
   Here*

C. Any A/S
   - pthread_create
   - Not Here

D. JES Initiator
   - BPXBATC
   - exec
   - Not Here

Enclave Services: A Dispatching Unit

- Standard dispatching
  - dispatchable units (DUs) are the TCB and the SRB
    - TCB runs at dispatching priority of address space and is pre-emptible
    - SRB runs at supervisory priority and is non-pre-emptible

- Advanced dispatching units
  - Enclave
    - Anchor for an address space-independent transaction managed by WLM
    - Can comprise multiple DUs (TCBs and Enclave SRBs) executing across multiple address spaces
  - Enclave SRB
    - Created and executed like an ordinary SRB but runs with Enclave dispatching priority and is pre-emptible

- Enclave Services enable a workload manager to create and control enclaves

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**Enclave Characteristics**

- Created by an address space (the "owner")
- One address space can own many enclaves
- One enclave can include multiple dispatchable units (SRBs/tasks) executing concurrently in multiple address spaces (the "participants")
  - Enclave SRBs are preemptible, like tasks
  - All its dispatchable units are managed as a group
- Many enclaves can have dispatchable units running in one participant address space concurrently
- RMF produces separate T72 SMF records for independent enclaves

---

**DDF and Enclave SRBs**

- **ssnmDIST (DDF)**
  - Enclave SRB
  - PC-call to DBM1
  - Create Enclave
  - Schedule SRB

- **DDFPROD**
  - RT=85%, 2s
  - Imp=1

- **DDFDEF**
  - RT=5s avg
  - Imp=3

- **STCHI**
  - Vel = 50%
  - Imp=1

- **STC rules**

- **DDF rules**

- **SMF 72**

- **SMF 30**

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WebSphere App Server Use of Enclaves

WAS on z/OS transactions, arriving at the Control Region, each run in an enclave that is classified under the "CB" rules.

WLM Managed DB2 Stored Procedures

- Stored Procedures run in WLM managed server regions in an application environment
- Distributed requests (DDF)
  - DBM processes SQL request under existing Enclave
- Local requests (CICS, batch)
  - DBM creates a dependent Enclave
- DBM inserts work request into WLM work queue
- Available task in server region selects the request and processes it under the Enclave
Execution Delay Monitoring Services

Allows you to assign goals to the transaction and let the system determine which work managers need the resources to meet these goals

- Infrastructure that allows WLM to assign resources for address spaces based on the behavior of the transactions being serviced by them
- Exploited by complex work managers, that do not allow WLM to individually manage resource consumption of the transactions
- Work managers can report their own view of transaction states
- Exploiting subsystems
  - CICS
  - IMS

CICS / IMS Transactional Goal Management

Use of CICS or IMS classification rules is optional
Manage Region Using Goals Of.....

STC Classification Rules

Manage Region
Using Goals Of
- REGION
- TRANSACTION

Performance index

- Separate PI is calculated for each service class period, across all sysplex hosts
- Different calculations produce a comparable value from different goal types
Policy adjustment cycle

- **Receiver**: Service class period not meeting goal by: Importance and Highest PI
  - Find Resource delay
- **Donor**: Service Class period meeting goal by: Lowest PI
  - Look for discretionary donor by: PI < 0.7, Goal: vel less or 30% or Resp > 1 Min
  - Fix Routines: Give Resource from Donor to Receiver
  - Receiver was selected. Go ahead for discretionary goal.
  - Adjustment is made on the basis of selected service class periods

Blocked Workload Support: IEAOPTxx

- **BLWLTRPCT**: Percentage of the CPU capacity of the LPAR to be used for promotion
  - Specified in units of 0.1%
  - Default is 5 (=0.5%)
  - Maximum is 200 (=20%)
  - Would only be spent when enough units of work exist which need promotion

- **BLWLINTHD**: Specifies threshold time interval for which a blocked address space or enclave must wait before being considered for promotion.
  - Minimum is 5 seconds. Maximum is 65535 seconds.
  - Default is 20 seconds.
# RMF Workload Activity Report – Batch

## REPORT BY: POLICY=WLMPOL01   WORKLOAD=BATCH   SERVICE CLASS=BATI2V50   RESOURCE GROUP=*NONE      PERIOD=1 IMPORTANCE=2

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### TRANSACTIONS

- **AVG**: 1025.81
- **ACTUAL**: 0
- **SSCHRT**: 1279
- **IOC**: 9537K
- **CPU**: 20893.24
- **CP**: 2313.1
- **BLK**: 0.000

### EXECUTION

- **AVG**: 1025.81
- **EXECUTION**: 0
- **RESP**: 0.8
- **CPU**: 4357M
- **SRB**: 76.975
- **AAPCP**: 8.24
- **ENQ**: 1.427
- **TOTAL**: 1492382

### ENDED

- **AVG**: 1454.83
- **QUEUED**: 0
- **CONN**: 0.4
- **MSO**: 1344M
- **RCT**: 0.000
- **IIPCP**: 0.00
- **CRM**: 0.000
- **SHARED**: 595.92

### GOAL: EXECUTION VELOCITY

**50.0%**

**VELOCITY MIGRATION:**

**I/O MGMT 54.3%**

**INIT MGMT 54.3%**

### RESPONSE TIME

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<thead>
<tr>
<th>SYSTEM</th>
<th>VEL%</th>
<th>INDX</th>
<th>ADRSP</th>
<th>CPU</th>
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<th>I/O</th>
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<th>CRY CNT</th>
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### RESPONSE TIME – TSO (1 of 2)

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### TRANSACTIONS

- **AVG**: 293.25
- **ACTUAL**: 2.335
- **SSCHRT**: 187.4
- **IOC**: 81821K
- **CPU**: 951.417
- **CP**: 114.26
- **BLK**: 0.000

### EXECUTION

- **AVG**: 293.23
- **EXECUTION**: 2.335
- **RESP**: 0.4
- **CPU**: 197358K
- **SRB**: 33.108
- **AAPCP**: 0.00
- **ENQ**: 0.000
- **TOTAL**: 767254.5

### ENDED

- **AVG**: 2616.59
- **QUEUED**: 80683
- **CONN**: 0.3
- **MSO**: 106510K
- **RCT**: 42.824
- **IIPCP**: 0.00
- **CRM**: 0.000
- **SHARED**: 563.70

### GOAL: RESPONSE TIME

**50.0%**

**VELOCITY MIGRATION:**

**I/O MGMT 54.3%**

**INIT MGMT 54.3%**

### RESPONSE TIME

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<tr>
<th>SYSTEM</th>
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<th>CPU</th>
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RMF Workload Activity Report – TSO (2 of 2)

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IBM Technical Training

- **Basic z/OS Tuning Using the Workload Manager (ES545) – 4.5 days, hands-on labs**
- **Advanced z/OS Performance: WLM, Sysplex, Unix Services, and Web - 4.5 days**
- [ibm.com/training](http://ibm.com/training)