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
Service definition structure

Service Definition

CLASSIFICATION RULES

SERVICE CLASSES

APPCL LDAP
CICS CB
IMS DB2
JES DDF
STC OMVS

SERVICE CLASSES

Service Policy NORMAL

Service Policy TEST1

Service definition workload types

WORKLOAD
Identify your workload(s) and categorize them

tasks in APPC initiators
WebSphere App Server Trans

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

Interactive TSO users
Linux in LPARs
started tasks
Comm Server work
forked and spawned USS programs
NetView, system automation tasks
MQSeries Workflow operations
LDAP Server work
JES2, JES3 batch jobs

CICS transaction programs
Sysplex parallel DB2 requests
DB2 DDF requests
IMS transaction programs
HTTP server requests
Classification rules

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

Filters or qualifiers

Example of a service class

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
Service definition hierarchy

Goal types

- Average Response Type
- Velocity
- Percentile Response Time
- Discretionary
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, MQSeries, 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 = 80% < 2 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

- I/O management option is selected, via the ISPF Service Coefficients Options menu

Transaction Flow

<table>
<thead>
<tr>
<th>CPU</th>
<th>I/O</th>
<th>DELAY</th>
<th>CPU</th>
<th>IDLE</th>
<th>I/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

- 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

Velocity formula:

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

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

*Delay = CPU Delay + I/O Delay + Paging Delay + Swapping Delay + MPL Delay

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
Service Class with Multiple Periods

- **PERIOD 1**
  - TRX
  - 70% in 3 sec
  - IMP=2
  - DUR=2000

- **PERIOD 2**
  - 10 sec avg
  - IMP=3
  - DUR=5000

- **PERIOD 3**
  - VEL=10
  - IMP=4

- **WLM**

- **Response time and Velocity measures**
  - DP
  - Working Set
  - I/O Qing
  - MPL

- 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>SYSTEM</td>
<td>DUR=800</td>
<td>DUR=3K</td>
<td>DISCRETIONARY</td>
</tr>
<tr>
<td>SYSSTC</td>
<td>R/T=0.5 sec</td>
<td>R/T=4 sec</td>
<td>Discretionary</td>
</tr>
<tr>
<td>1 - HIGHEST</td>
<td>IMP=1</td>
<td>IMP=3</td>
<td></td>
</tr>
<tr>
<td>2 - HIGH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - MED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 - LOW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - LOWEST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISCRETIONARY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSOTHER</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</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.

The WLM View

Address Spaces, and the transactions inside
Classify DB2 Address Spaces

Step 1:
Classify the DB2 Address Spaces as Started Tasks
Assign to an STC Service Class with appropriate Velocity Goal and Importance

Default Service Classes
- SYSTEM
- SYSSTC
- 1 - HIGHEST
- 2 - HIGH
- 3 - MED
- 4 - LOW
- 5 - LOWEST
- DISCRETIONARY
- SYSOTHER

WLM: Four Types of DB2 Work

- DB2 work that originates in another local subsystem
- DDF work requests
- Queries that DB2 creates by splitting a single, larger query and distributing it to other systems in a Parallel Sysplex
- DB2 Stored Procedure request
#1 – Local Attach

DB2 SQL activity runs under dispatchable unit of invoker
- IMS, CICS, TSO, Batch, etc.
- Inherited classification class of invoker
- Priority and management of home unit
- Service attributed back to invoker

#2 - Enclaves for DDF Work

- Represents a business unit of work
- Is managed separately from the address space
- Can include preemptible SRBs and TCBs
- Can span multiple address spaces
- Can have many enclaves in a single address space
- DB2 exploits the WLM Enclave interfaces
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
  - Client SRB
    - Created and executed like an ordinary SRB but runs with client (scheduler) dispatching priority and is pre-emptible
  - 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

DDF and Enclave SRBs

- ssnmDIST (DDF)
- DDF production requests
- DDF default requests
- STC rules
- PC-call to DBM1
- Enclave SRB non-swappable
- Enclave SRB
  - Create Enclave
  - Schedule SRB
- DDFPROD
  - RT=85%, 2s
  - Imp=1
- DDFDEF
  - RT=5s avg
  - Imp=3
- SMF 72
- SMF 30
- SMF 72
- SMF 72
- Vel = 50%
  - Imp=1
# DDF Work Classification Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting Information</td>
<td>AI</td>
<td>Can be passed from a DB2 Client via Client Information APIs</td>
</tr>
<tr>
<td>Correlation Information</td>
<td>CI</td>
<td>DB2 Connect assigns application program name by default but application can set via Client Information APIs</td>
</tr>
<tr>
<td>Collection Name</td>
<td>CN</td>
<td>Collection name of the first SQL package accessed by the DRDA requester in the unit of work</td>
</tr>
<tr>
<td>Connection Type</td>
<td>CT</td>
<td>Always 'DIST' for DDF server threads</td>
</tr>
<tr>
<td>Package Name</td>
<td>PK</td>
<td>Name of the first DB2 package accessed by the DRDA requester in the unit of work</td>
</tr>
<tr>
<td>Plan Name</td>
<td>PN</td>
<td>Always 'DISTSERV' for DDF server threads accessed via DRDA requesters</td>
</tr>
<tr>
<td>Procedure Name</td>
<td>PR</td>
<td>Name of the procedure called as the first request in the unit of work</td>
</tr>
<tr>
<td>Process Name</td>
<td>PC</td>
<td>Client application name by default but can be set via Client Information APIs</td>
</tr>
<tr>
<td>Subsystem Collection Name</td>
<td>SSC</td>
<td>Usually the DB2 data sharing group name</td>
</tr>
<tr>
<td>Subsystem Instance</td>
<td>SI</td>
<td>DB2 server's MVS subsystem name</td>
</tr>
<tr>
<td>Sysplex Name</td>
<td>PX</td>
<td>Name assigned to sysplex at IPL</td>
</tr>
<tr>
<td>Userid</td>
<td>UI</td>
<td>DDF server thread's primary AUTHID</td>
</tr>
</tbody>
</table>

#3 - Sysplex Query Parallelism

- Classification of originator doesn’t change
- Classification of participants is under “DB2” rules
Sysplex Query Parallelism

- Supports BI applications and complex queries
- DB2 query can be split across parallel sysplex
- Requires DB2 data sharing
- Classification of originator doesn't change
- Classification of participants is under 'DB2' rules
  - Classification attributes inherited from originator
- Accounting is done on the system where enclave runs
- Each remote piece starts in 1st period

#4 - DB2 Stored Procedures and WLM Application Environments

SQL work

- Enclave
- Process "CALL"

DB2 Subsystem

WLM Work Queue

- Application XYZ
- DB2 Stored Procedures

- Application ABC
- DB2 Stored Procedures

Stored proc TCB joins enclave of the caller
WLM managed DB2 stored procedures

- Stored Procedures run in WLM managed server regions in an application environment
- Distributed requests (DDF)
  - DBM1 processes SQL request under existing Enclave
- Local requests (CICS, batch)
  - DBM1 creates a dependent Enclave
- DBM1 inserts work request into WLM work queue
- Available task in server region selects the request and processes it under the Enclave

Stored Procedures and Enclaves

- Task
  - Listens for requests coming from outside of the system
  - Creates independent enclave
  - Schedules enclave SRB

- Task
  - Creates dependent enclave
  - Continuation of transaction CHARLIE

- Enclave A
  - query
  - result

- Enclave B
  - query
  - result

- Enclave C
  - query
  - result
Application environment example

1 Transactions reach work manager
2 Work manager creates or re-uses enclave
3 WLM uses classification rules to assign a service class to a newly created enclave.
4 Work manager builds a work request and inserts it with the enclave information into a WLM work queue

Work Manager Subsystem

WLM CDS Definition

Server address spaces

Application environment definition

• Specification of the server address space's procedure name and its parameters
  – Blank procedure name implies that server address spaces are manually managed
• Limits for server address spaces by subsystem instance
  – Do not confuse this with application environment limits that the subsystem might allow you to specify

Create an Application Environment

Application Environment . . . WLMENV2 Required
Description . . . . . . Large Stored Proc Env.
Subsystem Type . . . . . DB2
Procedure Name . . . . DSN1WLM
Start Parameters . . . DB2SSN=DB2A,NUMTCB=2,APPLENV=WLMENV2

Limit on starting server address spaces for a subsystem instance:
Select one of the following options:
1. Multiple server address spaces are allowed.
2. Only 1 server address space per MVS system is allowed.
SYSIBM.SYSROUTINES and WLM Appl Env's

HTTP / Servlet / EJB / DB2 Flow

DP does not flow; CICS / IMS Service Class set-up takes over
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