Performance Engineering & Tuning for WebSphere Version 6 & 7 on z/OS

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Agenda

- Engineer for Performance
  - Hardware Resources & Configuration
  - Software Levels: z/OS, WAS, & Java
  - Systems, Subsystems, & Security
  - System Topology - Client/Server placement
  - Application Server Configuration Options

- Tune your Runtime
  - Workload Manager Controls & Classification
  - Java Tuning

- Monitoring Performance
  - System and Application Monitors
  - Isolating Performance Problems

- Appendix
  - Tools & Documentation
Hardware Configuration

- **System z & zSeries provides superior performance**
  - Cycle speed, Super scalar, IEEE FP, Crypto, New H/W instructions
- **zAAPs and zIIPs can reduce Costs (TCO)**
  - Application Assist Processors (zAAPs) on Systems z10, z9 & zSeries
  - Integrated Information Processors (zIIPs) on System z10 & z9
- **More Storage required than traditional workloads**
  - System z10 can have up to 1.5 Terabytes; System z9 can have 512 Gb
    - Minimum entry system 1.5 Gb (sandbox testing)
    - Real world Application Server, 1 Gb or more per servant region (JVM).
  - Paging is BAD!
- **Parallel Sysplex & Coupling Facility for Production**
  - RRS Logstreams, RACF, Error logs, DB2 data sharing
- **Cached DASD**
  - System Libraries, HFS/zFS, Application Data, Logs
- **OSA Express 2**
  - Gigabit Ethernet, 10 Gigabit Ethernet, 1000BASE-T Ethernet

Software Configuration - Latest Software Levels Best

- **z/OS 1.9**
  - WLM improvements for zAAPs, New LDAP server
  - CFRM, z/OS XML System Services
  - LE, XPLink, USS asynchronous socket read and write
- **z/OS 1.10**
  - HiperDispatch & Capacity Provisioning Manager
- **DB2 V.9**
  - LOB improvements, Index optimization, Multi-row fetch
- **WebSphere V 6.1**
  - Web Container, EJB improvements, Web services, Imbedded Messaging
- **WebSphere V 7**
  - JDK improvements
  - Servant/Controller communication optimizations
  - Codepath improvements
- **Java 1.4, 5.0, 6.0 SDK**
  - JIT & GC performance enhancements with every release
  - SDK 5.0 showing ~30% performance improvement over 1.4.2
  - SDK 6.0 showing ~60% performance improvement over 5.0
Software configuration - Why WAS on z/OS?

• **Mainframe** qualities of robustness - not 'Mainframe like'
  
  Bold items help Performance:
  – **Hardware** - CPU, Storage, I/O Subsystem, Storage protect, MTTF
  – Operating System - Isolation, Recovery, Architecture
  – Virtualization – LPAR, IRD
  – **Optimizations** - Hyper-channel, Local TCP Stack Optimization
  – **Workload Management** – zWLM, IRD, Sysplex Distributor
  – GDPS or DR - Recovery based on capacity not box duplication
  – **Capacity planning** & Utilization - WLM & RMF reporting
  – Storage management – DFSMS, Backup, File sharing
  – **Sysplex distributor** - Client access distribution of TCP connections
  – **Scalability** - MQ shared queues, DB2 data sharing, etc.
  – Secure, Manageable environment

• **Benefits of “just showing up” on z/OS** (Mike Cox)

Optimization – z/OS exploitation

• **LOCALCOMM** (Path-length and latency avoidance)
  – Cross memory services to communicate between Servers rather than TCPIP
  – SSL avoidance, Security and WLM context propagated
  – Type-2 resource managers (IMS, CICS, MQ, DB2)

• **Thread affinity**
  – Dispatch stays on same thread if app. components in same server
  – Reduces communication costs

• **Common DataSpaces** used for shared memory
  – Avoids communication costs & allows for light weight serialization

• **Multi-system ENQ**

• **RRS** for transaction support

• **Encryption** - IBMJCECCA

• **IBM JDK** - zAAP exploitation, JZOS, JRIO, RACF

WebSphere for z/OS leverages zSeries architecture
**What's new in WAS V6.1 Performance**

- **Improved performance with Java 5 (SDK 1.5)**
  - Improved JIT compiled code efficiency
  - Improvements in Software Crypto performance
  - New memory allocation and garbage collection schemes
  - Java class cache in shared memory for faster startup time

- **Improved Web Container performance/scalability**
  - Caching enhancements
  - JSP engine improvements

- **EJB improvements**
  - Code path improvements
  - Higher performance access intent settings
  - Optimizations to persistence manager
  - Light weight Entity Beans

- **Improved Web services performance**
  - New XML parsing technology
  - Other web services improvements

- **Imbedded messaging**
  - Code path improvements
  - Option to use file system as message store

- **Misc.**
  - Finer grain authentication optimizations for data sources

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**WAS V6.1 & V7 use the new IBM J9 JVM**

(aka SDK 5.0, J2SE 5.0, J2RE 1.5.0; SDK 6.0, or 1.6 for WAS V7)

**Provide better Performance, Scalability, and Availability**

- **Garbage collector enhancements**
  - Incorporates for the first time generational garbage collection

- **Superior JIT (Just in time) compiler**
  - Multiple optimization methods from application profiling to more intelligent and better code optimization algorithms

- **Asynchronous compilation**
  - Compilation of Java methods proceeds on a background thread
    - Other application threads do not have to wait to execute the method
  - Improves startup time of heavily multithreaded applications on SMPs

- **Compile-time optimizations to remove contention**
  - escape analysis, lock coarsening, …

- **Fine-grained locking of VM data structures**
### z/OS Java 5 SDK Performance

#### Multithreaded benchmark

SDK 131 vs 142 vs 5.0 on z9 16way

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</table>

SDK 1.3.1 -> 142 = Java +25%
SDK 1.4.2 -> 5.0 = Java +30%
SDK 5.0 31-bit -> SDK 64-bit Java -12%
(but memory constraints relieved)

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### SDK6 Performance

#### What’s new

- Exploits z10 ISA features
- Multi-threaded performance improvements
  - Garbage collection improvements
  - Class library work
  - JIT improvements
- 64-bit SDK performance improvements in Java6 SR3
  - Compressed References (-Xcompressrefs)
- XML performance improvements
- Ahead-of-time JIT support for shared-classes

http://www.ibm.com/developerworks/java/jdk
SDK Multi-Threaded Benchmark

64 Bit Java - MultiThreaded - 2 Gig Heap z10, 16-Way, z/OS 1.9

SDK6 – Performance – Single Threaded Benchmarks

Single-Threaded Performance (z10)
Trade 6, DB2 V8, keepDynamic=Yes

12% Performance Improvement from WAS 5.1 to WAS 6.0.1
+9% from keepDynamic=YES (tuning)

3% Performance Improvement from WAS 6.0.1 to WAS 6.0.2
13% Performance Improvement from WAS 6.0.2 to WAS 6.1

When the dynamic statement cache is active, and an application is run that is bound with KEEP_DYNAMIC(YES), DB2 retains a copy of both the prepared statement and the statement string. The prepared statement is cached locally for the application process.

"WebSphere Performance on z/OS" by Bob St. John, IBM at SHARE session 2567, February, 2007

WebSphere Application Server on z/OS V7 Performance Improvements:

DayTrader 1.2 - WAS v6.1 to v7.0
• zWAS v7.0 performance is up 22% from v6.1 for 2-tier configuration
  – JDK improvements
  – Servant/Controller communication optimizations
  – Codepath improvements throughout WAS v7.0
• zWAS performance up 44% in 3-tier configuration

DayTrader 2.0 EJB3 - WAS v6.1 FeP to v7.0
• WAS v7.0 is 65% faster than v6.1 EJB3 FeP

SOABench - WAS v6.1+ WS Feature pack to v7.0
• zWAS v7.0 improved 25-50% for payload sizes ranging from 3kin3kout to 100kin100kout.
• Common payload 10kin10kout improved 45%
WAS Startup time

Startup time (CR, SR, CRA) with Trade 6 installed

9% reduction in startup CPU time with WAS 6.1; Add'l 18% reduction with WAS 7

50% reduction in startup elapsed time with WAS 6.1 Add'l 3% reduction with WAS 7

System Tuning

- z/OS or OS/390®
- Workload Manager
- UNIX System Services & HFS
- TCP/IP
- Language Environment (LE)
- System Logger & RRS
- Tracing & Logging - minimize as much as possible.

- Security & RACF®
- Java
- SMF
- GRS
- Library Search Order
- Other . . .

Performance Tuning guidance in the WebSphere Application Server "InfoCenter"

- Performance and Troubleshooting sections
- "Performance Tuning and Monitoring" PDF
Tune for effective use of storage:

- **Need large servant regions** (set REGION=0M on proc)
  - Biggest single affect on storage use
    - Default SR heap (512 Mb requires ~700 meg)
    - Also affects GC time (server delays)
  - Tune your Java heap size (often the biggest performance leverage item)
    - See "Tuning the JVM Heap" (later)
  - May have to tune # of Servant Regions and Threads

- Define more auxiliary storage (Page packs)
  - Test systems with 1Gb may work with good paging resources

- “64-bit” Addressing available if needed
  - SDK in /<app_server_root>/java64/ (symlinks to /shared/zWebSphere/V6R1/java64/)
  - Enable desired server(s) through AdminConsole (or WSADMIN.)
  - All regions in the server are updated – control, servant, adjunct.
  - Slight performance degradation, unless you NEED the extra Heap Size.
  - See WP100920 & WP101121 white papers on ibm.com/support/techdocs

UNIX System Services & HFS Tuning

- **Make sure you allow enough sockets, etc.**
  - BPXPRMxx parms – some limits increased with z/OS 1.7
    - MAXFILEPROC (Impacts OMVS kernel storage, only set as high as needed)
      - Applies to all USS user processes (or set at user level using RACF)
    - MAXSOCKETS (At least as high as MAXFILEPROC - No Impact on OMVS kernel storage)

- **HFS (Hierarchical File System)**
  - Product HFS (/usr/lpp/WebSphere/...) - Mount Read/Only
  - Configuration HFSes
    - Separate HFS for each node - make sure it is owned by the right system (if sharable)
    - Can be shared for testing, sharable for fail-over
  - **File Caching:** Use SMF 92 records for tuning

- **zFS** - Supported by WAS V6.1 customization
  - Should improve performance when writing to a shared file system (not recom’d.)

- **log4j recommendations**
  - Write log4j logstream to unshared zFS,
  - Write simple trace strings, Write without flush if possible,
  - Test before writing, and Write as seldom as possible.
Security is not "free" but can be tuned . . .

- **WebSphere** runs with security off by default until V.6.1.
- **SAF classes** can be enabled or disabled to control security
  - Disabled SAF classes: negligible overhead
  - Enabled SAF classes: number of profiles in class will affect performance

- **EJBROLE Class**
  - More EJBROLEs on a method will give you more access checks
  - Use GEJBROLEs to reduce the number of Profiles

- **Keep RACF classes and other info in memory**
  - RAELIST CBIND, EJBROLE, FACILITY, PTKDATA, SERVER, STARTED
  - Use VLF for ACEEs, GTS, and UID/GIDs

- **Disable SAF calls for successful HFS accesses**
  - Define the BPX.SAFFASTPATH facility class, or use the IRRSXT00 exit

- **Performance depends on your Repository Mechanism:**
  - ‘Custom’ *can* be better than RACF, which is better than LDAP

- **SSL security authentication**
  - Use IBM™ zSeries™ hardware assists to improve performance on z/OS
  - Reduce excessive SSL hand shakes for subsequent transactions

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**Server Topology Decisions**

- **Client location**
  - Remote vs. Local

- **Server(s) location**
  - Number & Configuration

- **Web Tier**
  - Cache static objects
  - Firewalls for DMZ
  - Authentication

- **HTTP servers**
  - HTTP vs. IIOP
  - Reverse Proxies
  - Use HTTP transport

- **DNS**

- **D-VIPA** (Sysplex Distributer)

- **Database servers**
**WAS Configuration Options**

- **Base Application Server**
  - Easy to set up & useful for testing
  - Responsive to server & application changes
  - Not suited for production
    - no clustering, single-systems config.

- **Network Deployment (ND)**
  - Managed by Deployment Manager & Node Agents
  - Multiple Application Servers
    - Group multiple AppServers into Clusters

- **ND Required for:**
  - Multi-systems configuration & Clustering
  - Horizontal scaling for increased throughput
  - Continuous availability & fail-over
  - Rolling upgrades for continuous operations

**WAS for z/OS clustering:**

- **Inner cluster - Server Instance**
  - Controller region - communication endpoint (HTTP, IIOP, MDB)
    - Performs work classification, security processing, queues to WLM
  - Servant region(s) - 1 or more address spaces (WLM managed)
    - JVM - Web & EJB container - where applications run
      - Isolated for availability & performance
      - Have identical runtime settings
      - Confined to a single z/OS system

- **Outer Cluster - Generic Server**
  - 1 or more server instances of a server.
  - All servers have the same applications
  - May have different runtime settings
  - May exist on multiple z/OS systems.

- **Cell consists of one or more clusters.**
  - Confined to one Parallel Sysplex
Clustered Servers

- Horizontal (cross-LPAR) vs. Vertical (Same LPAR)

  - Multiple instances of the same application server:
    - Increases Availability:
      - Remove single point of failure
      - Allows rolling updates.
    - Can improve performance
      - On multiple systems (horizontal scaling)
  - However:
    - Multiple instances on the same system normally won't improve performance.

Optimize application object flows

Deploy related applications in the same server:

1. Avoid application calls from one system to another
2. Provide a local replica of any required application server.
3. Deploy applications in the same server, because local calls are even faster.

- Use 'Pass by reference' (default ORB setting: "noLocalCopies")
  - must be in same EAR file or use Server Class Loader
Reduce unnecessary IIOP Flows

Avoid IIOP calls from one system to another - serialization/deserialization overhead can be excessive!

Connector Performance (over-simplified)

General:
- Use Local Connections over Remote
  - Avoids Network Delays
  - Requires less CPU resources
  - Use Pooled Connectors - queuing model between connectors & resource adapters
- **DB2**: JDBC Type 2 vs. Type 4
  - Static SQLJ out-performs dynamic SQL
  - Can benefit greatly from dynamic statement caching in the database engine.
- **CICS**: Use TransGateway which uses EXCI
  - Monitor/Manage the number of Pipes, and Threads (& Servant Regions)
- **IMS**: Use Local Connect Option vs. MSC vs. Remote IMS Connect
- **MQ**: Use Binding Mode vs. Client mode
- **Optimized Local Adapters**
  See "WebSphere for z/OS Connectivity Architectural Choices" SG24-6365
Replication - Managing the # of Servant Regions

- **Adminconsole: Appl. Server >> "Server Instances"**
  - **Check "Multiple Instances Enabled"**
    - Otherwise, WLM will only start 1 servant region for this appserver
    - If checked, and Min/Max = 1, transactions from different service classes may hang.
  - **"Minimum number of Instances"**
    - Useful for avoiding delays to start up server regions
    - To keep work from coming in thru the protocol handler before SRs are ready, use
      `protocol_accept_http_work_after_min_srs=nn`
  - **"Maximum number of Instances"**
    - Useful for limiting excessive server regions during server instance ramp-up or if
      you have limited real storage . . .

- **Caution!**
  - If you specify a maximum number of instances, WLM is restricted from starting
    more than this number of servant regions for this server instance.
    - The Maximum number must be >= number of service classes used by this
      application's transactions, or transactions will time out.
    - Account for default CB service class and enclaves that originate outside WebSphere.

Managing the number of Threads in the JVM

- **Workload Profile in ISC (adminconsole):**
  - **AppServer > ORB Service > Advanced Settings > "Workload Profile"**
    - ISOLATE (1 thread)
    - NORMAL (3 threads)
    - CPUBOUND (# of CPs-1, minimum of 3)
    - IOBOUND (Number of CPs*3, Min=5, Max=30)
    - LONGWAIT (40)
    - CUSTOM (V7): Set with servant_region_custom_thread_count, Min 1, Max 100
    - See message BBOO0234I in the controller job log to check the number.

- **Allow for increased concurrency**
  - WebSphere for z/OS doesn't need threads as placeholders for work
    - WLM queues are used for that
  - **Plan for # of in and ready threads to be 2-3X the # of CPs**
  - **Experiment with # of threads, # of servants to optimize performance.**
    - Too many servant regions take excessive storage
    - Too many threads in a JVM creates interference & more frequent GC.
    - Display # of threads: SDSF PS Panel, or MVS commands: D OMVS,PID= or
      Modify (F) <server>,DISPLAY,THREADS, then compare to JAVACORE dump
Classifying Work with WLM

- **Started Tasks**
- **OMVS work**
- **Transactions - changes with WAS 5.1**
  - 'CB' work
  - HTTP by URL
  - MDBs
  - IIOP

- **Resource managers:**
  - DB2
  - CICS
  - IMS
  - MQ
  - other
  - Network QoS

<table>
<thead>
<tr>
<th>WLM Subsystem Type Selection List for Rules</th>
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<tbody>
<tr>
<td>Action</td>
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</table>

**Controller Regions** (Daemon, Node Agent, Deployment Manager, App. Servers)
- Classify as High Importance & High Velocity

**Servant & Adjunct Regions**
- Classify with velocity goal, high enough to get started quickly, lower than controllers
  - Work is actually classified under the application environment

**Sample STC Classification Rules:**
- Use Unique Report Classes to track important Started Tasks:

<table>
<thead>
<tr>
<th>Qualifier</th>
<th>Qualifier</th>
<th>Starting Position</th>
<th>Service</th>
<th>Report Class</th>
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<tr>
<td># type</td>
<td>name</td>
<td></td>
<td>Class</td>
<td>Class</td>
</tr>
<tr>
<td>1 TN</td>
<td>WSDM*</td>
<td>OPS_HI</td>
<td>RWSDMGR</td>
<td></td>
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<tr>
<td>1 TN</td>
<td>WSSR%%%</td>
<td>OPS_HI</td>
<td>RWSAPCR</td>
<td></td>
</tr>
<tr>
<td>1 TN</td>
<td>WSSR%%%S</td>
<td>OPS_MED</td>
<td>RWSAPSR</td>
<td></td>
</tr>
<tr>
<td>1 TN</td>
<td>WSSR%%%C</td>
<td>OPS_MED</td>
<td>RWSAPCR</td>
<td></td>
</tr>
</tbody>
</table>

- **OPS_HI service class:** Importance= 1, Velocity = 70
- **OPS_MED service class:** Importance= 2, Velocity = 40
WLM / OMVS - Controller start-up Procedure

- **ApplyPTF step added to Control Region Proc:**
  - applyPTF.sh checks to see if service has been applied to WebSphere and "update files" for the new service.
  - Classify server controller jobnames with WLM OMVS rules.

- **OMVS Classification rules - see the WAS InfoCenter for details**

  | --------Qualifier-------- | --------Class-------- |
  | Type | Name | Start | Service | Report |
  | DEFAULTS: EBIZ_DEF | EBIZ_HI | RPTACR |
  | 1 TN | T6* | ___ | EBIZ_HI | RPTACR |
  | 1 TN | WS* | ___ | EBIZ_HI | RPTACR |

OMVS Classification rules - see the WAS InfoCenter for details

    | --------Qualifier-------- | --------Class-------- |
    | Type | Name | Start | Service | Report |
    | DEFAULTS: EBIZ_DEF | EBIZ_HI | RPTACR |
    | 1 TN | T6* | ___ | EBIZ_HI | RPTACR |
    | 1 TN | WS* | ___ | EBIZ_HI | RPTACR |

WLM/CB - Classifying WebSphere Transactions

- **Subsystem type = CB using the following criteria:**
  - **Generic Server name (CN)** - cluster transition name = the applenv name
  - **Server Instance name (SI)** - not useful because instances share work
  - **Userid assigned to the transaction (UI)** - usually not useful
  - **Transaction class (TC)** - assigned by "Workload Classification" xml document.

- **Percentage response time goal is recommended**
  - Example: 80% of trans less than 0.5 seconds (or high velocity default service class)
  - Response time goals better than Velocity goals in a true production environment.
    - Velocity goals need to be re-calibrated with environmental changes (CPU, workload)
  - Multi-period Goals may be used, but are not recommended.
  - Default is SYSOTHER (discretionary)

- **Other considerations:**
  - Requests that already have enclave tokens, run under these enclaves, and with the service class assigned for this enclave.
  - Control region maintains "internal queues" based on the service class:
    - A server region may switch queues if needed to, based on demand
Workload classification file

- Set transaction class (TC) of inbound work - .xml file
  - HTTP - host, port, URI
  - IIOP - application, module, component, and method name
  - MDB - message listener port, selector attribute
- Adminconsole: Environment >> Manage WebSphere Variables
  wlm_classification_file = <path>/MDBClassMap.xml
- See InfoCenter for details

```xml
<?xml version="1.0" encoding="UTF-8"?>
<InboundClassification type="iiop" schema_version="1.0"
  default_transaction_class="TCLASS1">
  <iiop_classification_info transaction_class="TCLASS2">
    CB Classification Rules:
    
    | # | type | name  | position | Service Class | Report Class |
    |---|------|-------|----------|--------------|-------------|
    | 1 | CN   | WSPROD| 1        | CBMED        | RWSPROD     |
    | 2 | . TC | TCLASS1|          | CBFAST       | RWSPRD1     |
    | 2 | . TC | TCLASS2|          | CBMED        | RWSPRD2     |
    
    Examples:
    a. www.ibm.com:80/Webap1/myservlet => TCLASS1 => CBFAST (RWSPRD1)
    b. www.ibm.com:443/Webap1/myservlet => TCLASS2 => CBMED (RWSPRD2)
```

How is my Classification File working?

- Displaying Classification of Work Requests

- See if classification scheme is classifying work as expected:
  - MVS oper command: F <server>,DISPLAY,WORK,CLINFO

```
F H5SR01D,DISPLAY,WORK,CLINFO
BBO002811 CLASSIFICATION COUNTERS FOR HTTP WORK
BBO002821I CHECKED 27976, MATCHED 27976, USED 816, COST 4, DESC: HTTP Default
BBO002821I CHECKED 27976, MATCHED 9053, USED 9053, COST 2, DESC: H5Servlets
BBO002821I CHECKED 18923, MATCHED 9021, USED 9021, COST 3, DESC: H5EJBs
BBO002821I CHECKED 9902, MATCHED 9086, USED 9086, COST 4, DESC: H5JSPs
BBO002831I FOR HTTP WORK: TOTAL CLASSIFIED 27976, WEIGHTED TOTAL COST 84777
BBO001881I END OF OUTPUT FOR COMMAND DISPLAY,WORK,CLINFO
```

- CHECKED - Number of times the rule has been examined.
- MATCHED - Number of times that this rule has been matched by the request.
- USED - Number of times that this rule has actually been used.
- COST - Number of compares required to determine if this is the correct rule to use.
- WEIGHTED COST - Number of times each rule was used multiplied by the cost, or number of rule compares that were done, and adding up across all rules.
- Reduce the cost by re-arranging your Classification File.
WLM Classification Guidelines

• Service Classes used to meet goals
  – Do not let work default to discretionary goals.
  – Set realistic (achievable) goals.
  – Assumes there is displaceable work when resources constrained.
  – Use Velocity for Address Spaces, Response Time for enclaves.
  – Avoid multi-period service classes for disparate work in the same server.
  – Avoid too many Service Classes.
  – Understand difference between Business Trans & RMF Trans.
    • WID Quality of Service: Activity Properties can change Scope of Transaction and RMF numbers. (New Tran, Participate, Commit Before/After Tran …)
    • Changes Ratio of Business Tran to RMF Trans

• Report Classes distinguish among items of interest
  – Do not lump components together.
  – Use RMF RCPER(rc*) to show Resp. time distribution, Delay break-out, etc.

WLM key to Configuring for Availability

Application availability based on sysplex availability principles.
• First Principle - "One" is a lonely number
• "Two" entities with failure isolation (Three are better!)

Application availability is dependent upon:
• Sysplex components - SYSPLEX distributor, data sharing, etc.
• Non-sysplex components - Edge servers, DNSs, routers, etc.
• Configuration changes & Operational procedures - Service upgrades, Backups, etc.

Ensure clients can always get to the server

Intelligent Routing:
• WLM-aware vs. Round-Robin
• Session Affinity within Server Instance and across Server Instances (Systems)
• Network Dispatcher (MNLB) load balances
• IHS or Web Server with WAS AE plug-in (rev-proxy)
• Sysplex Distributor good for TCP/IP load balancing
Workload Management & Availability

Multiple Server Instances provide Continuous Operation
- Cluster Horizontally across multiple LPARs (& Hardware Engines)
- Allows for Planned and Un-Planned Outages

Multiple Servants also allow for Continuity
- WLM will restart a Servant Region if one fails, or if killed by an operator (Cancel cmd, or SDSF 'K' action char.)
- Server Instances (Controller Regions) can be re-started by ARM (Automatic Restart Manager) or your System Automation Product
- Insulates from Garbage Collection interruptions.

- More Servants vs. More Threads (depends on many variables)

Distributing HTTP Requests on multiple Servants

- WAS uses a "hot server" strategy to route HTTP requests
  - Route to servant regions which had recently dispatched work with threads available.
  - "hot servers" have pages in memory, application methods and cache full of data.
  - HTTP requests with session affinity are routed to the servant region where the session object(s) reside.

- However, this can cause imbalances in some situations:
  - "Hot" servant regions can get over-loaded with work
  - GC and loss of a servant region can impact many sessions.

- Distribute HTTP requests evenly across servant regions:
  - Specify Adminconsole setting:
    - Servers > Applications servers > server_name > Server Infrastructure > Administration > Administration Services > Additional Properties > Custom Properties
    - Change 'WLMStatefulSession' to 'true'
  - Optimize the minimum and maximum number of servant regions.
    - May want to eliminate transaction class mapping.
  - Minimize the number of different service classes for these servers.
Java Tuning

- **Java level is reported in servant region joblog**
  - 5.0 SDK: JVM Build is J2RE 1.5.0 IBM J9 2.3 z/OS s390-31 j9vmmz3123ifx-20090225 (JIT enabled)
  - 6.0 SDK: JVM Build is J2RE 1.6.0 IBM J9 2.4 z/OS s390x-64 jvmmz6460-20081107_25433 (JIT enabled, AOT enabled)
  - Also indicates if the Just-in-Time and Ahead-of-Time Compilers are enabled.

- **Make sure the JIT is enabled**
  - Number of references (or loop iterations) before keeping JITed code in LE Heap:
    - 1.4.2 SDK: IBM_MIXED_MODE_THRESHOLD=nnn (default = 800-1107)
    - 5.0 SDK: IBM_JAVA_OPTIONS=-Xjit:count=<value> (defaults to progressive optimizations)
    - Recommendation: only change this if needed for benchmarking. Use default for production.

- **Turn off JRAS debugging support**
  - Turn off in adminconsole - Set *=all=disable
    - Note: you may be tracing and not know it if ras_trace_outputLocation=BUFFER
    - Verify by looking in SYSOUT dataset for trace setting

- **Other JVM Performance Options**
  - Most default values provide best performance.

- **Other tips:** www.ibm.com/servers/eserver/zseries/software/java/

---

5.0 JVM Heap & GC Tuning

- **Must be tailored to your Application & Workload**
  - Typically get 80% of maximum performance with 20% of the work by making good choices on a few key settings.
  - To get the best performance, you must know your applications memory allocation and runtime needs.

- **2 iterative tuning steps over a testing cycle:**
  - Step 1: Heap Size tuning
  - Step 2: GC Runtime Policy optimization

- **Key setting for the JVM: Heap Size (-Xms / -Xmx)**
  - Set min & max to values within your physical memory limitation,
  - Keep a large interval between GC’s, and a low duration:
    - Typical low end bound on frequency of GC’s is 10 sec
    - Typical high end bound on duration of GC’s is 1-2 sec
      (GC should account for less than 2% of the time)
    - May also have to increase the number of Servant regions.
J9 Memory management has 4 configurable policies:

- **Optimize for Throughput** – flat heap collector focused on maximum throughput
  
  “I want my application to run to completion as quickly as possible.”
  
  `-Xgcpolicy:optthruput` (default)

- **Optimize for Pause Time** – flat heap collector w/ concurrent mark & sweep to minimize GC pause time
  
  “My application requires good response time to unpredictable events.”
  
  `-Xgcpolicy:optavgpause`

- **Generational Concurrent** – divides heap into “nursery” & “tenured” segments - fast collection for short lived objects. Max. throughput w/ minimal pause time
  
  “My application has a high allocation and death rate.”
  
  `-Xgcpolicy:gencon`

- **Subpool** – flat heap technique to increase performance on MP systems, (> 8)
  
  Available on IBM pSeries™ and zSeries™
  
  “My application is running on big iron & high allocation rates on many threads.”
  
  `-Xgcpolicy:subpool`

### Notes on Fragmentation:
- Most Java Objects in the heap are moveable (not tied to a single space in memory)
- “Pinned objects” cannot be moved (permanently or temporarily.)
- J9 helps prevent fragmentation by moving pinned objects during compaction.

---

**Tuning your Java heap: Collect verboseGC stats**

```xml
<af type="nursery" id="35" timestamp="Thu Aug 11 21:47:11 2005" intervalms="10730.361">
  ...
  ...
  </gc>
  <tenured freebytes="189664320" totalbytes="268435456" percent="70">
    <soa freebytes="187251000" totalbytes="265751552" percent="70 />
    <loa freebytes="2413320" totalbytes="2683904" percent="89" />
  </tenured>
  <time totalms="224.006" />
  <time totalms="377.634" />
</af>
```

- **Adminconsole:** Server >> Process >> Servant >> JVM >> check "GC Verbose"
- **Results** appear in server region’s //SYSOUT DD file (or pipe to HFS file)
  - Don’t specify JVM LOGFILE or output from multiple SRs will be meaningless.
- **Key value:** percent free storage after each GC in each area.
  - Use `JVM_MINHEAPSIZE=JVM_HEAPSIZE` for base Java heap requirement
  - Run for a long time to make sure your application does not have a memory leak.
  - Steady state, this is your base Java heap requirement
- **Key value:** % of elapsed time spent in GC
  - “totalms = "XXX" (GC time) / intervalms="YYYY" (time since last GC) < 2%}
- **Visualizers**
  - See the ISA, APMT or GC Diagnostic tool on [www.alphaworks.ibm.com/tech/](http://www.alphaworks.ibm.com/tech/)
Profiling & Monitoring Tools for 5.0 SDK

- New Features & Interfaces included in JVM:
  - Monitoring Tool Interface (JVMTI) – replaces JVMDI for Profiling (JVMPI)

- Garbage Collection - verbose “visualizers”
  - (Need to clean out extraneous messages from SYSOUT.)
  - ISA – IBM Support Assistant
  - EVTK – IBM Solution Center
  - PMAT – IBM alphaWorks

- Application Profilers
  - Jprobe (Quest Software)
  - Jprofiler (ej-technologies)

Specialty Engines: zIIPs & zAAPs

- zIIP: zSeries Integrated Information Processor
  - System z10 & z9 + z/OS 1.6 + DB2 for z/OS V8 + FMIDs JBB77S9(1.6) or JBB772S(1.8)

- zAAP: zSeries Application Assist Processor
  - System z + z/OS 1.6 + IBM SDK for Java 1.4 + PTF for APAR PQ86689

- Not a performance boost (except systems w/ sub-capacity GCPs)
  - Maybe helpful in reducing General Purpose CPs and associated License fees

- Sub-capacity Processors receive extra benefits
  - (z10 BC, and z10EC*, z9 BC, and z9 EC)
    - Specialty engines run at full speed – may provide performance boost.

- Estimation of Usage:
  - z/OS Use RMF Workload Activity Report with IEAOPTxx PROJECTCPU=YES

- See Techdocs: TD103516, TD103460, and FLASH10432
Specialty Engines: zIIPs & zAAPs – which to use?

- **WSC Measurements of Trade 6 application using JDBC drivers:**
  - Type 2 drivers provide superior performance (resp. time & CPU usage) and use zAAPs.
  - Type 4 drivers can take advantage of both zIIPs and zAAPs with minimal degradation.

**CPU Usage per Trade 6 Transaction (preliminary results) - by Processor Type:**

![Bar chart showing CPU usage per Trade 6 Transaction]

Your results will vary – Very Application-dependent!

---

**Tuning Session Management**

- **Good practices for using HTTP Sessions** (InfoCenter)
  - Enable Security integration for securing HTTP sessions (use HTTPS)
  - Release HttpSession objects w/ javax.servlet.http.HttpSession.invalidate() when finished.
  - Avoid trying to save and reuse the HttpSession object outside of each servlet or JSP file.
  - Implement java.io.Serializable interface for new objects to be stored in the HTTP session.
  - The HttpSession API does not dictate transactional behavior for sessions. (Use EJBs.)
  - Ensure the Java objects you add to a session are in the correct class path.
  - Avoid storing large object graphs in the HttpSession object.
  - Utilize Session Affinity to help achieve higher cache hits in the WebSphere App. Server.
  - Maximize use of session affinity and avoid breaking affinity.
  - Secure all of the pages (not just some) when applying security to servlets or JSP files that use sessions with security integration enabled, .
  - Use manual update and either the sync() method or time-based write in applications that read session data, and update infrequently.
  - Tune HTTP Session Management for memory-to-memory or Database session replication.
  - Use EJB session beans to access EJB entity beans.
  - Exploit connectionFactory caching for J2C connections.
More WLM & WebSphere Options

• See Appendices
  – Server Start-up Options
  – WebSphere Routing Options
  – Sysplex Distributor & WLM Routing Options
  – Capping the Resources used by WebSphere
  – WLM Tools
  – MVS Commands & Displays
  – Resources & References

Performance Monitoring & Debugging

- Set Performance Expectations

- CPU resources
  - Understand where the CPU time is spent
  - & how to measure/account for it

- Performance Monitors
  - There are many from IBM and other vendors

- Performance Problem Determination
  - Response time delays
  - CPU delays
  - Memory usage
Set performance expectations

- **Request pre-sale capacity sizing estimate from your IBM Rep**
  - Fairly detailed input required
  - Estimate is rough, but getting more accurate
  - zPSG Version 2.3 tool for WAS 6 and WPS 6 available now

- **Use a client emulator program to test your application**
  - Determine your CPU cost per transaction
  - Determine your application environment response time
  - Determine your client response time (in a measurement environment)

- **After your application goes into production**
  - Keep key historical data for the WAS application environment
    - Transaction rate, response time, 90% resp time, appl %
  - Keep key historical data for WAS servant region proc
    - appl %

- **WAS application monitors can help keep historical data and detect problems**

---

**Where is CPU Time Accounted?**

- **Controller Region**
  - Communications End-point: Receives IIOP/HTTP/SSL request
  - Security authorization for IIOP requests
  - Classifies & Queues Request to WLM queue

- **Servant Region**
  - Selects work from WLM for a given Service Class
  - Some Java Garbage Collection
  - (plus any application created threads)

- **Enclaves**
  - J2EE Application code executes under an enclave (in JVM)
    - Includes JDBC & JNI calls & most Java Garbage Collection
    - Type 2 drivers - DB2 CPU time charged to the Enclave
    - Type 4 drivers - DB2 CPU time charged to the DDF address space
  - Use SDSF ENClaves panel, or RMF Monitor to display

- **Note: Difference between Reporting & Management Classes**
  - All work is Managed by WLM according to the CB-assigned Service Class
  - CPU time is Reported (Charged) to Enclave only if it is part of the transaction.
    - e.g., Garbage Collection is managed to the CB-assigned Service/Reporting Class, but CPU time charged to the servant region's STC-assigned Service/Reporting Class.
### RMF Monitor 1 Workload Activity Report

**Transactions/second**
- AVG=MPL=AVG ENC = # of enclaves in the period
- "Business Tran" may not = "WebSphere Tran"

**Response times**
- Actual R.T. ~= Execution R.T. (includes waiting on WLM queue)
- QUEUED delays

**CPU & Service Rates**
- CPU service units, & Service/Sec.
- APPL% = # of engines (CPs) in service (report) class
- CPUsec/Tran = TCB sec/ENDED

**Delays**
- QMPL means waiting for Servant Region (WLM)

#### CPU & Service Rates

**CPUsec/Tran** = TCB sec/ENDED

#### Delays

**QMPL** means waiting for Servant Region (WLM)

---

### zIIPs & zAAPs CPU Accounting - RMF

**Workload Activity Report: DDF & WAS Transactions:**

<table>
<thead>
<tr>
<th>LOAD</th>
<th>CLASS</th>
<th>PERIOD</th>
<th>IMPORTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB_WKL</td>
<td>DDF</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>WAS_WKL</td>
<td>TRADE</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

- **TRANSACTIONS**
  - AVG: Average
  - MPL: Maximum
  - ENDED: Ended
  - END/S: End with Service
  - AVG ENC: Average Enclosures
  - REM ENC: Remaining Enclosures

- **SERVICE TIMES**
  - CPU: Central Processor
  - SRB: Service Routines
  - RCT: Resource Control
  - MSO: Main storage
  - AAP: Affinity Affinity
  - AAPCP: Affinity Affinity CP
  - IIPCP: IIP Affinity CP

- **EXECUTION DELAYS**
  - CPU QMPL: CPU Queue Management

---

**RESP. TIME EX**
- Perf AVG: Performance Average
- USING%: Usage Percentage
- EXEC. DELAYS: Execution Delays
- % time used by zIIP-eligible transactions
- % time running on zIIPs

---

**RESP. TIME EX**
- Perf AVG: Performance Average
- USING%: Usage Percentage
- EXEC. DELAYS: Execution Delays
- % time used by zAAP-eligible transactions
- % time running on zAAPs

---

**EXPERIMENTAL DATA**
- IBM Corporation, 2007, 2009

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**IBM Washington Systems Center**

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Performance Monitoring & Management

- SMF/RMF on z/OS
- jinsightLive for System z - “Use Case” Profiler
- ITCAM for WebSphere (IBM Tivoli Composite Application Monitor)
- WebSphere Performance & Diagnostic Advisor (integrated in WAS)
- Tivoli Performance Viewer (Integrated into AdminConsole for WAS V.6.1)
- Tivoli Decision Support for z/OS (SMF Records (120) moved to DB2)
- CA Wily Technology Inc. Introscope (PowerPack for WAS on z/OS)
  & many others...

JinsightLive for IBM System z
- “Use Case” Profiler

http://www.alphaworks.ibm.com/tech/jinsightlive

Best way to see where time is going . . .

Profile each use case
- Look for 'poor' choices - Repeated tasks that can be avoided
- Profile in a production configuration (Data volume)

Look for common patterns
- Predominant use cases are visible

1st step in understanding use cases
- Quicker than reading unfamiliar code.
- Will not find latching bottlenecks nor identify ‘wait’ time from ‘CPU’ time
## Isolating problems

### Time spent & CPU activity at method level:
- WSAM, and other application monitors
- SMF 120 data (turn on activity records only for diagnostics)
  - Summary viewer: See PRS752 "Performance Summary Report for SMF 120..." on Techdocs
- Overhead tolerable in many environments.

<table>
<thead>
<tr>
<th>SMF Record Time</th>
<th>Server</th>
<th>Bean/WebAppName</th>
<th># of El.Time(mSec)</th>
<th>WLM Enc1 CPU_Time(uSec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>359 120.6 19:00:02 T5SRV1</td>
<td>MY_IVT_ApplicationMyIVTStatelessSession.jar</td>
<td>remove:</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>getContents:</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>create:</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>removeItem:java.lang.String</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>addItem:java.lang.String</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>360 120.8 19:00:02 T5SRV1</td>
<td>ivtservlet</td>
<td>ivtjeb</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SimpleFileServlet</td>
<td>29</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JSP 1.2 Processor</td>
<td>3</td>
<td>12095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ivtDate.jsp</td>
<td>3</td>
<td>144</td>
</tr>
</tbody>
</table>

### WAS V7 - New SMF 120.9 Records

- **WebSphere for z/OS creates SMF 120 records.**
  - Issues with prior versions of WebSphere for z/OS:
    - Insufficient user/request information for Chargeback
    - Not extendable
    - Costly to record, Not dynamically controlled
- **WebSphere Version 7 introduces new subtype-9**
  - Dynamically enabled/disabled
  - Contains more information for chargeback
  - Show Bytes transferred, Elapsed Times, CP, zAAP, zIIP times
  - Low overhead
  - Extendable with user inserted sections
- **SMF Record Interpreter** available from the WebSphere Application Server for z/OS Web site at:
  - Select “SMF Browser for WebSphere Application Server for z/OS V5 and V6”
Isolating CPU problems

CPU usage at the detailed level:

- SMF 120 records provide CPU usage at the method level
- CPU Time service (WSC program) can be used for your own detailed measurements
  - See PRS621 "CPU Time-used function for Java applications on z/OS" on Techdocs
  - See TD101339 "How-to find CPU TimeUsed in your WAS V5 for z/OS"
- WAS V5 has method `SMFJActivity.obtainTotalCpuTimeUsed()` in pmi.jar

```java
import com.ibm.ws390.sm.smf.SmfJActivity;
...
long startTime;
long stopTime;
long cpuTime;
startTime = SmfJActivity.obtainTotalCpuTimeUsed();
...
```

Zero in: Right tool for the problem?
Isolating problems - Delays

**WLM Delay Monitoring States:**
- DISP - waiting for response from a distributed server
- LOCL - waiting for session w/ server on the local system
- SYSP - waiting for TCP/IP session establish w/ local system
- REMT - waiting for TCP/IP session establish w/ remote system
- SSLT* - waiting for SSL session in controller
- REGT* - waiting for thread in controller
- WORK* - waiting to register work in controller
- OTHER - waiting for DNS or TCP/IP
- TYP1 - EJB Collaborator
- TYP2 - J2C Connector
- TYP3 - RM/IIOP
- TYP4 - OTS call to RRS

* Added w/ APARs for WLM OW51848 & RMF OW52227

---

**Work Manager Delays - WLMGL - Workload Activity Report**

<table>
<thead>
<tr>
<th>RESP</th>
<th>STATE SAMPLES BREAKDOWN (%)</th>
<th>STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB</td>
<td>TIME</td>
<td>--ACTIVE-- READY IDLE</td>
</tr>
<tr>
<td>TYPE</td>
<td>(%)</td>
<td>SUB APPL</td>
</tr>
<tr>
<td>CB</td>
<td>BTU</td>
<td>0.0 26.9</td>
</tr>
<tr>
<td>CB</td>
<td>EXE</td>
<td>0.0</td>
</tr>
</tbody>
</table>

---

**Displaying Threads & CPU Time Used:**

D OMVS, PID=nnnn, BRL, or SDSF – PS panel, D action character

(output goes to Syslog.)

```
BPX040I 13.27.01 DISPLAY OMVS 506
USER JOBNAME ASID PID PPID STATE START CT_SECS
H2ASRU H2SR01BS 0021 197284 84083363 HR---- 10.24.55 2231.967
THREAD_ID TCB@ PRI_JOB USERNAME ACC_TIME SC STATE
1450F9400000000 008D6AD0                      36.296 IPT  YU
1451AE0000000037 008C90A8                        .089PTC JR V
1451BD1000000038 008C5E88 WLM                      70.820 CLO JR V
1451CC2000000039 008C60D0 WLM                      70.586 CLO JR V
1451DB300000003A 008C62F0 WLM                      71.462 CLO JR V
1451EA400000003B 008C6510 WLM                      351.265 WRT JR V
1451F950000003C 008C6730 WLM                      69.749 CLO JR V
145208600000003D 008C6950 WLM                      348.383 CLO JR V
145217700000003E 008C87B0 WLM                      348.176 CLO JR V
145226800000003F 008C8E00 WLM                      70.408 CLO JR V
145244A000000040 008C8098 WLM                      69.230 CLO JR V
1451A80E000000037 008C90B8                      .287PTC JR V
```

CPU Time (Secs)
Using JAVACORE Dumps to identify threads

In the javacore, thread 27070580 used 178 seconds out of a total of 1950 (9%) why?

3XMTHREADINFO "Thread-34" (TID:0x556C1600, sys_thread_t:0x554EADD8, state:CW
ID:0x27070580) prio=5
4XESTACKTRACE at java/lang/Object.wait(Native Method)
4XESTACKTRACE at java/lang/Object.wait(Object.java:231(Compiled Code))
4XESTACKTRACE at
com/ibm/tivoli/itcam/toolkit/ai/gccollector/Semaphore.waitForAndLock(Semaphore.j
ava:69(Compiled Code))
.
.
Thread in stack trace suggests it relates to ITCAM monitoring GC.
• Missing fix pack resulted in higher overhead for collecting
  performance data.
• After installing the required fixes this percentage dropped to 2-3%.

See “Threads and excessive CPU consumption in WAS for z/OS”
  Techdoc WP101474

IBM Support Assistant (ISA)

Free application simplifies & automates software support
• Helps customers analyze & resolve questions and problems
  – ibm.com/software/support/isa/
  – ibm.com/developerworks/websphere/techjournal/0906_supauth/0906_supauth.html

Java and WebSphere Troubleshooting Tools
• IBM Monitoring and Diagnostic Tools for Java
  – Health Center
  – Dump Analyzer
  – Garbage Collection and Memory Visualizer (GCMV)
• Memory Dump Diagnostic for Java (MDD4J)
• IBM Pattern Modeling and Analysis Tool for Java Garbage Collector (PMAT)
• IBM Thread and Monitor Dump Analyzer for Java
• Thread Analyzer
• WebSphere Application Server extensions for Dump Analyzer
• IBM Trace and Request Analyzer for WebSphere Application Server
• Database Connection Pool Analyzer for IBM WebSphere Application Server
• Log Analyzer
• Symptom Editor
• Visual Configuration Explorer
More Tools . . .

- **Workload simulators**
  - Rational Performance Tester
  - WebSphere Studio Workload Simulator
  - MS Web Application Stress Tool - [www.microsoft.com/technet/default.mspx](http://www.microsoft.com/technet/default.mspx)
    - Search on ‘Web Application Stress Tool’
  - Loadrunner - [www.mercuryinteractive.com](http://www.mercuryinteractive.com)
  - Silk - [www.segue.com](http://www.segue.com)

- **Java tools**
  - Javadump formatters – see appropriate IBM SDK, Java™ Diagnostics Guide

- **HTTP sniffers**
  - tcpmon - [org.apache.axis.utils](http://www.apache.org/axis/)
  - ethereal - [www.ethereal.com](http://www.ethereal.com)

- **MVS Sysprog tools**
  - MXI - [www.mximvs.com/](http://www.mximvs.com/)

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Some Benchmark Experiences

The best tuned system cannot fix some application problems

- **Java Heap required by application**
  - Use JVM Verbose GC reports for information
  - Application requires much larger JVM heap
  - Application has a memory leak

- **Inefficient Application Code**
  - Application 'swallows' errors, making them invisible
  - Application use of storage and caching, caching algorithm used
  - Resource bundles or property files read for every transaction
  - Frequent, Verbose logging to Un-owned HFS
  - String handling, data conversions ASCII <-> EBCDIC
  - Check WebSphere error log for errors and correct
Appendices

1. More WLM Options & Tools
2. Controlling WebSphere Workload license charges
3. MVS Commands & Displays
4. Resources & References

WLM Startup Options for WebSphere

- **Number of Servers**: `server_name` > Java and process management > Server instance.
  - Select the Multiple instances enabled field.
  - Minimum Number and Maximum Number of Instances.

- **protocol_accept_http_work_after_min_srs**
  - Wait for minimum number of servants ready before starting HTTP transport channels.
  **True (1)**: HTTP transport channels start when minimum number of servants is ready for work.
  **False (0)**: HTTP transport channels start when the controller starts.

- **protocol_accept_iioop_work_after_min_srs**
  **True (1)**: IIOP transport channels start when minimum number of servants is ready for work.
  **False (0)**: IIOP transport channels start when the controller starts.

- **wlm_servant_start_parallel** (New with WAS V7)
  - 1: After first servant is initialized, server starts remaining address spaces in parallel.
  - 0: Server starts all servant address spaces sequentially.
WLM Workload Distribution Options

- **Even distribution of HTTP requests**: server_name > Server Infrastructure/Administration > Administration services > Additional Properties > Custom properties > Check “WLMStatefulSession” property.
  
  (general property wlm_stateful_session_placement_on is ignored.)

- **server_use_wlm_to_queue_work**
  
  Specifies whether WLM is used for workload queuing.
  
  1: if you are using stateless application models.
  
  0: if you are using conversational application models

- **server_work_distribution_algorithm**
  
  This is only used if server_use_wlm_to_queue_work=false.
  
  0: Hot thread algorithm is used. (not recommended.)
  
  1: The round robin algorithm is used. **This is the default.**

More WLM Options for WebSphere

- **control_region_wlm_dispatch_timeout**
  
  Limits the amount of time a client request waits on the WLM queue, as well as the time required for the application component to process the request.

- **protocol_iioplocal_propagate_wlm_enclave**
  
  Propagate the WLM enclave associated with currently dispatched request on an outbound IIOP request made to another server on the same z/OS system.

- **control_region_timeout_save_last_servant**
  
  Specifies whether the controller terminates the last available servant when a timeout situation occurs.
WLM WebSphere Routing Level algorithm

- New support in z/OS 1.9 uses displaceable CP capacity of systems as basis for routing work.
  - Function enabled on z/OS 1.6 and above with OA16486.
- In the past, WLM routing algorithm was round-robin.
- New IEAOPT parameter WASROUTINGLEVEL
  - =1 Use the old Round-Robin routing algorithm. (the default)
  - =0 Use LPAR capacity when making routing decisions.
    - “Over committed” systems shouldn’t get additional work.
    - WLM will avoid systems that are in 'stress' (real storage shortage.)
    - May change routing recommendations compared to current behavior.
- Keep the same WASROUTINGLEVEL option on all systems of the sysplex.
- This applies only to the Daemon Routing IIOP requests.

Sysplex Distributor WLM Routing Options

- VIPADISTribute DISTMethod=
  - BASEWLM – Route based on available GCP capacity.
  - SERVERWLM – Include zAAP/zIIPs in routing recommendations
  - WEIGHTEDActive – Balance requests proportional to connection weight.
  - ROUNDROBIN – (Ignore WLM routing.)
- OPTLOCAL (value) – Use local Server if Available & Healthy
  - Avoids traffic-routing through Sysplex Distributor.
  - Value=0: always use local connection (Req’d if ROUNDROBIN)
  - Value=1: use local connection unless server WLM weight=0
  - Value=2-16: multipliers to favor the local server’s WLM weight

Recommendations (?)
- While it may seem good to route based on available capacity, Overhead is significantly reduced if the work stays on the local system.
- Stateful sessions reduce flexibility & may create imbalance
**WLM Tools – WLMQUE & WLMOPT**


![WLM Queuing and Optimization Tools](image)

### WLMQUE – Application Env. Monitor

**Selection:**  >HELP< >SAVE< >OVW< >ALL<  
**System:**  SYSB  **Sysplex:**  WSCPLEX  **Version:**  z/OS 010900  **Time:**  13:03:24

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<th>Dyn</th>
<th>NQ</th>
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**Key:**

- **NQ** - Number of work queues (service classes)
- **QLen** - Total number of currently queued requests
- **QueIn** - Number of Requests inserted into work queue since last refresh
- **QueOut** - Number of Requests taken from queue since last refresh
- **QueLen** - Current queue length
- **QueTot** - Total number of requests seen so far
- **Binding** - Server class (work queue) from which the server AS selects work.
  - Shows dashes if the server address space is unbound
- **Have** - Number of instances which can select work
- **PEU** - Parallel execution units: number of defined server instances for the subsystem (for example: NUMTCB)
Controlling WebSphere Workload License Charges

- Limit WebSphere to a Maximum amount of MSUs
  - Customer wants to Control the Budget for Software Pricing based on MSUs
  - Useful for Getting Started SubCapacity (GSLS) Pricing
  - Useful in Test or Development Environments;
  - Not in Production where Performance Matters!

- Isolate an LPAR for WebSphere Work, and use:
  - PR/SM Capping, or . . .
  - Group Capacity limits (4-hour moving Average)
MVS Modify <server> Command - Help

F <server>,HELP
THE COMMAND MODIFY MAY BE FOLLOWED BY ONE OF THE FOLLOWING KEYWORDS:
CANCEL - CANCEL THIS CONTROL REGION
TRACEALL - SET OVERALL TRACE LEVEL
TRACEBASIC - SET BASIC TRACE COMPONENTS
TRACEDETAIL - SET DETAILED TRACE COMPONENTS
TRADESCIFIC - SET SPECIFIC TRACE POINTS
TRACEINIT - RESET TO INITIAL TRACE SETTINGS
TRACENONE - TURN OFF ALL TRACING
TRACETOSYSPRINT - SEND TRACE OUTPUT TO SYSPRINT (YES/NO)
DISPLAY - DISPLAY STATUS
TRACE EXCLUDE SPECIFIC - EXCLUDE SPECIFIC TRACE POINTS
JAVACORE - GENERATE JVM CORE DUMP
HEAPDUMP - GENERATE JVM HEAP DUMP
JAVATDUMP - GENERATE JVM TDUMP
TRACETJAVA - SET JAVA TRACE OPTIONS
TRACETOTRCFILE - SEND TRACE OUTPUT TO TRCFILE (YES/NO)
MDBSTATS - MDB DETAILED STATISTICS
PAUSELISTENERS - PAUSE THE COMMUNICATION LISTENERS
RESUMELISTENERS - RESUME THE COMMUNICATION LISTENERS
STACKTRACE - LOG JAVA THREAD STACK TRACEBACKS
TIMEOUTDUMPACTION - SET TIMEOUT DUMP ACTION
TIMEOUTDUMPACTIONSESSION - SET TIMEOUT DUMP ACTION SESSION
TIMEOUT_DELAY - SET TIMEOUT DELAY VALUE
WLM_MIN_MAX - RESET WLM MIN/MAX SERVANT SETTINGS
SMF - SET SMF120 OPTIONS
DPM - DISPATCH PROGRESS MONITOR


MVS Modify <server>,Display,Help

F <server>,DISPLAY,HELP
THE COMMAND DISPLAY, MAY BE FOLLOWED BY ONE OF THE FOLLOWING KEYWORDS:
SERVERS - DISPLAY ACTIVE CONTROL PROCESSES
SERVANTS - DISPLAY SERVANT PROCESSES OWNED BY THIS CONTROL PROCESS
LISTENERS - DISPLAY LISTENERS
CONNECTIONS - DISPLAY CONNECTION INFORMATION
TRACE - DISPLAY INFORMATION ABOUT TRACE SETTINGS
JVMHEAP - DISPLAY JVM HEAP STATISTICS
WORK - DISPLAY WORK ELEMENTS
ERRLOG - DISPLAY THE LAST 10 ENTRIES IN THE ERROR LOG
MODE - DISPLAY THE EXECUTION BITMODE
THREADS - DISPLAY THREAD STATUS (WAS V7)
WLM - DISPLAY WLM SETTINGS
SMF - DISPLAY SMF120-9 SETTINGS AND STATUS
FRCA - DISPLAY FRCA INFORMATION
DPM - DISPLAY DISPATCH PROGRESS MONITOR SETTINGS
END OF OUTPUT FOR COMMAND DISPLAY,HELP

Display a list of all the keywords you can use with the modify timeoutdumpacation or timeoutdumpactionsession command:

f <server>,timeoutdumpactionsession=help
BBO00178I MODIFY TIMEOUTDUMPACTIONSESSION= MAY BE FOLLOWED BY ONE OF
THE FOLLOWING KEYWORDS:
BBO00179I SVCDUMP - SVC DUMP
BBO00179I JAVACORE - JAVA CORE DUMP
BBO00179I NONE - NO DUMP

MVS Modify Command to Display Work

```bash
F <server_name>,DISPLAY,WORK,HELP
```

BBO00178I THE COMMAND DISPLAY,WORK, MAY BE FOLLOWED BY ONE OF THE FOLLOWING KEYWORDS:

BBO00179I EJB - DISPLAY EJB REQUEST COUNT INFORMATION
BBO00179I SERVLET - DISPLAY SERVLET REQUEST COUNT INFORMATION
BBO00179I MDB - DISPLAY MDB REQUEST COUNT INFORMATION
BBO00179I SIP - DISPLAY SIP REQUEST COUNT INFORMATION
BBO00179I SUMMARY - DISPLAY SUMMARY REQUEST COUNT INFORMATION
BBO00179I ALL - DISPLAY ALL REQUEST COUNT INFORMATION
BBO00179I CLINFO - DISPLAY WORK CLASSIFICATION INFORMATION
BBO00188I END OF OUTPUT FOR COMMAND DISPLAY,WORK,HELP

WebSphere Operator Display Commands to determine:

Work, Queued or Active + Deltas provided between invocations:

```bash
F H2SR01B,DISPLAY,WORK
```

BBO00255I TIME OF LAST WORK DISPLAY 2008/06/12 14:32:15.215714
BBO00261I TOTAL REQUESTS TO SERVER 414120 (DELTA 316139)
BBO00262I TOTAL CURRENT REQUESTS 9
BBO00263I TOTAL REQUESTS IN DISPATCH 9
BBO00268I TOTAL TIMED OUT REQUESTS 0 (DELTA 0)
BBO00188I END OF OUTPUT FOR COMMAND DISPLAY,WORK

WLM Dynamic Application Environments

```bash
D WLM,DYNAPPL=* 
```

IWM029I 12.57.17 WLM DISPLAY 590

DYNAMIC APPL. ENVIRON. NAME STATE STATE DATA

F6SR01 AVAILABLE
ATTRIBUTES: PROC=F6ASRA SUBSYSTEM TYPE: CB
SUBSYSTEM NAME: F6SR01A NODENAME: F6CELL

F6SR01ADJUNCT AVAILABLE
ATTRIBUTES: PROC=F6CRAA SUBSYSTEM TYPE: CB
SUBSYSTEM NAME: F6SR01A NODENAME: F6CELL

```bash
V WLM,DYNAPPL=F6SR01,RESUME | QUIESCE | REFRESH
```

Dynamic WLM Env’s Started and Stopped Dynamically, but can be used to:

- QUIESCE - WLM stops the server address spaces.
- RESUME - WLM starts the server address spaces.
- REFRESH - WLM stops the server address spaces, and starts new ones.
Resources & References

WebSphere Application Server Information Center
- ibm.com/software/webservers/appserv/was/library/
- Download a copy onto your workstation

WebSphere for z/OS "home page"
ibm.com/software/webservers/appserv/zos_os390/

Redbooks: www.redbooks.ibm.com
- Systems Programmer’s Guide to: Workload Manager – SG24-6472
- Performance Monitoring & Best Practices for WAS on z/OS - SG24-7269
- Monitoring WebSphere Application Performance on z/OS - SG24-6825
- Writing Optimized Java Applications for OS/390 - SG24-6541
- WebSphere for z/OS V6 Problem Determination - SG24-6880
- WebSphere V6 Scalability & Performance Handbook - SG24-6392
- WebSphere for z/OS to CICS & IMS Connectivity Performance – REDP-3959

Build a library of WAS & Java for z/OS pubs
- Developers & Sysprogs need access to z/OS specific information
- Information is perishable and time sensitive
- Out of date information is like no information or bad information.

Education

- Courses by IBM Learning Services, ITSO, & WSC
  www.ibm.com/services/learning/
  - ES685 - WAS V6 Implementation Workshop (4.5 Days)
  - OZ850 - “Maximizing WebSphere for z/OS V6 Performance” (4.5 Days)

- Wildfire Workshops:
  - WBSR7 - WebSphere V7 for z/OS Workshop "Gen 7" (2.5 days)
  - WSW07 - Security Workshop: WAS V7 for z/OS (2.5 Days)

- Conferences & User Group Meetings
  - SHARE & Regional User Groups
  - zSeries Expo
  - Large Systems z/OS Update
  - WebSphere Virtual Usergroup
WAS for z/OS Performance articles on Techdocs

White Papers:
- WP101206 Installing ITCAM V6.1 for WebSphere on z/OS
- WP101342 Understanding SMF Record Type 120, Subtype 9
- WP101374 WebSphere Application Server for z/OS V7 - Dispatch Timeout Improvements
- WP101138 WebSphere z/OS V6.1 - Hidden Gems and Little Known Features
- WP101121 The 64-bit Effect Five Different Ways to Look at Applications
- WP100678 Diagnosing Performance Problems with WebSphere Application Server on z/OS
- WP100558 Optimizing WebSphere for z/OS Performance
- WP100489 Mission: zAAP your costs Running WebSphere and Java on the zAAP
- WP100417 z/OS Performance: Capacity Planning Considerations for zAAP Processors
- WP100392 Exploiting web services in WebSphere for z/OS
- WP101476 Value of Co-Location with WebSphere for z/OS
- WP101490 Introduction to Optimized Local Adapters
- WP101474 Threads and excessive CPU Consumption in WebSphere on z/OS


More Performance articles on Techdocs

Hints & Tips:
- TD104172 WSC Guidelines for a Healthy WebSphere Runtime on z/OS
- TD103548 Capacity Planning for zAAP and zIIP Specialty Engines
- TD103036 Performance and tuning tips for WebSphere Application Server for z/OS
- TD102730 Classify the Application Control Region in WLM OMVS rules
- TD102454 How to find CPU Time Usage in your WebSphere V6 for z/OS java programs
- TD101645 Tivoli Performance Viewer Security
- TD101216 Tracing and Analyzing Java Garbage Collection in WebSphere for z/OS V5
- TD101199 Enabling the WSAD Application Profiler in a WAS V5 for z/OS Environment
- TD101152 Manage the Number of Servant Regions with WAS for z/OS V5 and WLM
- TD101151 How to Classify HTTP Transactions in WebSphere for z/OS V5

Presentations & Downloads:
- PRS752 Performance Summary Report for SMF 120 records from WAS for z/OS
- PRS2494 Performance Engineering for WebSphere Application Server for z/OS
- PRS3317 WLM Configuration & Advanced Topics for WAS on z/OS

Other Resources . . .

- Developer's Domain (WebSphere & Java Best Practices, Help, Docs & Tools)

- Java Specifications (J2EE, EJB, JSP, Servlet, JNDI) Papers
  - [java.sun.com/j2ee/docs/](http://java.sun.com/j2ee/docs/)

- Java Community Process
  - [jcp.org/](http://jcp.org/)

- z/OS Home Page

- IBM Support Assistant (ISA) V.4.1

- Publications on-line (view, print, order books)

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