IBM WebSphere Application Server for z/OS V5.0.2

Performance Tuning and Monitoring

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Note

Before using this information, be sure to read the general information under “Notices” on page 93.

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Contents

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Summary of Changes

This section describes what is new in WebSphere Application Server for z/OS in V5.0.2. It also provides a general overview of V5.

Introduction to this book

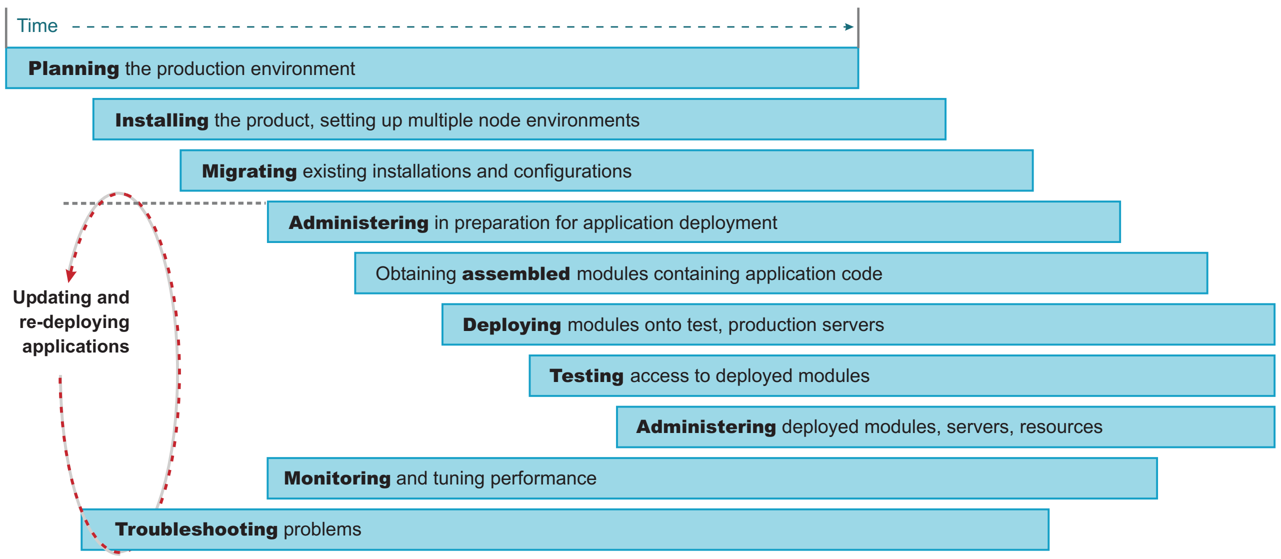
All of the documentation for WebSphere Application Server for z/OS is organized by task.

Task overviews

Task overviews are special sets of steps in this documentation. Each outlines a feasible sequence of tasks for working with an area of product functionality, such as security. Use task overviews to gain broad knowledge of the decisions and actions needed to accomplish your goals. From task overviews, you can drill down to more detailed sub-tasks.

The tasks in a task overview typically reflect the main activities, such as Migrating, Developing, Assembling, Deploying, and so on.

A simple timeline of activities for Planning, Installer and Administrator roles.


Time
Planning the production environment
Installing the product, setting up multiple node environments
Migrating existing installations and configurations
Administering in preparation for application deployment
Obtaining **assembled** modules containing application code
Deploying modules onto test, production servers
Testing access to deployed modules
Administering deployed modules, servers, resources
Monitoring and tuning performance
Troubleshooting problems
Updating and re-deploying applications

For learning purposes, task overviews outline one feasible sequence of tasks. In reality, several sequences might work. As you learn more, vary the sequence for your needs.

This book describes the planning, migrating, and installing tasks.

Chapter 1. Monitoring performance

WebSphere Application Server collects data on run-time and applications through the Performance Monitoring Infrastructure (PMI). Performance data can then be monitored and analyzed with a variety of tools.

WebSphere for z/OS relies on its use of WLM services to collect some of the accounting and performance data. This information gets presented back to the installation through RMF and RMF-written SMF records.

1. Enable performance monitoring services in the application server through the administrative console and Enable performance monitoring services in the NodeAgent through the administrative console if running WebSphere Application Server Network Deployment. In order to monitor performance data through the PMI interfaces, you must first enable the performance monitoring service through the administrative console and restart the server. If running in Network Deployment, you need to enable PMI services on both the server and on the node agent and restart the server and the node agent.
2. Setup workload management (WLM). Also see Workload management (WLM) tuning tips for z/OS.
3. Collect the data.

   The monitoring levels that determine which data counters are enabled can be set dynamically, without restarting the server. This can be done in one of the following ways:

   a. Enable performance monitoring services through Tivoli Performance Viewer (formerly Resource Analyzer).
   b. Enable performance monitoring services using the command line.

   For WebSphere for z/OS, also refer to Collecting performance diagnosis information.

WebSphere Application Server also collects data through PMI Request Metrics. This feature times requests as they travel through WebSphere Application Server components. For more information about PMI Request Metrics see the topic ″Measuring data requests (Performance Monitoring Infrastructure Request Metrics)″.

Related tasks

"Performance monitoring service settings" on page 15

Using the dynamic cache service to improve performance

Performance Monitoring Infrastructure

The Performance Monitoring Infrastructure (PMI) uses a client-server architecture. The server collects performance data from various WebSphere Application Server components. A client retrieves performance data from one or more servers and processes the data.

As shown in the figure, the server collects PMI data in memory. This data consists of counters such as servlet response time and data connection pool usage. The data points are then retrieved using a Web client, Java client or JMX client. WebSphere Application Server contains Tivoli Performance Viewer, a Java client which displays and monitors performance data. See the topics Tivoli performance monitoring and management solutions, Third-party performance monitoring and management solutions, and Developing your own monitoring applications for more information on monitoring tools″.

The figure shows the overall PMI architecture. On the right side, the server updates and keeps PMI data in memory. The left side displays a Web client, Java client and JMX client retrieving the performance data.

Related tasks

Chapter 1, "Monitoring performance"

"Developing your own monitoring applications" on page 30

Related reference

"Third-party performance monitoring and management solutions" on page 57

Performance data organization

Performance Monitoring Infrastructure (PMI) provides server-side monitoring and a client-side API to retrieve performance data. PMI maintains statistical data within the entire WebSphere Application Server domain, including multiple nodes and servers. Each node can contain one or more WebSphere Application Servers. Each server organizes PMI data into modules and submodules.

Counters are enabled at the module level and can be enabled or disabled for elements within the module. For example, in the figure, if the Enterprise beans module is enabled, its Avg Method RT counter is enabled by default. However, you can then disable the Avg Method RT counter even when the rest of the module counters are enabled. You can also, if desired, disable the Avg Method RT counter for Bean1, but the aggregate response time reported for the whole module will no longer include Bean1 data.

Each counter has a specified monitoring level: none, low, medium, high or maximum. If the module is set to lower monitoring level than required by a particular counter, that counter will not be enabled. Thus, if Bean1 has a medium monitoring level, Gets Found and Num Destroys are enabled because they require a low monitoring level. However, Avg Method RT is not enabled because it requires a high monitoring level.

Data collection can affect performance of the application server. The impact depends on the number of counters enabled, the type of counters enabled and the monitoring level set for the counters.

The following PMI modules are available to provide statistical data:

- Enterprise bean module, enterprise bean, methods in a bean

  Data counters for this category report load values, response times, and life cycle activities for enterprise beans. Examples include the average number of active beans and the number of times bean data is loaded or written to the database. Information is provided for enterprise bean methods and the remote interfaces used by an enterprise bean. Examples include the number of times a method is called and the average response time for the method.
- JDBC connection pools

  Data counters for this category contain usage information about connection pools for a database. Examples include the average size of the connection pool or number of connections, the average number of threads waiting for a connection, the average wait time in milliseconds for a connection, and the average time the connection is in use.
- J2C connection pool

  Data counters for this category contain usage information about the Java 2 Enterprise Edition (J2EE) Connector Architecture that enables enterprise beans to connect and interact with procedural back-end systems, such as Customer Information Control System (CICS), and Information Management System (IMS). Examples include the number of managed connections or physical connections and the total number of connections or connection handles.
- Servlet session manager

  Data counters for this category contain usage information for HTTP sessions. Examples include the total number of accessed sessions, the average amount of time it takes for a session to perform a request, and the average number of concurrently active HTTP sessions.
- Java Transaction API (JTA)

  Data counters for this category contain performance information for the transaction manager. Examples include the average number of active transactions, the average duration of transactions, and the average number of methods per transaction.

- Web applications, servlet

  Data counters for this category contain information for the selected server. Examples include the number of loaded servlets, the average response time for completed requests, and the number of requests for the servlet.
- Dynamic cache

  Data counters for this category contain information for the dynamic cache service. Examples include in memory cache size, number of invalidations and number of hits and misses.
- Web Services

  Data counters for this category contain information for the web services. Examples include number of loaded web services, number of requests delivered and processed, request response time, and average size of requests.

You can access PMI data via the getStatsObject and getStatsArray method in PerfMBean. You will need to pass the MBean ObjectName(s) to PerfMBean.

The following MBean types allow you to get PMI data in the related categories.

- DynaCache: for dynamic cache PMI data
- EJBModule*: for EJB module PMI data (BeanModule)
- EntityBean*: for a specific EJB PMI data (BeanModule)
- JDBCProvider*: for JDBC connection pool PMI data
- J2CResourceAdapter*: for J2C connection pool PMI data
- JVM: for Java Virtual machine PMI data
- MessageDrivenBean*: for a specific EJB PMI data (BeanModule)
- ORB: for Object Request Broker PMI data
- Server: for PMI data in the whole server, you must pass recurisive=true to PerfMBean
- SessionManager*: for HTTP Sessions PMI data
- StatefulSessionBean*: for a specific EJB PMI data (BeanModule)
- StatelessSessionBean*: for a specific EJB PMI data (BeanModule)
- SystemMetrics: for system level PMI data
- ThreadPool*: for thread pool PMI data
- TransactionService: for JTA Transaction PMI data
- WebModule*: for web application PMI data
- Servlet*: for a servlet PMI data
- WLMAppServer: for Workload Management PMI data
- WebServicesService: for web services PMI data
- WSGW*: for web services gateway PMI data

First, you will need to use the AdminClient API to query the ObjectName for each of the above MBean types. You can either query all the MBeans and then match the MBean type or use the query String for the type only: String query = ″WebSphere:type=mytype,node=mynode,server=myserver,*″;

You will need to set mytype, mynode, and myserver accordingly. Note that you get a Set when you call AdminClient to query MBean ObjectNames. It means that you may get multiple ObjectNames. In the above, the MBean types with a star (*) mean that there may be multiple ObjectNames in a server for the same MBean type. In this case, the ObjectNames can be identified by both type and name (but mbeanIdentifier will be the real UID for MBeans). However, the MBean names are not predefined -- they are decided at runtime based on the applications/resources. Once you get multiple ObjectNames, you can construct an array of ObjectNames that you are interested in. Then you can pass the ObjectNames to PerfMBean to get PMI data. You have the recursive and non-recursive options. Recursive option will return you Stats and sub-stats objects in a tree structure while non-recursive option will return you a Stats object for that MBean only. More programming information can be found in ″Develop your own monitoring applications″.

Related tasks

Chapter 1, “Monitoring performance,” on page 1

BeanModule data counters

Related reference

“Performance data organization” on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
creates	Number of times beans were created	3.5.5 and above	per home	CountStatistic	Low
removes	Number of times beans were removed	3.5.5 and above	per home	CountStatistic	Low
passivates	Number of times beans were passivated (entity and stateful)	3.5.5 and above	per home	CountStatistic	Low
activates	Number of times beans were activated (entity and stateful)	3.5.5 and above	per home	CountStatistic	Low
persistence loads	Number of times bean data was loaded from persistent storage (entity)	3.5.5 and above	per home	CountStatistic	Low
persistence stores	Number of times bean data was stored in persistent storage (entity)	3.5.5 and above	per home	CountStatistic	Low
instantiations	Number of times bean objects were instantiated	3.5.5 and above	per home	CountStatistic	Low
destroys	Number of times bean objects were freed	3.5.5 and above	per home	CountStatistic	Low
Num Ready Beans	Number of concurrently ready beans (entity and session). This counter was called concurrent active in Versions 3.5.5+ and 4.0.	3.5.5 and above	per home	RangeStatistic	High
concurrent live	Number of concurrently live beans	3.5.5 and above	per home	RangeStatistic	High
avg method rsp time	Average response time in milliseconds on the bean methods (home, remote, local)	3.5.5 and above	per home	TimeStatistic	High
avg method rsp time for create	Average time in milliseconds a bean create call takes including the time for the load if any	5.0	per home	TimeStatistic	Medium
avg method rsp time for load	Average time in milliseconds for loading the bean data from persistent storage (entity)	5.0	per home	TimeStatistic	Medium
avg method rsp time for store	Average time in milliseconds for storing the bean data to persistent storage (entity)	5.0	per home	TimeStatistic	Medium

avg method rsp time for remove	Average time in milliseconds a bean entries call takes including the time at the database, if any	5.0	per home	TimeStatistic	Medium
total method calls	total number of method calls	3.5.5 and above	per home	CountStatistic	High
avg method rsp time for activation	Average time in milliseconds a beanActivate call takes including the time at the database, if any	5.0	per home	TimeStatistic	Medium
avg method rsp time for passivation	Average time in milliseconds a beanPassivate call takes including the time at the database, if any	5.0	per home	TimeStatistic	Medium
active methods	Number of concurrently active methods - num methods called at the same time.	3.5.5 and above	per home	TimeStatistic	High
Per method invocations	Number of calls to the bean methods (home, remote, local)	3.5.5 and above	per method/per home	CountStatistic	Max
Per method rsp time	Average response time in milliseconds on the bean methods (home, remote, local)	3.5.5 and above	per home	TimeStatistic	Max
Per method concurrent invocations	Number of concurrent invocations to call a method	5.0	per method/per home	RangeStatistic	Max
getsFromPool	Number of calls retrieving an object from the pool (entity and stateless)	3.5.5 and above	per home/object pool	CountStatistic	Low
getsFound	Number of times a retrieve found an object available in the pool (entity and stateless)	3.5.5 and above	per home/object pool	CountStatistic	Low
returnsToPool	Number of calls returning an object to the pool (entity and stateless)	3.5.5 and above	per home/object pool	CountStatistic	Low
returnsDiscarded	Number of times the returning object was discarded because the pool was full (entity and stateless)	3.5.5 and above	per home/object pool	CountStatistic	Low
drainsFromPool	Number of times the daemon found the pool was idle and attempted to clean it (entity and stateless)	3.5.5 and above	per home/object pool	CountStatistic	Low
avgDrainSize	Average number of objects discarded in each drain (entity and stateless)	3.5.5 and above	per home/object pool	TimeStatistic	Medium
avgPoolSize	Number of objects in the pool (entity and stateless)	3.5.5 and above	per home/object pool	RangeStatistic	High
messageCount	Number of messages delivered to the bean onMessage method (message driven beans)	5.0	per type	CountStatistic	Low

messageBackoutCount	Number of messages failed to be delivered to the bean onMessage method (message driven beans)	5.0	per type	CountStatistic	Low
serverSessionWait	Average time to obtain a ServerSession from the pool (message drive bean)	5.0	per type	TimeStatistic	Medium
serverSessionUsage	Percentage of server session pool in use (message driven)	5.0	per type	RangeStatistic	High

JDBC connection pool data counters

PMI collects performance data for 4.0 and 5.0 JDBC data sources. For a 4.0 data source, the data source name is used. For a 5.0 data source, the JNDI name is used.

The JDBC connection pool counters are used to monitor the JDBC data sources performance. The data can be found by using the Tivoli Performance Viewer and looking under each application server. Click ***application_server*** > **JDBC connection pool**.

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
creates	Total number of connections created	3.5.5 and above	per connection pool	CountStatistic	Low
avg pool size	Average pool size	3.5.5 and above	per connection pool	BoundedRangeStatistic	High
free pool size	Average free pool size	5.0	per connection pool	BoundedRangeStatistic	High
allocates	Total number of connections allocated	3.5.5 and above	per connection pool	CountStatistic	Low
returns	Total number of connections returned	4.0 and above	per connection pool	CountStatistic	Low
avg waiting threads	Number of threads that are currently waiting for a connection	3.5.5 and above	per connection pool	RangeStatistic	High
connection pool faults	Total number of faults, such as, timeouts, in connection pool	3.5.5 and above	per connection pool	CountStatistic	Low
destroys	Number of times bean objects were freed	3.5.5 and above	per connection pool	CountStatistic	Low
avg wait time	Average waiting time in milliseconds until a connection is granted	5.0	per connection pool	TimeStatistic	Medium
avg time in use	Average time a connection is used (Difference between the time at which the connection is allocated and returned. This includes the JDBC operation time.)	5.0	per connection pool	TimeStatistic	Medium
percent used	Average percent of the pool that is in use	3.5.5 and above	per connection pool	RangeStatistic	High
percent maxed	Average percent of the time that all connections are in use	3.5.5 and above	per connection pool	RangeStatistic	High
Statement cache discard count	Total number of statements discarded by the LRU algorithm of the statement cache	4.0 and above	per connection pool	CountStatistic	Low

Number managed connections	Number of ManagedConnection objects in use	5.0	per connection factory	CountStatistic	Low
Number connections	Current number of connection objects in use	5.0	per connection factory	CountStatistic	Low
jdbcOperationTimer	Amount of time in milliseconds spent executing in the JDBC driver (includes time spent in JDBC driver, network and database)	5.0	per data source	TimeStatistic	Medium

J2C connection pool data counters

The J2C connection pool data counters are used to monitor the J2C connection pool performance. The data can be found by using the Tivoli Performance Viewer and looking under each application server. Click ***application_server*** > **J2C connection pool**.

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
Number managed connections	Number of ManagedConnection objects in use	5.0	per connection factory	CountStatistic	Low
Number connections	Current number of connection objects in use	5.0	per connection factory	CountStatistic	Low
Number managed connections created	Total number of connections created	5.0	per connection factory	CountStatistic	Low
Number managed connections destroyed	Total number of connections destroyed	5.0	per connection factory	CountStatistic	Low
Number managed connections allocated	Total number of connections allocated	5.0	per connection factory	CountStatistic	Low
Number managed connections freed	Total number of connections freed	5.0	per connection factory	CountStatistic	Low
faults	Number of faults, such as timeouts, in connection pool	5.0	per connection factory	CountStatistic	Low
free pool size	Number of free connections in the pool	5.0	per connection factory	BoundedRangeStatistic	High
pool size	Pool size	5.0	per connection factory	BoundedRangeStatistic	High
concurrent waiters	Average number of threads concurrently waiting for a connection	5.0	per connection factory	RangeStatistic	High
Percent used	Average percent of the pool that is in use	5.0	per connection factory	RangeStatistic	High
Percent maxed	Average percent of the time that all connections are in use	5.0	per connection factory	RangeStatistic	High
Average wait time	Average waiting time in milliseconds until a connection is granted	5.0	per connection factory	TimeStatistic	Medium
Average use time	Average time in milliseconds that connections are in use	5.0	per connection factory	TimeStatistic	Medium

Session data counters

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
createdSessions	Number of sessions created	3.5.5 and above	per web application	CountStatistic	Low
invalidatedSessions	Number of sessions invalidated	3.5.5 and above	per web application	CountStatistic	Low
sessionLifeTime	The average session lifetime	3.5.5 and above	per web application	TimeStatistic	Medium
activeSessions	The number of concurrently active sessions. A session is active if WebSphere is currently processing a request which uses that session.	3.5.5 and above	per web application	RangeStatistic	High
liveSession	The number of sessions that are currently cached in memory	5.0 and above	per web application	RangeStatistic	High
NoRoomForNewSession	Applies only to session in memory with AllowOverflow=false. The number of times that a request for a new session can not be handled because it would exceed the maximum session count.	5.0	per Web application	CountStatistic	Low
cacheDiscards	Number of session objects that have been forced out of the cache. (An LRU algorithm removes old entries to make room for new sessions and cache misses). Applicable only for persistent sessions.	5.0	per Web application	CountStatistic	Low
externalReadTime	Time (milliseconds) taken in reading the session data from persistent store. For multirow sessions, the metrics are for the attribute; for single row sessions, the metrics are for the whole session. Applicable only for persistent sessions. When using a JMS persistent store, the user has the choice of whether to serialize the data being replicated. If they choose not to serialize the data, the counter will not be available.	5.0	per Web application	TimeStatistic	Medium

externalReadSize	Size of session data read from persistent store. Applicable only for (serialized) persistent sessions; similar to externalReadTime above.	5.0	per Web application	TimeStatistic	Medium
externalWriteTime	Time (milliseconds) taken to write the session data from the persistent store. Applicable only for (serialized) persistent sessions. Similar to externalReadTime above.	5.0	per Web application	TimeStatistic	Medium
externalWriteSize	Size of session data written to persistent store. Applicable only for (serialized) persistent sessions. Similar to externalReadTime above.	5.0	per Web application	TimeStatistic	Medium
affinityBreaks	The number of requests received for sessions that were last accessed from another Web application. This can indicate failover processing or a corrupt plug-in configuration.	5.0	per Web application	CountStatistic	Low
serializableSessObjSize	The size in bytes of (the serializable attributes of) in-memory sessions. Only count session objects that contain at least one serializable attribute object. Note that a session may contain some attributes that are serializable and some that are not. The size in bytes is at a session level.	5.0	per Web application	TimeStatistic	Max
timeSinceLastActivated	The time difference in milliseconds between previous and current access time stamps. Does not include session time out.	5.0	per Web application	TimeStatistic	Medium
invalidatedViaTimeout	The number of requests for a session that no CountStatistic exists, presumeably because the session timed out.	5.0	per Web application	CountStatistic	Low
attemptToActivateNotExistentSession	Number of requests for a session that no longer exists, presumeably because the session timed out. Use this counter to help determine if the timeout is too short.	5.0	per Web application	CountStatistic	Low

Transaction data counters

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
Number global transactions begun	Total number of global transactions begun on server	4.0 and above	per transaction manager/server	CountStatistic	Low
Number global transactions involved	Total number of global trans involved on server (for example, begun and imported)	4.0 and above	per transaction manager/server	CountStatistic	Low
Number local transactions begun	Total number of local transactions begun on server	4.0 and above	per transaction manager/server	CountStatistic	Low
Active global transactions	Number of concurrently active global transactions	3.5.5 and above	per transaction manager/server	CountStatistic	Low
Active local transactions	Number of concurrently active local transactions	4.0 and above	per transaction manager/server	CountStatistic	Low
Global transactions duration	Average duration of global transactions	3.5.5 and above	per transaction manager/server	TimeStatistic	Medium
Local transaction duration	Average duration of local transactions	4.0 and above	per transaction manager/server	TimeStatistic	Medium
Local transactions before_completion time	Average duration of before_completion for local transactions	4.0 and above	per transaction manager or server	TimeStatistic	Medium
Global transaction commit time	Average duration of commit for global transactions	4.0 and above	per transaction manager/server	TimeStatistic	Medium
Global transaction prepare time	Average duration of prepare for global transactions	4.0 and above	per transaction manager/server	TimeStatistic	Medium
Local transaction before_completion time	Average duration of before_completion for local transactions	4.0 and above	per transaction manager/server	TimeStatistic	Medium
Local transaction commit time	Average duration of commit for local transactions	4.0 and above	per transaction manager/server	TimeStatistic	Medium
Number global transactions committed	Total number of global transactions committed	3.5.5 and above	per transaction manager/server	CountStatistic	Low
Number of global transactions rolled back	Total number of global transactions rolled back	3.5.5 and above	per transaction manager/server	CountStatistic	Low
Number global transactions optimized	Number of global transactions converted to single phase for optimization	4.0 and above	per transaction manager/server	CountStatistic	Low
Number of local transactions committed	Number of local transactions committed	4.0 and above	per transaction manager/server	CountStatistic	Low
Number of local transactions rolled back	Number of local transactions rolled back	4.0 and above	per transaction manager/server	CountStatistic	Low
Number of global transactions timed out	Number of global transactions timed out	4.0 and above	per transaction manager/server	CountStatistic	Low
Number of local transactions timed out	Number of local transactions timed out	4.0 and above	per transaction manager/server	CountStatistic	Low

Web application data counters

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
numLoadedServlets	Number of servlets that were loaded	3.5.5 and above	per Web application	CountStatistic	Low
numReloads	Number of servlets that were reloaded	3.5.5 and above	per Web application	CountStatistic	Low
totalRequests	Total number of requests a servlet processed	3.5.5 and above	per servlet	CountStatistic	Low
concurrentRequests	Number of requests that are concurrently processed	3.5.5 and above	per servlet	RangeStatistic	High
responseTime	The response time, in milliseconds, of a servlet request	3.5.5 and above	per servlet	TimeStatistic	Medium
numErrors	Total number of errors in a servlet or Java Server Page (JSP)	3.5.5 and above	per servlet	CountStatistic	Low

Dynamic cache data counters

The PMI data for Dynamic Cache are used to monitor the behavior and performance of the dynamic cache service. The functions and usages of dynamic cache can be found in Using the dynamic cache service to improve performance.

The related data can be accessed via the DynaCache MBean and displayed under Dynamic Cache in TPV.

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
maxInMemoryCacheSize	Maximum number of in-memory cache entries	5.0	per server	CountStatistic	Low
inMemoryCacheSize	Current number of in-memory cache entries	5.0	per server	CountStatistic	Low
totalTimeoutInvalidation	Aggregate of template timeouts and disk timeouts	5.0	per server	CountStatistic	Low
hitsInMemory	Requests for this cacheable object served from memory	5.0	per template	CountStatistic	Low
hitsOnDisk	Requests for this cacheable object served from disk	5.0	per template	CountStatistic	Low
explicitInvalidations	Total explicit invalidation issued for this template	5.0	per template	CountStatistic	Low
lruInvalidations	Cache entries evicted from memory by a Least Recently Used algorithm. These entries are passivated to disk if disk overflow is enabled.	5.0	per template	CountStatistic	Low
timeoutInvalidations	Cache entries evicted from memory and/or disk because their timeout has expired	5.0	per template	CountStatistic	Low

Entries	Current number of cache entries created from this template. Refers to the per-template equivalent of totalCacheSize.	5.0	per template	CountStatistic	Low
hitsRemove	Requests for this cacheable object served from other Java Virtual Machines (JVM) in the cluster	5.0	per template	CountStatistic	Low
Misses	Requests for this cacheable object that were not found in the cache	5.0	per template	CountStatistic	Low
RequestFromClient	Requests for this cacheable object generated by applications running on the application server	5.0	per template	CountStatistic	Low
requestsFromJVM	Requests for this cacheable object generated by cooperating caches in this cluster	5.0	per template	CountStatistic	Low
explicitInvalidationsFromMemory	Explicit invalidations resulting in an entry being removed from memory	5.0	per template	CountStatistic	Low
explicitInvalidationsFromDisk	Explicit invalidations resulting in an entry being removed from disk	5.0	per template	CountStatistic	Low
explicitInvalidationsNoOp	Explicit invalidations received for this template where no corresponding entry exists	5.0	per template	CountStatistic	Low
explicitInvalidationsLocal	Explicit invalidations generated locally, either programmatically or by a cache policy	5.0	per template	CountStatistic	Low
explicitInvalidationsRemote	Explicit invalidations received from a cooperating JVM in this cluster	5.0	per template	CountStatistic	Low
remoteCreations	Entries received from cooperating dynamic caches	5.0	per template	CountStatistic	Low

Web services data counters

Related reference

"Performance data organization" on page 2

Data counter definitions

Name	Description	Version	Granularity	Type	Level
numLoadedServices	Number of loaded Web services	5.02 and above	per service	CountStatistic	Low
numberReceived	Number of requests service received	5.02 and above	per Web service	CountStatistic	Low
numberDispatched	Number of requests service dispatched/delivered	5.02 and above	per web service	CountStatistic	Low

numberSuccessful	Number of requests service successfully processed	5.02 and above	per web service	TimeStatistic	Low
responseTime	The average response time, in milliseconds, for a successful request	5.02 and above	per web service	TimeStatistic	Medium
requestResponseTime	The average response time, in milliseconds, to prepare a request for dispatch	5.02 and above	per web service	TimeStatistic	Medium
dispatchResponseTime	The average response time, in milliseconds, to dispatch a request	5.02 and above	per web service	TimeStatistic	Medium
replyResponseTime	The average response time, in milliseconds, to prepare a reply after dispatch	5.02 and above	per web service	TimeStatistic	Medium
size	The average payload size in bytes of a received request/reply	5.02 and above	per web service	TimeStatistic	Medium
requestSize	The average payload size in bytes of a request	5.02 and above	per web service	TimeStatistic	Medium
replySize	The average payload size in bytes of a reply	5.02 and above	per web service	TimeStatistic	Medium

Performance data classification

Performance Monitoring Infrastructure provides server-side data collection and client-side API to retrieve performance data. Performance data has two components: static and dynamic.

The static component consists of a name, ID and other descriptive attributes to identify the data. The dynamic component contains information that changes over time, such as the current value of a counter and the time stamp associated with that value.

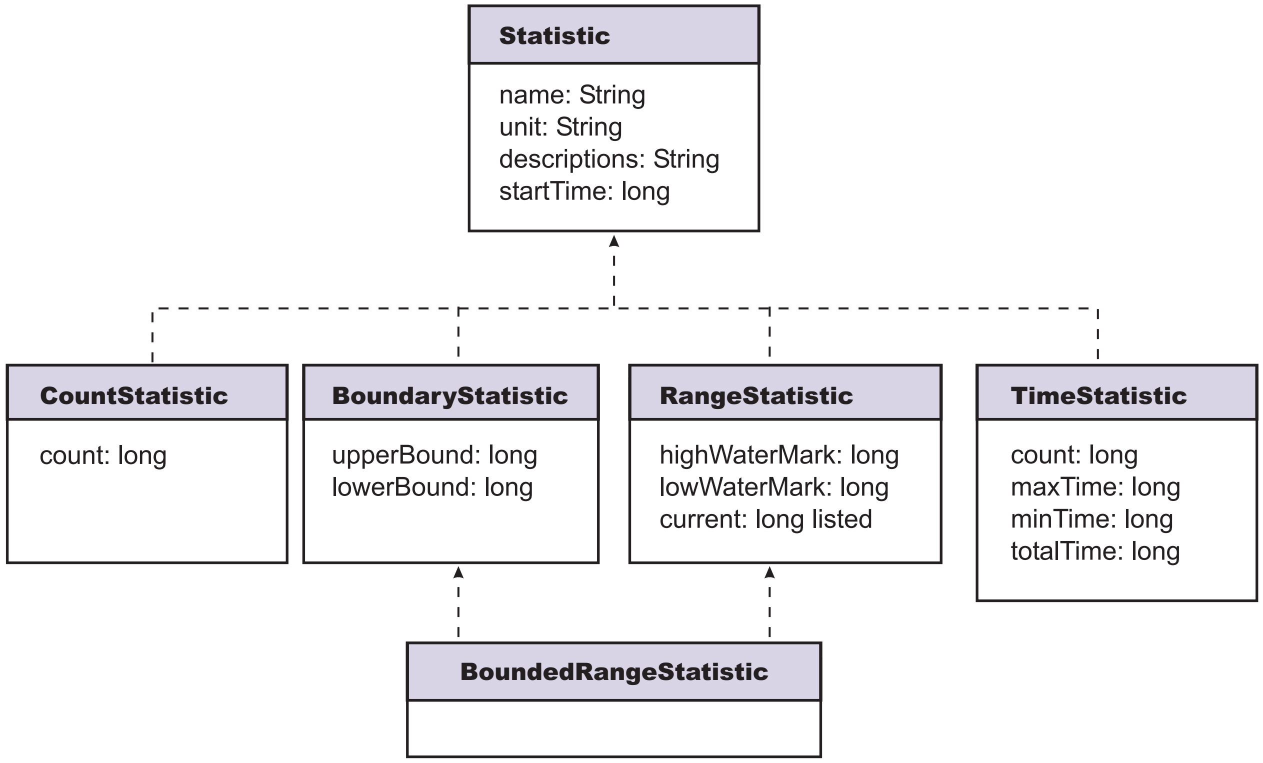
The PMI data can be one of the following statistical types defined in the JSR-077 specification:
- CountStatistic
- BoundaryStatistic
- RangeStatistic
- TimeStatistic
- BoundedRangeStatistic

RangeStatistic data contains current value, as well as lowWaterMark and highWaterMark.

In general, CountStatistic data require a *low* monitoring level and TimeStatistic data require a *medium* monitoring level. RangeStatistic and BoundedRangeStatistic require a *high* monitoring level.

There are a few counters that are exceptions to this rule. The average method response time, the total method calls, and active methods counters require a *high* monitoring level. The Java Virtual Machine Profiler Interface (JVMPI) counters, SerializableSessObjSize, and data tracked for each individual method

(method level data) require a *maximum* monitoring level.



In previous versions, PMI data was classified with the following types:

- **Numeric**: Maps to CountStatistic in the JSR-077 specification. Holds a single numeric value that can either be a long or a double. This data type is used to keep track of simple numeric data, such as counts.
- **Stat**: Holds statistical data on a sample space, including the number of elements in the sample set, their sum, and sum of squares. You can obtain the mean, variance, and standard deviation of the mean from this data.
- **Load**: Maps to the RangeStatistic or BoundedRangeStatistic, based on JSR-077 specification. This data type keeps track of a level as a function of time, including the current level, the time that level was reached, and the integral of that level over time. From this data, you can obtain the time-weighted average of that level. For example, this data type is used in the number of active threads and the number of waiters in a queue.

These PMI data types continue to be supported through the PMI API. Statistical data types are supported through both the PMI API and Java Management Extension (JMX) API.

The TimeStatistic type keeps tracking many counter samples and then returns the total, count and average of the samples. An example of this is an average method response time. Given the nature of this statistic type, it is also used to track non-time related counters, like average read and write size. You can always call getUnit method on the data configuration information to learn the unit for the counter.

In order to reduce the monitoring overhead, numeric and stat data are not synchronized. Since these data track the total and average, the extra accuracy is generally not worth the performance cost. Load data is very sensitive, therefore, load counters are always synchronized. In addition, when the monitoring level of a module is set to *max*, all numeric data are also synchronized to guarantee accurate values.

Related tasks

Chapter 1, “Monitoring performance,” on page 1

Enabling performance monitoring services in the application server through the administrative console

To monitor performance data through the performance monitoring infrastructure (PMI) interfaces, you must first enable PMI services through the administrative console.

1. Open the administrative console.
2. Click **Servers** > **Application Servers** in the console navigation tree.
3. Click *server*.
4. Click the **Configuration** tab. When in the Configuration tab, settings will apply once the server is restarted. When in the Runtime Tab, settings will apply immediately. Note that enablement of Performance Monitoring Service can only be done in the Configuration tab.
5. Click **Performance Monitoring Service**.
6. Select the checkbox **Startup**.
7. (Optional) Select the PMI modules and levels to set the **initial specification level** field.
8. Click **Apply** or **OK**.
9. Click **Save**.
10. Restart the application server. The changes you make will not take affect until you restart the application server.

When running in WebSphere Application Server Network Deployment, be sure to Enable performance monitoring services in the NodeAgent through the administrative console.

Related tasks

Chapter 1, "Monitoring performance," on page 1

"Enabling performance monitoring services in the NodeAgent through the administrative console" on page 16

Performance monitoring service settings

Use this page to specify settings for performance monitoring, including enabling performance monitoring, selecting the PMI module and setting monitoring levels.

To view this administrative console page, click **Servers** > **Application Servers** > *server* > **Performance Monitoring**.

Startup

Specifies whether the application server attempts to start the specified service. If an application server is started when the performance monitoring service is disabled, you will have to restart the server in order to enable it.

Initial specification level

Specifies a Performance Monitoring Infrastructure (PMI) string that stores PMI specification levels, for example module levels, for all components in the server.
Set the PMI specification levels by selecting the *none*, *standard* or *custom* checkbox. If you choose *none*, all PMI modules are set to the *none* level. Choosing *standard*, sets all PMI modules to *high* and enables all PMI data excluding the method level data and JVMPI data. Choosing custom, gives you the option to change the level for each individual PMI module. You can set the level to N, L, M, H or X (none, low, medium, high and maximum). **Note** that you should not change the module names.

Specifications

Specifies the PMI module and monitoring level that you have set.
Set the PMI specification levels by selecting the *none*, *standard* or *custom* checkbox. If you choose *none*, all PMI modules are set to the *none* level. Choosing *standard*, sets all PMI modules to *high* and enables all PMI data excluding the method level data and JVMPI data. Choosing custom, gives you the option to

change the level for each individual PMI module. You can set the level to N, L, M, H or X (none, low, medium, high and maximum). **Note** that you should not change the module names.

Enabling performance monitoring services in the NodeAgent through the administrative console

To monitor performance data through the performance monitoring infrastructure (PMI) interfaces, you must first enable PMI services through the administrative console.

1. Open the administrative console.
2. Click **System Administration** > **NodeAgents** in the console navigation tree.
3. Click *node_agent*.
4. Click **Performance Monitoring Service**.
5. Select the checkbox **Startup**.
6. (Optional) Select the PMI modules and levels to set the **initial specification level** field.
7. Click **Apply** or **OK**.
8. Click **Save**.
9. Restart the NodeAgent. The changes you make will not take affect until you restart the NodeAgent.

When in the Configuration tab, settings will apply once the server is restarted. When in the Runtime Tab, settings will apply immediately. Note that enablement of Performance Monitoring Service can only be done in the Configuration tab.

Related tasks

Chapter 1, “Monitoring performance,” on page 1

Related reference

“Performance monitoring service settings” on page 15

Enabling performance monitoring services using the command line

You can use the command line to enable performance monitoring services.

1. Enable PMI services through the administrative console. Make sure to restart the application server.
2. Run the **wsadmin** command. Using **wsadmin**, you can invoke operations on Perf Mbean to obtain the PMI data, set or obtain PMI monitoring levels and enable data counters.

   Note: If PMI data are not enabled yet, you need to first enable PMI data by invoking setInstrumentationLevel operation on PerfMBean.

   The following operations in Perf MBean can be used in **wsadmin**:

```
 /** Set instrumentation level using String format
*  This should be used by scripting for an easy String processing
*/ The level STR is a list of moduleName=Level connected by ":".
public void setInstrumentationLevel(String levelStr, Boolean recursive);

/** Get instrumentation level in String for all the top level modules
*  This should be used by scripting for an easy String processing
*/     public String getInstrumentationLevelString();

 /** Return the PMI data in String
*
*/     public String getStatsString(ObjectName on, Boolean recursive);

/** Return the PMI data in String
*  Used for PMI modules/submodules without direct MBean mappings.
*/     public String getStatsString(ObjectName on, String submoduleName,
Boolean recursive);

/**
* Return the submodule names if any for the MBean
*/
public String listStatMemberNames(ObjectName on);
```

If an MBean is a StatisticProvider and if you pass its ObjectName to getStatsString, you will get the Statistic data for that MBean. MBeans with the following MBean types are statistic providers:
- DynaCache
- EJBModule
- EntityBean
- JDBCProvider
- J2CResourceAdapter
- JVM
- MessageDrivenBean
- ORB
- Server
- SessionManager
- StatefulSessionBean
- StatelessSessionBean
- SystemMetrics
- TransactionService
- WebModule
- Servlet
- WLMAppServer
- WebServicesService
- WSGW

The following are sample commands in **wsadmin** you can use to obtain PMI data:

Obtain the Perf MBean ObjectName

```
wsadmin>set perfName [$AdminControl completeObjectName type=Perf,*]
wsadmin>set perfOName [$AdminControl makeObjectName $perfName]
```

Invoke getInstrumentationLevelString operation

- `use invoke since it has no parameter`

```
wsadmin>$AdminControl invoke $perfName getInstrumentationLevelString
```

This command returns the following:

```
beanModule=H:cacheModule=H:connectionPoolModule=H:j2cModule=H:jvmRuntimeModule=H
:orbPerfModule=H:servletSessionsModule=H:systemModule=H:threadPoolModule=H
:trans actionModule=H:webAppModule=H
```

Note that you can change the level (n, l, m, h, x) in the above string and then pass it to setInstrumentationLevel method.

Invoke setInstrumentationLevel operation - enable/disable PMI counters

- set parameters (″pmi=l″ is the simple way to set all modules to the low level)

```
wsadmin>set params [java::new {java.lang.Object[]} 2]
wsadmin>$params set 0 [java::new java.lang.String pmi=l]
wsadmin>$params set 1 [java::new java.lang.Boolean true]
```

- set signatures

```
wsadmin>set sigs  [java::new {java.lang.String[]} 2]
wsadmin>$sigs set 0 java.lang.String
wsadmin>$sigs set 1 java.lang.Boolean
```

- invoke the method: use invoke_jmx since it has parameter

```
wsadmin>$AdminControl invoke_jmx $perfOName setInstrumentationLevel $params $sigs
```

This command does not return anything.

Note that the PMI level string can be as simple as *pmi=level* (where level is n, l, m, h, or x) or something like *module1=level1:module2=level2:module3=level3* with the same format shown in the string returned from `getInstrumentationLevelString`.

Invoke getStatsString(ObjectName, Boolean) operation If you know the MBean ObjectName, you can invoke the method by passing the right parameters. As an example, JVM MBean is used here.

- get MBean query string - e.g., JVM MBean

```
wsadmin>set jvmName [$AdminControl completeObjectName type=JVM,*]
```

- set parameters

```
 wsadmin>set params [java::new {java.lang.Object[]} 2]
wsadmin>$params set 0 [$AdminControl makeObjectName $jvmName]
wsadmin>$params set 1 [java::new java.lang.Boolean true]
```

- set signatures

```
wsadmin>set sigs  [java::new {java.lang.String[]} 2]
wsadmin>$sigs set 0 javax.management.ObjectName wsadmin>$sigs set 1 java.lang.Boolean
```

- invoke method

```
wsadmin>$AdminControl invoke_jmx $perfOName getStatsString $params $sigs
```

This command returns the following:

```
{Description jvmRuntimeModule.desc} {Descriptor {{Node wenjianpc} {Server server
1} {Module jvmRuntimeModule} {Name jvmRuntimeModule} {Type MODULE}}} {Level 7} {
Data {{{Id 4} {Descriptor {{Node wenjianpc} {Server server1} {Module jvmRuntimeM
odule} {Name jvmRuntimeModule} {Type DATA}}} {PmiDataInfo {{Name jvmRuntimeModul
e.upTime} {Id 4} {Description jvmRuntimeModule.upTime.desc} {Level 1} {Comment {
The amount of time in seconds the JVM has been running}} {SubmoduleName null} {T
ype 2} {Unit unit.second} {Resettable false}}} {Time 1033670422282} {Value {Coun
t 638} }} {{Id 3} {Descriptor {{Node wenjianpc} {Server server1} {Module jvmRunt
imeModule} {Name jvmRuntimeModule} {Type DATA}}} {PmiDataInfo {{Name jvmRuntimeM
odule.usedMemory} {Id 3} {Description jvmRuntimeModule.usedMemory.desc} {Level 1
} {Comment {Used memory in JVM runtime}} {SubmoduleName null} {Type 2} {Unit uni
t.kbyte} {Resettable false}}} {Time 1033670422282} {Value {Count 66239} }} {{Id
2} {Descriptor {{Node wenjianpc} {Server server1} {Module jvmRuntimeModule} {Nam
e jvmRuntimeModule} {Type DATA}}} {PmiDataInfo {{Name jvmRuntimeModule.freeMemor
y} {Id 2} {Description jvmRuntimeModule.freeMemory.desc} {Level 1} {Comment {Fre
e memory in JVM runtime}} {SubmoduleName null} {Type 2} {Unit unit.kbyte} {Reset
table false}}} {Time 1033670422282} {Value {Count 34356} }} {{Id 1} {Descriptor
{{Node wenjianpc} {Server server1} {Module jvmRuntimeModule} {Name jvmRuntimeMod
ule} {Type DATA}}} {PmiDataInfo {{Name jvmRuntimeModule.totalMemory} {Id 1} {Des
cription jvmRuntimeModule.totalMemory.desc} {Level 7} {Comment {Total memory in
JVM runtime}} {SubmoduleName null} {Type 5} {Unit unit.kbyte} {Resettable false}
}} {Time 1033670422282} {Value {Current 100596} {LowWaterMark 38140} {HighWaterM
ark 100596} {MBean 38140.0} }}}}
```

Invoke getStatsString (ObjectName, String, Boolean) operation This operation takes an additional String parameter and it is used for PMI modules that do not have matching MBeans. In this case, the parent MBean is used with a String name representing the PMI module. The String names available in a MBean can be found by invoking listStatMemberNames. For example, beanModule is a logic module aggregating PMI data over all EJBs but there is no MBean for beanModule. Therefore, you can pass server MBean ObjectName and a String "beanModule" to get PMI data in beanModule.

- get MBean query string - e.g., server MBean

```
wsadmin>set mySrvName [$AdminControl completeObjectName type=Server,name=server1,
node=wenjianpc,*]
```

- set parameters

```
wsadmin>set params [java::new {java.lang.Object[]} 3]
wsadmin>$params set 0 [$AdminControl makeObjectName $mySrvName]
wsadmin>$params set 1 [java::new java.lang.String beanModule]
wsadmin>$params set 2 [java::new java.lang.Boolean true]
```

- set signatures

```
wsadmin>set sigs  [java::new {java.lang.String[]} 3]
wsadmin>$sigs set 0 javax.management.ObjectName
wsadmin>$sigs set 1 java.lang.String
wsadmin>$sigs set 2 java.lang.Boolean
```

- invoke method

```
wsadmin>$AdminControl invoke_jmx $perfOName getStatsString $params $sigs
```

This command returns PMI data in all the EJBs within the BeanModule hierarchy since the recursive flag is set to true.

Note that this method is used to get stats data for the PMI modules that do not have direct MBean mappings.

Invoke listStatMemberNames operation

- get MBean queryString - for example, Server

```
wsadmin>set mySrvName [$AdminControl completeObjectName type=Server,name=server1,
node=wenjianpc,*]
```

- set parameter

```
wsadmin>set params [java::new {java.lang.Object[]} 1]
wsadmin>$params set 0 [$AdminControl makeObjectName $mySrvName]
```

- set signatures

```
wsadmin>set sigs  [java::new {java.lang.String[]} 1]
wsadmin>$sigs set 0 javax.management.ObjectName
wsadmin>$AdminControlinvoke_jmx $perfOName listStatMemberNames $params $sigs
```

This command returns the PMI module and submodule names, which have no direct MBean mapping. The names are seperated by a space " ". You can then use the name as the String parameter in getStatsString method, for example:

```
beanModule connectionPoolModule j2cModule servletSessionsModule threadPoolModule
webAppModule
```

Related tasks

"Enabling performance monitoring services in the application server through the administrative console" on page 15

Launching scripting clients

Related reference

Wsadmin tool

Monitoring and analyzing performance data

WebSphere Application Server performance data, once collected, can be monitored and analyzed with a variety of tools.

1. Monitor performance data with Tivoli Performance Viewer. This tool is included with WebSphere Application Server.
2. Monitor performance data with user-developed monitoring tools. Write your own applications to monitor performance data.
3. Monitor performance with third-party monitoring tools.
4. RMF Workload Activity reports and RMF Monitor III.
5. WLM Delay Monitoring.

Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)

The Resource Analyzer has been renamed *Tivoli Performance Viewer*.

Tivoli Performance Viewer (which is shipped with WebSphere) is a Graphical User Interface (GUI) performance monitor for WebSphere Application Server. Tivoli Performance Viewer can connect to a local or to a remote host. Connecting to a remote host will minimize performance impact to the application server environment.

Monitor and analyze the data with Tivoli Performance Viewer with these tasks:

1. Start the Tivoli Performance Viewer.
2. Set monitoring levels.
3. View summary reports.
4. (Optional) Store data to a log file.
5. (Optional) Replay a performance data log file.
6. (Optional) View and modify performance chart data.
7. (Optional) Scale the performance data chart display.
8. (Optional) Refresh data.
9. (Optional) Clear values from tables and charts.
10. (Optional) Reset counters to zero.

Related tasks

Chapter 1, “Monitoring performance,” on page 1

Related reference

Using the Performance Advisor in Tivoli Performance Viewer

Tivoli Performance Viewer features

Tivoli Performance Viewer is a Java client which retrieves the Performance Monitoring Infrastructure (PMI) data from an application server and displays it in a variety of formats.

You can do the following tasks with the Tivoli Performance Viewer:

- View data in real time
- Record current data in a log, and replay the log later
- View data in chart form, allowing visual comparison of multiple counters. Each counter can be scaled independently to enable meaningful graphs.
- View data in tabular form
- Compare data for single resources to aggregate data across a node

To minimize the performance impact, Tivoli Performance Viewer polls the server with the PMI data at an interval set by the user. All data manipulations are done in the Tivoli Performance Viewer client, which can be run on a separate machine, further reducing the impact.

The Tivoli Performance Viewer graphical user interface includes the following:

- Resource selection panel
- Data monitoring panel
- Menu bar
- Toolbar icons
- Node icons
- Status bar

Layout of the console

The performance viewer main window consists of two panels: the Resource Selection panel and the Data Monitoring panel. The Resource Selection panel, located on the left, provides a view of resources for which performance data can be displayed. The Data Monitoring panel, located on the right, displays numeric and statistical data for the resources that are highlighted (selected) in the Resource Selection panel.

You can adjust the width of the Resource Selection and Data Monitoring panels by dragging the split bar left or right. You can rearrange the order of the table columns in the Data Monitoring panel by dragging the column heading left or right. You can also adjust the width of the columns by dragging the edge of the column left or right.

Resource selection panel

The Resource Selection panel provides a hierarchical (tree) view of resources and the types of performance data available for those resources. Use this panel to select which resources to monitor and to start and stop data retrieval for those resources.

The Resource Selection panel displays resources and associated resource categories in an indented tree outline. Clicking the plus (+) and minus (-) symbols expands and collapses the tree to reveal the categories for the various resource instances. The resource tree can also be navigated by using the up and down arrow keys to cycle through the branches and by using the left and right arrow keys to expand and collapse the tree of resources. Resource instances can be expanded to reveal the instances they contain, if applicable. For example, when a EJB JAR instance is expanded, the enterprise bean instances in the EJB JAR are revealed. The Data Monitoring panel automatically displays the appropriate selection of counters for any objects highlighted in the Resource Selection panel.

The first level of the hierarchy includes all nodes (machines) in the administrative domain, followed by all application servers on the node. Below each application server, all resource categories are listed. If the enterprise beans category is expanded, all EJB JAR instances in the server are displayed. Next, all enterprise bean instances appear below the EJB JAR in the hierarchy. Then, a methods resource is associated with each bean. Clicking an individual bean or EJB JAR instance causes its corresponding counters to be displayed in the Data Monitoring panel. For enterprise beans, the counters displayed depend on whether the bean is an entity bean or a session bean. For EJB JARs, the counters are aggregate counters for all enterprise beans in the EJB JARs. See the InfoCenter article Performance data organization for more information.

Data monitoring panel

The Data Monitoring panel enables the selection of multiple counters and displays the resulting performance data for the currently selected resource. It contains two panels: the Viewing Counter panel above and the Counter Selection panel below.

Counter selection panel

The Counter Selection panel shows the counters available for the resource performance category selection.

Two factors determine the list of available counters in the Counter Selection panel:
- Only counters associated with the resource that is selected in the Resource Selection panel are displayed.
- Only counters having impact cost ratings within or below the instrumentation or monitoring level that is set for that resource in the administrative domain are displayed.

The first three counters shown for each resource performance category are selected by default. All counters can be selected or deselected, and the resulting output, shown in the top panel, automatically reflects the selection.

The columns in the Counter Selection panel provide the following information for each counter:
- **Name**. The names of the counters that are available for selection with this resource.
- **Description**. A brief description of the function of each counter.
- **Value**. The value for the counter, displayed according to the display mode in effect. Values are actual values (not scaled values used for the chart, if applicable).
- **Select**. A check box that indicates whether a counter is to be reflected in the chart. To hide data, clear the check box. The column representing that counter is then removed from the View Data window, and the graphic display for that counter is removed from the View Chart window.
- **Scale**. A value indicating whether data has been scaled (amplified or diminished) from its actual value to fit on the chart. This value is reflected only in the View Chart window.

  The value for the **Scale** column can be set manually by editing the value of the **Scale** field. See Scaling the chart display manually for information on manually setting the scale.

Viewing Counter panel

When a counter on the list in the Counter Selection panel is selected, the statistics gathered from that counter are displayed in the Viewing Counter panel at the top of the Data Monitoring panel.

The View Data window shows the counter's output in table format; the View Chart window displays a graph with time represented on the *x-axis* and the performance value represented on the *y-axis*. One or more performance counters can be simultaneously graphed on a single chart. The chart plots data from *n* data points, where *n* is the current table size (number of rows).

Display of multiple resources and aggregate data

When a single resource is selected in the Resource Selection panel, the Data Monitoring panel displays a choice of a table view or a chart view. If multiple resources are selected, the Data Monitoring panel displays a single data sheet for viewing summary information for the selected resources. The data sheet displays the tables for all objects of similar type for the selected resources. For example, if three servlet instances are selected, the data sheet displays a table of counter values for all the servlets. By default, the display buffer size is set to 40 rows, corresponding to the values of the last 40 data points retrieved.

The performance viewer provides aggregate data at the module level. If aggregate data is available for a group, it is displayed in the Data Monitoring panel. For example, for each enterprise bean home interface, counters track the number of active enterprise beans of that home. Each EJB JAR has an aggregate value that is the sum of all the enterprise beans in that EJB JAR. The enterprise beans resource category (module) within the application server has an aggregate value that is the sum of all enterprise beans in all EJB JARs.

Menu bar

The menu bar contains the following options:
- **File** menu. Used to change to current mode (from logging mode), to open an existing log file, and to exit from the performance viewer. The **File** menu contains the following items:
  - **Refresh**. Queries the administrative server for any newly started resources since data retrieval began or for additional counters to report. This operation is also recursive over all components subordinate to the selected resources. Tivoli Performance Viewer refreshes data every 10 seconds. When changing the refresh rate, you must use an integer greater than or equal to 1.
  - **Current Activity**. Resumes the display of real-time data in tables and charts. This menu option is used to stop viewing data from a log file and return to viewing real-time data.
  - **Log**. Displays a dialog box for specifying the name and location of an existing log file to be replayed.

  - **Exit**. Closes the performance viewer. If you made changes to the instrumentation levels of any resources during the session, a dialog box opens to ask whether you want to save the changed settings before closing the tool.
- **Logging** menu. Provides **On** and **Off** options that are used to start and stop recording data in a log file. If you start a new log file and specify the same file name, the file is overwritten.
- **Setting** menu. Used to start and stop the reporting of data, and to clear and refresh data. The **Setting** menu contains the following items:
  - **Clear Buffer**. Deletes the values currently displayed in tables and charts. For example, after stopping a counter, you can use this operation to remove the remaining data from a table.
  - **Reset to Zero**. Resets cumulative counters of the selected performance group back to zero.
  - **View Data As**. Specifies how counter values are displayed. You can choose whether to display absolute values, changes in values, or rates of change. How data is displayed differs slightly depending on where you are viewing data. The choices follow:
    - **Raw Value**. Displays the absolute value. If the counter represents load data, such as the average number of connections in a database pool, then the Tivoli Performance Viewer displays the current value followed by the average. For example, 18 (avg:5).
    - **Change in Value**. Displays the change in the current value from the previous value.
    - **Rate of Change**. Displays the ratio *change*/(*T1* - *T2*), where *change* is the change in the current value from the previous value, *T1* is the time when the current value was retrieved and *T2* is the time when the previous value was retrieved.
  - **Log Replay**. Includes **Rewind Stop Play Fast Forward**.

  Note that right-clicking a resource in the Resource Selection panel displays a menu that provides the following options: **Refresh**, **Clear Buffer**, and **Reset to Zero**.
- **Help** menu. Provides information for users.

Toolbar icons

Toolbar icons provide shortcuts to frequently used commands. The toolbar includes the following icons:
- **Refresh**. Updates data and structures for the selected resources. That is, it polls the administrative server to retrieve new information about additional counters to display or new servers recently added to the domain.
- **Clear Buffer**. Deletes the values currently displayed in all tables and charts.
- **Reset to Zero**. Resets the counters.

Node icons

In the Resource Selection panel, the color of the node icon indicates the current state and availability of the application server in the domain.
- Green--The resource is running and available.
- Red--The resource is stopped.

Status bar

The status bar across the bottom of the performance viewer window dynamically displays the current state of the reporting values. The following state information is reported in the status bar:
- The current setting for the refresh rate
- The buffer size in use in the current Viewing Counter panel
- The display mode in use in the current Viewing Counter panel
- The current state of the logging setting

Related tasks

"Storing data to a log file" on page 28

"Changing the refresh rate of data retrieval" on page 26

"Changing the display buffer size" on page 26

"Viewing and modifying performance chart data" on page 26

"Scaling the performance data chart display" on page 26

"Viewing summary reports" on page 25

Related reference

"Performance data organization" on page 2

Starting the Tivoli Performance Viewer

You can also start the Tivoli Performance Viewer with security enabled. To do this see Running your monitoring applications with security enabled.

1. Start the Tivoli Performance Viewer. This can be done in two ways:
   a. Start performance monitoring from the command line. Go to the `product_installation_directory/bin` directory and run the `tperfviewer` script.

      You can specify the host and port in Windows NT, 2000, and XP environments as:

      ```
      tperfviewer.bat host_name port_number connector_type
      ```

      or

      On the AIX and other UNIX platforms, use

      ```
      tperfviewer.sh host_name port_number connector_type
      ```

      for example:

      ```
      tperfviewer.bat localhost 8879 SOAP
      ```

      Connector_type can be either SOAP or RMI. The port numbers for SOAP/RMI connector can be configured in the Administrative Console under **Servers** > **Application Servers** > **server_name** > **End Points**.

      If you are connecting to WebSphere Application Server, use the application server host and connector port. If additional servers have been created, then use the appropriate server port for which data is required. Tivoli Performance Viewer will only display data from one server at a time when connecting to WebSphere Application Server.

      If you are connecting to WebSphere Application Server Network Deployment, use the deployment manager host and connector port. Tivoli Performance Viewer will display data from all the servers in the cell. Tivoli Performance Viewer cannot connect to an individual server in WebSphere Application Server Network Deployment.

      8879 is the default SOAP connector port for WebSphere Application Server Network Deployment.

      8880 is the default SOAP connector port for WebSphere Application Server.

      9809 is the default RMI connector port for WebSphere Application Server Network Deployment.

      2809 is the default RMI connector port for WebSphere Application Server.

      On iSeries, you can connect the Tivoli Performance Viewer to an iSeries instance from either a Windows, an AIX, or a UNIX client as described above. To discover the RMI or SOAP port for the iSeries instance, start Qshell and enter the following command:

      ```
      product_installation_directory/bin/dspwasinst -instance myInstance
      ```

      where
      - *product_installation_directory* is your iSeries install directory
      - *myInstance* is the instance used when you created iSeries instance.

   b. Click **Start** > **Programs** > **IBM WebSphere** > **Application Server v.50** > **Tivoli Performance Viewer**.

      Tivoli Performance Viewer detects which package of WebSphere Application Server you are using and connects using the default SOAP connector port. If the connection fails, a dialog is displayed to provide new connection parameters.

      You can connect to a remote host or a different port number, by using the command line to start the performance viewer.

2. Adjust the data collection settings. Refer to the instructions in the topicSetting performance monitoring levels.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

"Running your monitoring applications with security enabled" on page 57

"Performance monitoring service settings" on page 15

Setting performance monitoring levels

The monitoring settings determine which counters are enabled. Changes made to the settings from Tivoli Performance Viewer affect all applications that use the Performance Monitoring Infrastructure (PMI) data.

To view monitoring settings:

1. Choose the **Data Collection** icon on the Resource Selection panel. This selection provides two options on the Counter Selection panel. Choose the **Current Activity** option to view and change monitoring settings. Alternatively, use **File**> **Current Activity** to view the monitoring settings.
2. Set monitoring levels by choosing one of the following options:
   - **None**: Provides no data collection
   - **Standard**: Enables data collection for all modules with monitoring level set to high
   - **Custom**: Allows customized settings for each module

   These options apply to an entire application server.
3. (Optional) Fine tune the monitoring level settings.
   a. Click **Specify**. This sets the monitoring level to custom.
   b. Select a monitoring level. For each resource, choose a monitoring level of **None**, **Low**, **Medium**, **High** or **Maximum**. The dial icon will change to represent this level. **Note:** The instrumentation level is set recursively to all elements below the selected resource. You can override this by setting the levels for children AFTER setting their parents.
4. Click **OK**.
5. Click **Apply**.

If the instrumentation level excludes a counter, that counter does not appear in the tables and charts of the performance viewer. For example, when the instrumentation level is set to low, the thread pool size is not displayed because that counter requires a level of high.

Note that monitoring levels can also be set through the administrative console. See Enabling data collection through the administrative console for more information.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Viewing summary reports

Summary reports are available for each application server. Before viewing reports, make sure data counters are enabled and monitoring levels are set properly. See Setting performance monitoring levels.

The standard monitoring level will enable all reports except the report on EJB methods. To enable EJB methods report, use the custom monitoring setting and set the monitoring level to Max for the Enterprise Beans module.

To view the summary reports:

1. Click the application server icon in the navigation tree.
2. Click the appropriate column header to sort the columns in the report.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Changing the refresh rate of data retrieval

By default, the Tivoli Performance Viewer retrieves data every 10 seconds.

To change the rate at which data is retrieved:

1. Click **Setting** > **Set Refresh Rate**.
2. Type a positive integer representing the number of seconds in the **Set Refresh Rate** dialog box.
3. Click **OK**.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Changing the display buffer size

To change the size of the buffer and the number of rows displayed:

1. Click **Setting** > **Set Buffer Size**.
2. Type the number of rows to display in the **Set Buffer Size** dialog box.
3. Click **OK**.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Viewing and modifying performance chart data

The **View Chart** tab displays a graph with time as the *x-axis* and the performance value as the *y-axis*.

1. Click a resource in the Resource Selection panel. The Resource Selection panel, located on the left side, provides a hierarchical (tree) view of resources and the types of performance data available for those resources. Use this panel to select which resources to monitor and to start and stop data retrieval for those resources. See Tivoli Performance Viewer features for information on the Resource Selection panel.
2. Click the **View Chart** tab in the Data Monitoring panel. The Data Monitoring panel, located on the right side, enables the selection of multiple counters and displays the resulting performance data for the currently selected resource. It contains two panels: the Viewing Counter panel above and the Counter Selection panel below. If necessary, you can set the scaling factors by typing directly in the scale field. See Scaling the performance data chart display for more information.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Scaling the performance data chart display

You can manually adjust the scale for each counter so that the graph allows meaningful comparisons of different counters. Follow these steps to manually adjust the scale:

1. Double-click the **Scale** column for the counter that you want to modify.
2. Type the desired value in the field for the **Scale** value.

The **View Chart** display immediately reflects the change in the scaling factor.

The possible values for the **Scale** field range from 0 to 100 and show the following relationships:
- A value equal to 1 indicates that the value is the actual value.
- A value greater than 1 indicates that the variable value is amplified by the factor shown. For example, a scale setting of 1.5 means that the variable is graphed as one and one-half times its actual value.
- A value less than 1 indicates that the variable value is decreased by the factor shown. For example, a scale setting of .5 means that the variable is graphed as one-half its actual value.

Scaling only applies to the graphed values.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Refreshing data

The refresh operation is a local, not global, operation that applies only to selected resources. The refresh operation is recursive; all subordinate or children resources refresh when a selected resource refreshes. To refresh data:

1. Click one or more resources in the Resource Selection panel.
2. Click **File** > **Refresh**. Alternatively, click the **Refresh** icon or right-click the resource and select **Refresh**. Clicking refresh with server selected under the viewer icon causes TPV to query the server for new PMI and product configuration information. Clicking refresh with server selected under the advisor icon causes TPV to refresh the advice provided, but will not refresh PMI or product configuration information.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Performance data refresh behavior: New performance data can become available in either of the following situations:
- An administrator uses the console to change the instrumentation level for a resource (for example, from medium to high).
- An administrator uses the console to add a new resource (for example, an enterprise bean or a servlet) to the run time.

In both cases, if the resource in question is already polled by the Tivoli Performance Viewer or the parent of the resource is being polled, the system is automatically refreshed. If more counters are added for a group that the performance viewer is already polling, the performance viewer automatically adds the counters to the table or chart views. If the parent of the newly added resource is polled, the new resource is detected automatically and added to the Resource Selection tree. You can refresh the Resource Selection tree, or parts of it, by selecting the appropriate node and clicking the **Refresh** icon, or by right-clicking a resource and choosing **Refresh**.

When an application server runs, the performance viewer tree automatically updates the server local structure, including its containers and enterprise beans, to reflect changes on the server. However, if a stopped server starts *after* the performance viewer starts, a manual refresh operation is required so that the server structure accurately reflects in the Resource Selection tree.

Clicking refresh with server selected under the viewer icon causes TPV to query the server for new PMI and product configuration information. Clicking refresh with server selected under the advisor icon causes TPV to refresh the advice provided, but will not refresh PMI or product configuration information.

Related tasks

"Refreshing data"

Using the Performance Advisor in Tivoli Performance Viewer

Clearing values from tables and charts

Selecting **Clear Values** removes remaining data from a table or chart. You can then begin populating the table or chart with new data.

To clear the values currently displayed:

1. Click one or more resources in the Resource Selection panel.
2. Click **Setting** > **Clear Buffer**. Alternatively, right-click the resource and select **Clear Buffer**

   Related tasks

   "Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Storing data to a log file

You can save all data reported by the Tivoli Performance Viewer in a log file and write the data in binary format (serialized Java objects) or XML format.

To start recording data:

1. Click **Logging** > **On** or click the **Logging** icon.
2. Specify the name, location, and format type of the log file in the **Save** dialog box. The **Files of type** field allows an extension of `*.perf` for binary files or `*.xml` for XML format.

   Note: The `*.perf` files may not be compatible between fix levels.
3. Click **OK**.

To stop logging, click **Logging** > **Off** or click the **Logging** icon.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Performance data log file: An example of the performance data log file format is below.

Location

By default, this file is written to:

product_installation_root`/logs/ra_mmdd_hhmm.xml`

where mmdd=month and date, and hhmm=hour and minute

Usage Notes

This read-write data file is created by Tivoli Performance Viewer and provides data collected by the performance viewer. The log file is not updated, but remains available for you to replay the collected data. The performance data log file does not have an effect on the WebSphere environment.

Example

```
<?xml version="1.0"?>
<RALog version="5.0">
<RAGroupSnapshot time="1019743202343" numberGroups="1">
  <CpdCollection name="root/peace/Default Server/jvmRuntimeModule" level="7">
   <CpdData name="root/peace/Default
            Server/jvmRuntimeModule/jvmRuntimeModule.total/Memory" id="1">
    <CpdLong value="39385600" time="1.019743203334E12"/>
   </CpdData>
   <CpdData name="root/peace/Default
         Server/jvmRuntimeModule/jvmRuntimeModule.freeMemory" id="2">
    <CpdLong value="4815656" time="1.019743203334E12"/>
   </CpdData>
   <CpdData name="root/peace/Default
        Server/jvmRuntimeModule/jvmRuntimeModule.usedMemory" id="3">
    <CpdLong value="34569944" time="1.019743203334E12"/>
   </CpdData>
  </CpdCollection>
 </RAGroupSnapshot>
</RALog>
```

Related tasks

"Storing data to a log file" on page 28

Replaying a performance data log file

You can replay both binary and XML logs by using the Tivoli Performance Viewer.

To replay a log file, do the following:

1. Click **Data Collection** in the navigation tree.
2. Click the **Log** radio button in the **Performance data from** field.
3. Click **Browse** to locate the file that you want to replay or type the file path name in the **Log** field.
4. Click **Apply**.
5. Play the log by using the **Play** icon or click **Setting** > **Log Replay** > **Play**.

By default, the data replays at the same rate it was collected or written to the log. You can choose **Fast Forward** mode in which the log replays without simulating the refresh interval. To **Fast Forward**, use the button in the tool bar or click **Setting** > **Log Replay** > **FF**.

To rewind a log file, click **Setting** > **Log Replay** > **Rewind** or use the **Rewind** icon in the toolbar.

While replaying the log, you can choose different groups to view by selecting them in the Resource Selection pane. You can also view the data in either of the views available in the tabbed Data Monitoring panel.

You can stop and resume the log at any point. However, you cannot replay data in reverse.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

Resetting counters to zero

Some counters report relative values based on how much the value has changed since the counter was enabled. The **Reset to Zero** operation resets those counters so that they will report changes in values since the reset operation. This operation will also clear the buffer for the selected resources. See ″Clearing values from tables and charts″ in Related Links for more information about clearing the buffer for selected resources. Counters based on absolute values can not be reset and will not be affected by the **Reset to Zero** operation.

To reset the start time for calculating relative counters:

1. Click one or more resources in the Resource Selection panel.
2. Click **Setting** > **Reset to Zero**. Alternatively, right-click the resource and click **Reset to Zero**.

Related tasks

"Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)" on page 20

"Clearing values from tables and charts" on page 28

Developing your own monitoring applications

You can use the Performance Monitoring Infrastructure (PMI) interfaces to develop your own applications to collect and display performance information.

There are three such interfaces - a Java Machine Extension (JMX)-based interface, a PMI client interface, and a servlet interface. All three interfaces return the same underlying data. The JMX interface is accessible through the AdminClient tool. The PMI client interface is a Java interface. The servlet interface is perhaps the simplest, requiring minimal programming, as the output is XML.

1. Developing your own monitoring application using Performance Monitoring Infrastructure client .
2. Developing your own monitoring applications with PMI servlet
3. Compiling your monitoring applications
4. Running your new monitoring applications
5. Accessing Performance Monitoring Infrastructure data through the Java Management Extension interface.
6. Developing Performance Monitoring Infrastructure interfaces (Version 4.0).

Performance Monitoring Infrastructure client interface

The data provided by the Performance Monitoring Infrastructure (PMI) client interface is documented here. Access to the data is provided in a hierarchical structure. Descending from the object are node information objects, module information objects, CpdCollection objects and CpdData objects. Using Version 5.0, you will get Stats and Statistic objects. The node and server information objects contain no performance data, only static information.

Each time a client retrieves performance data from a server, the data is returned in a subset of this structure; the form of the subset depends on the data retrieved. You can update the entire structure with new data, or update only part of the tree, as needed.

The JMX statistic data model is supported, as well as the existing CPD data model from Version 4.0. When you retrieve performance data using the Version 5.0 PMI client API, you get the Stats object, which includes Statistic objects and optional sub-Stats objects. When you use the Version 4.0 PMI client API to collect performance data, you get the CpdCollection object, which includes the CpdData objects and optional sub-CpdCollection objects.

The following are additional Performance Monitoring Infrastructure (PMI) interfaces:

- BoundaryStatistic
- BoundedRangeStatistic
- CountStatistic
- MBeanStatDescriptor
- MBeanLevelSpec
- New Methods in PmiClient
- RangeStatistic
- Stats
- Statistic
- TimeStatistic

The following PMI interfaces introduced in Version 4.0 are also supported:

- CpdCollection
- CpdData
- CpdEventListener and CpdEvent
- CpdFamily class
- CpdValue
  - CpdLong
  - CpdStat

  - CpdLoad
- PerfDescriptor
- PmiClient class

The CpdLong maps to CountStatistic; CpdStat maps to Time Statistic; CpdCollection maps to Stats; and CpdLoad maps to RangeStatistic and BoundedRangeStatistic.

Note: Version 4.0 PmiClient APIs are supported in this version, however, there are some changes. The data hierarchy is changed in some PMI modules, notably the enterprise bean module and HTTP sessions module. If you have an existing PmiClient application, and you want to run it against Version 5.0, you might have to update the PerfDescriptor(s) based on the new PMI data hierarchy. Also, the getDataName and getDataId methods in PmiClient are changed to be non-static methods in order to support multiple WebSphere Application Server versions. You might have to update your existing application which uses these two methods.

Related tasks

"Developing your own monitoring application using Performance Monitoring Infrastructure client"

Developing your own monitoring application using Performance Monitoring Infrastructure client

The following is the programming model for Performance Monitoring Infrastructure (PMI) client:

1. Create an instance of PmiClient. This is used for all subsequent method calls.
2. Call the listNodes() and listServers(nodeName) methods to find all the nodes and servers in the WebSphere Application Server domain.
3. Call listMBeans and listStatMembers to get all the available MBeans and MBeanStatDescriptors.
4. Call the getStats method to get the Stats object for the PMI data.
5. (Optional) The client can also call setStatLevel or getStatLevel to set and get the monitoring level. Use the MBeanLevelSpec objects to set monitoring levels.

Related reference

"Performance Monitoring Infrastructure client package" on page 56

"Performance Monitoring Infrastructure client interface" on page 30

Performance Monitoring Infrastructure client:

A Performance Monitoring Infrastructure (PMI) client is an application that receives PMI data from servers and processes this data.

In Version 4.0, PmiClient API takes PerfDescriptor(s) and returns PMI data as a CpdCollection object. Each CpdCollection could contain a list of CpdData, which has a CpdValue of the following types:
- CpdLong
- CpdStat
- CpdLoad

Version 4.0 PmiClient APIs are supported in this version, however, there are some changes. The data hierarchy is changed in some PMI modules, notably the enterprise bean module and HTTP sessions module. If you have an existing PmiClient application, and you want to run it against Version 5.0, you might have to update the PerfDescriptor(s) based on the new PMI data hierarchy. Also, the getDataName and getDataId methods in PmiClient are changed to be non-static methods in order to support multiple WebSphere Application Server versions. You might have to update your existing application which uses these two methods.

Related tasks

"Developing your own monitoring application using Performance Monitoring Infrastructure client"

Example: Performance Monitoring Infrastructure client with new data structure:

The following is example code using Performance Monitoring Infrastructure (PMI) client data structure:

```
import com.ibm.websphere.pmi.*;
import com.ibm.websphere.pmi.stat.*;
import com.ibm.websphere.pmi.client.*;
import com.ibm.websphere.management.*;
import com.ibm.websphere.management.exception.*;
import java.util.*;
import javax.management.*;
import java.io.*;

/**
 * Sample code to use PmiClient API (new JMX-based API) and
get Statistic/Stats objects.
 */

public class PmiClientTest implements PmiConstants {

    static PmiClient pmiClnt = null;
    static String nodeName = null;
    static String serverName = null;
    static String portNumber = null;
    static String connectorType = null;
    static boolean success = true;


    /**
     * @param args[0] host
     * @param args[1] portNumber, optional, default is 2809
     * @param args[2] connectorType, optional, default is RMI connector
     * @param args[3]serverName, optional, default is the first server found
     */
    public static void main(String[] args) {

        try {

            if(args.length > 1) {
                System.out.println("Parameters: host [portNumber]
[connectorType] [serverName]");
                return;
            }

            // parse arguments and create an instance of PmiClient
            nodeName = args[0];

            if (args.length > 1)
            portNumber = args[1];

            if (args.length > 2)
            connectorType = args[2];

            // create an PmiClient object
            pmiClnt = new PmiClient(nodeName, portNumber, "WAS50", false, connectorType);

            // Uncomment it if you want to debug any problem
            //pmiClnt.setDebug(true);

            // update nodeName to be the real host name
            // get all the node PerfDescriptor in the domain
               PerfDescriptor[] nodePds = pmiClnt.listNodes();
               if(nodePds == null) {
               System.out.println("no nodes");
               return;
                                     }
           // get the first node
```

```
  nodeName = nodePds[0].getName();
System.out.println("use node " + nodeName);

if (args.length == 4)
    serverName = args[3];
else { // find the server you want to get PMI data
    // get all servers on this node
    PerfDescriptor[] allservers = pmiClnt.listServers(nodeName);
    if (allservers == null || allservers.length == 0) {
        System.out.println("No server is found on node " + nodeName);
        System.exit(1);
    }

    // get the first server on the list. You may want to get a different server
    serverName = allservers[0].getName();
    System.out.println("Choose server " + serverName);
}

// get all MBeans
ObjectName[] onames = pmiClnt.listMBeans(nodeName, serverName);

// Cache the MBeans we are interested
ObjectName perfOName = null;
ObjectName serverOName = null;
ObjectName wlmOName = null;
ObjectName ejbOName = null;
ObjectName jvmOName = null;
ArrayList myObjectNames = new ArrayList(10);

// get the MBeans we are interested in
if(onames != null) {
    System.out.println("Number of MBeans retrieved= " + onames.length);
    AttributeList al;
    ObjectName on;
    for(int i=0; i<onames.length; i++) {
        on = onames[i];
        String type = on.getKeyProperty("type");

        // make sure PerfMBean is there.
        // Then randomly pick up some MBeans for the test purpose
        if(type != null && type.equals("Server"))
            serverOName = on;
        else if(type != null && type.equals("Perf"))
            perfOName = on;
        else if(type != null && type.equals("WLM")) {
            wlmOName = on;
        }
        else if(type != null && type.equals("EntityBean")) {
            ejbOName = on;

            // add all the EntityBeans to myObjectNames
            myObjectNames.add(ejbOName);  // add to the list
        }
        else if(type != null && type.equals("JVM")) {
            jvmOName = on;
        }
    }

    // set monitoring level for SERVER MBean
    testSetLevel(serverOName);

    // get Stats objects
    testGetStats(myObjectNames);

    // if you know the ObjectName(s)
    testGetStats2(new ObjectName[]{jvmOName, ejbOName});
```

```
            // assume you are only interested in a server data in WLM MBean,
            // then you will need to use StatDescriptor and MBeanStatDescriptor
            // Note that wlmModule is only available in ND version
            StatDescriptor sd = new StatDescriptor(new String[] {"wlmModule.server"});
            MBeanStatDescriptor msd = new MBeanStatDescriptor(wlmOName, sd);
            Stats wlmStat = pmiClnt.getStats(nodeName, serverName, msd, false);
            if (wlmStat != null)
                System.out.println("\n\n WLM server data\n\n + " + wlmStat.toString());
            else
                System.out.println("\n\n No WLM server data is availalbe.");

            // how to find all the MBeanStatDescriptors
            testListStatMembers(serverOName);

            // how to use update method
            testUpdate(jvmOName, false, true);
        }
        else {
            System.out.println("No ObjectNames returned from Query" );
        }

    }
    catch(Exception e) {
        new AdminException(e).printStackTrace();
        System.out.println("Exception = " +e);
        e.printStackTrace();
        success = false;
    }


    if(success)
        System.out.println("\n\n All tests are passed");
    else
        System.out.println("\n\n Some tests are failed. Check for the exceptions");

}

/**
 * construct an array from the ArrayList
 */
private static MBeanStatDescriptor[] getMBeanStatDescriptor(ArrayList msds) {
    if(msds == null || msds.size() == 0)
        return null;

    MBeanStatDescriptor[] ret = new MBeanStatDescriptor[msds.size()];
    for(int i=0; i<ret.length; i++)
        if(msds.get(i) instanceof ObjectName)
            ret[i] = new MBeanStatDescriptor((ObjectName)msds.get(i));
        else
            ret[i] = (MBeanStatDescriptor)msds.get(i);
    return ret;
}

/**
 * Sample code to navigate and display the data value from the Stats object.
 */
private static void processStats(Stats stat) {
    processStats(stat, "");
}

/**
 * Sample code to navigate and display the data value from the Stats object.
 */
private static void processStats(Stats stat, String indent) {
    if(stat == null)  return;

    System.out.println("\n\n");
```

```
        // get name of the Stats
        String name = stat.getName();
        System.out.println(indent + "stats name=" + name);

        // Uncomment the following lines to list all the data names
        /*
        String[] dataNames = stat.getStatisticNames();
        for (int i=0; i<dataNames.length; i++)
            System.out.println(indent + "    " + "data name=" + dataNames[i]);
        System.out.println("\n");
        */

        // list all datas
        com.ibm.websphere.management.statistics.Statistic[] allData = stat.getStatistics();

        // cast it to be PMI's Statistic type so that we can have get more
        Statistic[] dataMembers = (Statistic[])allData;
        if(dataMembers != null) {
            for(int i=0; i<dataMembers.length; i++)  {
                System.out.print(indent + "    " + "data name="
+ PmiClient.getNLSValue(dataMembers[i].getName())
                                 + ", description="
+ PmiClient.getNLSValue(dataMembers[i].getDescription())
                                 + ", unit=" + PmiClient.getNLSValue(dataMembers[i].getUnit())
                                 + ", startTime=" + dataMembers[i].getStartTime()
                                 + ", lastSampleTime=" + dataMembers[i].getLastSampleTime());
                if(dataMembers[i].getDataInfo().getType() == TYPE_LONG) {
                    System.out.println(", count="
+ ((CountStatisticImpl)dataMembers[i]).getCount());
                }
                else if(dataMembers[i].getDataInfo().getType() == TYPE_STAT) {
                    TimeStatisticImpl data = (TimeStatisticImpl)dataMembers[i];
                    System.out.println(", count=" + data.getCount()
                                       + ", total=" + data.getTotal()
                                       + ", mean=" + data.getMean()
                                       + ", min=" + data.getMin()
                                       + ", max=" + data.getMax());
                }
                else if(dataMembers[i].getDataInfo().getType() == TYPE_LOAD) {
                    RangeStatisticImpl data = (RangeStatisticImpl)dataMembers[i];
                    System.out.println(", current=" + data.getCurrent()
                                       + ", lowWaterMark=" + data.getLowWaterMark()
                                       + ", highWaterMark=" + data.getHighWaterMark()
                                       + ", integral=" + data.getIntegral()
                                       + ", avg=" + data.getMean());
                }
            }
        }

        // recursively for sub-stats
        Stats[] substats = (Stats[])stat.getSubStats();
        if(substats == null || substats.length == 0)
            return;
        for(int i=0; i<substats.length; i++) {
            processStats(substats[i], indent + "    ");
        }
    }

    /**
     * test set level and verify using get level
     */
    private static void testSetLevel(ObjectName mbean) {
        System.out.println("\n\n testSetLevel\n\n");
        try {
            // set instrumentation level to be high for the mbean
            MBeanLevelSpec spec = new MBeanLevelSpec(mbean, null, PmiConstants.LEVEL_HIGH);
            pmiClnt.setStatLevel(nodeName, serverName, spec, true);
            System.out.println("after setInstrumentaionLevel high on server MBean\n\n");

            // get all instrumentation levels
            MBeanLevelSpec[] mlss = pmiClnt.getStatLevel(nodeName, serverName, mbean, true);

            if(mlss == null)
                System.out.println("error: null from getInstrumentationLevel");
            else {
                for(int i=0; i<mlss.length; i++)
                    if(mlss[i] != null) {
                        // get the ObjectName, StatDescriptor,
and level out of MBeanStatDescriptor
                        int mylevel = mlss[i].getLevel();
                        ObjectName myMBean = mlss[i].getObjectName();
                        StatDescriptor mysd = mlss[i].getStatDescriptor();  // may be null
                        // Uncomment it to print all the mlss
                        //System.out.println("mlss " + i + ":, " + mlss[i].toString());
                    }
            }
        }
        catch(Exception ex) {
            new AdminException(ex).printStackTrace();
            ex.printStackTrace();
            System.out.println("Exception in testLevel");
            success = false;
        }
    }

    /**
     * Use listStatMembers method
     */
    private static void testListStatMembers(ObjectName mbean) {

        System.out.println("\n\ntestListStatMembers \n");
        // listStatMembers and getStats
        // From server MBean until the bottom layer.
        try {
            MBeanStatDescriptor[] msds = pmiClnt.listStatMembers(nodeName, serverName, mbean);
            if(msds == null) return;
            System.out.println(" listStatMembers for server MBean, num members
(i.e. top level modules) is " + msds.length);


            for(int i=0; i<msds.length; i++) {
                if(msds[i] == null)  continue;

                // get the fields out of MBeanStatDescriptor if you need them
                ObjectName myMBean = msds[i].getObjectName();
                StatDescriptor mysd = msds[i].getStatDescriptor();      // may be null

                // uncomment if you want to print them out
                //System.out.println(msds[i].toString());
            }

            for(int i=0; i<msds.length; i++) {
                if(msds[i] == null)  continue;
                System.out.println("\n\nlistStatMembers for msd=" + msds[i].toString());
                MBeanStatDescriptor[] msds2 =
pmiClnt.listStatMembers(nodeName, serverName, msds[i]);

                // you get msds2 at the second layer now and the
listStatMembers can be called recursively
                // until it returns now.
            }

        }
        catch(Exception ex) {
            new AdminException(ex).printStackTrace();
            ex.printStackTrace();
            System.out.println("Exception in testListStatMembers");
            success = false;
        }

    }

    /**
     * Test getStats method
     */
    private static void testGetStats(ArrayList mbeans) {
        System.out.println("\n\n testgetStats\n\n");
        try {
            Stats[] mystats = pmiClnt.getStats(nodeName,
serverName, getMBeanStatDescriptor(mbeans), true);

            // navigate each of the Stats object and get/display the value
            for(int k=0; k<mystats.length; k++) {
                processStats(mystats[k]);
            }

        }
        catch(Exception ex) {
            new AdminException(ex).printStackTrace();
            ex.printStackTrace();
            System.out.println("exception from testGetStats");
            success = false;
        }
    }

    /**
     * Test getStats method
     */
    private static void testGetStats2(ObjectName[] mbeans) {
        System.out.println("\n\n testGetStats2\n\n");
        try {
            Stats[] statsArray = pmiClnt.getStats(nodeName, serverName, mbeans, true);

            // You can call toString to simply display all the data
            if(statsArray != null) {
                for(int k=0; k<statsArray.length; k++)
                    System.out.println(statsArray[k].toString());
            }
            else
                System.out.println("null stat");
        }
        catch(Exception ex) {
            new AdminException(ex).printStackTrace();
            ex.printStackTrace();
            System.out.println("exception from testGetStats2");
            success = false;
        }
    }

    /**
     * test update method
     */
    private static void testUpdate(ObjectName oName, boolean keepOld,
boolean recursiveUpdate) {
        System.out.println("\n\n testUpdate\n\n");
        try {
            // set level to be NONE
            MBeanLevelSpec spec = new MBeanLevelSpec(oName, null, PmiConstants.LEVEL_NONE);
            pmiClnt.setStatLevel(nodeName, serverName, spec, true);
            // get data now - one is non-recursive and the other is recursive
            Stats stats1 = pmiClnt.getStats(nodeName, serverName, oName, false);
            Stats stats2 = pmiClnt.getStats(nodeName, serverName, oName, true);

            // set level to be HIGH
            spec = new MBeanLevelSpec(oName, null, PmiConstants.LEVEL_HIGH);
            pmiClnt.setStatLevel(nodeName, serverName, spec, true);

            Stats stats3 = pmiClnt.getStats(nodeName, serverName, oName, true);
            System.out.println("\n\n stats3 is");
            processStats(stats3);

            stats1.update(stats3, keepOld, recursiveUpdate);
            System.out.println("\n\n update stats1");
            processStats(stats1);

            stats2.update(stats3, keepOld, recursiveUpdate);
            System.out.println("\n\n update stats2");
            processStats(stats2);

        }
        catch(Exception ex) {
            System.out.println("\n\n Exception in testUpdate");
            ex.printStackTrace();
            success = false;
        }

    }


}
```

Related tasks

"Developing your own monitoring application using Performance Monitoring Infrastructure client" on page 31

Developing your own monitoring applications with Performance Monitoring Infrastructure servlet

The performance servlet uses the Performance Monitor Interface (PMI) infrastructure to retrieve the performance information from WebSphere Application Server.

The performance servlet `.ear` file `perfServletApp.ear` is located in the *`install_root`* directory.

The performance servlet is deployed exactly as any other servlet. To use it, follow these steps:

1. Deploy the servlet on a single application server instance within the domain.
2. After the servlet deploys, you can invoke it to retrieve performance data for the entire domain. Invoke the performance servlet by accessing the following default URL:

   `http://`*`hostname/wasPerfTool/servlet/perfservlet`*

The performance servlet provides performance data output as an XML document, as described by the provided document type definition (DTD). The output structure provided is called `leaves`. The paths that lead to the leaves provide the context of the data. See the topic ″Performance Monitoring Infrastructure (PMI) servlet″ for more information about the PMI servlet output.

Performance Monitoring Infrastructure servlet:

The Performance Monitoring Infrastructure (PMI) servlet is used for simple end-to-end retrieval of performance data that any tool, provided by either IBM or a third-party vendor, can handle.

The PMI servlet provides a way to use an HTTP request to query the performance metrics for an entire WebSphere Application Server administrative domain. Because the servlet provides the performance data through HTTP, issues such as firewalls are trivial to resolve.

The performance servlet provides the performance data output as an XML document, as described in the provided document type description (DTD). In the XML structure, the `leaves` of the structure provide the actual observations of performance data and the paths to the leaves that provide the context. There are three types of leaves or output formats within the XML structure:
- PerfNumericInfo
- PerfStatInfo
- PerfLoadInfo

PerfNumericInfo. When each invocation of the performance servlet retrieves the performance values from Performance Monitoring Infrastructure (PMI), some of the values are raw counters that record the number of times a specific event occurs during the lifetime of the server. If a performance observation is of the type PerfNumericInfo, the value represents the raw count of the number of times this event has occurred since the server started. This information is important to note because the analysis of a single document of data provided by the performance servlet might not be useful for determining the current load on the system. To determine the load during a specific interval of time, it might be necessary to apply simple statistical formulas to the data in two or more documents provided during this interval. The PerfNumericInfo type has the following attributes:
- time--Specifies the time when the observation was collected (Java System.currentTimeMillis)
- uid--Specifies the PMI identifier for the observation
- val--Specifies the raw counter value

The following document fragment represents the number of loaded servlets. The path providing the context of the observation is not shown.

```
<numLoadedServlets>
     <PerfNumericData time="988162913175" uid="pmi1"
val="132"/>
</numLoadedServlets>
```

PerfStatInfo.When each invocation of the performance servlet retrieves the performance values from PMI, some of the values are stored as statistical data. Statistical data records the number of occurrences of a specific event, as the PerfNumericInfo type does. In addition, this type has sum of squares, mean, and total for each observation. This value is relative to when the server started.

The PerfStatInfo type has the following attributes:
- time--Specifies the time the observation was collected (Java System.currentTimeMillis)
- uid--Specifies the PMI identifier for this observation
- num--Specifies the number of observations
- sum_of_squares--Specifies the sum of the squares of the observations
- total--Specifies the sum of the observations
- mean--Specifies the mean (total number) for this counter

The following fragment represents the response time of an object. The path providing the context of the observation is not shown:

```
<responseTime>
     <PerfStatInfo mean="1211.5" num="5"
sum_of_squares="3256265.0"
time="9917644193057" total="2423.0"
uid="pmi13"/>
</responseTime>
```

PerfLoadInfo. When each invocation of the performance servlet retrieves the performance values from PMI, some of the values are stored as a load. Loads record values as a function of time; they are averages. This value is relative to when the server started.

The PerfLoadInfo type has the following attributes:

- time--Specifies the time when the observation was collected (Java System.currentTimeMillis)
- uid--Specifies the PMI identifier for this observation
- currentValue--Specifies the current value for this counter
- integral--Specifies the time-weighted sum
- timeSinceCreate--Specifies the elapsed time in milliseconds since this data was created in the server
- mean--Specifies time-weighted mean (integral/timeSinceCreate) for this counter

The following fragment represents the number of concurrent requests. The path providing the context of the observation is not shown:

```
<poolSize>
     <PerfLoadInfo currentValue="1.0" integral="534899.0
" mean="0.9985028962051592"
time="991764193057" timeSinceCreate="535701.0
"uid="pmi5"</poolSize>
```

When the performance servlet is first initialized, it retrieves the list of nodes and servers located within the domain in which it is deployed. Because the collection of this data is expensive, the performance servlet holds this information as a cached list. If a new node is added to the domain or a new server is started, the performance servlet does not automatically retrieve the information about the newly created element. To force the servlet to refresh its configuration, you must add the refreshConfig parameter to the invocation as follows:

```
http://hostname/wasPerfTool/servlet/perfservlet?refreshConfig=true
```

By default, the performance servlet collects all of the performance data across a WebSphere domain. However, it is possible to limit the data returned by the servlet to either a specific node, server, or PMI module.

- **Node.**The servlet can limit the information it provides to a specific host by using the node parameter. For example, to limit the data collection to the node rjones, invoke the following URL:

  ```
  http://hostname/wasPerfTool/servlet/perfservlet?Node=rjones
  ```
- **Server.**The servlet can limit the information it provides to a specific server by using the server parameter. For example, in order to limit the data collection to the TradeApp server on all nodes, invoke the following URL:

  ```
  http://hostname/wasPerfTool/servlet/perfservlet?Server=TradeApp
  ```

  To limit the data collection to the TradeApp server located on the host rjones, invoke the following URL:

  ```
  http://hostname/wasPerfTool/servlet/perfservlet?Node=rjones&Server=TradeApp
  ```
- **Module.**The servlet can limit the information it provides to a specific PMI module by using the module parameter. You can request multiple modules from the following Web site:

  ```
  http://hostname/wasPerfTool/servlet/perfservlet?Module=beanModule+jvmRuntimeModule
  ```

  For example, to limit the data collection to the beanModule on all servers and nodes, invoke the following URL:

  ```
  http://hostname/wasPerfTool/servlet/perfservlet?Module=beanModule
  ```

  To limit the data collection to the beanModule on the server TradeApp on the node rjones, invoke the following URL:

  ```
  http://hostname/wasPerfTool/servlet/perfservlet?Node=rjones&Server=TradeApp
  &Module=beanModule>
  ```

Related tasks

"Developing your own monitoring applications with Performance Monitoring Infrastructure servlet" on page 38

Developing your own monitoring application with the Java Management Extension interface

WebSphere Application Server allows you to invoke methods on MBeans through the AdminClient Java Management Extension (JMX) interface. You can use AdminClient API to get Performance Monitoring Infrastructure (PMI) data by using either PerfMBean or individual MBeans. See information about using individual MBeans at bottom of this article.

Individual MBeans provide the Stats attribute from which you can get PMI data. The PerfMBean provides extended methods for PMI administration and more efficient ways to access PMI data. To set the PMI module instrumentation level, you must invoke methods on PerfMBean. To query PMI data from multiple MBeans, it is faster to invoke the getStatsArray method in PerfMBean than to get the Stats attribute from multiple individual MBeans. PMI can be delivered in a single JMX cell through PerfMBean, but multiple JMX calls have to be made through individual MBeans.

See the topic ″Developing an administrative client program″ for more information on AdminClient JMX.

After the performance monitoring service is enabled and the application server is started or restarted, a PerfMBean is located in each application server giving access to PMI data. To use PerfMBean:

1. Create an instance of AdminClient. When using AdminClient API, you need to first create an instance of AdminClient by passing the host name, port number and connector type.

   The example code is:

```
        AdminClient ac = null;
        java.util.Properties props = new java.util.Properties();
        props.put(AdminClient.CONNECTOR_TYPE, connector);
        props.put(AdminClient.CONNECTOR_HOST, host);
        props.put(AdminClient.CONNECTOR_PORT, port);
        try {
            ac = AdminClientFactory.createAdminClient(props);
        }
        catch(Exception ex) {
            failed = true;
            new AdminException(ex).printStackTrace();
            System.out.println("getAdminClient: exception");
        }
```

2. Use AdminClient to query the MBean ObjectNames Once you get the AdminClient instance, you can call queryNames to get a list of MBean ObjectNames depending on your query string. To get all the ObjectNames, you can use the following example code. If you have a specified query string, you will get a subset of ObjectNames.

```
  javax.management.ObjectName on = new javax.management.ObjectName("WebSphere:*");
        Set objectNameSet= ac.queryNames(on, null);
 // you can check properties like type, name, and process to find a specified ObjectName
```

   After you get all the ObjectNames, you can use the following example code to get all the node names:

```
  HashSet nodeSet = new HashSet();
        for(Iterator i = objectNameSet.iterator(); i.hasNext(); on =
(ObjectName)i.next()) {
            String type = on.getKeyProperty("type");
            if(type != null && type.equals("Server")) {
  nodeSet.add(servers[i].getKeyProperty("node"));
            }
 }
```

   Note, this will only return nodes that are started. To list running servers on the node, you can either check the node name and type for all the ObjectNames or use the following example code:

```
     StringBuffer oNameQuery= new StringBuffer(41);
        oNameQuery.append("WebSphere:*");
        oNameQuery.append(",type=").append("Server");
        oNameQuery.append(",node=").append(mynode);
        oSet= ac.queryNames(new ObjectName(oNameQuery.toString()), null);
        Iterator i = objectNameSet.iterator ();
    while (i.hasNext ()) {
    on=(objectName) i.next();
   String process= on[i].getKeyProperty("process");
   serversArrayList.add(process);
  }
```

3. Get the PerfMBean ObjectName for the application server from which you want to get PMI data. Use this example code:

```
  for(Iterator i = objectNameSet.iterator(); i.hasNext(); on = (ObjectName)i.next()) {
     // First make sure the node name and server name is what you want
     // Second, check if the type is Perf
            String type = on.getKeyProperty("type");
     String node = on.getKeyProperty("node");
     String process= on.getKeyProperty("process");
            if (type.equals("Perf") && node.equals(mynode) &
& server.equals(myserver)) {
  perfOName = on;
            }
 }
```

4. Invoke operations on PerfMBean through the AdminClient. Once you get the PerfMBean(s) in the application server from which you want to get PMI data, you can invoke the following operations on the PerfMBean through AdminClient API:

```
- setInstrumentationLevel: set the instrmentation level
            params[0] = new MBeanLevelSpec(objectName, optionalSD, level);
            params[1] = new Boolean(true);
            signature= new String[]{ "com.ibm.websphere.pmi.stat.MBeanLevelSpec",
"java.lang.Boolean"};
            ac.invoke(perfOName, "setInstrumentationLevel", params, signature);

- getInstrumentationLevel: get the instrumentation level
            Object[] params = new Object[2];
            params[0] = new MBeanStatDescriptor(objectName, optionalSD);
            params[1] = new Boolean(recursive);
            String[] signature= new String[]{
"com.ibm.websphere.pmi.stat.MBeanStatDescriptor", "java.lang.Boolean"};
            MBeanLevelSpec[] mlss = (MBeanLevelSpec[])ac.invoke(perfOName,
"getInstrumentationLevel", params, signature);

- getConfigs: get PMI static config info for all the MBeans
            configs = (PmiModuleConfig[])ac.invoke(perfOName, "getConfigs", null, null);

- getConfig: get PMI static config info for a specific MBean
     ObjectName[] params = {objectName};
     String[] signature= { "javax.management.ObjectName" };
            config = (PmiModuleConfig)ac.invoke(perfOName, "getConfig", params,
signature);

- getStatsObject: you can use either ObjectName or MBeanStatDescriptor
            Object[] params    = new Object[2];
            params[0] = objectName;  // either ObjectName or or MBeanStatDescriptor
            params[1] = new Boolean(recursive);
            String[] signature = new String[] { "javax.management.ObjectName",
"java.lang.Boolean"};
            Stats stats  = (Stats)ac.invoke(perfOName, "getStatsObject", params,
signature);

  Note: The returned data only have dynamic information (value and time stamp).
See PmiJmxTest.java for additional code to link the configuration information with the
returned data.

- getStatsArray: you can use either ObjectName or MBeanStatDescriptor
            ObjectName[] onames = new ObjectName[]{objectName1, objectName2};
            Object[] params = new Object[]{onames, new Boolean(true)};
            String[] signature = new String[]{"[Ljavax.management.ObjectName;",
"java.lang.Boolean"};
            Stats[] statsArray = (Stats[])ac.invoke(perfOName, "getStatsArray",
params, signature);

  Note: The returned data only have dynamic information (value and time stamp).
See PmiJmxTest.java for additional code to link the configuration information with the
returned data.

- listStatMembers: navigate the PMI module trees

            Object[] params = new Object[]{mName};
            String[] signature= new String[]{"javax.management.ObjectName"};
            MBeanStatDescriptor[] msds = (MBeanStatDescriptor[])ac.invoke(perfOName,
"listStatMembers", params, signature);

or,

            Object[] params = new Object[]{mbeanSD};
            String[] signature= new String[]
{"com.ibm.websphere.pmi.stat.MBeanStatDescriptor"};
            MBeanStatDescriptor[] msds = (MBeanStatDescriptor[])ac.invoke
(perfOName, "listStatMembers", params, signature);
```

- **To use an individual MBean:** You need to get the AdminClient instance and the ObjectName for the individual MBean. Then you can simply get the Stats attribute on the MBean.

Related tasks

Developing an administrative client program

Example: Administering Java Management Extension-based interface:

The following is example code directly using Java Management Extension (JMX) API. For information on compiling your source code, see ″Compiling your monitoring applications.″

```
package com.ibm.websphere.pmi;

import com.ibm.websphere.management.AdminClient;
import com.ibm.websphere.management.AdminClientFactory;
import com.ibm.websphere.management.exception.ConnectorException;
import com.ibm.websphere.management.exception.InvalidAdminClientTypeException;
import com.ibm.websphere.management.exception.*;

import java.util.*;
import javax.management.*;
import com.ibm.websphere.pmi.*;
import com.ibm.websphere.pmi.client.*;
import com.ibm.websphere.pmi.stat.*;

/**
 * Sample code to use AdminClient API directly to get PMI data from PerfMBean
 * and individual MBeans which support getStats method.
 */

public class PmiJmxTest implements PmiConstants
{
    private AdminClient    ac = null;
    private ObjectName     perfOName   = null;
    private ObjectName     serverOName = null;
    private ObjectName     wlmOName    = null;
    private ObjectName     jvmOName    = null;
    private ObjectName     orbtpOName    = null;
    private boolean failed = false;
    private PmiModuleConfig[] configs = null;

    /**
     *  Creates a new test object
     *  (Need a default constructor for the testing framework)
     */
    public PmiJmxTest()
    {
    }

    /**
     * @param args[0] host
     * @param args[1] port, optional, default is 8880
     * @param args[2] connectorType, optional, default is SOAP connector
     *
     */
    public static void main(String[] args)
    {
        PmiJmxTest instance = new PmiJmxTest();

        // parse arguments and create AdminClient object
        instance.init(args);

        // navigate all the MBean ObjectNames and cache those we are interested
        instance.getObjectNames();

        // set level, get data, display data
        instance.doTest();

        // test for EJB data
        instance.testEJB();

        // how to use JSR77 getStats method for individual MBean other than PerfMBean
        instance.testJSR77Stats();

    }

    /**
     * parse args and getAdminClient
     */
    public void init(String[] args)
    {
        try
        {
            String  host    = null;
            String  port    = "8880";
            String  connector = "SOAP";
            if(args.length < 1)
            {
                System.err.println("ERROR: Usage: PmiJmxTest <host> [<port>] [<connector>]");
                System.exit(2);
            }
            else
            {
                host = args[0];

                if(args.length > 1)
                    port = args[1];

                if(args.length > 2)
                    connector = args[2];
            }

            if(host == null)
            {
                host = "localhost";
            }
            if(port == null)
            {
                port = "8880";
            }
            if(connector == null)
            {
                connector = AdminClient.CONNECTOR_TYPE_SOAP;
            }
            System.out.println("host=" + host + " , port=" + port +
                 ", connector=" + connector);

            //--------------------------------------------------------
            // Get the ac object for the AppServer
            //--------------------------------------------------------
            System.out.println("main: create the adminclient");
            ac = getAdminClient(host, port, connector);

        }
        catch(Exception ex)
        {
            failed = true;
            new AdminException(ex).printStackTrace();
            ex.printStackTrace();
        }
    }

    /**
     * get AdminClient using the given host, port, and connector
     */
    public AdminClient getAdminClient(String hostStr, String portStr, String connector)
    {
        System.out.println("getAdminClient: host=" + hostStr + " , portStr=" + portStr);
        AdminClient ac = null;
        java.util.Properties props = new java.util.Properties();
        props.put(AdminClient.CONNECTOR_TYPE, connector);
        props.put(AdminClient.CONNECTOR_HOST, hostStr);
        props.put(AdminClient.CONNECTOR_PORT, portStr);
        try
        {
            ac = AdminClientFactory.createAdminClient(props);
        }
        catch(Exception ex)
        {
            failed = true;
            new AdminException(ex).printStackTrace();
            System.out.println("getAdminClient: exception");
        }
        return ac;
    }


    /**
     * get all the ObjectNames.
     */
    public void getObjectNames()
    {

        try
        {
            //----------------------------------------------------------------------------
            // Get a list of object names
            //----------------------------------------------------------------------------
            javax.management.ObjectName on = new javax.management.ObjectName("WebSphere:*");

            //----------------------------------------------------------------------------
            // get all objectnames for this server
            //----------------------------------------------------------------------------
            Set objectNameSet= ac.queryNames(on, null);

            //----------------------------------------------------------------------------
            // get the object names that we care about:
```

```
        // Perf, Server, JVM, WLM (only applicable in ND)
        //-----------------------------------------------------------------------------
        if(objectNameSet != null)
        {
            Iterator i = objectNameSet.iterator();
            while(i.hasNext())
            {
                on = (ObjectName)i.next();
                String type = on.getKeyProperty("type");

                // uncomment it if you want to print the ObjectName for each MBean
                // System.out.println("\n\n" + on.toString());

                // find the MBeans we are interested
                if(type != null && type.equals("Perf"))
                {
                    System.out.println("\nMBean: perf =" + on.toString());
                    perfOName = on;
                }
                if(type != null && type.equals("Server"))
                {
                    System.out.println("\nMBean: Server =" + on.toString());
                    serverOName = on;
                }
                if(type != null && type.equals("JVM"))
                {
                    System.out.println("\nMBean: jvm =" + on.toString());
                    jvmOName = on;
                }
                if(type != null && type.equals("WLMAppServer"))
                {
                    System.out.println("\nmain: WLM =" + on.toString());
                    wlmOName = on;
                }
                if(type != null && type.equals("ThreadPool"))
                {
                    String name = on.getKeyProperty("name");
                    if(name.equals("ORB.thread.pool"))
                        System.out.println("\nMBean: ORB ThreadPool =" + on.toString());
                    orbtpOName = on;
                }
            }
        }
        else
        {
            System.err.println("main: ERROR: no object names found");
            System.exit(2);
        }

        // You must have Perf MBean in order to get PMI data.
        if(perfOName == null)
        {
            System.err.println("main: cannot get PerfMBean. Make sure PMI is enabled");
            System.exit(3);
        }
    }
    catch(Exception ex)
    {
        failed = true;
        new AdminException(ex).printStackTrace();
        ex.printStackTrace();
    }

}

/**
 * Some sample code to set level, get data, and display data.
 */
public void doTest()
{
    try
    {
        // first get all the configs  - used to set static info for Stats
        // Note: server only returns the value and time info.
        //       No description, unit, etc is returned
        //       with PMI data to reduce communication cost.
        //       You have to call setConfig to bind the static info and Stats data later.
        configs = (PmiModuleConfig[])ac.invoke(perfOName, "getConfigs", null, null);

        // print out all the PMI modules and matching mbean types
        for(int i=0; i<configs.length;i++>
            System.out.println("config: moduleName=" + configs[i].getShortName() +
                               ", mbeanType=" + configs[i].getMbeanType());

        // set the instrumentation level for the server
        setInstrumentationLevel(serverOName, null, PmiConstants.LEVEL_HIGH);

        // example to use StatDescriptor.
        // Note WLM module is only available in ND.
        StatDescriptor sd = new StatDescriptor(new String[]{"wlmModule.server"});
        setInstrumentationLevel(wlmOName, sd, PmiConstants.LEVEL_HIGH);

        // example to getInstrumentationLevel
        MBeanLevelSpec[] mlss = getInstrumentationLevel(wlmOName, sd, true);
        // you can call getLevel(), getObjectName(), getStatDescriptor() on mlss[i]

        // get data for the server
        Stats stats = getStatsObject(serverOName, true);
        System.out.println(stats.toString());

        // get data for WLM server submodule
        stats = getStatsObject(wlmOName, sd, true)
         if(stats == null)
            System.out.println("Cannot get Stats for WLM data");
        else
            System.out.println(stats.toString());

        // get data for JVM MBean
        stats = getStatsObject(jvmOName, true);
        processStats(stats);

        // get data for multiple MBeans
        ObjectName[] onames = new ObjectName[]{orbtpOName, jvmOName};
        Object[] params = new Object[]{onames, new Boolean(true)};
        String[] signature = new String[]{"[Ljavax.management.ObjectName;",
            "java.lang.Boolean"};
        Stats[] statsArray = (Stats[])ac.invoke(perfOName, "getStatsArray",
                                                params, signature);
        // you can call toString or processStats on statsArray[i]

        if(!failed)
            System.out.println("All tests passed");
        else
            System.out.println("Some tests failed");
    }
    catch(Exception ex)
    {
        new AdminException(ex).printStackTrace();
        ex.printStackTrace();
    }
}


/**
```

```
 * Sample code to get level
 */
protected MBeanLevelSpec[] getInstrumentationLevel(ObjectName on, StatDescriptor sd,
                                                    boolean recursive)
{
    if(sd == null)
        return getInstrumentationLevel(on, recursive);
    System.out.println("\ntest getInstrumentationLevel\n");
    try
    {
        Object[] params = new Object[2];
        params[0] = new MBeanStatDescriptor(on, sd);
        params[1] = new Boolean(recursive);
        String[] signature= new String[]{ "com.ibm.websphere.pmi.stat.MBeanStatDescriptor",
            "java.lang.Boolean"};
        MBeanLevelSpec[] mlss = (MBeanLevelSpec[])ac.invoke(perfOName,
                     "getInstrumentationLevel", params, signature);
        return mlss;
    }
    catch(Exception e)
    {
        new AdminException(e).printStackTrace();
        System.out.println("getInstrumentationLevel: Exception Thrown");
        return null;
    }
}

/**
 * Sample code to get level
 */
protected MBeanLevelSpec[] getInstrumentationLevel(ObjectName on, boolean recursive)
{
    if(on == null)
        return null;
    System.out.println("\ntest getInstrumentationLevel\n");
    try
    {
        Object[] params = new Object[]{on, new Boolean(recursive)};
        String[] signature= new String[]{ "javax.management.ObjectName",
            "java.lang.Boolean"};
        MBeanLevelSpec[] mlss = (MBeanLevelSpec[])ac.invoke(perfOName,
                             "getInstrumentationLevel", params, signature);
        return mlss;
    }
    catch(Exception e)
    {
        new AdminException(e).printStackTrace();
        failed = true;
        System.out.println("getInstrumentationLevel: Exception Thrown");
        return null;
    }
}

/**
 * Sample code to set level
 */
protected void setInstrumentationLevel(ObjectName on, StatDescriptor sd, int level)
{
    System.out.println("\ntest setInstrumentationLevel\n");
    try
    {
        Object[] params       = new Object[2];
        String[] signature    = null;
        MBeanLevelSpec[] mlss = null;
        params[0] = new MBeanLevelSpec(on, sd, level);
        params[1] = new Boolean(true);
```

```
            signature= new String[]{ "com.ibm.websphere.pmi.stat.MBeanLevelSpec",
                "java.lang.Boolean"};
            ac.invoke(perfOName, "setInstrumentationLevel", params, signature);
        }
        catch(Exception e)
        {
            failed = true;
            new AdminException(e).printStackTrace();
            System.out.println("setInstrumentationLevel: FAILED: Exception Thrown");
        }
    }

    /**
     * Sample code to get a Stats object
     */
    public Stats getStatsObject(ObjectName on, StatDescriptor sd, boolean recursive)
    {

        if(sd == null)
            return getStatsObject(on, recursive);

        System.out.println("\ntest getStatsObject\n");
        try
        {
            Object[] params    = new Object[2];
            params[0] = new MBeanStatDescriptor(on, sd);  // construct MBeanStatDescriptor
            params[1] = new Boolean(recursive);
            String[] signature = new String[] {
                "com.ibm.websphere.pmi.stat.MBeanStatDescriptor", "java.lang.Boolean"};
            Stats stats  = (Stats)ac.invoke(perfOName, "getStatsObject", params, signature);

            if(stats == null) return null;

            // find the PmiModuleConfig and bind it with the data
            String type = on.getKeyProperty("type");
            if(type.equals(MBeanTypeList.SERVER_MBEAN))
                setServerConfig(stats);
            else
                stats.setConfig(PmiClient.findConfig(configs, on));

            return stats;

        }
        catch(Exception e)
        {
            failed = true;
            new AdminException(e).printStackTrace();
            System.out.println("getStatsObject: Exception Thrown");
            return null;
        }
    }

      /**
     * Sample code to get a Stats object
     */
    public Stats getStatsObject(ObjectName on, boolean recursive)
    {
        if(on == null)
            return null;
    System.out.println("\ntest getStatsObject\n");

        try
        {
            Object[] params  = new Object[]{on, new Boolean(recursive)};
            String[] signature = new String[] { "javax.management.ObjectName",
                "java.lang.Boolean"};
            Stats stats  = (Stats)ac.invoke(perfOName, "getStatsObject", params,
                                        signature);

            // find the PmiModuleConfig and bind it with the data
            String type = on.getKeyProperty("type");
            if(type.equals(MBeanTypeList.SERVER_MBEAN))
                setServerConfig(stats);
            else
                stats.setConfig(PmiClient.findConfig(configs, on));

            return stats;

        }
        catch(Exception e)
        {
            failed = true;
            new AdminException(e).printStackTrace();
            System.out.println("getStatsObject: Exception Thrown");
            return null;
        }
    }

    /**
     * Sample code to navigate and get the data value from the Stats object.
     */
    private void processStats(Stats stat)
    {
        processStats(stat, "");
    }

    /**
     * Sample code to navigate and get the data value from the Stats and Statistic object.
     */
    private void processStats(Stats stat, String indent)
    {
        if(stat == null)  return;

        System.out.println("\n\n");

        // get name of the Stats
        String name = stat.getName();
        System.out.println(indent + "stats name=" + name);

        // list data names
        String[] dataNames = stat.getStatisticNames();
        for(int i=0; i<dataNames.length;i++)
          System.out.println(indent + "    " + "data name=" + dataNames[i]);
        System.out.println("");

        // list all datas
        com.ibm.websphere.management.statistics.Statistic[] allData = stat.getStatistics();

        // cast it to be PMI's Statistic type so that we can have get more
        // Also show how to do translation.
        Statistic[] dataMembers = (Statistic[])allData;
        if(dataMembers != null)
        {
            for(int i=0; i<dataMembers.length;i++)
            {
                System.out.print(indent + "    " + "data name=" +
                                 PmiClient.getNLSValue(dataMembers[i].getName())
                                 + ", description=" +
                                 PmiClient.getNLSValue(dataMembers[i].getDescription())
                                 + ", startTime=" + dataMembers[i].getStartTime()
                                 + ", lastSampleTime=" + dataMembers[i].getLastSampleTime());
                if(dataMembers[i].getDataInfo().getType() == TYPE_LONG)
                {
                    System.out.println(", count=" +
                                       ((CountStatisticImpl)dataMembers[i]).getCount());
                }
                else if(dataMembers[i].getDataInfo().getType() == TYPE_STAT)
                {
                    TimeStatisticImpl data = (TimeStatisticImpl)dataMembers[i];
                    System.out.println(", count=" + data.getCount()
                                       + ", total=" + data.getTotal()
                                       + ", mean=" + data.getMean()
                                       + ", min=" + data.getMin()
                                       + ", max=" + data.getMax());
                }
                else if(dataMembers[i].getDataInfo().getType() == TYPE_LOAD)
                {
                    RangeStatisticImpl data = (RangeStatisticImpl)dataMembers[i];
                    System.out.println(", current=" + data.getCurrent()
                                       + ", integral=" + data.getIntegral()
                                       + ", avg=" + data.getMean()
                                       + ", lowWaterMark=" + data.getLowWaterMark()
                                       + ", highWaterMark=" + data.getHighWaterMark());
                }
            }
        }

        // recursively for sub-stats
        Stats[] substats = (Stats[])stat.getSubStats();
        if(substats == null || substats.length == 0)
            return;
        for(int i=0; i<substats.length; i++)
        {
            processStats(substats[i], indent + "    ");
        }
      }


    /**
     * The Stats object returned from server does not have static config info.
     * You have to set it on client side.
     */
    public void setServerConfig(Stats stats)
    {
        if(stats == null) return;
        if(stats.getType() != TYPE_SERVER) return;

        PmiModuleConfig config = null;

        Stats[] statList = stats.getSubStats();
        if(statList == null || statList.length == 0)
            return;
        Stats oneStat = null;
        for(int i=0; i<statList.length; i++)
        {
            oneStat = statList[i];
            if(oneStat == null) continue;
            config = PmiClient.findConfig(configs, oneStat.getName());
            if(config != null)
                oneStat.setConfig(config);
            else
                System.out.println("Error: get null config for " + oneStat.getName());
        }
    }

    /**
     * sample code to show how to get a specific MBeanStatDescriptor
     */
    public MBeanStatDescriptor getStatDescriptor(ObjectName oName, String name)
    {
        try
```

```
        {
            Object[] params = new Object[]{serverOName};
            String[] signature= new String[]{"javax.management.ObjectName"};
            MBeanStatDescriptor[] msds = (MBeanStatDescriptor[])ac.invoke(perfOName,
                                            "listStatMembers", params, signature);
            if(msds == null)
                return null;
            for(int i=0; i<msds.length; i++)
            {
                if(msds[i].getName().equals(name))
                    return msds[i];
            }
            return null;
        }
        catch(Exception e)
        {
            new AdminException(e).printStackTrace();
            System.out.println("listStatMembers: Exception Thrown");
            return null;
        }

    }

    /**
     * sample code to show you how to navigate MBeanStatDescriptor via listStatMembers
     */
    public MBeanStatDescriptor[] listStatMembers(ObjectName mName)
    {
        if(mName == null)
            return null;

        try
        {
            Object[] params = new Object[]{mName};
            String[] signature= new String[]{"javax.management.ObjectName"};
            MBeanStatDescriptor[] msds = (MBeanStatDescriptor[])ac.invoke(perfOName,
                                            "listStatMembers", params, signature);
            if(msds == null)
                return null;
            for(int i=0; i<msds.length; i++)
            {
                if(msds[i].getName().equals(name))
                    return msds[i];
            }
            return null;
        }
        catch(Exception e)
        {
            new AdminException(e).printStackTrace();
            System.out.println("listStatMembers: Exception Thrown");
            return null;
        }

    }

    /**
     * sample code to show you how to navigate MBeanStatDescriptor via listStatMembers
     */
    public MBeanStatDescriptor[] listStatMembers(ObjectName mName)
    {
        if(mName == null)
            return null;

        try
        {
            Object[] params = new Object[]{mName};
            String[] signature= new String[]{"javax.management.ObjectName"};
            MBeanStatDescriptor[] msds = (MBeanStatDescriptor[])ac.invoke(perfOName,
                                            "listStatMembers", params, signature);
            if(msds == null)
                return null;
            for(int i=0; i<msds.length; i++)
            {
                MBeanStatDescriptor[] msds2 = listStatMembers(msds[i]);
            }
            return null;
        }
        catch(Exception e)
        {
            new AdminException(e).printStackTrace();
            System.out.println("listStatMembers: Exception Thrown");
            return null;
        }

    }


    /**
     * Sample code to get MBeanStatDescriptors
     */
    public MBeanStatDescriptor[] listStatMembers(MBeanStatDescriptor mName)
    {
        if(mName == null)
            return null;

        try
        {
            Object[] params = new Object[]{mName};
            String[] signature= new String[]{"com.ibm.websphere.pmi.stat.MBeanStatDescriptor"};
            MBeanStatDescriptor[] msds = (MBeanStatDescriptor[])ac.invoke(perfOName,
                                            "listStatMembers", params, signature);
            if(msds == null)
                return null;
            for(int i=0; i<msds.length; i++)
            {
                MBeanStatDescriptor[] msds2 = listStatMembers(msds[i]);
                // you may recursively call listStatMembers until find the one you want
            }
            return msds;
        }
        catch(Exception e)
        {
            new AdminException(e).printStackTrace();
            System.out.println("listStatMembers: Exception Thrown");
            return null;
        }

    }

    /**
     * sample code to get PMI data from beanModule
     */
    public void testEJB()
    {

        // This is the MBeanStatDescriptor for Enterprise EJB
        MBeanStatDescriptor beanMsd = getStatDescriptor(serverOName, PmiConstants.BEAN_MODULE);
        if(beanMsd == null)
            System.out.println("Error: cannot find beanModule");

        // get the Stats for module level only since recursive is false
        Stats stats = getStatsObject(beanMsd.getObjectName(), beanMsd.getStatDescriptor(),
                                false); // pass true if you wannt data from individual beans
```

```
                                         // find the avg method RT
        TimeStatisticImpl rt = (TimeStatisticImpl)stats.getStatistic(EJBStatsImpl.METHOD_RT);
        System.out.println("rt is " + rt.getMean());

        try
        {
            java.lang.Thread.sleep(5000);
        }
        catch(Exception ex)
        {
            ex.printStackTrace();
        }

        // get the  Stats again
        Stats stats2 = getStatsObject(beanMsd.getObjectName(), beanMsd.getStatDescriptor(),
                         false); // pass true if you wannt data from individual beans

                                          // find the avg method RT
        TimeStatisticImpl rt2 = (TimeStatisticImpl)stats2.getStatistic(EJBStatsImpl.METHOD_RT);
        System.out.println("rt2 is " + rt2.getMean());

        // calculate the difference between this time and last time.
        TimeStatisticImpl deltaRt = (TimeStatisticImpl)rt2.delta(rt);
        System.out.println("deltaRt is " + rt.getMean());

    }

    /**
     * Sample code to show how to call getStats on StatisticProvider MBean directly.
     */
    public void testJSR77Stats()
    {
        // first, find the MBean ObjectName you are interested.
        // Refer method getObjectNames for sample code.

        // assume we want to call getStats on JVM MBean to get statistics
        try
        {

            com.ibm.websphere.management.statistics.JVMStats stats =
            (com.ibm.websphere.management.statistics.JVMStats)ac.invoke(jvmOName,
                                                        "getStats", null, null);

            System.out.println("\n get data from JVM MBean");

            if(stats == null)
            {
                System.out.println("WARNING: getStats on JVM MBean returns null");
            }
            else
            {

                // first, link with the static info if you care
                ((Stats)stats).setConfig(PmiClient.findConfig(configs, jvmOName));

                // print out all the data if you want
                //System.out.println(stats.toString());

                // navigate and get the data in the stats object
                processStats((Stats)stats);

                // call JSR77 methods on JVMStats to get the related data
                com.ibm.websphere.management.statistics.CountStatistic upTime =
                stats.getUpTime();
                com.ibm.websphere.management.statistics.BoundedRangeStatistic heapSize =
                stats.getHeapSize();
                if(upTime != null)
                    System.out.println("\nJVM up time is " + upTime.getCount());
                if(heapSize != null)
                    System.out.println("\nheapSize is " + heapSize.getCurrent());
            }
        }
        catch(Exception ex)
        {
            ex.printStackTrace();
            new AdminException(ex).printStackTrace();
        }
    }
}
```

Related tasks

"Developing your own monitoring application using Performance Monitoring Infrastructure client" on page 31

"Compiling your monitoring applications"

Developing Performance Monitoring Infrastructure interfaces

This section discusses the use of the Performance Monitoring Infrastructure (PMI) client interfaces in applications. The basic steps in the programming model follow:

1. Retrieve an initial collection or snapshot of performance data from the server. A client uses the CpdCollection interface to retrieve an initial collection or snapshot from the server. This snapshot, which is called Snapshot in this example, is provided in a hierarchical structure as described in data organization and hierarchy, and contains the current values of all performance data collected by the server. The snapshot maintains the same structure throughout the lifetime of the CpdCollection instance.
2. Process and display the data as specified. The client processes and displays the data as specified. Processing and display objects, for example, filters and GUIs, can register as CpdEvent listeners to data of interest. The listener works only within the same Java virtual machine (JVM). When the client receives updated data, all listeners are notified.
3. Display the new CpdCollection instance through the hierarchy. When the client receives new or changed data, the client can simply display the new CpdCollection instance through its hierarchy. When it is necessary to update the Snapshot collection, the client can use the update method to update Snapshot with the new data.

   ```
   Snapshot.update(S1);
   // ...later...
   Snapshot.update(S2);
   ```

Steps 2 and 3 are repeated through the lifetime of the client.

Compiling your monitoring applications

To compile your Performance Monitoring Infrastructure (PMI) code, you must have the following JAR files in your classpath:

- admin.jar
- wsexception.jar
- jmxc.jar
- pmi.jar
- pmiclient.jar
- ras.jar
- wasjmx.jar
- j2ee.jar
- soap.jar
- soap-sec.jar
- nls.jar

- ws-config-common.jar
- namingclient.jar

If your monitoring applications use APIs in other packages, also include those packages on the classpath.

Related tasks

"Developing your own monitoring applications" on page 30

Running your new monitoring applications

1. Obtain the `pmi.jar` and `pmiclient.jar` files. The `pmi.jar` and `pmiclient.jar` files are required for client applications using PMI client APIs. The `pmi.jar` and `pmiclient.jar` files are distributed with WebSphere Application Server and are also a part of WebSphere Java thin client package. You can get it from either a WebSphere Application Server installation or WebSphere Java Thin Application Client installation. You also need the other JAR files in WebSphere Java Thin Application Client installation in order to run a PMI application.
2. Use PMI client API to write your own application.
3. Compile the newly written PMI application and place it on the classpath.
4. Run the application with the following script:

```
call "%~dp0setupCmdLine.bat"

set WAS_CP=%WAS_HOME%\properties
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\pmi.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\pmiclient.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\ras.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\admin.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\wasjmx.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\j2ee.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\soap.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\soap-sec.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\nls.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\wsexception.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\ws-config-common.jar
set WAS_CP=%WAS_CP%;%WAS_HOME%\lib\namingclient.jar

%JAVA_HOME%\bin\java "%CLIENTSOAP%" "%CLIENTSAS%" "-Dws.ext.dirs=%WAS_EXT_DIRS%"
%DEBUGOPTS% -classpath "%WAS_CP%" com.ibm.websphere.pmi.PmiClientTest host name
[port] [connectorType]
```

Performance Monitoring Infrastructure client package:

Performance Monitoring Infrastructure (PMI) client package provides a wrapper class PmiClient to deliver PMI data to a client.

As shown in the following figure, PmiClient uses the AdminClient API to communicate the Perf MBean in an application server.

PmiClient communicates with the network manager first, retrieving an AdminClient instance to each application server. Once the PmiClient receives the instance, it uses it to communicate with the application server directly for performance or level setting changes. Since level settings are persistent through PmiClient, you are only required to set it once, unless you want to change it.

Performance Monitoring Infrastructure and Java Management Extensions

The PmiClient API does not work if the Java Management Extensions (JMX) infrastructure and Perf MBean are not running. If you prefer to use the AdminClient API directly to retrieve PMI data, you still have a dependency on the JMX infrastructure.

When using the PmiClient API, you have to pass the JMX connector protocol and port number to instantiate an object of the PmiClient. Once you get a PmiClient object, you can call its methods to list nodes, servers and MBeans, set the monitoring level, and retrieve PMI data.

The PmiClient API creates an instance of the AdminClient API and delegates your requests to the AdminClient API. The AdminClient API uses the JMX connector to communicate with the PerfMBean in the corresponding server and then returns the data to the PmiClient, which returns the data to the client.

Related concepts

"Performance Monitoring Infrastructure client" on page 31

Related tasks

"Running your new monitoring applications" on page 56

Running your monitoring applications with security enabled:

In order to run a Performance Monitoring Infrastructure client application with security enabled, you must have `%CLIENTSOAP%` and `%CLIENTSAS%` properties on your Java virtual machine command line. The `%CLIENTSOAP%` and `%CLIENTSAS%` properties are defined in the `setupCmdLine.bat` or `setupCmdline.sh` files.

1. Set `com.ibm.SOAP.securityEnabled` to **True** in the `soap.client.props` file for the SOAP connector. The `soap.client.props` property file is located in the `WAS_ROOT/properties` directory.
2. Set `com.ibm.SOAP.loginUserid` and `com.ibm.SOAP.loginPassword` as the user ID and password for login.
3. Set the `sas.client.props` file or type the user ID and password in the pop-up window if you do not put them in the property file for RMI connector A common mistake is leaving extra spaces at the end of the lines in the property file. Do not leave extra spaces at the end of the lines, especially for the user ID and password lines.

Related tasks

"Running your new monitoring applications" on page 56

Third-party performance monitoring and management solutions

Several other companies provide performance monitoring, problem determination and management solutions that can be used with WebSphere Application Server.

These products use WebSphere Application Server interfaces, including Performance Monitoring Infrastructure (PMI), Java Management Extensions (JMX).

See the topic Performance: Resources for learning for a link to IBM business partners providing monitoring solutions for WebSphere Application Server.

Related reference

"Performance: Resources for learning" on page 61

RMF Workload Activity reports and RMF Monitor III

Performance metrics include transaction rates and response times. Resource utilization includes CPU, I/O (channel), and storage utilization.

Transactions/second
: This is shown in the AVG, MPL, and AVG ENC fields which is equal to the average number of enclaves in the period in the RMF Monitor I report below.

Response times
: The actual response times of the WLM transaction is shown in the TRANS.-TIME SS.TTT' column n the RMF Monitor I report below and are measured in milliseconds. (This also includes time waiting on WLM queue.)

Service Rates
: Resource utilization in CPU service units, and Service Units per Sec. The APPL% field shows the number of processor engines (CPs) required to drive the work in the service (report) class.

Controller Regions Example: Here is the report for the WebSphere controller regions which were all assigned a particular reporting class according to the STC classification rules based on the started class jobname. There is only one transaction active in the system, there are no response time figures, and required 37.2% of a processor engine to support its work.

```
TRANSACTIONS    TRANS.-TIME  SS.TTT   ---SERVICE--   --SERVICE RATES--
AVG      1.00   ACTUAL            0   IOC        0   ABSRPTN     89615
MPL      1.00   EXECUTION         0   CPU   522567   TRX SERV    89615
ENDED       0   QUEUED            0   MSO    10159K  TCB          39.9
END/S    0.00   R/S AFFINITY      0   SRB    61728   SRB           4.7
#SWAPS      0   INELIGIBLE        0   TOT    10743K  RCT           0.0
EXCTD       0   CONVERSION        0   /SEC   89630   IIT           0.0
AVG ENC  0.00   STD DEV           0                  HST           0.0
REM ENC  0.00                                        APPL %       37.2
```

Servant Regions Example: Here is the report for the WebSphere servant regions which were all assigned a particular reporting class according to the STC classification rules based on the stared class jobname. There are only two transactions active in the system (meaning there were two servant regions), there are no response time figures, and they required 10% of a processor engine to support their work.

```
TRANSACTIONS    TRANS.-TIME  SS.TTT   ---SERVICE--   --SERVICE RATES--
AVG      2.00   ACTUAL            0   IOC        0   ABSRPTN    122075
MPL      2.00   EXECUTION         0   CPU   143957   TRX SERV   122075
ENDED       0   QUEUED            0   MSO    29113K  TCB          11.0
END/S    0.00   R/S AFFINITY      0   SRB    12460   SRB           1.0
#SWAPS      0   INELIGIBLE        0   TOT    29270K  RCT           0.0
EXCTD       0   CONVERSION        0   /SEC  244192   IIT           0.0
AVG ENC  0.00   STD DEV           0                  HST           0.0
REM ENC  0.00                                        APPL %       10.0
```

WebSphere Transactions (Enclaves) Example: Here is the report for the real WebSphere transaction work which runs as enclaves in this particular reporting class. The average number of these kind of transactions active in the system was 241.52, the average response time was 276 milliseconds, and required 2.129 processor engines to support this work.

```
TRANSACTIONS    TRANS.-TIME  SS.TTT   ---SERVICE--   --SERVICE RATES--
AVG    241.52   ACTUAL          276   IOC        0   ABSRPTN       115
MPL    241.52   EXECUTION       272   CPU     3343K  TRX SERV      115
ENDED  106717   QUEUED            4   MSO        0   TCB         255.5
END/S  890.32   R/S AFFINITY      0   SRB        0   SRB           0.0
#SWAPS      0   INELIGIBLE        0   TOT     3343K  RCT           0.0
EXCTD       0   CONVERSION        0   /SEC      17   IIT           0.0
AV ENC 241.52   STD DEV          66                  HST           0.0
REM ENC  0.00                                        APPL %      212.9
```

Delays Example: The QMPL field in the following report means that the server was waiting for a Server Region to select work off the WLM queue. Here is a queue delay report which shows that work was delayed 23.5% of the time waiting for the CPU and 12.6% of the time waiting for a servant region:

```
         EX   PERF   AVG   --USING%--  ----- EXECUTION DELAYS % -----
         VEL  INDX  ADRSP   CPU   I/O  TOTAL   CPU QMPL
GOAL    40.0%
ACTUALS 45.3%  .89   13.4   0.1   0.0   36.1  23.5 12.6
```

Started Class Classification Example: Here is an example of the STC classification rules/panel in WLM which can be used to classify the non-enclave time in the websphere server regions. WebSphere production controller region with a jobname of WSPRODC is assigned a service class of STCCR and reporting class of RCTLREG, production controller region with a jobname of WSPRODC is assigned a service class of STCSR and reporting class of RSRVREG, and testregions (servant and controllers) with a jobname starting with WSTare assigned a service class of STCWSTST and reporting class of RWSTST.

```
  Subsystem Type . . . . . . . : STC
  Description  . . . . . . . . . All started tasks
    -------Qualifier-------------           -------Class--------
    Type       Name     Start               Service     Report
    Type       Name     Start               Service     Report
                              DEFAULTS: STCMED__    RSTCMED_
 1  TNG        WSPRODC  ___                 STCCR___    RCTLREG_
 1  TNG        WSPRODS  ___                 STCSR___    RSRVREG_
 1  TNG        WST*     ___                 STCWSTST    RWSTST__
```

Steps for capturing a workload activity report

The following RMF1 job reads the data from RMF data buffers.

Run the RMF Monitor 1 post processor as a batch job which can read the RMF data buffers from memory and produce a report.

1. Here is a sample job to run the RMF Monitor 1 post processor: (You will need to change the time and date parameters.)

   ```
   //RMF1JOB  JOB 1,CLASS=A
   //RMFPP    EXEC PGM=ERBRMFPP,REGION=0M
   //MFPMSGDS DD   SYSOUT=*
   //SYSIN    DD   *
    SYSOUT(O)
    NOSUMMARY
    SYSRPTS(WLMGL(SCPER(WSHIGH,WSMED,WSLOW,SYSSTC,OPS_DEF)))
    DATE(04172003,04172003)        /* <== SET TO MEAS. DATE  MMDDYYYY  */
    RTOD(1430,1500)                /* <== SET TO MEAS. TIME OF DAY HHMM*/
    DINTV(0002)
   /*
   //
   ```

   This will take the raw SMF data, in this case the MANE data, and produce the workload activity report as an H output class in SDSF.
2. Using the Workload Activity Reports, observe the measurements in the service and reporting classes. After your measurement run is over, you should reset the SMF parameters to their standard settings with the `SET SMF=xx` command.

WLM Delay Monitoring

WebSphere Application Server for z/OS Version 5 can use Workload Manager (WLM) services to report transaction begin-to-end response times and execution delay times. The WLM data collected by Resource Measurement Facility (RMF) is captured in two phases of the RMF report:

- BTE - the begin-to-end phase applies to requests handled by the controller
- EXE - the execution phase applies to requests handled by the servant

You can use this status information to determine where possible performance bottlenecks are occurring. This feature is available on z/OS V1R2 and above with WLM APAR OW51848 and RMF APAR OW52227.

When a new transaction enters the system, the WebSphere Application Server for z/OS application control region (ACR) starts the classify service. Delays associated with the WebSphere Application Server for z/OS ACR service class are counted separately for the BTE phase and the EXE phase. This support allows WLM to associate a performance block (PB) with an enclave to record delays that occur in the flow of a transaction. The state samples are collected on an ongoing basis and reported as a percentage of average transaction response time. The following table shows the states, their codes, the section of the RMF report where each is reported, the meaning, and suggested response. You can use this information in the RMF report to determine where some of your system's performance problems may be occurring.

Table 1. WLM delay monitoring states

State	Code	Report	Meaning	Response
ACTIVE	ACTIVE SUB	Both BTE and EXE	WebSphere is actively processing request	

Table 1. WLM delay monitoring states (continued)

ACTIVE_APPLIC	ACTIVE APPL	Both BTE and EXE	Application is running	Use application monitoring tool to determine the cause of the delay.
WAITING TYPE1	TYP1	EXE	EJB collaborator delay	
WAITING TYPE2	TYP2	EXE	Resource manager delay	Called a J2C connector to perhaps DB2, CICS, IMS. Investigate other resource manager using their monitoring tools.
WAITING TYPE3	TYP3	EXE	Servant called to a different distributed object server using RMI/IIOP	1. Investigate the delay on the other server. The delay may point to session caches. 2. Look for any network problems. 3. Avoid outbound calls.
WAITING TYPE 4	TYP4	BTE	OTS call to RRS. Occurs only in controller when controller is trying to commit a distributed transaction.	1. Investigate the delay on the other server. 2. Look for any network problems. 3. Consider combining application into one server to avoid delay.
WAITING REGIST TO WORKTABLE	WORK	BTE	An indication of contention within the controller while trying to process concurrent requests.	If delay is excessive, consider adding another controller and splitting work off to it.
WAITING OTHER_PRODUCT	OTHER	BTE	Indicates a configuration problem in DNS or TCP/IP	Check to make sure all the DNS servers are running. You might want to look at OPING or ONSLOOKUP.
WAITING DISTRIB	DIST	BTE	Controller as a client went outbound waiting for a response.	1. Investigate the delay on the other server. 2. Look for any network problems. 3. Consider combining application into one server to avoid delay.
WAITING SESS_NETWORK	REMT	BTE	Time spent waiting for a TCP/IP session to be established on the network.	The two session delays should be observable in conjunction with TYP3 delays. Look at TCP/IP configuration.
WAITING SESS_SYSPLEX	SYSP	BTE	Time spent waiting for a TCP/IP session to be established on the sysplex.	The two session delays should be observable in conjunction with TYP3 delays. Look at TCP/IP configuration.
WAITING REGULAR_THREAD	REGT	BTE	Waiting for a thread in the controller. Work is bottlenecked in the controller because it is receiving more requests than it can process.	Split the controller.
WAITING SSL_THREAD	SSLT	BTE	Waiting for an SSL thread in the controller. Work is bottlenecked in the controller because it is receiving more requests for SSL handshakes than it can process.	Split controller in increase SSL threads. 1. Increase SSL threads. 2. Look at SSL configuration. 3. Split the controller to increase SSL threads.
WAITING SESS_LOCALMVS	LOCL	BTE	Time spent communicating with a different distributed object server using local optimized communication.	1. Investigate the delay on the other server. 2. Avoid outbound calls.

RMF report examples

This section includes several examples of RMF reports with WLM delay monitoring information.

```
             RESP  ------------- STATE SAMPLES BREAKDOWN (%) -------  ------STATE------
SUB    P    TIME  --ACTIVE-- READY IDLE  ------WAITING FOR---------  SWITCHED SAMPL(%)
TYPE         (%)   SUB  APPL             TYP1                        LOCAL SYSPL REMOT
CB    BTE   0.0   0.0   0.0   0.0  0.0   0.0                         0.0   0.0   0.0
CB    EXE  95.7   0.5  74.7   0.0  0.0  24.9                         0.0   0.0   0.0
```

```
           RESP  ----------- STATE SAMPLES BREAKDOWN (%) ---------  ------STATE------
SUB    P   TIME  --ACTIVE-- READY IDLE  ------WAITING FOR---------  SWITCHED SAMPL(%)
TYPE        (%)   SUB  APPL             TYP4 REGT LOCL              LOCAL SYSPL REMOT
CB    BTE   0.0  26.9   0.0   0.0  0.0  65.4  3.8  3.8              0.0   0.0   0.0
CB    EXE   0.0   0.0   0.0   0.0  0.0   0.0  0.0  0.0              0.0   0.0   0.0
           RESP  ------------- STATE SAMPLES BREAKDOWN (%) -------  ------STATE------
SUB    P   TIME  --ACTIVE-- READY IDLE  ------WAITING FOR---------  SWITCHED SAMPL(%)
TYPE        (%)   SUB  APPL                                         LOCAL SYSPL REMOT
CB    BTE   0.0   100   0.0   0.0  0.0                              0.0   0.0   0.0
CB    EXE   0.0   0.0   0.0   0.0  0.0                              0.0   0.0   0.0
           RESP  ------------ STATE SAMPLES BREAKDOWN (%) --------  ------STATE------
SUB    P   TIME  --ACTIVE-- READY IDLE  ------WAITING FOR---------  SWITCHED SAMPL(%)
TYPE        (%)   SUB  APPL             TYP4 REGT SYSP              LOCAL SYSPL REMOT
CB    BTE   0.0  40.7   0.0   0.0  0.0  51.9  3.7  3.7              0.0   0.0   0.0
CB    EXE   0.0   0.0   0.0   0.0  0.0   0.0  0.0  0.0              0.0   0.0   0.0
           RESP  ------------- STATE SAMPLES BREAKDOWN (%) -------  ------STATE------
SUB    P   TIME  --ACTIVE-- READY IDLE  ------WAITING FOR---------  SWITCHED SAMPL(%)
TYPE        (%)   SUB  APPL             TYP4 REGT WORK              LOCAL SYSPL REMOT
CB    BTE   0.0  40.0   0.0   0.0  0.0  50.0  7.5  2.5              0.0   0.0   0.0
CB    EXE   0.0   0.0   0.0   0.0  0.0   0.0  0.0  0.0              0.0   0.0   0.0
```

Performance: Resources for learning

Use the following links to find relevant supplemental information about performance. The information resides on IBM and non-IBM Internet sites, whose sponsors control the technical accuracy of the information.

These links are provided for convenience. Often, the information is not specific to the IBM WebSphere Application Server product, but is useful for understanding the product. When possible, links are provided to technical papers and Redbooks that supplement the broad coverage of the release documentation with in-depth examinations of particular product areas. The following sections are covered in this reference:

View links to additional information about:
- Monitoring performance with third-party tools
- Tuning performance
- Garbage collection

Monitoring performance with third-party tools
- Enterprise Web Application Management WebSphere Performance Management Business Partner Solution Finder

  Find a list of IBM's business partners that offer performance monitoring tools compliant with WebSphere Application Server.

Tuning performance
- Hints on Running a high-performance Web server

  Read hints about running Apache on a heavily loaded Web server. The suggestions include how to tune your kernel for the heavier TCP/IP load, and hardware and software conflicts
- Application tuning

  See WebSphere Application Server Development Best Practices for Performance and Scalability for more information on application tuning.
- Performance Analysis for Java Web sites
- WebSphere Application Server Development Best Practices for Performance and Scalability

  Describes development best practices for Web applications with servlets, JSP files, JDBC connections, and enterprise applications with EJB components.

Garbage collection
- IBM developerWorks

Search the IBM developerWorks Web site for a list of garbage collection documentation, including ″Understanding the IBM Java Garbage Collector″, a three-part series. To locate the documentation, search on ″sensible garbage collection″ in the developerWorks search application.

Review ″Understanding the IBM Java Garbage Collector″ for a description of the IBM verbose:gc output and more information about the IBM garbage collector.

- Tuning Garbage Collection with the 1.3.1 JavaTM Virtual Machine

  Learn more about using garbage collection in a Solaris operating environment.

Related concepts

Application Response Measurement
Application Response Measurement (ARM) is an Open Group standard composed of a set of interfaces implemented by an ARM agent that provides information on elapsed time for process hops.

Related tasks

“Monitoring performance with Tivoli Performance Viewer (formerly Resource Analyzer)” on page 20

Chapter 2, “Tuning performance parameter index,” on page 63

Chapter 2. Tuning performance parameter index

5.0.1 + Tuning parameter index for z/OS

5.0.1 + Performance tuning for WebSphere for z/OS becomes a complex exercise because the nature of the runtime involves many different components of the operating system and middleware. Use the Tuning parameter index for z/OS to find information and parameters for tuning the z/OS operating system, subsystems, the WebSphere for z/OS runtime environment, and some J2EE application tuning tips.

5.0.1 + **Recommendation:** Before you read a description of WebSphere for z/OS tuning guidelines, it is important to note that, no matter how well the middleware is tuned, it cannot make up for poorly designed and coded applications. Focusing on the application code can help improve performance. Often, poorly written or designed application code changes will make the most dramatic improvements to overall performance.

The tuning guide focuses on server tuning. If you want to tune your applications, see Performance: Resources for learning for more information about application tuning.

For your convenience, procedures for tuning parameters in other products, such as DB2, Web servers and operating systems are included. Because these products might change, consider these descriptions as suggestions.

Each WebSphere Application Server process has several parameters influencing application performance. You can use the WebSphere Application Server administrative console to configure and tune applications, Web containers, EJB containers, application servers and nodes in the administrative domain.

If you are a WebSphere Application Server Administrator or Systems programmer on z/OS, refer to Tuning index for WebSphere Application Server for z/OS for z/OS specific tuning tips.

Each parameter in the tuning parameter index links to information that explains the parameter, provides reasons to adjust the parameter, how to view or set the parameter, as well as default and recommended values.
- Application servers

  The WebSphere Application Server contains interrelated components that must be harmoniously tuned to support the custom needs of your end-to-end e-business application.
- Java virtual machines

  The JVM offers several tuning parameters affecting the performance of WebSphere Application Servers (which are primarily Java applications), as well as the performance of your applications.
- Applications

  Several topics including Web modules, EJB modules, client modules, Web services and application services comprise the application programming model and provide numerous services supporting deployed applications.
- Databases

  WebSphere supports the integration of several different database systems. Each is tuned in its own manor. DB2 tuning parameters are provided for your convenience.
- Java messaging service

  Java messaging service (JMS) can be tuned to balance memory with the servicing of the JMS subscribers.
- Security

  Security may have an affect on performance depending on certain actions taken.

Related tasks

Using the Performance Advisor in Tivoli Performance Viewer

Tuning application servers

Tuning Java virtual machines

Tuning databases

Tuning Java messaging service

Tuning security

Tuning Web servers

Related reference

DB2 tuning parameters

Secure Sockets Layer performance tips

EJB method Invocation Queuing

Java memory tuning tips

Performance troubleshooting tips

xrun_transport.dita.

Recommended hardware configuration

The tuning guidelines presented in this chapter will have the most benefit on the following recommended configuration:

- IBM S/390 G5 Model 9672-Rx6, or later

  Note: IEEE floating point, which is commonly used in Java, is emulated on earlier machines.
- Storage

  Storage requirements are higher than for traditional workloads
  - Virtual storage default should be about 370 MB per servant, which includes a 256 MB default heap size and a default initial LE heap size of 80 MB.
  - Real storage minimum is 376 MB per LPAR for a light load such as the IVP. For most real-world applications, we recommend 2 GB or higher.
- DASD

  To maximize your performance, we recommend a fast DASD subsystem (for example, IBM Shark), running with a high cache read/write hit rate.
- Networking

  For high bandwidth applications, we recomend at least a 1 Gb Ethernet connection. If your applications have extremely high bandwidth requirements, you may need additional Ethernet connections.
- Cryptography

  For applications that make heavy use of cryptography, we recommend the zSeries or S/390 cryptographic hardware and the Integrated Cryptographic Service Facility.

Tuning index for WebSphere Application Server for z/OS

One of the goals of the WebSphere Application Server for z/OS programming model and runtime is to significantly simplify the work required for application developers to write and deploy applications. Sometimes we say that WebSphere Application Server for z/OS relieves the application programmer of many of the plumbing tasks involved in developing applications. For example, application code in WebSphere Application Server for z/OS does not concern itself directly with remote communication--it locates objects which may be local or remote and drives methods. Therefore, you won't see any direct use of socket calls or TCP/IP programming in a WebSphere Application Server for z/OS application.

This separation of what you want to do from where you do it is one aspect of removing the application programmers from plumbing tasks. Other considerations are not having to deal with data calls for some types of beans, potentially user authentication, and threading. There are generally no calls from the application code to touch sockets, RACF calls, or management of threading. Removing this from the application programmer doesn't mean this work won't get done. Rather, it means that there may be more work for the DBA, the network administrator, the security administrator, and the performance analyst.

There are four layers of tuning that need to be addressed:
- Tuning the z/OS operating system
- Tuning for Subsystems
- Tuning the WebSphere Application Server for z/OS runtime
- Tuning for J2EE applications

We deal with the first three in separate sections under this article and briefly touch on the fourth. For more information on tuning applications, refer to Using application clients.

Related tasks

Using application clients

Tuning the z/OS operating system

Steps involved in tuning the z/OS operating system to optimize WebSphere performance include:
- Tuning storage
- z/OS or OS/390 operating system tuning tips
- Resource Recovery Service tuning tips for z/OS
- UNIX System Services tuning tips for z/OS
- Workload management (WLM) tuning tips for z/OS

Tuning storage

WebSphere for z/OS puts much higher demands on virtual memory than a traditional workload. Ensure that you don't underestimate the amount of virtual storage applied to the WebSphere for z/OS servers. Generally, they use significantly more virtual memory than traditional application servers on z/OS or OS/390. Since real storage is needed to back the virtual storage, its usage is also high.

1. Allocate enough virtual storage. The setting of REGION on the JCL for the proc should be large (at least 200MB to run), and much larger if high throughput is required. You can get an idea of the virtual storage usage through RMF or other performance monitors. It would not be unreasonable for the servant procs to specify REGION=0M, which tells the operating system to give all the available region (close to 2GB).

   Note: For more information on REGION=0M and IEFUSI, please see ″Preparing the base OS/390 or z/OS environment″ in the Getting Started section of the InfoCenter.

   If you choose to not put most of the runtime in LPA, as described in the program locations section, be sure to specify more region (as high as 512MB). Also, in conjunction with the increase in storage usage, you may have to define more paging space or auxiliary storage to back up the additional virtual storage used.
2. Optional: Allocate enough real storage. Expect a requirement of at least 376MB of real storage for a small configuration. For controllers and servants, real storage utilizations depends on the size of the JVM heapsize.

   Recommendation: It can be the case that in a heavy use environment 2G of central storage is not enough to handle the real storage demands of a high volume Java application. In this case, we recommend that you configure with 64-bit real storage, which will give you the ability to dedicate more central storage to the LPAR. Installations with a zSeries processor (z800, z900) have the ability to run OS/390 Release 10 in 64-bit mode. z/OS on a zSeries will always run in 64-bit mode. Running in 64-bit mode gives you the ability to define more than 2 GB of central storage When you configure for 64-bit real all of the storage is defined as central storage. For non-zSeries processors, or 31-bit mode, you can minimize paging by defining more expanded storage.

3. Tune the Java virtual machine storage. Also refer to Best practices for maintaining the run-time environment.

   Related reference

   Preparing for diagnosis

Java virtual machine storage tuning tips for z/OS: Specifying a sufficient `JVM Heap Size` is important to Java performance. The JVM has thresholds it uses to manage the JVM's storage. When the thresholds are reached, the garbage collector (GC) gets invoked to free up unused storage. GC can cause significant degradation of Java performance.

Use the administrative console to specify the Initial Heap Size and the Maximum Heap Size for the JVM.

To view this administrative console page, click **Servers > Application Servers >***server_name* **> Process Definition > Java Virtual Machine**. Access the configuration tab to change these settings.

- In order to get it to run less frequently, you can give the JVM more memory. This is done by specifying a larger value for `Initial Heap Size`. The default of 256M is a good starting point but may need to be raised for larger applications. When specifying either a larger or smaller JVM heap size value, IBM recommends that you code **both** the initial and maximum values that you desire.
- It is good for the Initial Heap Size to equal the Maximum Heap Size because it allows the allocated storage to be completely filled before GC kicks in. Otherwise, GC will run more frequently than necessary, potentially impacting performance.
- Make sure the region is large enough to hold the specified JVM heap.
- Beware of making the `Initial Heap Size` *too* large. While it initially improves performance by delaying garbage collection, it ultimately affects response time when garbage collection eventually kicks in (because it runs for a longer time).
- Paging activity on your system must also be considered when you set your JVM heap size. If your system is already paging heavily, increasing the JVM heap size might make performance worse rather than better.
- To determine if you are being affected by garbage collection, you can enable Verbose Garbage Collection on the JVM Configuration tab. The default is not enabled. This will write a report to the output stream each time the garbage collector runs. This report should give you an idea of what is going on with Java GC.

  Example: This is an example of a verboseGC report.

  ```
  ..
  <AF[21]: Allocation Failure. need 32784 bytes, 32225 ms since last AF
  >
  <AF[21]: managing allocation failure, action=1 (84320/131004928)
                                                  (3145728/3145728)>
  <GC(21): GC cycle started Wed Feb 27 22:46:11 2002
  <GC(21): freed 99587928 bytes, 76% free (102817976/134150656),
   in 118 ms>
  <GC(21): mark: 103 ms, sweep: 15 ms, compact: 0 ms>
  <GC(21): refs: soft 0 (age >= 32), weak 0, final 878, phantom 0>
  <AF[21]: completed in 118 ms
  >.
  ..
  ```

  Key things to look for in a verboseGC report are:
  – Time spent in garbage collection.

    Ideally, you want to be spending less than 5% of the time in GC. To determine percentage of time spent in GC, divide the time it took to complete the collection by the time since the last AF and multiply the result by 100. For example,

    ```
    118/32225 * 100 = 0.366%
    ```

    If you are spending more than 5% of your time in GC and if GC is occurring frequently, you may need to increase your Java heap size.
  – Growth in the allocated heap.

To determine this, look at the %free. You want to make sure the number is not continuing to decline. If the %free continues to decline you are experiencing a gradual growth in allocated heap from GC to GC which could indicate that your application has a memory leak.

You can also use the MVS console command, *modify display, jvmheap* to display JVM heap information. See ″Modify command″ for details. In addition, you can check the server activity and interval SMF records. The JVM heap size is also made available to PMI and can be monitored using the Tivoli Performance Viewer.

z/OS or OS/390 operating system tuning tips

This section provides tuning tips for various components of z/OS or OS/390.

- CTRACE

  The first place to review is your CTRACE configuration. Ensure that all components are either set to MIN or OFF. To display the CTRACE options for all components on your system, issue the following command from the operator console:

  ```
  D TRACE,COMP=ALL
  ```

  To change the setting for an individual component to its minimum tracing value, use the following command (where 'xxx' is the component):

  ```
  TRACE CT,OFF,COMP=xxxx
  ```

  This will eliminate any unnecessary overhead of collecting trace information that is not being used. Often during debug, CTRACE is turned on for a component and not shut off when the problem is resolved.
- SMF

  Ensure that you are not collecting more SMF data than you need. Review the SMFPRMxx to ensure that only the minimum number of records are being collected.

  Use SMF 92 or 120 only for diagnostics.

  – SMF Type 92

    SMF Type 92 records are created each time an HFS file is opened, closed, deleted, and so forth. Almost every web server request references HFS files, so thousands of SMF Type 92 records are created. Unless you specifically need this information, turn off SMF Type 92 records. In the following example, we have disabled the collection of SMF type 92 records:

    Example:

    ```
    ACTIVE,
    DSNAME(SYS1.&.SYSNAME..SMF.MAN1;SYS1.&SYSNAME..SMF.MAN2;),
    NOPROMPT,
    REC(PERM),
    MAXDORM(3000),
    STATUS(010000),
    JWT(0510),
    SID(&SYSNAME;(1:4)),
    LISTDSN,
    SYS(NOTYPE(19,40,92)),
    INTVAL(30),
    SYNCVAL(00),
    SYS(DETAIL,INTERVAL(SMF,SYNC)),
    SYS(EXITS(IEFACTRT,IEFUJI,IEFU29,IEFU83,IEFU84,IEFU85,IEFUJV,IEFUSI))
    ```

  – SMF Type 120

    You may find that running with SMF 120 records in production is appropriate, since these records give information specific to WebSphere applications such as response time for J2EE artifiacts, bytes transferred, and so forth. If you do choose to run with SMF 120 records enabled, we recommend that you use server interval SMF records and container interval SMF records rather than server activity records and container activity records. For details of the SMF 120 record, refer to Record Type 120 (78) - WebSphere for z/OS performance statistics.

For steps involved in controlling collection of SMF 120 records refer to Enabling SMF recording. To enable specific record types, specify the following properties:
- server_SMF_server_activity_enabled=0
- server_SMF_server_interval_enabled=1
- server_SMF_container_activity_enabled=0
- server_SMF_container_interval_enabled=1
- server_SMF_web_container_activity_enabled=0
- server_SMF_web_container_interval_enabled=1
- server_SMF_interval_length=1800

- You might also want to review your DB2 records and the standard RMF written SMF records, and ensure that the SMF datasets are allocated optimally. Information on ensuring a high performance SMF recording environment can be found in the chapter on Customizing SMF in *z/OS MVS System Management Facilities (SMF)*.

Related information

Record Type 120 (78) - WebSphere for z/OS performance statistics
The following section defines the SMF Record Type 120 (78) - WebSphere for z/OS performance statistics.

Resource Recovery Service (RRS) tuning tips for z/OS

- For best throughput, use coupling facility (CF) logger.

  DASD logger can limit your throughput because it is I/O-sensitive. The CF logger has much more throughput (in one measurement, the CF logger was six times faster than the DASD logger). Throughput will benefit from moving the RRS logs in logger to a coupling facility (CF) logstream. Doing so will help transactions complete quickly and not require any DASD I/O. If it's not possible to use CF logs, use well performing DASD and make sure the logs are allocated with large CI sizes.
- Ensure that your logger configuration is optimal by using SMF 88 records.

  See the tuning section of *z/OS MVS Setting Up a Sysplex* or the chapter on System Logger Accounting in *z/OS MVS System Management Facilities (SMF)* for details. In any case, you should monitor the logger to ensure that there is a sufficient size in the CF and that offloading is not impacting the overall throughput. The transaction logs are one of the only shared I/O intensive resources in the mainline and can affect throughput dramatically if they are mistuned.
- Set adequate default values for the LOGR policy.

  Default values of LOGR policy may have an impact on performance. We recommend the default settings in the table below.

Table 2. Recommended default setting for LOGR

Log Stream	Initial Size	Size
RM.DATA	1 MB	1MB
MAIN.UR	5 MB	50 MB
DELAYED .UR	5 MB	50 MB
RESTART	1 MB	5 MB
ARCHIVE	5 MB	50 MB

- Review XA Resource Managers log sizes.

  If you are using XA Resource Managers and you have chosen to put the logs in the logger, you may have to review the log sizes. As of this writing, we cannot give specific recommendations.
- Eliminate archive log if not needed.

  If you don't need the archive log, we recommend that you eliminate it since it can introduce extra DASD I/Os. The archive log contains the results of completed transactions. Normally, the archive log is not needed. Following is an example of disabling archive logging.

  Example:

```
//STEP1 EXEC PGM=IXCMIAPU
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
    DATA TYPE(LOGR)
    DELETE LOGSTREAM NAME(ATR.WITPLEX.ARCHIVE)

    DELETE LOGSTREAM NAME(ATR.WITPLEX.MAIN.UR)
    DELETE LOGSTREAM NAME(ATR.WITPLEX.RESTART)
    DELETE LOGSTREAM NAME(ATR.WITPLEX.RM.DATA)
    DELETE LOGSTREAM NAME(ATR.WITPLEX.DELAYED.UR)
    DELETE STRUCTURE NAME(RRSSTRUCT1)
/*
//STEP2 EXEC PGM=IXCMIAPU
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
    DATA TYPE(LOGR)
    DEFINE STRUCTURE NAME(RRSSTRUCT1)
           LOGSNUM(9)


    DEFINE LOGSTREAM NAME(ATR.WITPLEX.MAIN.UR)
           STRUCTNAME(RRSSTRUCT1)
           STG_DUPLEX(YES)
           DUPLEXMODE(UNCOND)
           LS_DATACLAS(SYSPLEX)
           LS_STORCLAS(LOGGER)
           HLQ(IXGLOGR)
           AUTODELETE(YES)
           RETPD(3)
    DEFINE LOGSTREAM NAME(ATR.WITPLEX.RESTART)
           STRUCTNAME(RRSSTRUCT1)
           STG_DUPLEX(YES)
           DUPLEXMODE(UNCOND)
           LS_DATACLAS(SYSPLEX)
           LS_STORCLAS(LOGGER)
           HLQ(IXGLOGR)
           AUTODELETE(YES)
           RETPD(3)
    DEFINE LOGSTREAM NAME(ATR.WITPLEX.RM.DATA)
           STRUCTNAME(RRSSTRUCT1)
           STG_DUPLEX(YES)
           DUPLEXMODE(UNCOND)
           LS_DATACLAS(SYSPLEX)
           LS_STORCLAS(LOGGER)
           HLQ(IXGLOGR)
           AUTODELETE(YES)
           RETPD(3)
    DEFINE LOGSTREAM NAME(ATR.WITPLEX.DELAYED.UR)
           STRUCTNAME(RRSSTRUCT1)
           STG_DUPLEX(YES)
           DUPLEXMODE(UNCOND)
           LS_DATACLAS(SYSPLEX)
           LS_STORCLAS(LOGGER)
           HLQ(IXGLOGR)
           AUTODELETE(YES)
           RETPD(3)
/*

//* DEFINE LOGSTREAM NAME(ATR.WITPLEX.ARCHIVE)
           //* STRUCTNAME(RRSSTRUCT1)
           //* STG_DUPLEX(YES)
           //* DUPLEXMODE(UNCOND)
           //* LS_DATACLAS(SYSPLEX)
           //* LS_STORCLAS(LOGGER)
           //* HLQ(IXGLOGR)
           //* AUTODELETE(YES)
           //* RETPD(3)
```

LE tuning tips for z/OS

- For best performance, use the LPALSTxx parmlib member to ensure that LE and C++ runtimes are loaded into LPA, as shown in the following example:

  Example: sys1.parmlib(LPALSTxx):

```
********************************* Top of Data ********************
USER.LPALIB,
ISF.SISFLPA,                         SDSF
CEE.SCEELPA,
                            LANGUAGE ENVIRONMENT
CBC.SCLBDLL,                         C++ RUNTIME
.
.
.

******************************** Bottom of Data ******************
```

- Ensure that you are **NOT** using the following options during production:
  - RPTSTG(ON)
  - RPTOPTS(ON)
  - HEAPCHK(ON)
- Turn LE heappools on.

  If you are running a client on z/OS, setting the following: SET LEPARM='HEAPP(ON)' in a shell script, turns on LE heappools, which should improve the performance of the client.
- Fine tune the LE Heap options.

Fine tuning the LE heap:

The LE Heap is an area of storage management to be concerned with. For servers, IBM has compiled default values for HEAP and HEAPPOOL into the server main programs. These are good starting points for simple applications. To fine tune the LE Heap settings, use the following procedure:

1. Generate a report on storage utilization for your application servers. Use the LE function RPTSTG(ON) in a SET LEPARM= statement in JCL as shown in the example:.

   ```
   SET LEPARM='RPTOPTS(ON),RPTSTG(ON)'
   ```

   Results appear in servant joblog.
2. To bring the server down cleanly, use the following VARY command:

   ```
   VARY WLM,APPLENV=xxxx,QUIESCE
   ```

   The following example shows the servant SYSPRINT DD output from the `RPTSTG(ON)` option.

   Example:

   ```
   .   .   .
   0    HEAP statistics:
          Initial size:                                  83886080

          Increment size:                                 5242880
          Total heap storage used (sugg. initial size):  184809328

          Successful Get Heap requests:                    426551
          Successful Free Heap requests:                   424262
          Number of segments allocated:                         1
          Number of segments freed:                             0
      .   .   .

     Suggested Percentages for current Cell Sizes:
       HEAPP(ON,8,6,16,4,80,42,808,45,960,5,2048,20)
   ```

```
  Suggested Cell Sizes:
    HEAPP(ON,32,,80,,192,,520,,1232,,2048,)

 . . .
```

3. Take the heap values from the ″Suggested Cell Sizes″ line in the storage utilization report and use them in another RPTSTG(ON) function to get another report on storage utilization as shown below:

   ```
   SET LEPARM='RPTOPTS(ON),RPTSTG(ON,32,,80,,192,,520,,1232,,2048,)'
   ```

   The following example shows the servant joblog output from the RPTOPTS(ON),RPTSTG(ON,32,,80,,192,,520,,1232,,2048,) option.

   Example:

   ```
      .   .
   0    HEAP statistics:
          Initial size:                                  83886080

          Increment size:                                 5242880
          Total heap storage used (sugg. initial size):   195803218

          Successful Get Heap requests:                    426551
          Successful Free Heap requests:                   424262
          Number of segments allocated:                         1
          Number of segments freed:                             0
      .   .   .

     Suggested Percentages for current Cell Sizes:
       HEAPP(ON,32,8,80,43,192,48,520,20,1232,5,2048,20)

     Suggested Cell Sizes:
       HEAPP(ON,32,,80,,192,,520,,1232,,2048,)
    . . .
   ```

4. Take the heap values from the ″Suggested Percentages for current Cell Sizes″ line of the second storage utilization report and use them in another RPTSTG(ON) function to get a third report on storage utilization as shown below:

   ```
   SET LEPARM='RPTOPTS(ON),RPTSTG(ON,32,8,80,43,192,48,520,20,1232,5,2048,20)'
   ```

   The following example shows the servant joblog output from the RPTOPTS(ON),RPTSTG(ON,32,8,80,43,192,48,520,20,1232,5,2048,20) option.

   Example:

   ```
      .   .
   0    HEAP statistics:
          Initial size:                                  83886080

          Increment size:                                 5242880
          Total heap storage used (sugg. initial size):   198372130

          Successful Get Heap requests:                    426551
          Successful Free Heap requests:                   424262
          Number of segments allocated:                         1
          Number of segments freed:                             0
      .   .   .

     Suggested Percentages for current Cell Sizes:
       HEAPP(ON,32,8,80,43,192,48,520,20,1232,5,2048,20)
     Suggested Cell Sizes:
       HEAPP(ON,32,,80,,192,,520,,1232,,2048,)
    . . .
   ```

5. On the third storage utilization report, look for the ″Total heap storage used (sugg. initial size):″ line and use this value for your initial LE heap setting. For example, in the report in third report example this value is 198372130.

6. Make sure that you remove RPTSTG since it does incur a small performance penalty to collect the storage use information.
7. For your client programs that run on z/OS or OS/390, we recommend that you at least specify HEAPP(ON) on the proc of your client to get the default LE heappools. LE will be providing additional pools (more than 6) and larger than 2048MB cell size in future releases of z/OS. You may be able to take advantage of these increased pools and cell sizes, if you have that service on your system.
8. If you use LE HEAPCHECK, make sure to turn it off once you have ensured that your code doesn't include any uninitialized storage. HEAPCHECK can be very expensive.

UNIX System Services (USS) tuning tips for z/OS

WebSphere Application Server for z/OS V5 no longer requires or recommends the shared file system for the configuration files, since it maintains its own mechanism for managing this data in a cluster. However, WebSphere for z/OS does require the shared files system for XA partner logs. Your application may also use the shared file system. This article provides some basic tuning information for the shared file system.

For basic z/OS UNIX System Services performance information, refer to the following web site: http://www.ibm.com/servers/eserver/zseries/ebusiness/perform.html

- Mount the shared file system R/O.

  Special consideration needs to be made to file system access when you run in a sysplex. If you mount the file system R/W in a shared file system environment, only one system will have local access to the files. All other systems have remote access to the files which negatively affects performance. You may choose to put all of the files for WebSphere in their own mountable file system and mount it R/O to improve performance. However, to change your current application or install new applications, the file system must be mounted R/W. You will need to put operational procedures in place to ensure that the file system is mounted R/W when updating or installing applications.
- HFS files caching.

  HFS Files Caching Read/Write files are cached in kernel dataspaces. In order to determine what files would be good candidates for file caching you can use SMF 92 records.

  Initial cache size is defined in BPXPRMxx.
- Consider using zFS.

  z/OS has introduced a new file system called zFS which should provide improved file system access. You may benefit from using the zFS for your UNIX file system. See *z/OS UNIX System Services Planning* for more information.
- Use the filecache command.

  High activity, read-only files can be cached in the USS kernel using the filecache command. Access to files in the filecache can be much more efficient than access to files in the shared file system, even if the shared file system files are cached in dataspaces. GRS latch contention, which sometimes is an issue for frequently accessed files shared file system, will not affect files in the filecache.

  To filecache important files at startup, you can add filecache command to your /etc/rc file. Unfortunately, files which are modified after being added to the filecache may not be eligible for caching until the file system is unmounted and remounted, or until the system is re-IPLed. Refer to *z/OS UNIX System Services Command Reference* for more information about the filecache command.

  Example of using the filecache command:

  ```
  /usr/sbin/filecache -a /usr/lpp/WebSphere/V5R0M0/MQSeries/java/samples/base/de_DE/mqsample.html
  ```

Workload management (WLM) tuning tips for z/OS

If you are running z/OS 1.2 or higher, you may choose to use the dynamic application environment. In that case, use the Administrative console to turn on the dynamic application environment. Use the Administrative console to provide the JCL proc name for the servant and the JCL Parm for the servant. Whether or not you use the dynamic application environment, you will need to follow the instructions below to set the WLM goals.

Setting the WLM goals properly can have a very significant effect on application throughput. The WebSphere for z/OS system address spaces should be given a fairly high priority. As work comes into the system, the work classification of the enclaves should be based on your business goals.

- Classify location service daemons and controllers as SYSSTC or high velocity.
- Use STC classification rules to classify velocity goals for application servers.

  Java garbage collection runs under this classification. Java GC is a CPU and storage intensive process, so if you set the velocity goal too high GC could consume more of the system resources than desired. On the other hand, if your Java heap is correctly tuned, GC for each server region should run no more than 5% of the time. Also, providing proper priority to GC processing is necessary since other work in the server region is stopped during much of the time GC is running.

  JSP compiles run under this classification. If your system is configured to do these compiles at runtime, setting the velocity goal too low could result in longer delays waiting for JSP compiles to complete.

  Application work is actually classified under the work manager.
- Application Environment for work running under servants
  - Subsystem type = CB
  - Classify based on Application Server name and Userid
  - Percentage response time goal is recommended

    It is usually a good idea to make the goals achievable. For example, a goal that 80% of the work will complete in .25 seconds is a typical goal. Velocity goals for application work are not meaningful and should be avoided.
  - Provide a high velocity default service class for CB transactions (Default is SYSOTHER)
- Set your Application environment to ″No Limit″
  - Required if you need more than one servant per application server.
  - Under WLM, you can control how many servants can be started for each server. If you need more than one servant in a server make sure that ″No Limit″ is selected for the application environment associated with your server. For information about setting up WLM performance goals, see *z/OS MVS Planning: Workload Management*.

    Example:

    ```
    Application-Environment  Notes  Options  Help
    --------------------------------------------------------------------------
                        Modify an Application Environment
    Command ===> ______________________________________________________________

    Application Environment Name . : BBOASR2
    Description  . . . . . . . . . . WAS.V40.WB02 Application server
    Subsystem Type . . . . . . . . . CB
    Procedure Name . . . . . . . . . BBOASR2S
    Start Parameters . . . . . . . . IWMSSNM=&IWMSSNM
                                     ___________________________________________
                                     ___________________________________________

    Limit on starting server address spaces for a subsystem instance:
    1   1.  No limit

        2.  Single address space per system
        3.  Single address space per sysplex
    ```

    Note: When the WLM configuration is set to no limit, you can control the maximum and minimum number of servants by specifying the product variables wlm_maximumSRCount=*x* and wlm_minimumSRCount=*y*. To specify these variables, click **Severs** > **Application servers** and go the application server page. **Caution:** If you specify wlm_maximumSRCount you must ensure that you specify a wlm_maximumSRCount value that is greater than or equal to the number of service classes you have defined for this application environment. Failure to do so can result in timeouts due to an insufficient number of server regions.
  - Results reported in RMF Postprocessor workload activity report:
    - Transactions per second (not always the same as client tran rate)

- Average response times (and distrubution of response times)
- CPU time used
- Percent response time associated with various delays

Related tasks

Defining application server processes

Using IWMARIN0 (example of steps for defining an application environment)

Tuning for subsystems

Steps involved in tuning the z/OS subsystems to optimize WebSphere performance include:
- DB2 tuning tips for z/OS
- RACF tuning tips for z/OS
- TCP/IP tuning tips for z/OS
- Message tuning tips for z/OS
- GRS tuning tips for z/OS
- Java virtual machine (JVM) tuning tips for z/OS
- CICS tuning tips for z/OS

DB2 tuning tips for z/OS

Performance tuning for DB2 is usually critical to the overall performance of a WebSphere for z/OS application. DB2 is often the preferred datastore for a session or EJB. There are many books that cover DB2 tuning-we can't possibly provide as thorough a treatment of DB2 here as we would like. Listed here are some basic guidelines for DB2 tuning as well as some guidelines for tuning DB2 for WebSphere. For more complete information on DB2 tuning refer to DB2 Universal Database for OS/390 and z/OS Administration Guide Version 7 Document Number SC26-9931-02.

General DB2 tuning tips:

- First, ensure that your DB2 logs are large enough, are allocated on the fastest volumes you have, and make sure they have optimal CI sizes.
- Next, ensure that you have tuned your bufferpools so that the most often-read data is in memory as much as possible. Use ESTOR and hyperpools.
- You many want to consider pre-formatting tables that are going to be heavily used. This avoids formatting at runtime.

DB2 for WebSphere tuning tips:

- Turn off any JDBC tracing in db2sqljjdbc.properties.

  Example:
  ```
  DB2SQLJSSID=DB2
  DB2SQLJATTACHTYPE=RRSAF
  DB2SQLJMULTICONTEXT=YES
  DB2SQLJDBRMLIB=MVSDSOM.DB2710.DBRMLIB.DATA
  #DB2SQLJ_TRACE_FILENAME=/tmp/mytrc
  ```
- We recommend that you ensure indexes are defined on all your object primary keys. Failure to do so will result in costly tablespace scans.
- Ensure that, once your tables are sufficiently populated, you do a re-org to compact the tables. Executing RUNSTATS will ensure that the DB2 catalog statistics about table and column sizes and accesses are most current so that the best access patterns are chosen by the optimizer.
- You will have to define more connections called threads in DB2. WebSphere for z/OS uses a lot of threads. Sometimes this is the source of throughput bottlenecks since the server will wait at the create thread until one is available.
- Make sure you are current with JDBC maintenance. Many performance improvements have been made to JDBC recently. To determine the JDBC maintenance level, enter the following from the shell:
  ```
  java COM.ibm.db2os390.sqlj.util.DB2DriverInfo
  ```

If this returns a class not found, either you are at a level of the driver that is older and doesn't support this command or you have not issued the command properly.

- We recommend that you enable dynamic statement caching in DB2. To do this, modify your ZPARMS to say `CACHEDYN(YES) MAXKEEPD(16K)`. Depending on the application, this can make a very significant improvement in DB2 performance. Specifically, it can help JDBC and LDAP query.
- Increase DB2 checkpoint interval settings to a large value. To do this, modify your ZPARMS to include `CHKFREQ=xxxxx`, where xxxxx is set at a high value when doing benchmarks. On production systems there are other valid reasons to keep checkpoint frequencies lower, however.

Example: This example identifies zparm values discussed in this article.

```
//DB2INSTE   JOB MSGCLASS=H,CLASS=A,NOTIFY=IBMUSER
/*JOBPARM SYSAFF=*
//*******************************************************************
//* JOB NAME = DSNTIJUZ
//*
//* DESCRIPTIVE NAME = INSTALLATION JOB STREAM
//*
//*    LICENSED MATERIALS - PROPERTY OF IBM
//*    5675-DB2
//*    (C) COPYRIGHT 1982, 2000 IBM CORP.  ALL RIGHTS RESERVED.
//*
//*    STATUS = VERSION 7
//*
//* FUNCTION = DSNZPARM AND DSNHDECP UPDATES
//*
//* PSEUDOCODE =
//*   DSNTIZA  STEP  ASSEMBLE DSN6.... MACROS, CREATE DSNZPARM
//*   DSNTIZL  STEP  LINK EDIT DSNZPARM
//*   DSNTLOG  STEP  UPDATE PASSWORDS
//*   DSNTIZP  STEP  ASSEMBLE DSNHDECP DATA-ONLY LOAD MODULE
//*   DSNTIZQ  STEP  LINK EDIT DSNHDECP LOAD MODULE
//*   DSNTIMQ  STEP  SMP/E PROCESSING FOR DSNHDECP
//*
//* NOTES = STEP DSNTIMQ MUST BE CUSTOMIZED FOR SMP.  SEE THE NOTES
//*         NOTES PRECEDING STEP DSNTIMQ BEFORE RUNNING THIS JOB.
//*
//*  LOGLOAD=16000000,
//*********************************************************************/
//*
//DSNTIZA EXEC PGM=ASMA90,PARM='OBJECT,NODECK'
//STEPLIB DD DSN=ASM.SASMMOD1,DISP=SHR
//SYSLIB   DD  DISP=SHR,
//         DSN=DB2710.SDSNMACS
//         DD  DISP=SHR,
//         DSN=SYS1.MACLIB
//SYSLIN   DD  DSN=&LOADSET(DSNTILMP),DISP=(NEW,PASS),
//             UNIT=SYSALLDA,
//             SPACE=(800,(50,50,2)),DCB=(BLKSIZE=800)
//SYSPRINT DD  SYSOUT=*
//SYSUDUMP DD  SYSOUT=*
//SYSUT1   DD  UNIT=SYSALLDA,SPACE=(800,(50,50),,,ROUND)
//SYSUT2   DD  UNIT=SYSALLDA,SPACE=(800,(50,50),,,ROUND)
//SYSUT3   DD  UNIT=SYSALLDA,SPACE=(800,(50,50),,,ROUND)
//SYSIN    DD  *
    DSN6ENV    MVS=XA
    DSN6SPRM   RESTART,                 X
               .
               .
               .
               AUTH=YES,
                                               X
               AUTHCACH=1024,                                  X
               BINDNV=BINDADD,                                 X
               BMPTOUT=4,                                      X
```

```
            CACHEDYN=YES,
                                        X
            .
            .
            .
            MAXKEEPD=16000,
                                      X
            .
            .
            .
DSN6ARVP    ALCUNIT=CYL,                                     X
            .
            .
            .
DSN6LOGP    DEALLCT=(0),                                     X
            .
            .
            .
DSN6SYSP    AUDITST=NO,                                      X
            BACKODUR=5,                                      X
           CHKFREQ=16000000,
                                    X
            CONDBAT=400,                                     X
            CTHREAD=1200,                                    X
            DBPROTCL=PRIVATE,                                X
            DLDFREQ=5,                                       X
            DSSTIME=5,                                       X
            EXTRAREQ=100,                                    X
            EXTRASRV=100,                                    X
            EXTSEC=NO,                                       X
            IDBACK=1800,
                                          X
            .
            .
            .
          //*
```

Related information

Creating and configuring a JDBC provider using the administrative console

WebSphere Application Server tuning tips for use with DB2:
Prepared statement caching effects on DB2 for OS/390 JDBC cursor objects

WebSphere Application Server uses JDBC prepared statement caching as a performance enhancing feature. If you are using this feature together with DB2 for OS/390, be aware of the potential impact on the number of DB2 JDBC cursor objects available.

When you obtain a *ResultSet* object by executing a *PreparedStatement* object, a DB2 JDBC cursor object is bound to it until the corresponding DB2 prepared statement is closed. This happens when the DB2 *Connection* object is released from the WebSphere Application Server connection pool. From an application perspective, the result set, prepared statement, and connection are each closed in turn. However, the underlying DB2 *Connection* is pooled by the WebSphere Application Server, the underlying DB2 *PreparedStatement* is cached by the application server, and each underlying DB2 JDBC cursor object associated with each *ResultSet* created on this *PreparedStatement* object is not yet freed.

Each *PreparedStatement* object in the cache can have one or more result sets associated with it. If a result set is opened and not closed, even though you close the connection, that result set is still associated with the prepared statement in the cache. Each of the result sets has a unique JDBC cursor attached to it. This cursor is kept by the statement and is not released until the prepared statement is cleared from the WebSphere Application Server cache.

If there are more of the cached statements than there are cursors, eventually the execution of a *PreparedStatement* object results in the following exception:

```
java.sql.SQLException: DB2SQLJJDBCProfile Error: No more JDBC Cursors without hold
```

Some WebSphere Application Server tuning suggestions to help avoid this problem are:

1. Decrease the *statement cache size* setting on the DB2 for OS/390 data source definition. Setting this value to zero (0) eliminates statement caching, but causes a noticeable performance impact.
2. Decrease the *minConnections* connection pool setting on the DB2 for OS/390 data source definition.
3. Decrease the *Aged Timeout* connection pool setting on the DB2 for OS/390 data source definition. However, it is **NOT** recommended that you set this to zero (0), as this disables the Aged Timeout function.

RACF tuning tips for z/OS

Follow these guidelines for RACF tuning:

- As is always the case, don't turn things on unless you need them. In general, the cost of security has been highly optimized. However, if you don't need EJBROLEs, then don't enable the class in RACF.
- Use the RACLIST to place into memory those items that will improve performance. Specifically, ensure that you RACLIST (if used):
  - CBIND
  - EJBROLE
  - SERVER
  - STARTED

  Example:

  ```
  RACLIST (CBIND, EJBROLE, SERVER, STARTED)
  ```
- Use of things like SSL come at a price. If you are a heavy SSL user, ensure that you have appropriate hardware, such as PCI crypto cards, to speed up the handshake process.
- Here's how you define the BPX.SAFFASTPATH facility class profile. This profile allows you to bypass SAF calls which can be used to audit successful shared file system accesses.
  - Define the facility class profile to RACF.

    ```
    RDEFINE FACILITY BPX.SAFFASTPATH UACC(NONE)
    ```
  - Activate this change by doing one of the following:
    - re-IPL
    - invoke the SETOMVS or SET OMVS operator commands.

  Note: Do not use this option if you need to audit successful HFS accesses or if you use the IRRSXT00 exit to control HFS access.
- Use VLF caching of the UIDs and GIDs as shown in the example COFVLFxx parmlib member below:

  Example: sys1.parmlib(COFVLFxx):

  ```
  ********************************* Top of Data ********************.
  .

  CLASS NAME(IRRGMAP) EMAJ(GMAP)
  CLASS NAME(IRRUMAP) EMAJ(UMAP)
  CLASS NAME(IRRGTS) EMAJ(GTS)
  CLASS NAME(IRRACEE) EMAJ(ACEE)
  .
  ******************************** Bottom of Data ******************
  ```

  To avoid a costly scan of the RACF databases, make sure all HFS files have valid GIDs and UIDs.

TCP/IP tuning tips for z/OS

TCP/IP can be the source of some significant remote method delays. Follow these tips to tune TCP/IP:

- First, ensure that you have defined enough sockets to your system and that the default socket time-out of 180 seconds is not too high. To allow enough sockets, update the BPXPRMxx parmlib member:

- Set MAXSOCKETS for the AF_INET filesystem high enough.
- Set MAXFILEPROC high enough.

  We recommend setting MAXSOCKETS and MAXFILEPROC to at least 5000 for low-throughput, 10000 for medium-throughput, and 35000 for high-throughput WebSphere transaction environments. Setting high values for these parameters should not cause excessive use of resources unless the sockets or files are actually allocated.

Example:

```
/* Open/MVS Parmlib Member                                        */
/* CHANGE HISTORY:                                                */
/*   01/31/02 AEK Increased MAXSOCKETS on AF_UNIX from 10000 to 50000*/
/*              per request from Michael Everett                  */
/*   10/02/01 JAB Set up shared HFS                               */

/* KERNEL RESOURCES              DEFAULT            MIN MAX         */
/* =======================      ================== === =========== */
   .
   .
   MAXFILEPROC(65535)           /* 64              3   65535       */

   .
   .
    NETWORK DOMAINNAME(AF_INET) DOMAINNUMBER(2) MAXSOCKETS(30000)
   .
```

- Next check the specification of the port in TCPIP profile dataset to ensure that NODELAYACKS is specified as follows:

```
PORT 8082 TCP NODELAYACKS
```

  In your runs, changing this could improve throughput by as much as 50% (this is particularly useful when dealing with trivial workloads). This setting is important for good performance when running SSL.
- You should ensure that your DNS configuration is optimized so that lookups for frequently-used servers and clients are being cached.

  Caching is sometimes related to the name server's Time To Live (TTL) value. On the one hand, setting the TTL high will ensure good cache hits. However, setting it high also means that, if the Daemon goes down, it will take a while for everyone in the network to be aware of it.

  A good way to verify that your DNS configuration is optimized is to issue the oping and onslookup USS commands. Make sure they respond in a reasonable amount of time.
- Increase the size of the TCPIP send and receive buffers from the default of 16K to at least 64K. This is the size of the buffers including control information beyond what is present in the data that you are sending in your application.To do this specify the following:

```
TCPCONFIG TCPSENDBFRSIZE 65535
          TCPRCVBUFRSIZE 65535
```

  Note: It would not be unreasonable, in some cases, to specify 256K buffers.
- Increase the default listen backlog. This is used to buffer spikes in new connections which come with a protocol like HTTP. The default listen backlog is 10 requests. We recommend that you increase this value to something larger. For example:

```
protocol_http_backlog=100
protocol_https_backlog=100
protocol_iiop_backlog=100
protocol_ssl_backlog=100
```

- Reduce the finwait2 time.

  In the most demanding benchmarks you may find that even defining 65K sockets and file descriptors does not give you enough 'free' sockets to run 100%. When a socket is closed (for example, no longer needed) it is not made available immediately. Instead it is placed into a state called finwait2 (this is what shows up in the netstat -s command). It waits there for a period of time before it is made available in the free pool. The default for this is 600 seconds.

Note: Unless you have trouble using up sockets, we recommend that you leave this set to the default value.

If you are using z/OS V1.2 or above, you can control the amount of time the socket stays in finwait2 state by specifying the following in the configuration file:

```
FINWAIT2TIME 60
```

MQ/JMS tuning tips for z/OS

JMS tuning tips

WebSphere Application Server Version 5 supports 3 different JMS providers:
- Integral JMS provider (IJP)
- MQ series JMS provider
- Generic JMS - used when a third-party JMS provider is used.

Tuning JMS involves the use of the JMS provider, design requirements of the applications, and the use of message driven beans (MDB). The JMS provider could be any of the three listed above. Application design depends on the requirements of the applications, which fall under two main categories:
- Quality of service
  - Guaranteed delivery
  - Persistence
  - Transaction
  - Security
- Messaging programming style
  - Point to point (P2P)
  - Publish/Subscribe

When using IJP as the JMS provider, we highly recommend that you not change any settings, since WebSphere has a view of what it thinks is going on. The following tuning tips are applicable in case of both IJP and MQ series JMS

Non-persitenet, non-durable and transaction-not-supported messages perform better, but at the cost that they are non-recoverable due to the lack of persistence.
- Turn off all tracing. Use the display trace command to get the trace number.

  ```
  D TRACE
  ```

  Then use the stop trace global command to turn off the specific trace number

  ```
  STOP TRACE (G) TNO(xxx)
  ```
- Create long-lived queue manager connections rather than creating and destroying connections on every message.

  Reuse connections and sessions.
- Use bindings mode if your queue manager and client both reside on the same zOS image. Bindings mode is a cross-memory interface that eliminates the need for MQ to call TCP/IP. It can be implemented by not setting the TransportType on the connection. Use bindings only in case of MQ series JMS provider
- Client acknowledgements required that an ack be received from the client before another message is sent. Auto acknowledgements are a better choice and reduce delays.

- Performance will be best if the client and queue manager have the same CCSID so the queue manager does not need to translate message headers.
- Small messages are best. Use of system resources and throughput will be proportional to the size of MQ messages. However, if you must send large amounts of data, one larger message is preferable to multiple small ones. If using very large messages (for example, over 1MB) see ″WebSphere MQ Tips″.
- Persistent, transacted messages perform better than persisted non-transacted messages because multiple MQ commits can be delayed until the end of the transaction.
- Express (nonpersistent) messages perform most optimally, so use them if your application does not require persistence.
- MQ Application Server Framework (ASF) generally adds more overhead then non-ASF messaging.
- MQ local queues defined as DEFSOPT(SHARED) with the SHARE option, and shared by multiple threads or processes generally perform better than non-shared queues and use fewer resources.
- MDBs are asynchronous by nature, therefore, should never be forced to run in a serial mode (maxsession=1). Set a realistic number for maxsession for the number of concurrent sessions.

MQ tuning tips

- Turn off MQ tracing in the MQ ZPARMS by specifying:.

```
TRACSTR=NO,          TRACING AUTO START               X
```

Example:

```
//*
//*             Assemble step for CSQ6LOGP
//*
//LOGP   EXEC PGM=ASMA90,PARM='DECK,NOOBJECT,LIST,XREF(SHORT)',
//             REGION=4M

//SYSLIB   DD DSN=MQSERIES.V5R3M0.SCSQMACS,DISP=SHR


//         DD DSN=SYS1.MACLIB,DISP=SHR
//SYSUT1   DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSPUNCH DD DSN=&&LOGP;,
//            UNIT=SYSDA,DISP=(,PASS),
//            SPACE=(400,(100,100,1))
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
         CSQ6LOGP INBUFF=60,         LOG INPUT BUFFER SIZE (KB)        X
               MAXRTU=2,             MAX ALLOCATED ARCHIVE LOG UNITS   X
               DEALLCT=0,            ARCHIVE LOG DEALLOCATE INTERVAL   X
               MAXARCH=500,          MAX ARCHIVE LOG VOLUMES           X
               OFFLOAD=YES,          ARCHIVING ACTIVE                  X
               OUTBUFF=4000,         LOG OUTPUT BUFFER SIZE (KB)       X
               TWOACTV=YES,          DUAL ACTIVE LOGGING               X
               TWOARCH=YES,          DUAL ARCHIVE LOGGING              X
               TWOBSDS=YES,          DUAL BSDS                         X
               WRTHRSH=20            ACTIVE LOG BUFFERS
         END
/*
//*
//*             Assemble step for CSQ6ARVP
//*
//ARVP   EXEC PGM=ASMA90,COND=(0,NE),
//             PARM='DECK,NOOBJECT,LIST,XREF(SHORT)',
//             REGION=4M

//SYSLIB   DD DSN=MQSERIES.V5R3M0.SCSQMACS,DISP=SHR


//         DD DSN=SYS1.MACLIB,DISP=SHR
//SYSUT1   DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSPUNCH DD DSN=&&ARVP;,
//            UNIT=SYSDA,DISP=(,PASS),
//            SPACE=(400,(100,100,1))
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
         CSQ6ARVP ALCUNIT=BLK,       UNITS FOR PRIQTY/SECQTY           X
               ARCPFX1=WIT.MQ1.WITA, DSN PREFIX FOR ARCHIVE LOG 1      X
               ARCPFX2=WIT.MQ2.WITA, DSN PREFIX FOR ARCHIVE LOG 2      X
               ARCRETN=9999,         ARCHIVE LOG RETENION TIME (DAYS)  X
               ARCWRTC=(1,3,4),      ARCHIVE WTO ROUTE CODE            X
               ARCWTOR=NO,           PROMPT BEFORE ARCHIVE LOG MOUNT   X
               BLKSIZE=24576,        ARCHIVE LOG BLOCKSIZE             X
               CATALOG=YES,          CATALOG ARCHIVE LOG DATA SETS     X
               COMPACT=NO,           ARCHIVE LOGS COMPACTED            X
               PRIQTY=4320,          PRIMARY SPACE ALLOCATION          X
               PROTECT=NO,           DISCRETE SECURITY PROFILES        X
               QUIESCE=5,            MAX QUIESCE TIME (SECS)           X
               SECQTY=540,           SECONDARY SPACE ALLOCATION        X
               TSTAMP=YES,           TIMESTAMP SUFFIX IN DSN           X
               UNIT=DASD,            ARCHIVE LOG DEVICE TYPE 1         X
               UNIT2=                ARCHIVE LOG DEVICE TYPE 2
         END
/*
//*
//*             Assemble step for CSQ6SYSP
//*
//SYSP   EXEC PGM=ASMA90,COND=(0,NE),
//             PARM='DECK,NOOBJECT,LIST,XREF(SHORT)',
//             REGION=4M

//SYSLIB   DD DSN=MQSERIES.V5R3M0.SCSQMACS,DISP=SHR


//         DD DSN=SYS1.MACLIB,DISP=SHR
//SYSUT1   DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSPUNCH DD DSN=&&SYSP;,
//            UNIT=SYSDA,DISP=(,PASS),
//            SPACE=(400,(100,100,1))
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *

CSQ6SYSP CTHREAD=600,       TOTAL NUMBER OF CONNECTIONS
 X
               CMDUSER=CSQOPR,       DEFAULT USERID FOR COMMANDS       X
               EXITLIM=30,           EXIT TIMEOUT (SEC)                X
               EXITTCB=8,            NUMBER OF EXIT SERVER TCBS        X

IDBACK=500,            NUMBER OF NON-TSO CONNECTIONS
X
               IDFORE=100,           NUMBER OF TSO CONNECTIONS         X

LOGLOAD=900000,       LOG RECORD CHECKPOINT NUMBER
X
               OTMACON=(,,DFSYDRU0,2147483647,CSQ),  OTMA PARAMETERS   X
               QMCCSID=0,            QMGR CCSID                        X
               QSGDATA=(,,,),        QUEUE-SHARING GROUP DATA          X
               RESAUDIT=YES,         RESLEVEL AUDITING                 X
               ROUTCDE=1,            DEFAULT WTO ROUTE CODE            X
               SMFACCT=NO,           GATHER SMF ACCOUNTING             X
               SMFSTAT=NO,           GATHER SMF STATS                  X
               STATIME=30,           STATISTICS RECORD INTERVAL (MIN)  X
               TRACSTR=NO,           TRACING AUTO START                X

               TRACTBL=99,           GLOBAL TRACE TABLE SIZE X4K       X
               WLMTIME=30,           WLM QUEUE SCAN INTERVAL (SEC)     X
               SERVICE=0             IBM SERVICE USE ONLY
         END
/*
```

```
//*
//*  LINKEDIT CSQARVP, CSQLOGP and CSQSYSP into a
//*  system parameter module.
//*
//LKED   EXEC PGM=IEWL,COND=(0,NE),
//      PARM='SIZE=(900K,124K),RENT,NCAL,LIST,AMODE=31,RMODE=ANY'
//*
//*   OUPUT AUTHORIZED APF LIBRARY FOR THE NEW SYSTEM
//*   PARAMETER MODULE.
//*
//SYSLMOD  DD DSN=SYS1.WITA.LINKLIB,DISP=SHR
//SYSUT1   DD UNIT=SYSDA,DCB=BLKSIZE=1024,
//            SPACE=(1024,(200,20))
//SYSPRINT DD SYSOUT=*
//ARVP     DD DSN=&&ARVP;,DISP=(OLD,DELETE)
//LOGP     DD DSN=&&LOGP;,DISP=(OLD,DELETE)
//SYSP     DD DSN=&&SYSP;,DISP=(OLD,DELETE)
//*
//*   LOAD LIBRARY containing the default system
//*   parameter module (CSQZPARM).
//*
//OLDLOAD  DD DSN=MQSERIES.V520.SCSQAUTH,DISP=SHR
//SYSLIN   DD *
   INCLUDE SYSP
   INCLUDE ARVP
   INCLUDE LOGP
   INCLUDE OLDLOAD(CSQZPARM)
 ENTRY CSQZMSTR
 NAME CSQZPARM(R)                  Your system parameter module name
/*
```

- Similarly, you are advised to turn off tracing in the channel initiator. Unlike base MQ tracing, this parameter cannot be enabled dynamically. To turn tracing back on for debug purposes, you will need to reassemble your MQ XPARMS. Enabling channel initiator tracing can degrade your system by 5-10%.

  The variable to set is as follows:

  ```
  TRAXSTR=NO,       START TRACE AUTOMATICALLY  YES|NO
  ```

- For improved performance in the laboratory, the following WebSphere MQ tuning parameters required modification from their default settings.The difference in most cases was significant.
  - Optimize the number of concurrent queue manager connections

    ```
    CTHREAD parameter of CSQ6SYSP (Maximum number of  concurrent
                                   connections to MQ)
    IDBACK parameter of CSQ6SYSP (Maximum number of background concurrent
                                  threads connected to MQ)
    ```

    CTHREAD is the maximum number of simultaneous connections to the queue manager. It should be greater than, or equal to, the sum of IDFORE and IDBACK. IDFORE is the number of concurrent TSO connections to WebSphere MQ, and IDBACK is the number of concurrent background connections, which includes jms threads. If any or all of these parameters are too low, applications will be unable to connect to the queue manager. These parameters are found in the CSQ6SYSP section of the MQ ZPARMS. You can update the MQ ZPARMS at any time; the updates will take effect the next time you restart the queue manager.
  - Adjust the WebSphere MQ checkpoint interval and active log buffers

    ```
    LOGLOAD parameter of CSQ6SYSP (number of log records written
                                   before a checkpoint)
    WRTHRSH parameter of CSQ6LOGP (Number of active log buffers)
    ```

    When using persistent messages, it is particularly important to pay attention to logging characteristics. MQ logs should always be placed on high performance volumes with DASD fast write enabled. MQ logs are often the single most significant bottleneck when using persistent messages. The LOGLOAD parameter controls the number of log records written before a checkpoint (assuming, of course, that the log is large enough to hold this number of records). Checkpoints generally should occur no more frequently than every 5 or 6 minutes. If your MQ checkpoints are more frequent, you may need to increase either the size of the logs, the value of LOGLOAD, or both. In the laboratory, we use a LOGLOAD value of 900000 because we execute high throughput jms workloads that are very write-intensive. When the space on the log is exhausted, a log switch occurs which disrupts performance. You can avoid frequent log switches by increasing the size of the log(s).

WRTHRSH is the number of active log buffers, and determines how much data is held in memory before a log write occurs. If you have a high I/O rate to your log volume(s), you may wish to increase this parameter. In the laboratory, we use a value of 200.

Generally speaking, your message rate for persistent messages cannot exceed the bandwidth capacity of your slowest log volume. For example, if your were sending messages of 5KB at a throughput rate of 300 per second, you would be writing at least 1.9 MB of data per second to the log (this is roughly 1.3KB plus the user message size for each logged message).

– Specify the size of the archive logs

```
SECQTY parameter of CSQ6ARVP  (archive log space allocation)
PRIQTY parameter of CSQ6ARVP  (archive log space allocation)
ALCUNIT parameter of CSQ6ARVP  (archive Log allocation unit)
TWOARCH parameter of CSQ6LOGP  (dual archive logs)
```

The PRIQTY and SECQTY parameters control the size of the archive logs. Generally it is best to allocate them (ALCUNIT) in cylinders in lieu of blocks. Depending upon your data integrity requirements, you may or may not choose to have dual archive logging.

– Specify the number of buffers

```
BUFFERS  (number of buffers on the DEFINE BUFFERPOOL statement)
```

Use the DEFINE BUFFERPOOL statement to specify the number of buffers. It is important to insure the number of buffers is large enough to hold at least an entire message (and its headers). Otherwise, WebSphere MQ will be forced to write to the Page Data sets for every message. For example, a 100MB message requires at least 26000 pages in the bufferpool. MQ Buffer Manager statistics can be used to determine the number of times a buffer was unavailable. See Support Pac MP1B, MQSeries for OS/390 V5.2 - Interpreting accounting and statistics data.

– Specify queue definitions

```
INDXTYPE(NONE)  (index specification for queue definitions) or
INDXTYPE(CORRELID)
DEFPSIST(NO)
```

Unless your applications retrieve messages by other than correlation ID (which is the case for jms publish/subscribe) or message ID, it is normally best not to specify message selectors on queue definitions. You should, however, make sure you have specified INDXTYPE(CORRELID) on the SYSTEM.JMS.ND/D queues, and/or on the SYSTEM.JMS.ND.CC / .D.CC queues, and/or on any shared message queues for publish/subscribe. Specify DEFPSIST(NO) unless you want messages on a particular queue to default to persistent. Since DEFPSIST(YES) will affect performance, make sure you really want persistent messages.

– Specify channel definitions

```
BATCHSZ parameter for queue definitions (Number of messages
                                        sent as a batch)
```

We did not modify the BATCHSZ parameter in the laboratory.

GRS tuning tips for z/OS

WebSphere for z/OS uses GRS to communicate information between servers in a sysplex. When there are multiple servers defined in a system or a sysplex, a request may end up on the wrong server. To determine where the transaction is running WebSphere uses GRS. Therefore, if you are using global transactions, WebSphere will issue an enqueue for that transaction at the start of the transaction and hold on to that enqueue until the transaction ends. WebSphere for z/OS uses GRS enqueues for the following:

- Two-phase commit transactions involving more than one server
- HTTP sessions in memory
- Stateful EJBs
- ″Sticky″ transactions to keep track of pseudo-conversational states.
- If you **are not** in a sysplex, you should configure GRS=NONE.
- If you **are** in a sysplex, we strongly recommend GRS=STAR.

This requires configuring GRS to use the coupling facility. See the GRS documentation for details on setting this up.

Java virtual machine (JVM) tuning tips for z/OS

Before you begin:

1. Ensure that you have the most recent version of JVM that is supported by WebSphere for z/OS. As of this writing, the JVM level for WebSphere Application Server for z/OS V5 is 1.3.1 and PTF 20.
2. Have the most recent PTFs, since almost every PTF level has improved performance of the JVM.
3. Have sufficient JVM Heap Size. Refer to "Java virtual machine storage tuning tips for z/OS" on page 66for a discussion of this setting.

How to view or set: Use the WebSphere Administrative console :

1. Click **Servers > Application Servers >** ***server_name*** **> Process Definition > Java Virtual Machine**
2. Select the options listed in the section belong on the Configuration Tab.

- Run with the JIT (Just In Time) compiler active.

  In the General Properties section of the Configuration Tab, ensure that Disable JIT is not selected. The default is JIT support enabled.
- Do not specify the debug version of the JVM `libjava_g` in your libpath. Severe performance degradation is likely when running with the debug version of the JVM.
- Have Classpath point to only the classes you need (the classes that are referenced most frequently should be located near the front of the path, if possible).

  In the General Properties section of the Configuration Tab, enter the Classpath in the text box of the Classpath option.
- Verify the Classpath as part of the Java configuration.
- To speed up JVM initialization and improve server startup time, specify the following command line arguments in the General JVM Arguments field in the General Properties section of the Configuration Tab.

  ```
  -Xquickstart
  -Xverify:none
  ```

  These options can reduce servant startup time by as much as 40%. However, they will reduce runtime throughput by about 8%.
- Sometimes poor performance is caused by a missing class. The class loader will look in it's tables of already loaded classes and if the class is not found to be already loaded it will search for it. This search process can cause a high amount of I/O activity to the HFS volumes. To determine if this is the problem you can collect CTRACE records from the file system. Once you determine which class is not being found you can repair the problem by providing the class or by removing the need for it.

  Note: Please see the ″Applications″ section in the WebSphere Application Server for z/OS V5.0 InfoCenter, access to which can be obtained through the WebSphere forz/OS library Web site http://www.ibm.com/software/webservers/appserv/zos_os390/library.html for more information on ″Application client troubleshooting tips.″
- For more information about JVM performance on z/OS and OS/390, see http://www.s390.ibm.com/java/perform.html.

Related information

"Java virtual machine storage tuning tips for z/OS" on page 66

Application client troubleshooting tips

CICS tuning tips for z/OS

These recommendations only apply to WebSphere applications that access CICS.

The LGDFINT system initialization parameter specifies the log defer interval used by CICS log manager when determining how long to delay a forced journal write request before invoking the MVS system logger. The value is specified in milliseconds. Performance evaluations of typical CICS transaction workloads have shown that the default setting of 5 milliseconds gives the best balance between response time and central processor cost. Be aware that CICS performance can be adversely affected by a change to the log defer interval value. Too high a value will delay CICS transaction throughput due to the additional wait before invoking the MVS system logger. An example of a scenario where a reduction in the log defer interval might be beneficial to CICS transaction throughout would be where many forced log writes are being issued, and little concurrent task activity is occurring. Such tasks will spend considerable amounts of their elapsed time waiting for the log defer period to expire. In such a situation, there is limited advantage in delaying a call to the MVS system logger to write out a log buffer, since few other log records will be added to the buffer during the delay period.

- Set the LGDFINT system initialization parameter to 5.

  While CICS is running, you can use the CEMT SET SYSTEM[LOGDEFER(*value*)] command to alter the LGDFINT setting dynamically.
- Set the CICS RECEIVECOUNT value high enough to handle all concurrent EXCI pipes on the system.

  The default value is 4. You set this value in the EXCI sessions resource definition.

For more detailed information on CICS, refer to the *CICS Performance Guide*.

Tuning the WebSphere Application Server for z/OS runtime

Steps involved in tuning the WebSphere Application Server for z/OS runtime to optimize performance include reviewing the:
- WebSphere Application Server for z/OS configuration
- Internal tracing tips for WebSphere Application Server for z/OS
- Location of executable programs tips for z/OS
- Security tuning tips for z/OS
- Servlet and EJB integrated runtime tuning tips for z/OS

Review the WebSphere for z/OS configuration

The first thing to do is review the WebSphere for z/OS configuration. One simple way to do this is to look in your application control and server regions in SDSF. When each server starts, the runtime prints out the current configuration data in the joblog.

Internal tracing tips for WebSphere for z/OS

WebSphere traces can be extremely helpful in detecting and diagnosing problems. By properly setting trace options, you can capture the information needed to detect problems without significant performance overhead.

- Ensure that you are not collecting more diagnostic data than you need.

  You should check your WebSphere for z/OS tracing options to ensure that ras_trace_defaultTracingLevel=0 or 1, and that ras_trace_basic and ras_trace_detail are not set.

  How to view or set: Use the WebSphere administrative console:
  1. Click **Environment > Manage WebSphere Variables**.
  2. On the Configuration Tab check for any of these variables in the name field and observe the variable setting in the value field.
  3. To change or set a variable, specify the variable in the name field and specify the setting in the value field. You can also describe the setting in the description field on this tab.

- If you use any level of tracing, including ras_trace_defaultTracingLevel=1, ensure that you set ras_trace_outputLocation to BUFFER.

  ras_trace_defaultTracingLevel=1 will write exceptions to the trace log as well as to the ERROR log.
  - It is best to trace to CTRACE.

    If you are tracing to sysprint with ras_trace_defaultTracingLevel=3, you may experience an almost 100% throughput degradation. If you are tracing to CTRACE, however, you may only experience a 15% degradation in throughput.
- Set the ras_trace_BufferCount=4 and ras_trace_BufferSize=128.

  This will get 512KB of storage for the trace buffers (the minimum allowed) and reduce memory requirements.
- Make sure you disable JRAS tracing.

  To do this, look for the following lines in the trace.dat file pointed to by the JVM properties file:

  ```
  com.ibm.ejs.*=all=disable

  com.ibm.ws390.orb=all=disable
  ```

  Ensure that both lines are set to **=disable** or delete the two lines altogether.

  Note: If ras_trace_outputLocation is set, you may be tracing and not know it.

Location of executable programs tips for z/OS

The next thing to review in the configuration is where your program code is located. IBM recommends that you install as much of the WebSphere for z/OS code in LPA as is reasonable, and the remainder in the linklist. This ensures that you have eliminated any unnecessary steplibs which can adversely affect performance. If you must use STEPLIBs, verify that any `STEPLIB DD`s in the controller and servant procs do not point to any unnecessary libraries. Refer to “UNIX System Services (USS) tuning tips for z/OS” on page 72 for USS shared file system tuning considerations.

If you choose to not put most of the runtime in LPA, you may find that your processor storage gets a bigger workout as the load increases. At a minimum, WebSphere for z/OS will start three address spaces, so that any code that is not shared will load three copies rather than one. As the load increases, many more servants may start and will contribute additional load on processor storage.

Review the `PATH` statement to ensure that only required programs are in the PATH and that the order of the PATH places frequently-referenced programs in the front.

Related information

“UNIX System Services (USS) tuning tips for z/OS” on page 72

Security tuning tips for z/OS

As a general rule, two things happen when you increase security: the cost per transaction increases and throughput decreases.

By default, WebSphere for z/OS runs with security off. With security turned off there is virtually no overhead. However, we recommend that you run with security enabled, even though the runtime will always incur a small price to collect and carry the security credential information for users and the server.

- When a SAF (RACF or equivalent) class is active, the number of profiles in a class will affect the overall performance of the check.

  Placing these profiles in a (RACLISTed) memory table will improve the performance of the access checks. Audit controls on access checks also affect performance. Usually, you audit failures and not successes. Audit events are logged to DASD and will increase the overhead of the access check. Since all the security authorization checks are done with SAF (RACF or equivalent), you can choose to enable and disable SAF classes to control security. A disabled class will cost a negligible amount of overhead.
- Use a minimum number of EJBROLEs on methods.

If you are using EJBROLEs, specifying more roles on a method will lead to more access checks that need to be executed and a slower overall method dispatch. If you are not using EJBROLEs, do not activate the class.

- If you do not need Java 2 security, you should disable it.

  For instructions on how to disable Java 2 security, refer to Configuring Java 2 security
- Use the lowest level of authorization consistent with your security needs.

  You have several options when dealing with authentication:
  - **Local authentication:** Local authentication is the fastest type because it is highly optimized.
  - **UserID and password authentication:** Authentication that utilizes a userID and password has a high first-call cost and a lower cost with each subsequent call.
  - **Kerberos security authentication:** We have not adequately characterized the cost of kerberos security yet.
  - **SSL security authentication:** SSL security is notorious in the industry for its performance overhead. Luckily, there is a lot of assists available from hardware to make this reasonable on z/OS.
- If using SSL, select the lowest level of encryption consistent with your security requirements.

  WebSphere allows you to select which cipher suites you use. The cipher suites dictate the encryption strength of the connection. The higher the encryption strength, the greater the impact on performance. For more information refer to Secure Sockets Layer performance tips

Related tasks

Configuring Java 2 security

Related information

Session Management settings
Use this page to manage HTTP session support. This support includes specifying a session tracking mechanism, setting maximum in-memory session count, controlling overflow, and configuring session timeout.

Secure Sockets Layer performance tips

Servlet and EJB integrated runtime tuning tips for z/OS

If you are running with an HTTP server (DGW) as well as WebSphere on your z/OS system, you can run servlets and JSPs under the HTTP server or you can run servlets and JSPs under WebSphere in an environment called the servlet/EJB integrated runtime. Normally, servlets and JSPs are run under the HTTP server since this is more efficient. However, the integrated runtime provides a more powerful environment and the performance impact of using the integrated runtime is only significant if servlets/JSPs perform only trivial functions.

If you are running just a servlet, the integrated runtime may not initially show an improvement in performance. However, when a servlet is calling on an EJB, it will benefit greatly from the integrated runtime. Essentially, the integrated runtime will convert the remote method calls to local in-process EJB invocations (which are much faster).

The Servlet/EJB integrated runtime provides functions such as access to transactional resource managers and it is the only way to get true J2EE compliance with WebSphere for z/OS.

Tuning for J2EE applications

Steps involved in tuning the J2EE applications performance include:
- Topology planning and performance
- J2EE container and applications
- J2EE application programming tips
- Tuning for SOAP

Topology planning and performance

Topology can have a significant effect on WebSphere performance. This article describes some of the topology considerations you should be aware of when configuring and installing WebSphere for z/OS.

- Single server or multiple servers?

  WebSphere for z/OS gives you the ability to install your application either in a single server or spread it across multiple servers. There are many reasons for partitioning your application. However, for performance, placing your application all in the same server will always provide better performance than partitioning it. If you do choose to partition your application across servers, you will get better performance if there are at least replica servers on each system in the sysplex. The WebSphere for z/OS runtime will try to keep calls local to the system if it can, which will, for example, use local interprocess calls rather than sockets.

- One tran or multiple trans?

  You also have a choice of running server regions with an isolation policy of one tran per server region or multiple trans per server region. From a performance perspective, running more threads in a server region will consume less memory but at the cost of thread contention. This contention is application-dependent. We generally recommend the use of multiple trans unless you run into contention problems.

  Specify the threads setting using the *server_region_workload_profile*. The variables include:
  - ISOLATE - sets the value to 1 thread.
  - CPUBOUND
  - IOBOUND - default
  - LONGWAIT - 40

  The thread value increases with each variable to the maximum number available with the LONGWAIT setting (40). For more information refer to ORB services advanced settings

  Note: Please see the ″Servers″ section in the WebSphere Application Server for z/OS V5.0 InfoCenter, access to which can be obtained through the WebSphere forz/OS library Web site http://www.ibm.com/software/webservers/appserv/zos_os390/library.html for more information on ORB services advanced settings.

- Local client or remote client?

  On a local client, the client and the optimized communication are done on the same system. This has some additional client CPU costs but less communication cost. On a remote client, the client cost is replaced by the additional communication overhead of sockets. The CPU cost on either system is almost equivalent. Latency is better for a local client than for a remote client, meaning you will get better response time with a local client.

- One copy of a server or many clones?

  You can define more than one copy of a server on a system. These copies are called clones. We have found slight improvements in performance when running with a couple of clones as opposed to just one (very large configuration). While there is some benefit, IBM does not recommend, at this time, the creation of replicated control regions for the sole purpose of improving performance. We do, however, recommend them for eliminating a single point of failure and for handling rolling upgrades without introducing an outage.

  Related information

  ORB services advanced settings
  Use this page to support ORB service advanced settings. This support includes ORB listener keep alive, ORB SSL listener keep alive, control threads, workload profile.

J2EE container and applications

In WebSphere for z/OS, there are several types of EJBs and several transaction policies supported. Selection of each type has performance implications. While we won’t be able to give an exhaustive treatise on this yet, we will give some basic rules.

Enterprise bean development performance ramifications: There are three basic bean types in WebSphere for z/OS: session, entity, and message driven.

- Session beans

  Within a session bean in WebSphere for z/OS, there are stateless and stateful session beans.

  Stateless session bean
  : The lowest overhead type of bean. They are cheap to create, do very little automatically and, if not cleaned up by the application, will go away when the server terminates.

  Stateful session bean
  : The default for a stateful session bean is to not harden its state to a backing store except in the case of a controlled server shut down. In this configuration, a stateful bean is slightly more overhead than a stateless bean. The configuration overhead of hardening the stateful bean state at the end of each transaction has yet to be quantified.

- Entity beans

  In WebSphere Application Server for z/OS V5, entity beans come in two flavors: bean managed persistence (BMP) and container managed persistence (CMP).

  Since managing persistence is the responsibility of the bean in BMP, it really depends on the way the load and store is implemented whether a BMP is faster than a CMP. CMP beans manage persistence. The CMP bean implementation is highly optimized and will often produce better performance than a typical BMP bean. Additional improvements are expected which will add even more flexibility to CMP beans.

- Message-driven beans (MDBs)
- Marking a bean method with the `readonly` extended deployment descriptor will cause the runtime to avoid writing the state of the bean back out. Specify this value on a method when you know that the method does not update any attributes of the bean.

  Related information

  Application clients

  Message-driven beans - an overview

Transaction policy tuning tips: There are seven transaction policies in WebSphere for z/OS:

- TRANSACTION_REQUIRES
- TRANSACTION_REQUIRES_NEW
- TRANSACTION_SUPPORTS
- TRANSACTION_NOT_SUPPORTED
- TRANSACTION_BEAN_MANAGED
- TRANSACTION_NEVER
- TRANSACTION_MANDATORY

These transaction policies control how EJBs are associated with global or local transactions. Generally, local transactions are the fastest.

J2EE application programming tips

These programming tips relate to the following topics:

- **JavaServer pages (JSPs)**
  - Disable session state of JSPs.

    <%@ page language="java" contentType="text/html" session="false" %>
  - By default, JSPs will save session state

    <%@ page language="java" contentType="text/html" %>
  - Replace setProperties() calls in your JSPs with direct calls to the appropriate setxxx methods.
- **Java Database Connectivity (JDBC)**
  - Make sure you are at the current JDBC level.
  - Use prepared statements to allow dynamic statement cache of DB2 on z/OS.
  - Don't include literals in the prepared statements, use a parameter marker "?" to allow dynamic statement cache of DB2 on z/OS.

– Use the right getxxx method by each data type of DB2.
– Turn auto commit off when just read-only operations are performed.
– Use explicit connection context objects.
– When coding an iterator, you have a choice of named or positioned. For performance, we recommend positioned iterators.
– Close prepared statements before reusing the statement handle to prepare a different SQL statement within the same connection.
– As a bean developer, you have the choice of JDBC or SQLJ. JDBC makes use of dynamic SQL whereas SQLJ generally is static and uses pre-prepared plans. SQLJ requires an extra step to create and bind the plan whereas JDBC does not. SQLJ, as a general rule, is faster than JDBC.
– With JDBC and SQLJ, you are better off writing specific calls that retrieve just what you want rather than generic calls that retrieve the entire row. There is a high per-field cost.

Related tasks

Developing J2EE application client code

Tuning for SOAP

The Simple Object Access Protocol (SOAP) is a lightweight protocol which provides a mechanism to use XML for exchanging structured and typed information between peers in a decentralized, distributed environment.

- Specify noLocalCopies in servant.jvm.options (-Dcom.ibm.CORBA.iiop.noLocalCopies=1). This will allow passing of parameters by reference instead of by value. This only applies if you are exposing an EJB as a web service. Refer to Object Request Broker service settings in administrative console.
- Make certain that all traces are disabled unless you are actively debugging a problem.
- When defining transaction policies for your application, specify TX_NOT_SUPPORTED and select local transactions. Local transactions perform better than global transactions because WebSphere is not required to coordinate commit scope over multiple resource managers.
- Avoid passing empty attributes or empty elements in SOAP messages. Do not include extraneous and unneeded data in SOAP messages. If you can use document/literal style web services invocation to batch requests into a single SOAP message, this is preferable to sending multiple individual SOAP messages. SOAP applications will perform better with smaller SOAP messages containing fewer XML elements and especially fewer XML attributes. The contents of SOAP messages must be serialized and parsed. These are expensive operations and should be minimized. In other words, it is preferable to send 1, 10KB message than 10, 1KB messages. However, very large messages (for example, over 200KB) may impact system resources like memory.
- You may need to increase the default Java heap size. SOAP and XML (DOM) are storage-intensive and small heap sizes may result in excessive Java garbage collection. We found a heapsize of 256M (the default) was optimal for most test cases in the laboratory. You can monitor garbage collection using the verbose:gc Java directive.
- Insure TCP/IP send/receive buffers are large enough to hold the bulk of the xml messages that will be sent.
- Consider using a Document Model rather than the RPC model. It provides complete control over the format of the XML but requires additional programming effort.
- When using RPC-style messages, try to send strings if possible.
- Consider writing your own serializers and deserializers, avoiding reflection.
- Consider writing a servlet to use a SAX parser rather than the SOAP runtime if you require improved performance. Alternately, you can download and install Apache AXIS, or use the Web Services Technology Preview.

SOAP V 2.3 in WebSphere V 5.0.1:

One- to three-sentence description that will appear as the first paragraph of the finished article.

SOAP 2.3 has a number of enhancements over SOAP 2.2. They are described in full in http://ws.apache.org/soap/releases.html#v2.2. Some of the key enhancements in WebSphere V 5.0 are as follows:

- Support for document-oriented messaging
- Web Services Definition Language (WSDL) Version 1.1
- Universal Description, Discovery, and Integration, UDDI4J Version 2.0, logging
- Web Services Invocation Framework (WSIF)
- Web Services Caching
- Some minor SOAP performance enhancements
- Elimination of the Nagle Algorithm

Web Services is a more expensive protocol than HTTP or socket communication. It is best used where its benefits can be exploited. For example, for integration of decentralized distributed environment, where the clients have little knowledge of the application implementation. We do not recommend that programs running in the same JVM use Web Services as a means of communication or invocation. For obvious reasons, calling a method using SOAP generally has longer response time than other forms of invocation. XML parsing serialization/deserialization and network latency are all inhibitors to Web Services performance. There is no support for locally optimized invocation such that network protocols can be avoided when client and server are collocated.

We have observed, one of the most expensive operations in the processing of a SOAP message, whether by SOAP, AXIS or the Tech preview, is the deserialization of the inbound SOAP message. This step converts the message from an inbound string in wire format to an XML document. Therefore, if either the client or the server receives a large SOAP message, that entity normally has the highest CPU cost. We have found the CPU time to be similar for z/OS acting as either a SOAP server or a SOAP client as long as the inbound and outbound message sizes are comparable.

There are many forms of an XML message that are equivalent, for example, messages with additional white space are equivalent to messages with fewer blanks or spaces. Therefore, it is advisable to create SOAP messages without formatted nesting (pretty printing), which adds additional spaces. The XML parser must examine all characters, including blanks. Therefore, XML documents with additional blank characters will take longer to parse.

Document-oriented messaging, unlike RPC messaging, is not required to be synchronous. The UDDI Registry is a special purpose data base wherein, establishments can register the WSDL Service Interface Definition and the Service Implementation Definition for Web Services. WSDL describes the interfaces to the web service. This essentially makes them available to other establishments or business partners. WebSphere V 5.0 for z/OS also supports a Private UDDI Registry for private access to Web Services.

Tuning hardware capacity and settings

These parameters include considerations for selecting and configuring the hardware on which the application servers can run.

- **Optimize disk speed**
  - **Description:** Disk speed and configuration can have a dramatic effect on the performance of application servers that run applications that are heavily dependent on database support, that use extensive messaging, or are processing workflow. Using disk I/O subsystems that are optimized for performance, for example RAID array, are essential components for optimum application server performance in these environments.
  - **How to view or set:** None
  - **Default value:** None
  - **Recommended value:** Spread the disk processing across as many disks as possible to avoid contention issues that typically occur with 1 or 2 disk systems. Placing database tables on disks that are separate from the disks used for the database log files can reduce disk contention and improve throughput.

- **Increase processor speed and processor cache**
  - **Description:** In the absence of other bottlenecks, increasing the processor speed often helps throughput and response times. A processor with a larger L2 or L3 cache can yield higher throughput even if the processor speed is the same as a CPU with a smaller L2 or L3 cache.
  - **How to view or set:** None
  - **Default value:** None
  - **Recommended value:** None
- **Increase system memory**
  - **Description:** Increase memory to prevent the system from paging memory to disk, improving performance. Allow a minimum of 256MB of memory for each processor. Adjust the available memory when the system is paging and processor utilization is low because of the paging.
  - **How to view or set:** None
  - **Default value:** None
  - **Recommended value:** 512MB per application server
- **Run network cards and network switches at full duplex.**
  - **Description:** Running at half duplex decreases performance. Verify that the network speed of adapters, cables, switches, and other devices can accommodate the required throughput.
  - **How to view or set:** None
  - **Default value:** None
  - **Recommended value:** Make sure that the highest speed is in use on 10/100/1000 Ethernet networks.

Tuning applications

Application assembly tools are used to build J2EE components and modules into J2EE applications. Generally, assembling consists of defining application components and their attributes including enterprise beans, servlets and resource references. Many of these application configuration settings and attributes play an important role in the run-time performance of the deployed application.

5.0.1 5.0.2 Use the following information as a check list of important parameters and advice for finding optimal settings: 5.0.1 5.0.2

- EJB modules
  - Entity bean Bean Cache - Activate at and Bean Cache - Load at settings
  - Method extensions Isolation level and Access intent settings
  - Container transactions assembly settings
- Web modules
  - Web modules assembly settings
    - Distributable
    - Reload interval
    - Reload enabled
- Web components
  - Load on startup

Related tasks

5.0.2 + Assembling applications with the Assembly Toolkit
Assemble enterprise application modules (EAR files) from new or existing Java 2 Platform, Enterprise Edition (J2EE) Version 1.2 or 1.3 modules, including these archives: Web application archives (WAR), resource adapter archives (RAR), enterprise bean (EJB) JAR files, and application client archives (JAR). This packaging and configuration of code artifacts into application modules or stand-alone Web modules is necessary for deploying the applications onto the application server.

Chapter 2, “Tuning performance parameter index,” on page 63

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