Red Hat JBoss Enterprise Application Platform 8.0

Performance tuning for Red Hat JBoss Enterprise Application Platform

Instructions for evaluating Red Hat JBoss Enterprise Application Platform performance, and for configuring updates to improve performance.

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Legal Notice

Abstract

This book is a guide of performance tuning for Red Hat JBoss Enterprise Application Platform.

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PROVIDING FEEDBACK ON JBOSS EAP DOCUMENTATION

To report an error or to improve our documentation, log in to your Red Hat Jira account and submit an issue. If you do not have a Red Hat Jira account, then you will be prompted to create an account.

Procedure

1. Click the following link to **create a ticket**.
2. Enter a brief description of the issue in the **Summary**.
3. Provide a detailed description of the issue or enhancement in the **Description**. Include a URL to where the issue occurs in the documentation.
4. Clicking **Submit** creates and routes the issue to the appropriate documentation team.

MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Due to the enormity of this endeavor, these changes will be gradually implemented over upcoming releases. For more details on making our language more inclusive, see our CTO Chris Wright's message .

CHAPTER 1. INTRODUCTION TO PERFORMANCE TUNING

A JBoss EAP installation is optimized by default. However, configurations to your environment, applications, and use of JBoss EAP subsystems can impact performance, meaning additional configuration might be needed.

This guide provides optimization recommendations for common JBoss EAP use cases, as well as instructions for monitoring performance and diagnosing performance issues.

IMPORTANT

You should stress test and verify all performance configuration changes under anticipated conditions in a staging or testing environment prior to deploying them to production.

1.1. ABOUT THE USE OF EAP_HOME IN THIS DOCUMENT

In this document, the variable ***EAP_HOME*** is used to denote the path to the JBoss EAP installation. Replace this variable with the actual path to your JBoss EAP installation.

- If you installed the JBoss EAP compressed file, the install directory is the **jboss-eap-8.0** directory where you extracted the compressed archive.
- If you used the installer to install JBoss EAP, the default path for ***EAP_HOME*** is **${user.home}/EAP-8.0.0**:
  - For Red Hat Enterprise Linux and Solaris: **/home/*USER_NAME*/EAP-8.0.0/**
  - For Microsoft Windows: **C:\Users\*USER_NAME*\EAP-8.0.0\**
- If you used the JBoss Tools installer to install and configure the JBoss EAP server, the default path for ***EAP_HOME*** is **${user.home}/devstudio/runtimes/jboss-eap**:
  - For Red Hat Enterprise Linux: **/home/*USER_NAME*/devstudio/runtimes/jboss-eap/**
  - For Microsoft Windows: **C:\Users\*USER_NAME*\devstudio\runtimes\jboss-eap** or **C:\Documents and Settings\USER_NAME\devstudio\runtimes\jboss-eap\**

NOTE

If you set the **Target runtime** to **8.0** or a later runtime version in JBoss Tools, your project is compatible with the Jakarta EE 8 specification.

NOTE

EAP_HOME is not an environment variable. ***JBOSS_HOME*** is the environment variable used in scripts.

CHAPTER 2. MONITORING PERFORMANCE

You can monitor JBoss EAP performance using any tool that can examine JVMs running on your machine. Red Hat recommends that you use either JConsole, for which JBoss EAP includes a preconfigured wrapper script, or Java Mission Control (JMC). Both these tools provide basic monitoring of JVM processes, including memory usage, thread utilization, loaded classes, and other JVM metrics.

If you will be running one of these tools locally on the same machine that JBoss EAP is running on, then no configuration is necessary. However, if you will be running one of these tools to monitor JBoss EAP running on a remote machine, then some configuration is required for JBoss EAP to accept remote JMX connections.

2.1. CONFIGURING JBOSS EAP FOR REMOTE MONITORING CONNECTIONS

2.1.1. Configuring remote monitoring connections for a standalone server

Procedure

1. Ensure that you have created a management user. You might want to create a separate management user to monitor your JBoss EAP server.
2. When starting JBoss EAP, bind the management interface to the IP address that you will use to remotely monitor the server:

   ```
   $ EAP_HOME/bin/standalone.sh -bmanagement=IP_ADDRESS
   ```

   WARNING

   This exposes all the JBoss EAP management interfaces, including the management console and management CLI, to the specified network. Ensure that you only bind the management interface to a private network.

3. Use the following URI with your management user name and password in your JVM monitoring tool to connect to the JBoss EAP server. The URI below uses the default management port (**9990**).

   ```
   service:jmx:remote+http://IP_ADDRESS:9990
   ```

2.1.2. Configuring JBoss EAP remote monitoring connections for a managed domain host

Using the preceding procedure of binding the management interface on a managed domain host will only expose the host controller JVM for remote monitoring, and not the individual JBoss EAP servers running on that host.

To configure JBoss EAP to remotely monitor individual servers on a managed domain host, follow the procedure below.

Procedure

1. Create a new user in the **ApplicationRealm** that you will use to connect to the JBoss EAP servers for remote monitoring.

2. To configure the **remoting** subsystem to use Elytron, execute the following commands:

```
/profile=full/subsystem=jmx/remoting-connector=jmx:add(use-management-endpoint=false)
/socket-binding-group=full-sockets/socket-binding=remoting:add(port=4447)
/profile=full/subsystem=remoting/connector=remoting-connector:add(socket-binding=remoting,sasl-authentication-factory=application-sasl-authentication)
```

3. When starting your JBoss EAP managed domain host, bind one or both of the following interfaces to an IP address that you will use for monitoring.

   - If you want to connect to individual JBoss EAP server JVMs running on your managed domain host, bind the public interface:

   ```
   $ EAP_HOME/bin/domain.sh -b=IP_ADDRESS
   ```

   - If you want to connect to the JBoss EAP host controller JVM, also bind the management interface:

   ```
   $ EAP_HOME/bin/domain.sh -bmanagement=IP_ADDRESS
   ```

   WARNING

   This exposes all the JBoss EAP management interfaces, including the management console and management CLI, to the specified network. Ensure that you only bind the management interface to a private network.

4. Use the following details in your JVM monitoring tool:

   - To connect to individual JBoss EAP server JVMs running on your managed domain host, use the following URI with your **ApplicationRealm** user name and password that was created earlier.

   ```
   service:jmx:remote+http://IP_ADDRESS:4447
   ```

   To connect to different JBoss EAP servers on a single host, add the respective server's port offset value to the above port number.

   - To connect to the JBoss EAP host controller JVM, use the following URI with a management user name and password.

   ```
   service:jmx:remote+http://IP_ADDRESS:9990
   ```

2.2. JCONSOLE

A preconfigured JConsole wrapper script is bundled with JBoss EAP. Using this wrapper script ensures that all the required libraries are added to the class path, and also provides access to the JBoss EAP management CLI from within JConsole.

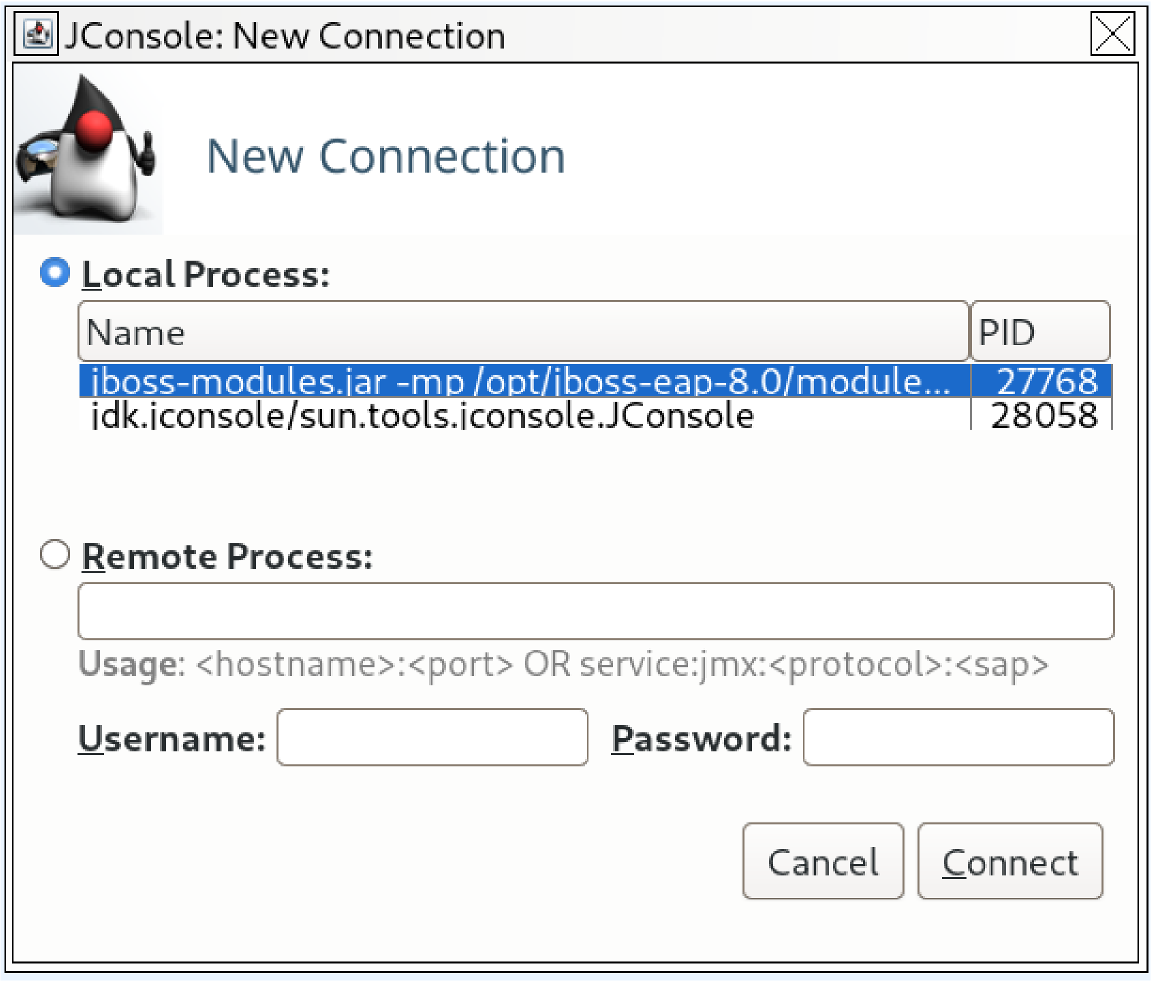
2.2.1. Connecting to a local JBoss EAP JVM using JConsole

To connect to a JBoss EAP JVM running on the same machine as JConsole:

Procedure

1. Run the **jconsole** script in ***EAP_HOME*/bin**.
2. Under **Local Process**, select the JBoss EAP JVM process that you want to monitor.
   - For a standalone JBoss EAP server, there is one JBoss EAP JVM process.

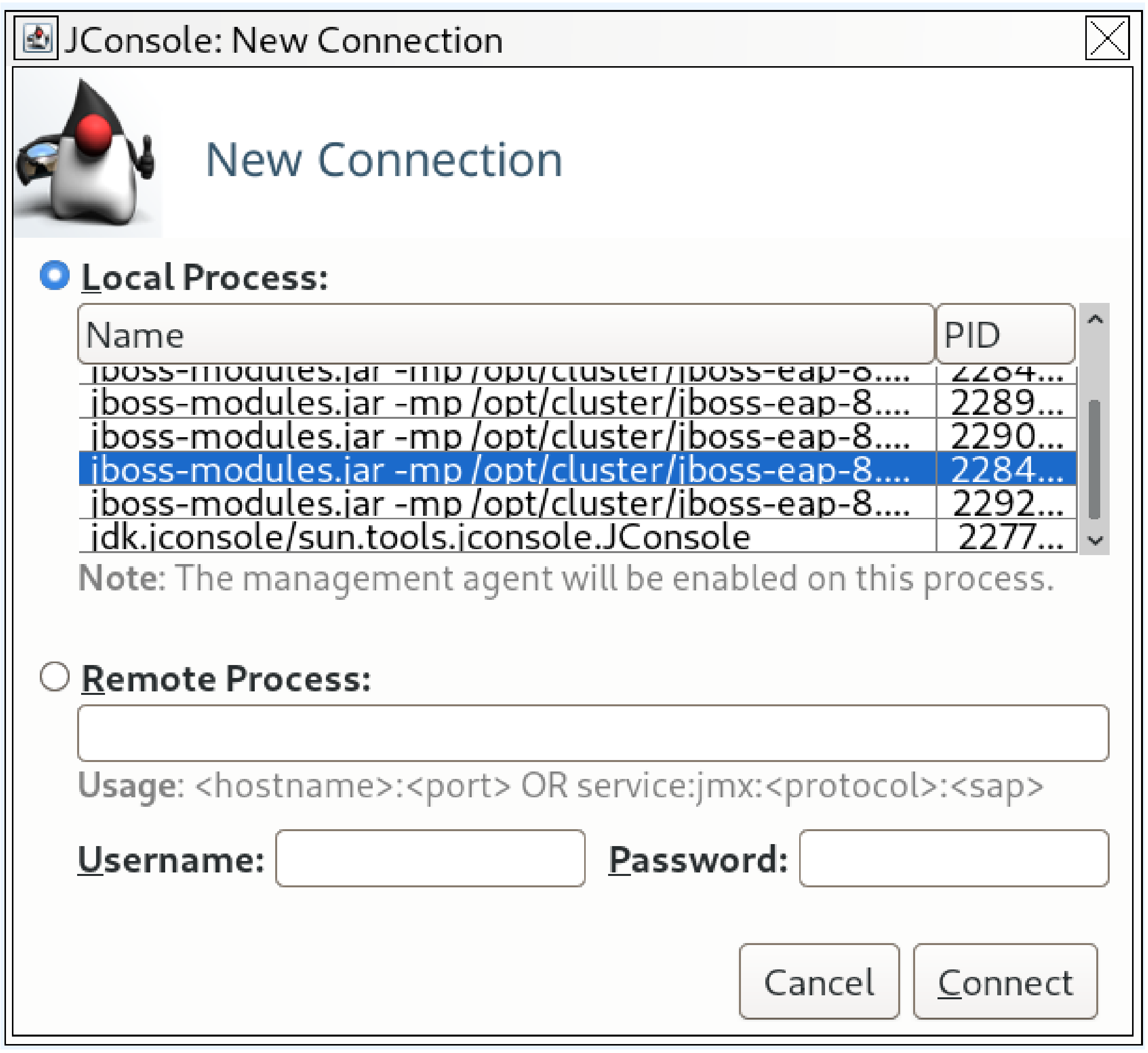
     Figure 2.1. JConsole Local Standalone JBoss EAP Server JVM

Name	PID
jboss-modules.jar -mp /opt/jboss-eap-8.0/module...	27768
jdk.jconsole/sun.tools.jconsole.JConsole	28058

   - A JBoss EAP managed domain host has multiple JVM processes you can connect to: a host controller JVM process, a process controller JVM process, and a JVM process for each JBoss EAP server on the host. You can determine which JVM you have connected to by looking at the JVM arguments.

Figure 2.2. JConsole Local Managed Domain JBoss EAP JVMs


JConsole: New Connection

New Connection

Local Process:

Name	PID
jboss-modules.jar -mp /opt/cluster/jboss-eap-8....	2284...
jboss-modules.jar -mp /opt/cluster/jboss-eap-8....	2289...
jboss-modules.jar -mp /opt/cluster/jboss-eap-8....	2290...
jboss-modules.jar -mp /opt/cluster/jboss-eap-8....	2284...
jboss-modules.jar -mp /opt/cluster/jboss-eap-8....	2292...
jdk.jconsole/sun.tools.jconsole.JConsole	2277...

Note: The management agent will be enabled on this process.

Remote Process:

Usage: <hostname>:<port> OR service:jmx:<protocol>:<sap>

Username: Password:

3. Click **Connect**.

2.2.2. Connecting to a Remote JBoss EAP JVM Using JConsole

You can use JConsole to connect to a remote JBoss EAP JVM using the **jconsole** script.

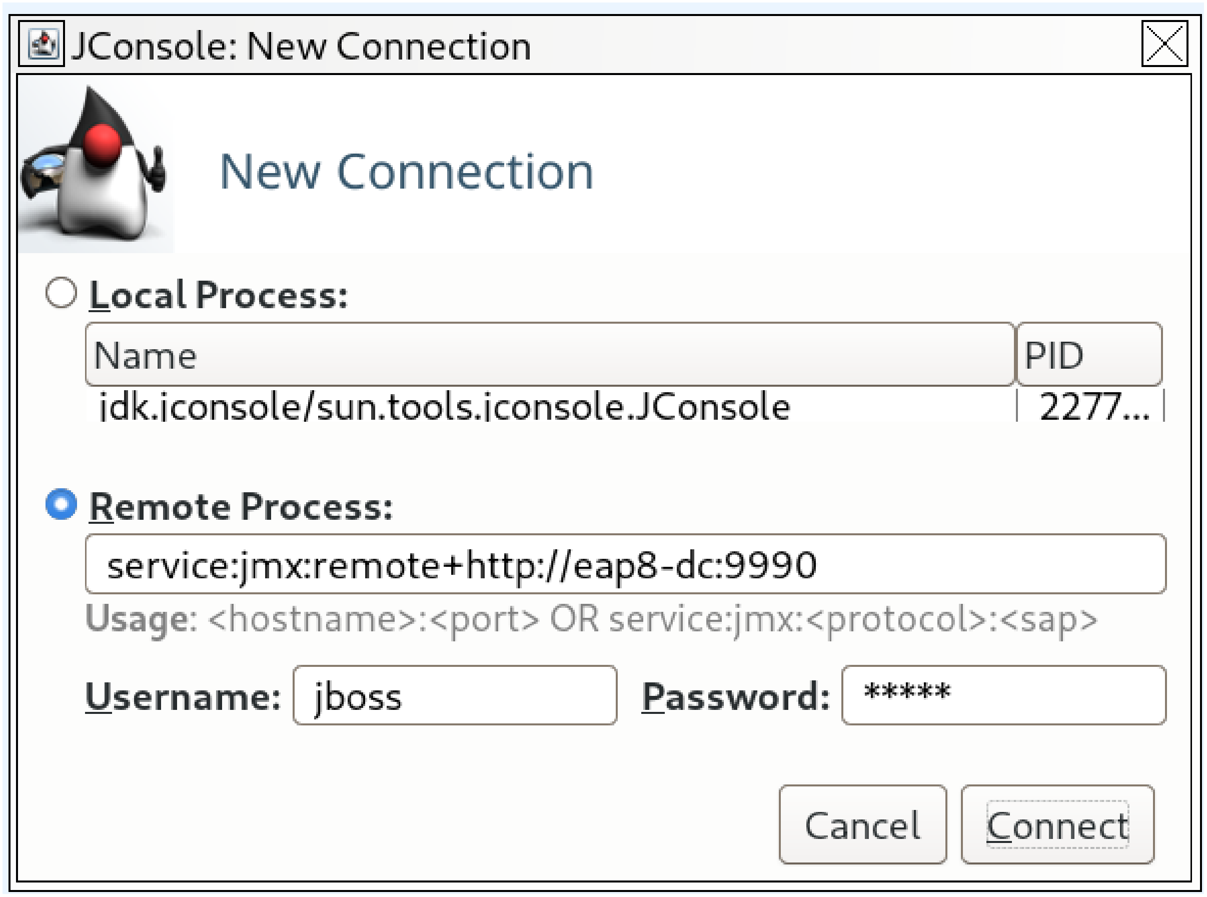
Prerequisites

- Configure JBoss EAP for remote monitoring connections.
- Download and extract a ZIP installation of JBoss EAP to your local machine.

Procedure

1. Run the **jconsole** script in ***EAP_HOME*/bin**.
2. Under **Remote Process**, insert the URI for the remote JBoss EAP JVM process that to want to monitor.

Figure 2.3. JConsole Remote JBoss EAP JVM


JConsole: New Connection

New Connection

Local Process:

Name	PID
jdk.jconsole/sun.tools.jconsole.JConsole	2277...

[✓ Remote Process:]

service:jmx:remote+http://eap8-dc:9990

Usage: <hostname>:<port> OR service:jmx:<protocol>:<sap>

Username: jboss

Password: *****

3. Ensure that you provide the user name and password for the monitoring connection.

4. Click **Connect**.

2.3. JAVA MISSION CONTROL

Developers can use Java Mission Control (JMC) to identify performance issues. JMC is a profiling and diagnostic tool that consists of the following components:

- **Java Virtual Machine (JVM) Browser**to view running Java applications and their related JVMs.
- **Java Management (JMX) Console** to monitor JVMs.
- **Java Flight Recorder (JFR)** to collect diagnostic data from running Java applications.
- **Plug-ins** for heap dump analysis.

Additional resources

- For more information about connecting JMC to local or remote JBoss EAP JVMs, see How to connect Java Mission Control with EAP remotely? on the Red Hat Customer Portal.
- For more information about downloading and installing JMC, see *Install JDK Mission Control and Supported Plug-ins* section of the Oracle JDK Mission Control user guide.

CHAPTER 3. DIAGNOSING PERFORMANCE ISSUES

3.1. ENABLING GARBAGE COLLECTION LOGGING

Examining garbage collection logs can be useful when attempting to troubleshoot Java performance issues, especially those related to memory usage.

Other than some additional disk I/O activity for writing the log files, enabling garbage collection logging does not significantly affect server performance.

Garbage collection logging is already enabled by default for a standalone JBoss EAP server running on OpenJDK or Oracle JDK. For a JBoss EAP managed domain, garbage collection logging can be enabled for the host controller, process controller, or individual JBoss EAP servers.

1. Get the correct JVM options for enabling garbage collection logging for your JDK. Replace the path in the options below to where you want the log to be created.

   NOTE

   The Red Hat Customer Portal has a JVM Options Configuration Tool that can help you generate optimal JVM settings.

   - For OpenJDK 11 or Oracle JDK 11:

     ```
     -verbose:gc -Xloggc:<path_to_directory>/gc.log -XX:+PrintGCDetails -
     XX:+PrintGCDateStamps -XX:+UseGCLogFileRotation -XX:NumberOfGCLogFiles=5 -
     XX:GCLogFileSize=3M -XX:-TraceClassUnloading
     ```

   - For versions 9 or later of OpenJDK, Oracle JDK, or any JDK that supports JEP 271:

     ```
     -Xlog:gc*:file=<path_to_directory>/gc.log:time,uptimemillis:filecount=5,filesize=3M
     ```

Additional resources

- For more information about JEP 271, see JEP 271: Unified GC Logging on the OpenJDK web page.

3.2. JAVA HEAP DUMPS

A Java heap dump is a snapshot of a JVM heap created at a certain point in time. Creating and analyzing heap dumps can be useful for diagnosing and troubleshooting issues with Java applications.

Depending on which JDK you are using, there are different ways of creating and analyzing a Java heap dump for a JBoss EAP process. This section covers common methods for Oracle JDK and OpenJDK.

3.2.1. Creating a heap dump using OpenJDK and Oracle JDK

3.2.1.1. Create an on-demand heap dump

You can use the **jcmd** command to create an on-demand heap dump for JBoss EAP running on OpenJDK or Oracle JDK.

Procedure

1. Determine the process ID of the JVM that you want to create a heap dump from.
2. Create the heap dump with the following command:

   ```
   $ jcmd JAVA_PID GC.heap_dump -all=true FILENAME.hprof
   ```

   This creates a heap dump file in the HPROF format, usually located in ***EAP_HOME*** or ***EAP_HOME*/bin**. Alternatively, you can specify a file path to another directory.

3.2.1.2. Create a heap dump automatically on OutOfMemoryError

You can use the **-XX:+HeapDumpOnOutOfMemoryError** JVM option to automatically create a heap dump when an **OutOfMemoryError** exception is thrown.

This creates a heap dump file in the HPROF format, usually located in ***EAP_HOME*** or ***EAP_HOME*/bin**. Alternatively, you can set a custom path for the heap dump using **-XX:HeapDumpPath=*/path/***. If you specify a file name using **-XX:HeapDumpPath**, for example, **-XX:HeapDumpPath=*/path/filename.hprof***, the heap dumps will overwrite each other.

3.2.2. Analyzing a heap dump

3.2.2.1. Heap dump analysis tools

There are many tools that can analyze heap dump files and help identify issues. Red Hat Support recommends using the Eclipse Memory Analyzer tool (MAT), which can analyze heap dumps formatted in either HPROF or PHD formats.

Additional resources

For information on using Eclipse MAT, see the Eclipse MAT documentation.

3.2.2.2. Heap dump analysis tips

Sometimes the cause of the heap performance issues are obvious, but other times you may need an understanding of your application's code and the specific circumstances that cause issues like an **OutOfMemoryError**. This can help to identify whether an issue is a memory leak, or if the heap is just not large enough.

Some suggestions for identifying memory usage issues include:

- If a single object is not found to be consuming too much memory, try grouping by class to see if many small objects are consuming a lot of memory.
- Check if the biggest usage of memory is a thread. A good indicator of this is if the **OutOfMemoryError**-triggered heap dump is much smaller than the specified **Xmx** maximum heap size.
- A technique to make memory leaks more detectable is to temporarily double the normal maximum heap size. When an **OutOfMemoryError** occurs, the size of the objects related to the memory leak will be about half the size of the heap.

When the source of a memory issue is identified, you can view the paths from garbage collection roots to see what is keeping the objects alive.

3.3. JAVA FLIGHT RECORDER

3.3.1. About Java Flight Recorder

The Oracle *JDK Mission Control user guide* describes Java Flight Recorder (JFR) as a "profiling and event collection framework". Developers can use JFR with JDK Mission Control (JMC) to collect data about Java Virtual Machines (JVMs) and other Java applications. Developers can use this data to identify and fix performance issues.

JFR has been carefully designed so that it requires a low level of overhead (consumption of resources). This means that JFR profiling can run continuously in certain production environments with minimal impact. Developers can use JFR and JMC to quickly analyze runtime information after an incident.

NOTE

JFR is available from Java OpenJDK **8u262** or later as part of the Java Diagnostic Command Tool.

Additional resources

- For more information about JFR, see section *Flight Recorder* in the Oracle *JDK Mission Control user guide*.

3.3.2. Java Flight Recorder profiling configurations

Developers can modify the profiling configurations to customize their instance of Java Flight Recorder (JFR). Two different profiling configurations are available with JFR:

- **default**: provides a sparse sampling of information; low profiling detail
- **profile**: provides a more comprehensive sampling of information; medium profiling detail

Developers can modify either configuration files to enable additional event metrics sampling.

3.3.3. Enable Java Flight Recorder profile capture

Developers can use Java Flight Recorder (JFR) to profile a JBoss EAP installation on bare metal or using Red Hat OpenShift Container Platform.

To learn about using JFR with OpenShift, see Introduction to Cryostat: JDK Flight Recorder for containers.

3.3.3.1. Enable Java Flight Recorder profiling on bare metal

Developers can start a Java Flight Recorder (JFR) profile using the command line or the Java Management Extensions (JMX) with the Java Mission Control (JMC) desktop application.

3.3.3.2. Configure Java Flight Recorder profiling for JBoss EAP using Java Virtual Machine configuration flags

You can use configuration flags to configure Java Flight Recorder (JFR) profiling with JBoss EAP on Java Virtual Machines (JVMs).

Example JVM configuration

```
-XX:StartFlightRecording=delay=15s,duration=60s,name=jboss-eap-profile,
filename=C:\TEMP\jboss-eap-profile.jfr,settings=default
```

The **StartFlightRecording=delay** configuration flag allows you to set the amount of time JFR waits after the JVM boots before starting a profiling session. In the preceding example, **StartFlightRecording=delay** is set to 15 seconds, which means profiling will start after a 15 second delay.

The **duration** configuration flag allows you to set the length of time for each profiling session. In the preceding example, **duration** is set to 60 seconds.

The **name** configuration flag allows you to set the in memory profile name. In this example, the in memory profile name is set to **jboss-eap-profile**.

The **filename** configuration flag allows you to set the filename and path where you would like the file to be saved. In this example, **filename** is set to **C:\TEMP\jboss-eap-profile.jfr**.

The **settings** configuration flag allows you to select a profiling configuration. In this example, **settings** is set to **default**. Note that the file extension for the profiling configuration is excluded.

After the profiling session is complete, a file will be created at the file path defined by the **filename** option.

3.3.3.3. Profiling using Java command tool for a running JBoss EAP Java Virtual Machine

You can use the Java Flight Recorder (JFR) **JFR.start** command to configure a running JBoss EAP Java Virtual Machine (JVM) for profiling using the Java command tool, **jcmd**.

Procedure

- Use one of the following commands:
  - For a Linux operating system:

    ```
    $ jcmd <PID> JFR.start duration=TIME filename=path/to/YOUR_PROFILE_NAME.jfr
    ```

    For example:

    ***JFR.start* command for Linux example**

    ```
    $ jcmd <PID> JFR.start duration=60s filename=/tmp/jboss-eap-profile.jfr
    ```

    Once a JFR profiling session starts, you will receive the following confirmation message:

    ```
    $ jcmd <PID> JFR.start duration=60s filename=/tmp/jboss-eap-profile.jfr
    <PID>:
    Started recording 1. The result will be written to:

    /tmp/jboss-eap-profile.jfr
    ```

  - For a Windows operating system:

    ```
    > jcmd.exe <PID> JFR.start duration=TIME filename=path/to/YOUR_PROFILE_NAME.jfr
    ```

    For example:

JFR.start **command for Windows example**

```
> jcmd.exe <PID> JFR.start duration=60s filename=C:\TEMP\jboss-eap-profile.jfr
```

Once a JFR profiling session starts, you will receive the following confirmation message:

```
> jcmd.exe <PID> JFR.start duration=60s filename=C:\TEMP\jboss-eap-profile.jfr
<PID>:
Started recording 1. The result will be written to:

C:\TEMP\jboss-eap-profile.jfr
```

The **duration** option allows you to set the length of time for each profiling session. In the preceding example commands, **duration** is set to 60 seconds.

The **filename** option allows you to set the filename and path where you would like the file to be saved. In the preceding example commands, **filename** is set to **/tmp/jboss-eap-profile.jfr** in the Linux example, and **C:\TEMP\jboss-eap-profile.jfr** in the Windows example.

3.3.3.4. Connect a local Java Virtual Machine using Java Mission Control

You can use Java Mission Control (JMC) to connect a local Java Virtual Machine (JVM) running on the same server as your instance of JMC.

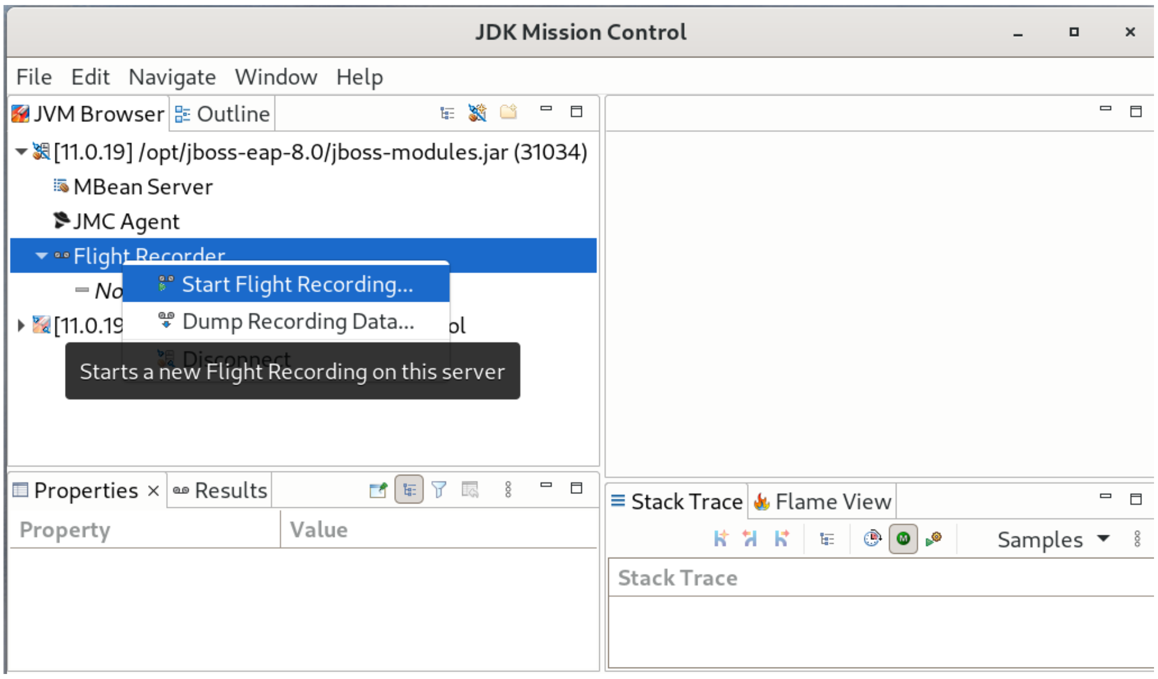
Prerequisites

- Java Mission Control with JBoss EAP libraries is configured. See How to connect Java Mission Control with EAP remotely? for instructions.
- JBoss EAP is configured for remote monitoring connections, and a user is created in the **ApplicationRealm** for monitoring.

Procedure

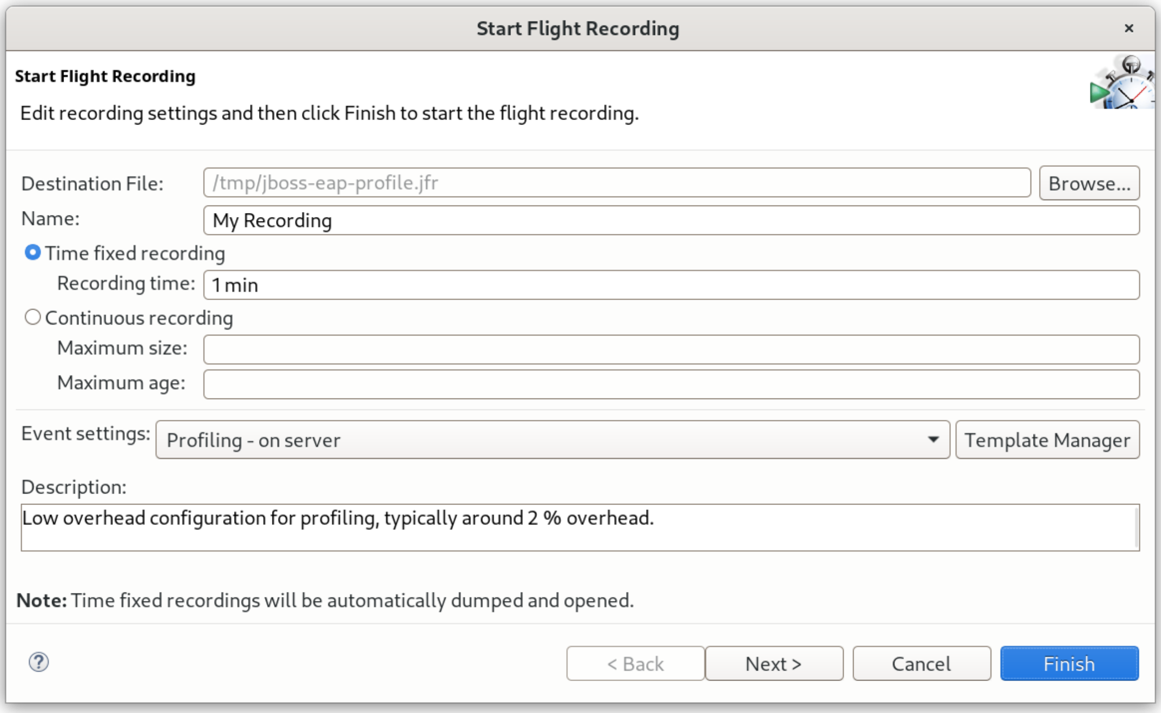
1. Open Java Mission Control.
2. In the **JVM Browser** pane, select the JVM to profile.
3. Expand the dropdown menu for the JVM to reveal the **Flight Recorder** item.
   a. Right click **Flight Recorder** to open the sub-menu, select **Start Flight Recording...**

Figure 3.1. JVM Browser in JMC



4. In the **Start Flight Recording** window configure options for profiling.

   Figure 3.2. JVM profiling settings



Start Flight Recording

Start Flight Recording

Edit recording settings and then click Finish to start the flight recording.

Destination File: /tmp/jboss-eap-profile.jfr

Name: My Recording

[✓ Time fixed recording]

Recording time: 1 min

Continuous recording

Maximum size:

Maximum age:

Event settings: Profiling - on server

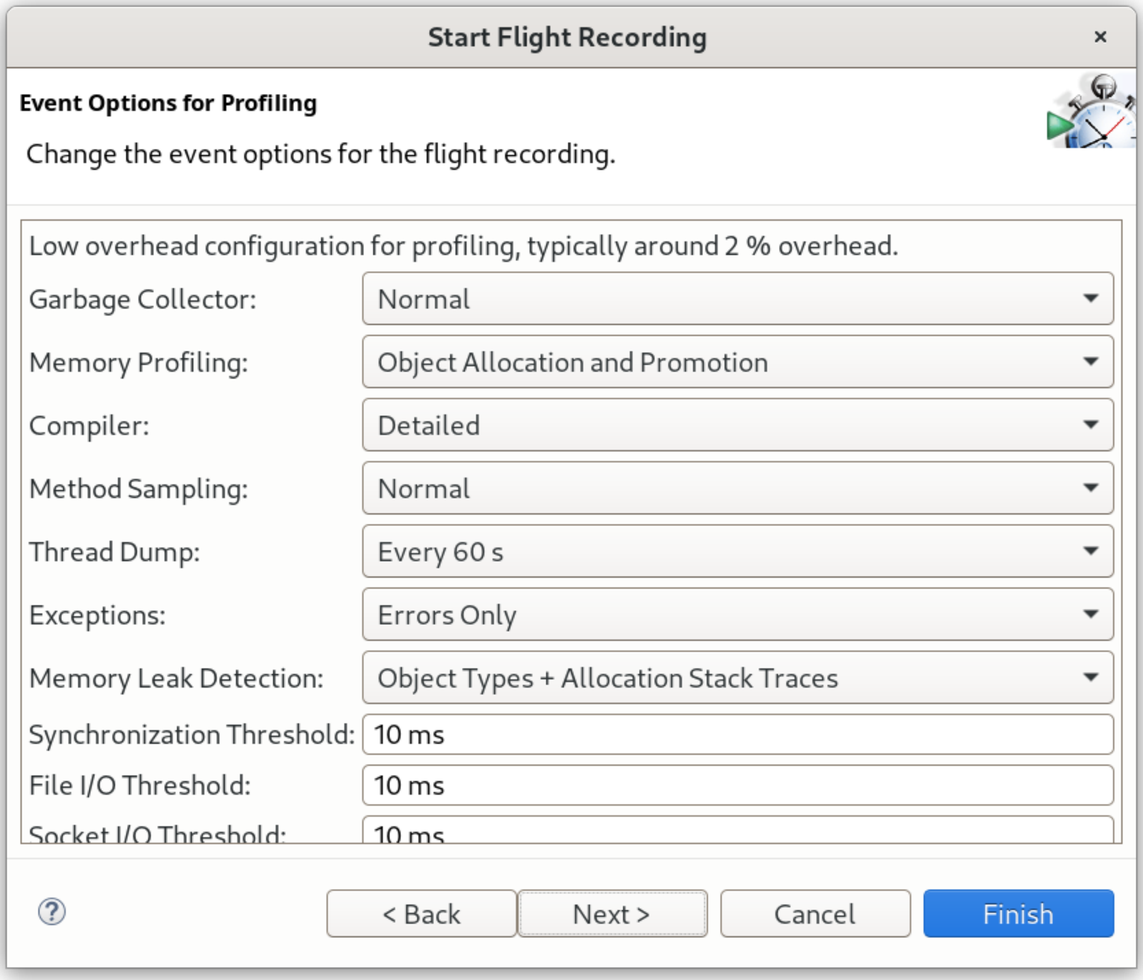
Description:

Low overhead configuration for profiling, typically around 2 % overhead.

Note: Time fixed recordings will be automatically dumped and opened.

5. Click **Next** for detailed low level settings.

Figure 3.3. JVM profiling advanced settings



Change the event options for the flight recording.

Low overhead configuration for profiling, typically around 2 % overhead.

Garbage Collector:	Normal
Memory Profiling:	Object Allocation and Promotion
Compiler:	Detailed
Method Sampling:	Normal
Thread Dump:	Every 60 s
Exceptions:	Errors Only
Memory Leak Detection:	Object Types + Allocation Stack Traces
Synchronization Threshold:	10 ms
File I/O Threshold:	10 ms
Socket I/O Threshold:	10 ms

6. Click **Finish** to start profiling.

3.3.3.5. Connect a remote Java Virtual Machine using Java Mission Control

You can use Java Mission Control (JMC) to connect to a remote Java Virtual Machine (JVM) profile.

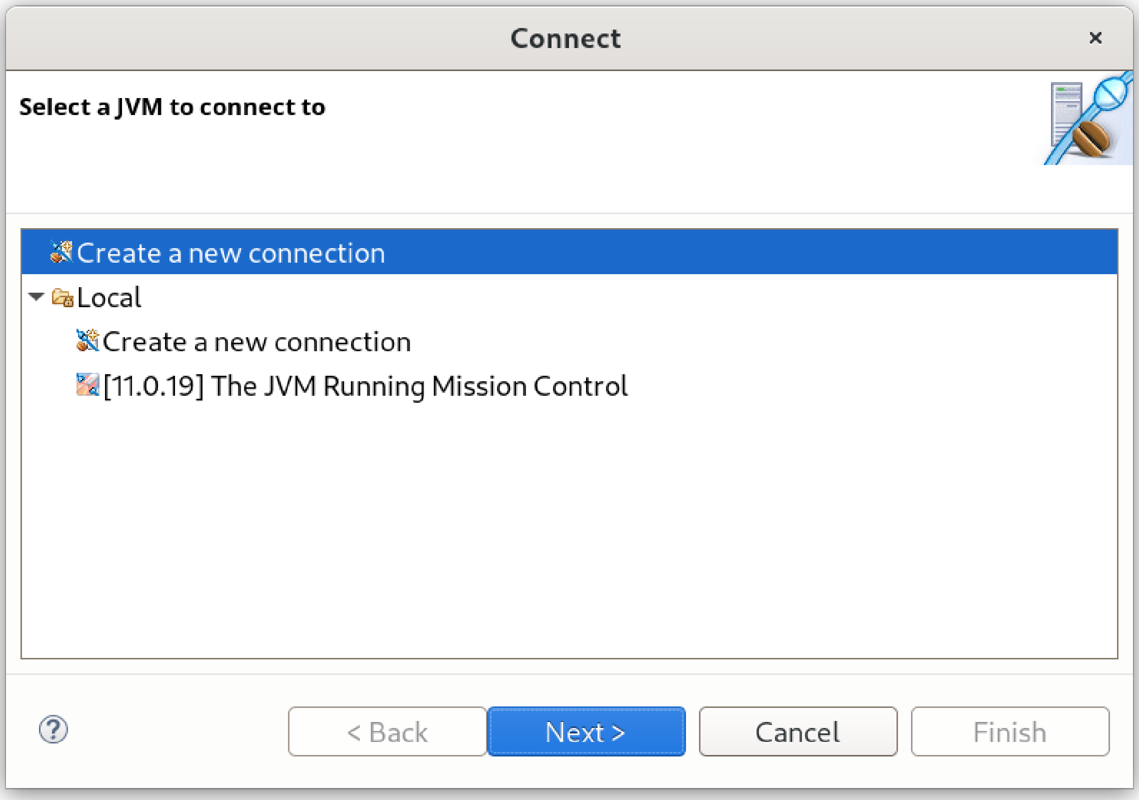
Prerequisites

- Configure Java Mission Control with JBoss EAP libraries. See How to connect Java Mission Control with EAP remotely? for instructions.
- Configure JBoss EAP for remote monitoring connections, with a user created in the **ApplicationRealm** for monitoring.

Procedure

1. Open Java Mission Control.
2. In the **File** menu, select **Connect**.
3. In the **Connect** window, select *Create a new connection*, then click **Next**.

Figure 3.4. Connect window in JMC

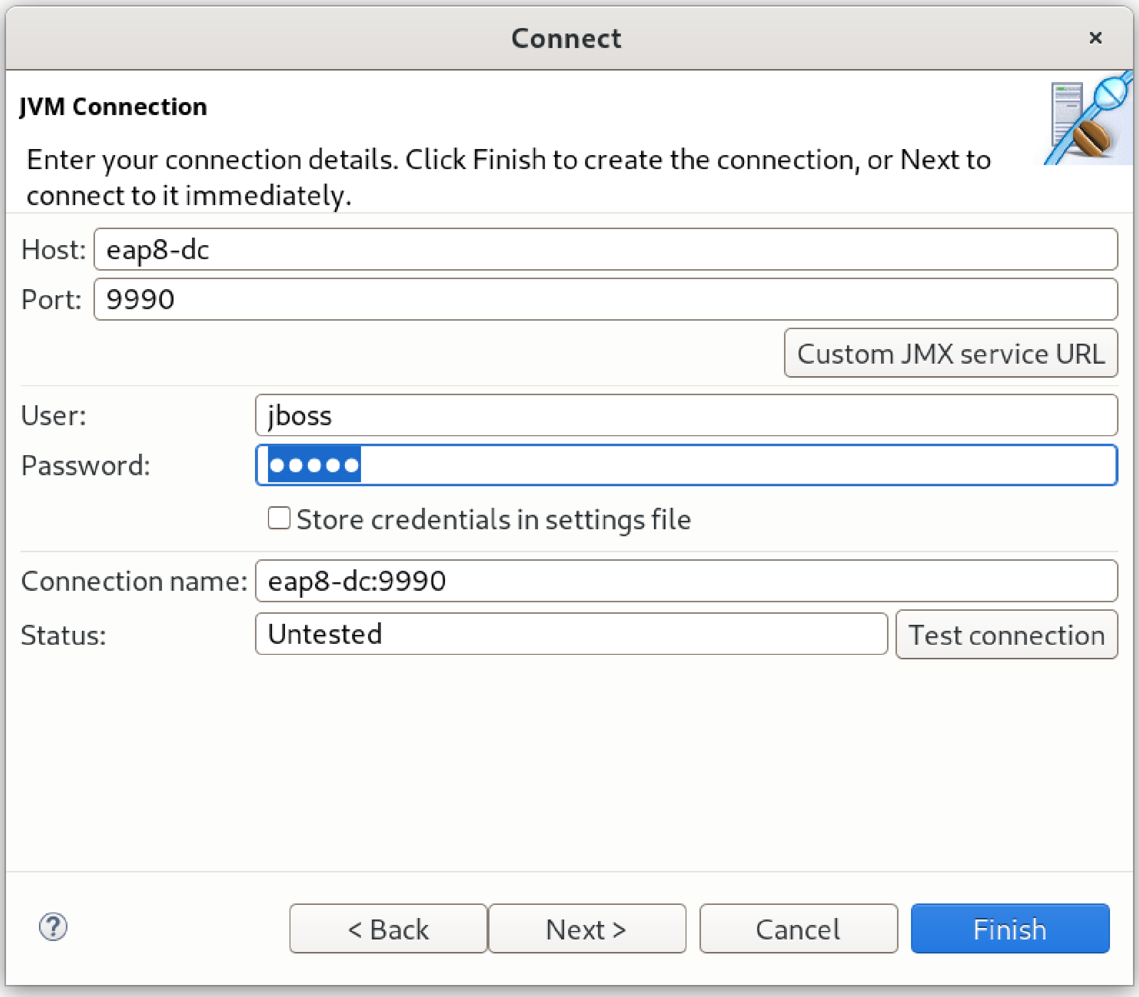

Connect

Select a JVM to connect to

Create a new connection
- Local
  - Create a new connection
  - [11.0.19] The JVM Running Mission Control

4. In the *JVM Connection* window, complete the details for your remote JBoss EAP JVM to be profiled.

Figure 3.5. JVM connection details in JMC



Connect

JVM Connection

Enter your connection details. Click Finish to create the connection, or Next to connect to it immediately.

Host: eap8-dc

Port: 9990

User: jboss

Password: ●●●●●

☐ Store credentials in settings file

Connection name: eap8-dc:9990

Status: Untested

a. In the **Host** field, add your hostname or an IP address.

b. In the **Port** field, add your port number.

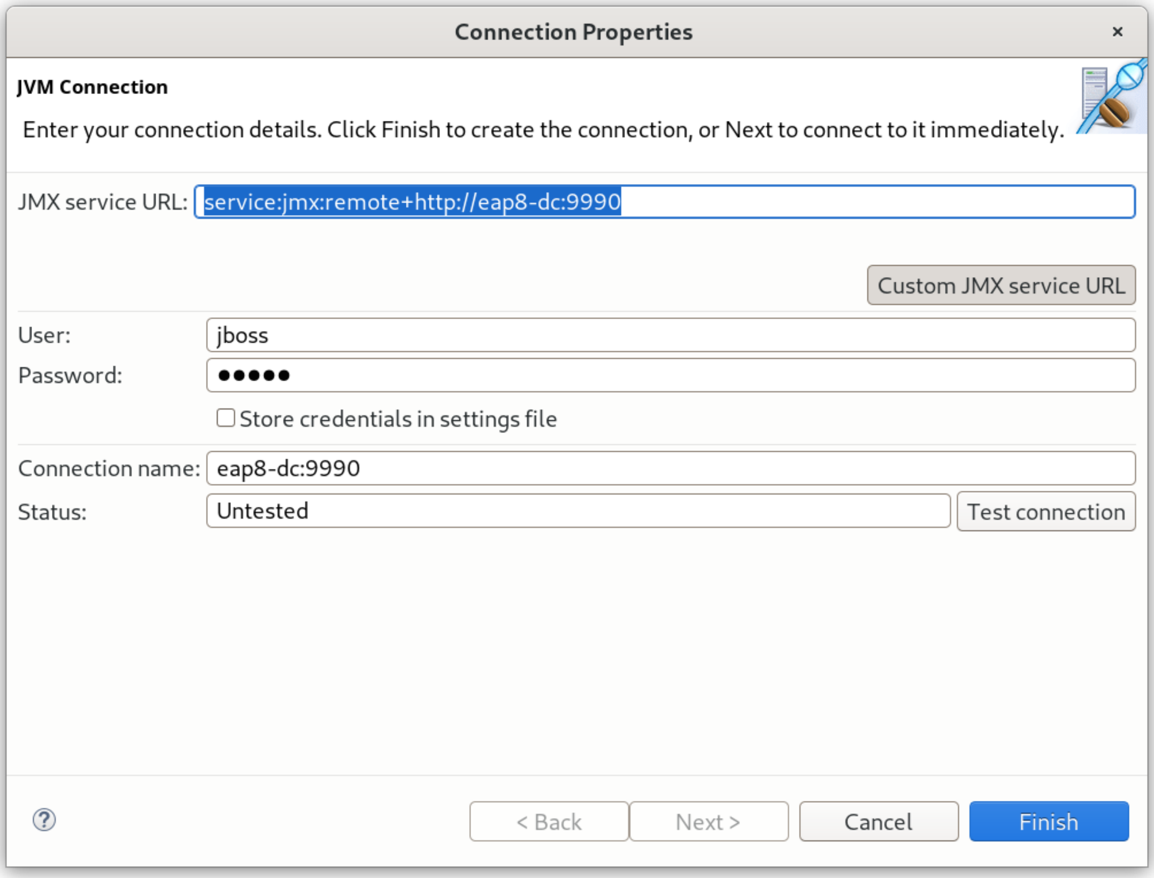
c. In the **User** field, add the user that you created in the **ApplicationRealm**.

d. In the **Password** field, add your password created in the **ApplicationRealm**.

e. **Optional** To store credentials in a settings file, click the checkbox next to **Store credentials in settings file**.

5. Click **Custom JMX Service URL**to override the default setting.

Figure 3.6. JMX Service URL for JVM connection



Connection Properties

JVM Connection

Enter your connection details. Click Finish to create the connection, or Next to connect to it immediately.

JMX service URL: service:jmx:remote+http://eap8-dc:9990

Custom JMX service URL

User: jboss

Password: ●●●●●

☐ Store credentials in settings file

Connection name: eap8-dc:9990

Status: Untested

Test connection

< Back | Next > | Cancel | Finish

6. Change the JMX service URL to define the JBoss remoting protocol.

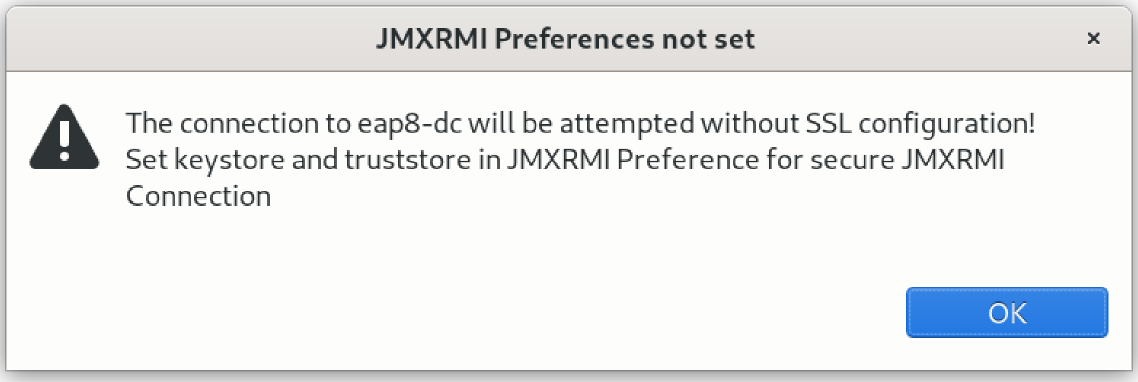
```
service:jmx:remote+http://<host>:9990
```

7. Click **Test connection** to verify your settings.

8. Click **Finish** to save your settings.

9. A *JMXRMI Preferences not set* warning message will appear.

Figure 3.7. JMXRMI preferences warning message



JMXRMI Preferences not set

The connection to eap8-dc will be attempted without SSL configuration! Set keystore and truststore in JMXRMI Preference for secure JMXRMI Connection

OK

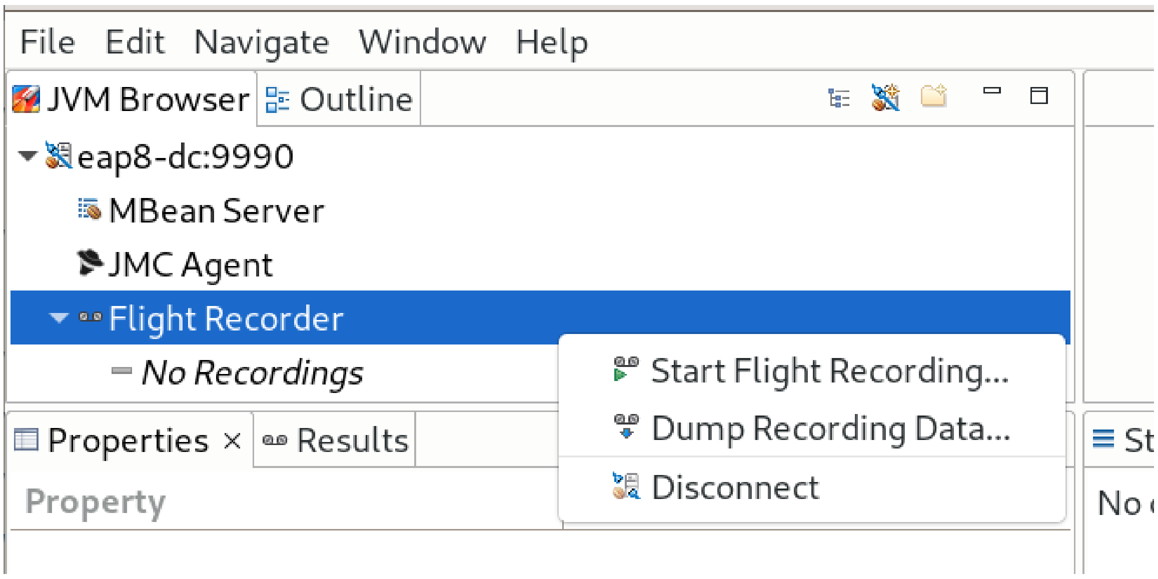
   a. Click **OK** to accept the connection attempt.

10. In the **JVM Browser** pane, select the JVM to profile.

a. Expand the dropdown menu for the JVM to reveal the **Flight Recorder** item.

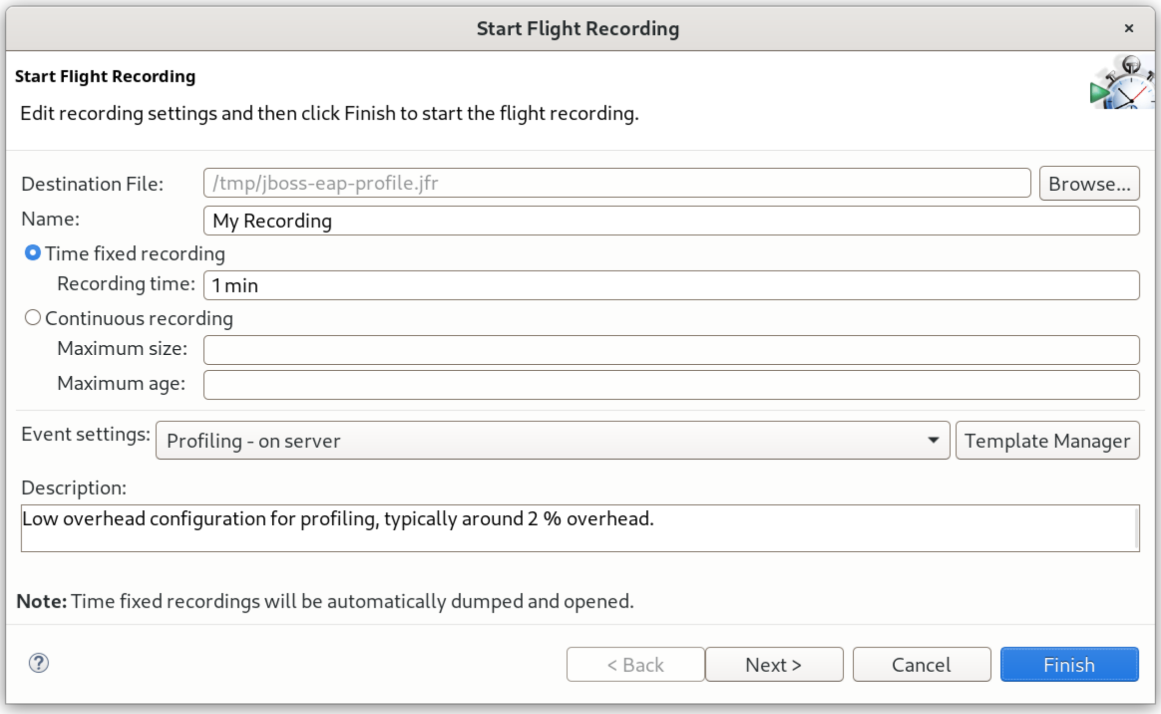
b. Right click **Flight Recorder** to open the sub-menu, then select **Start Flight Recording...**

Figure 3.8. Connect a remote JVM using JMC profile menu



11. In the **Start Flight Recording** window configure options for profiling.

Figure 3.9. JVM profiling settings



Start Flight Recording

Start Flight Recording

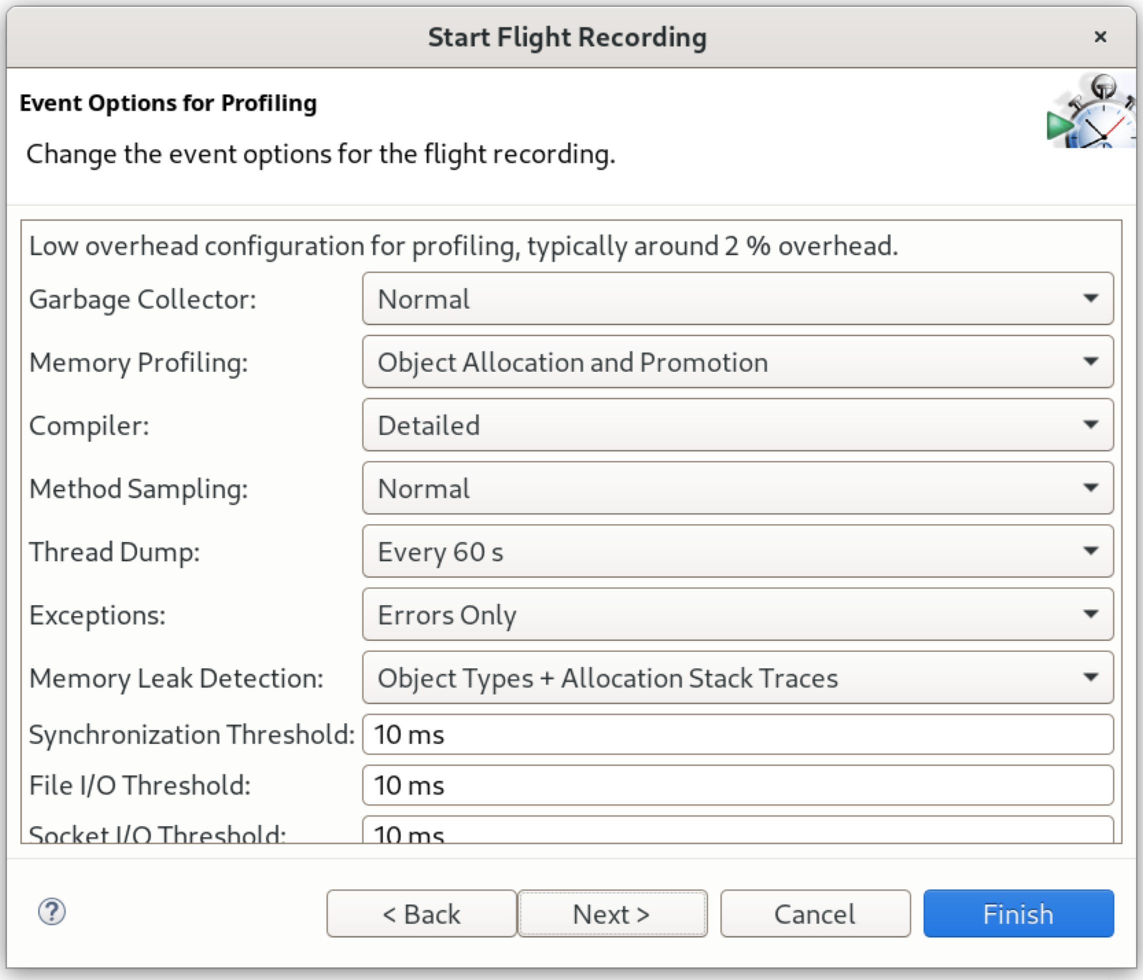
Edit recording settings and then click Finish to start the flight recording.

Destination File:	/tmp/jboss-eap-profile.jfr
Name:	My Recording
● Time fixed recording	
Recording time:	1 min
○ Continuous recording	
Maximum size:	
Maximum age:	
Event settings:	Profiling - on server
Description:	Low overhead configuration for profiling, typically around 2 % overhead.

Note: Time fixed recordings will be automatically dumped and opened.

12. Click **Next** for detailed low level settings.

Figure 3.10. JVM profiling advanced settings



Event Options for Profiling

Change the event options for the flight recording.

Low overhead configuration for profiling, typically around 2 % overhead.

Garbage Collector:	Normal
Memory Profiling:	Object Allocation and Promotion
Compiler:	Detailed
Method Sampling:	Normal
Thread Dump:	Every 60 s
Exceptions:	Errors Only
Memory Leak Detection:	Object Types + Allocation Stack Traces
Synchronization Threshold:	10 ms
File I/O Threshold:	10 ms
Socket I/O Threshold:	10 ms

13. Click **Finish** to start profiling.

3.4. IDENTIFYING HIGH CPU UTILIZATION BY JAVA THREADS

NOTE

For customers using JBoss EAP on Red Hat Enterprise Linux or Solaris, the JVMPeg lab tool on the Red Hat Customer Portal helps collect and analyze Java thread information to identify high CPU utilization. Follow the instructions for using the JVMPeg lab tool instead of using the following procedure.

For OpenJDK and Oracle JDK environments, Java thread diagnostic information is available using the **jstack** utility.

1. Identify the process ID of the Java process that is utilizing a high percentage of the CPU.
   It can also be useful to obtain per-thread CPU data on high-usage processes. This can be done using the **top -H** command on Red Hat Enterprise Linux systems.

2. Using the **jstack** utility, create a stack dump of the Java process. For example, on Linux and Solaris:

```
jstack -l JAVA_PROCESS_ID > high-cpu-tdump.out
```

You might need to create multiple dumps at intervals to see any changes or trends over a period of time.

3. Analyze the stack dumps. You can use a tool such as the Thread Dump Analyzer (TDA) .

3.5. RUNTIME STATISTICS FOR MANAGED EXECUTOR SERVICES AND MANAGED SCHEDULED EXECUTOR SERVICES

You can monitor the performance of managed executor services and managed scheduled executor services by viewing the runtime statistics generated with the management CLI attributes. You can view the runtime statistics for a standalone server or for an individual server mapped to a host.

IMPORTANT

The **domain.xml** configuration does not include a resource for the runtime statistic management CLI attributes, so you cannot use the management CLI attributes to view the runtime statistics for a managed domain.

Table 3.1. Displays management CLI attributes for monitoring the performance of managed executor services and of managed scheduled executor services.

Attribute	Description
active-thread-count	The approximate number of threads that are actively executing tasks.
completed-task-count	The approximate total number of tasks that have completed execution.
hung-thread-count	The number of executor threads that are hung.
max-thread-count	The largest number of executor threads.
current-queue-size	The current size of the executor’s task queue.
task-count	The approximate total number of tasks that have been submitted for execution.
thread-count	The current number of executor threads.

Example of viewing the runtime statistics for a managed executor service running on a standalone server.

```
[standalone@localhost:9990 /] /subsystem=ee/managed-executor-service=default:read-
resource(include-runtime=true,recursive=true)
```

Example of the runtime statistics for a managed scheduled executor service running on a standalone server.

```
[standalone@localhost:9990 /] /subsystem=ee/managed-scheduled-executor-service=default:read-resource(include-runtime=true,recursive=true)
```

Example of viewing the runtime statistics for a managed executor service running on a server mapped to a host.

```
[domain@localhost:9990 /] /host=<host_name>/server=<server_name>/subsystem=ee/managed-executor-service=default:read-resource(include-runtime=true,recursive=true)
```

Example of the runtime statistics for a managed scheduled executor service running on a server mapped to a host.

```
[domain@localhost:9990 /] /host=<host_name>/server=<server_name>/subsystem=ee/managed-scheduled-executor-service=default:read-resource(include-runtime=true,recursive=true)
```

CHAPTER 4. JVM TUNING

Configuring optimal JVM options for your applications and JBoss EAP environment is one of the most fundamental ways to tune performance. This chapter covers configuring some general JVM options.

NOTE

Many of the JVM options listed in this chapter can be easily generated using the JVM Options Configuration Tool on the Red Hat Customer Portal.

4.1. SETTING A FIXED HEAP SIZE

You must set an appropriate heap size to prevent out of memory errors.

The **-Xms** option sets the initial heap size, and **-Xmx** sets the maximum heap size. It is recommended for production environments that you set the initial and maximum heap size options to the same size, so that the heap size is fixed and pre-allocated.

For example, the following options set a 2048 MB heap size:

```
-Xms2048M -Xmx2048M
```

It is recommended that you test your applications under load in a development environment to determine the maximum memory usage. Your production heap size should be at least 25% higher than the tested maximum to allow room for overhead.

4.2. CONFIGURING THE GARBAGE COLLECTOR

Although the parallel garbage collector, also known as the throughput garbage collector, is the default garbage collector in Java 8 for server-class machines, Red Hat recommends using the G1 garbage collector, which is expected to be the default from Java 9 onward. The G1 garbage collector generally performs better than the CMS and parallel garbage collectors in most scenarios.

To enable the G1 collector, use the following JVM option:

```
-XX:+UseG1GC
```

4.2.1. Garbage collection logging options

Garbage collection logging is enabled by default for standalone JBoss EAP servers.

4.3. ENABLING LARGE PAGES

Enabling large pages for JBoss EAP JVMs results in pages that are locked in memory and cannot be swapped to disk like regular memory.

Especially for memory-intensive applications, the advantage of using large pages is that the heap cannot be paged or swapped to disk, and is thus always readily available.

One disadvantage of using large pages is that other processes running on the system might not have quick access to memory, which might result in excessive paging for these processes.

As with any other performance configuration change, it is recommended that you test the impact of the change in a testing environment.

1. You must ensure that your operating system configuration allows for processes to use large pages.
   - For Red Hat Enterprise Linux systems, you must explicitly configure **HugeTLB** pages to guarantee that JBoss EAP processes will have access to large pages.
   - For Windows Server systems, the user that is running JBoss EAP must have the large pages privilege assigned:
     1. Select **Control Panel → Administrative Tools → Local Security Policy**.
     2. Select **Local Policies → User Rights Assignment**.
     3. Double-click **Lock pages in memory**.
     4. Add the Windows Server users and user groups that you want to use large pages.
     5. Restart the machine.
2. Enable or disable large page support:
   - To explicitly enable large page support for JBoss EAP JVMs, use the following JVM option:

     ```
     -XX:+UseLargePages
     ```
   - To explicitly disable large page support for JBoss EAP JVMs, use the following JVM option:

     ```
     -XX:-UseLargePages
     ```
3. When starting JBoss EAP, ensure that there are no warnings related to reserving memory.
   - On Red Hat Enterprise Linux, an error might look like:

     ```
     OpenJDK 64-Bit Server VM warning: Failed to reserve shared memory. (error = 1)
     ```
   - On Windows Server, an error might look like:

     ```
     Java HotSpot(TM) 64-Bit Server VM warning: JVM cannot use large page memory
     because it does not have enough privilege to lock pages in memory.
     ```

   If you do see warnings, verify that your operating system configuration and JVM options are configured correctly.

For more information, see the Oracle documentation on Java support for large pages .

4.4. SETTING ULIMITS

For Red Hat Enterprise Linux and Solaris platforms, you must configure appropriate **ulimit** values for JBoss EAP JVM processes. The "soft" **ulimit** can be temporarily exceeded, while the "hard" **ulimit** is the strict ceiling for the usage of a resource. Appropriate **ulimit** values vary depending on your environment and applications.

If the limits applied to JBoss EAP processes are too low, you will see a warning like the following when starting JBoss EAP:

```
WARN  [org.jboss.as.warn.fd-limit] (main) WFLYSRV0071: The operating system has limited the
number of open files to 1024 for this process; a value of at least 4096 is recommended.
```

To see your current **ulimit** values, use the following commands:

- For soft **ulimit** values:

  ```
  ulimit -Sa
  ```

- For hard **ulimit** values:

  ```
  ulimit -Ha
  ```

To set the **ulimit** for the maximum number of open files, use the following commands with the number you want to apply:

- To set the soft **ulimit** for the maximum number of open files:

  ```
  ulimit -Sn 4096
  ```

- To set the hard **ulimit** for the maximum number of open files:

  ```
  ulimit -Hn 4096
  ```

NOTE

To guarantee that a **ulimit** setting is effective, it is recommended on production systems to set the soft and hard limits to the same value.

Additional resources

For more information on setting **ulimit** values using a configuration file, see How to set ulimit values on the Customer Portal.

4.5. HOST CONTROLLER AND PROCESS CONTROLLER JVM TUNING

JBoss EAP managed domain hosts have separate JVMs for the host controller and process controller.

You can tune the host controller and process controller JVM settings, but even for large managed domain environments, the default JVM configuration for the host controller and process controller should suffice.

The default configurations for host controller and process controller JVMs have been tested with a managed domain size of up to 20 JBoss EAP hosts each running 10 JBoss EAP servers, for a total domain size of 200 JBoss EAP servers.

If you experience issues with larger managed domains, you might need to monitor the host controller or process controller JVMs in your environment to determine appropriate values for JVM options such as heap size.

CHAPTER 5. JAKARTA ENTERPRISE BEANS SUBSYSTEM TUNING

JBoss EAP can cache Jakarta Enterprise Beans to save initialization time. This is accomplished using bean pools.

There are two different bean pools that can be tuned in JBoss EAP: bean instance pools and bean thread pools.

Appropriate bean pool sizes depend on your environment and applications. It is recommended that you experiment with different bean pool sizes and perform stress testing in a development environment that emulates your expected real-world conditions.

5.1. BEAN INSTANCE POOLS

Bean instance pools are used for Stateless Session Beans (SLSBs) and Message Driven Beans (MDBs). By default, SLSBs use the instance pool **default-slsb-instance-pool**, and MDBs use the instance pool **default-mdb-instance-pool**.

The size of a bean instance pool limits the number of instances of a particular enterprise bean that can be created at one time. If the pool for a particular enterprise bean is full, the client will block and wait for an instance to become available. If a client does not get an instance within the time set in the pool's **timeout** attributes, an exception is thrown.

The size of a bean instance pool is configured using either **derive-size** or **max-pool-size**. The **derive-size** attribute allows you to configure the pool size using one of the following values:

- **from-worker-pools**, which indicates that the maximum pool size is derived from the size of the total threads for all worker pools configured on the system.
- **from-cpu-count**, which indicates that the maximum pool size is derived from the total number of processors available on the system. Note that this is not necessarily a 1:1 mapping, and might be augmented by other factors.

If **derive-size** is undefined, then the value of **max-pool-size** is used for the size of the bean instance pool.

NOTE

The **derive-size** attribute overrides any value specified in **max-pool-size**. **derive-size** must be undefined for the **max-pool-size** value to take effect.

You can configure an enterprise bean to use a specific instance pool. This allows for finer control of the instances available to each enterprise bean type.

5.1.1. Creating a bean instance pool

This section shows you how to create a new bean instance pool using the management CLI. You can also configure bean instance pools using the management console by navigating to the **Jakarta Enterprise Beans** subsystem from the **Configuration** tab, and then selecting the **Bean Pool** tab.

To create a new instance pool, use one of the following commands:

- To create a bean instance pool with a derived maximum pool size:

```
/subsystem=ejb3/strict-max-bean-instance-pool=POOL_NAME:add(derive-size=DERIVE_OPTION,timeout-unit=TIMEOUT_UNIT,timeout=TIMEOUT_VALUE)
```

The following example creates a bean instance pool named **my_derived_pool** with a maximum size derived from the CPU count, and a timeout of 2 minutes:

```
/subsystem=ejb3/strict-max-bean-instance-pool=my_derived_pool:add(derive-size=from-cpu-count,timeout-unit=MINUTES,timeout=2)
```

- To create a bean instance pool with an explicit maximum pool size:

```
/subsystem=ejb3/strict-max-bean-instance-pool=POOL_NAME:add(max-pool-size=POOL_SIZE,timeout-unit=TIMEOUT_UNIT,timeout=TIMEOUT_VALUE)
```

The following example creates a bean instance pool named **my_pool** with a maximum of 30 instances and a timeout of 30 seconds:

```
/subsystem=ejb3/strict-max-bean-instance-pool=my_pool:add(max-pool-size=30,timeout-unit=SECONDS,timeout=30)
```

5.1.2. Specifying the instance pool a bean should use

You can set a specific instance pool that a particular bean will use either by using the **@org.jboss.ejb3.annotation.Pool** annotation, or by modifying the **jboss-ejb3.xml** deployment descriptor of the bean.

5.1.3. Disabling the default bean instance pool

The default bean instance pool can be disabled, which results in an enterprise bean not using any instance pool by default. Instead, a new enterprise bean instance is created when a thread needs to invoke a method on an enterprise bean. This might be useful if you do not want any limit on the number of enterprise bean instances that are created.

To disable the default bean instance pool, use the following management CLI command:

```
/subsystem=ejb3:undefine-attribute(name=default-slsb-instance-pool)
```

NOTE

> If a bean is configured to use a particular bean instance pool, disabling the default instance pool does not affect the pool that the bean uses.

5.2. BEAN THREAD POOLS

By default, a bean thread pool named **default** is used for asynchronous enterprise bean calls and enterprise bean timers.

NOTE

From JBoss EAP 7 onward, remote enterprise bean requests are handled in the worker defined in the **io** subsystem by default.

If required, you can configure each of these enterprise bean services to use a different bean thread pool. This can be useful if you want finer control of each service’s access to a bean thread pool.

When determining an appropriate thread pool size, consider how many concurrent requests you expect will be processed at once.

5.2.1. Creating a bean thread pool

This section shows you how to create a new bean thread pool using the management CLI. You can also configure bean thread pools using the management console by navigating to the **Jakarta Enterprise Beans** subsystem from the **Configuration** tab and selecting **Container → Thread Pool** in the left menu.

To create a new thread pool, use the following command:

```
/subsystem=ejb3/thread-pool=POOL_NAME:add(max-threads=MAX_THREADS)
```

The following example creates a bean thread pool named **my_thread_pool** with a maximum of 30 threads:

```
/subsystem=ejb3/thread-pool=my_thread_pool:add(max-threads=30)
```

5.2.2. Configuring enterprise bean services to use a specific bean thread pool

The enterprise bean asynchronous invocation service and timer service can each be configured to use a specific bean thread pool. By default, both these services use the **default** bean thread pool.

This section shows you how to configure the above enterprise bean services to use a specific bean thread pool using the management CLI. You can also configure these services using the management console by navigating to the **Enterprise Bean** subsystem from the **Configuration** tab, selecting the **Services** tab, and choosing the appropriate service.

To configure an enterprise bean service to use a specific bean thread pool, use the following command:

```
/subsystem=ejb3/service=SERVICE_NAME:write-attribute(name=thread-pool-
name,value=THREAD_POOL_NAME)
```

Replace **SERVICE_NAME** with the an enterprise bean service you want to configure:

- **async** for the enterprise bean asynchronous invocation service
- **timer-service** for the enterprise bean timer service

The following example sets the enterprise bean async service to use the bean thread pool named **my_thread_pool**:

```
/subsystem=ejb3/service=async:write-attribute(name=thread-pool-name,value=my_thread_pool)
```

5.3. RUNTIME DEPLOYMENT INFORMATION FOR BEANS

You can add runtime deployment information to your beans for performance monitoring.

For details about the available runtime data, see the **ejb3** subsystem in the JBoss EAP management model. An application can include the runtime data as annotations in the bean code or in the deployment descriptor. An application can use both options.

Additional resources

- For more information about available runtime data, see the **ejb3** subsystem in the JBoss EAP management model.

5.3.1. Command line options for retrieving runtime data from Jakarta enterprise beans

Runtime data from Jakarta Enterprise Beans is available from the management CLI so you can evaluate the performance of your Jakarta Enterprise Beans.

The command to retrieve runtime data for all types of beans uses the following pattern:

```
/deployment=<deployment_name>/subsystem=ejb3/<bean_type>=<bean_name>:read-resource(include-runtime)
```

Replace **<deployment_name>** with the name of the deployment **.jar** file for which to retrieve runtime data. Replace **<bean_type>** with the type of the bean for which to retrieve runtime data. The following options are valid for this placeholder:

- **stateless-session-bean**
- **stateful-session-bean**
- **singleton-bean**
- **message-driven-bean**

Replace **<bean_name>** with the name of the bean for which you to retrieve runtime data.

The system delivers the result to **stdout** formatted as JavaScript Object Notation (JSON) data.

Example command to retrieve runtime data for a singleton bean named ManagedSingletonBean deployed in a file named ejb-management.jar

```
/deployment=ejb-management.jar/subsystem=ejb3/singleton-bean=ManagedSingletonBean:read-resource(include-runtime)
```

Example output runtime data for the singleton bean

```
{
    "outcome" => "success",
    "result" => {
        "async-methods" => ["void async(int, int)"],
        "business-local" => ["sample.ManagedSingletonBean"],
        "business-remote" => ["sample.BusinessInterface"],
        "component-class-name" => "sample.ManagedSingletonBean",
        "concurrency-management-type" => undefined,
        "declared-roles" => [
            "Role3",
            "Role2",
            "Role1"
        ],
        "depends-on" => undefined,
        "execution-time" => 156L,
        "init-on-startup" => false,
        "invocations" => 3L,
        "jndi-names" => [
            "java:module/ManagedSingletonBean!sample.ManagedSingletonBean",
            "java:global/ejb-management/ManagedSingletonBean!sample.ManagedSingletonBean",
            "java:app/ejb-management/ManagedSingletonBean!sample.ManagedSingletonBean",
            "java:app/ejb-management/ManagedSingletonBean!sample.BusinessInterface",
            "java:global/ejb-management/ManagedSingletonBean!sample.BusinessInterface",
            "java:module/ManagedSingletonBean!sample.BusinessInterface"
        ],
        "methods" => {"doIt" => {
            "execution-time" => 156L,
            "invocations" => 3L,
            "wait-time" => 0L
        }},
        "peak-concurrent-invocations" => 1L,
        "run-as-role" => "Role3",
        "security-domain" => "other",
        "timeout-method" => "public void sample.ManagedSingletonBean.timeout(javax.ejb.Timer)",
        "timers" => [{
            "time-remaining" => 4304279L,
            "next-timeout" => 1577768415000L,
            "calendar-timer" => true,
            "persistent" => false,
            "info" => "timer1",
            "schedule" => {
                "year" => "*",
                "month" => "*",
                "day-of-month" => "*",
                "day-of-week" => "*",
                "hour" => "0",
                "minute" => "0",
                "second" => "15",
                "timezone" => undefined,
                "start" => undefined,
                "end" => undefined
            }
        }],
        "transaction-type" => "CONTAINER",
        "wait-time" => 0L,
        "service" => {"timer-service" => undefined}
    }
}
```

Example command to retrieve runtime data for a message-driven bean named NoTimerMDB deployed in a file named ejb-management.jar

```
/deployment=ejb-management.jar/subsystem=ejb3/message-driven-bean=NoTimerMDB:read-resource(include-runtime)
```

Example output for the message-driven bean

```
{
    "outcome" => "success",
    "result" => {
        "activation-config" => [
            ("destination" => "java:/queue/NoTimerMDB-queue"),
            ("destinationType" => "javax.jms.Queue"),
            ("acknowledgeMode" => "Auto-acknowledge")
        ],
        "component-class-name" => "sample.NoTimerMDB",
        "declared-roles" => [
            "Role3",
            "Role2",
            "Role1"
        ],
        "delivery-active" => true,
        "execution-time" => 0L,
        "invocations" => 0L,
        "message-destination-link" => "queue/NoTimerMDB-queue",
        "message-destination-type" => "javax.jms.Queue",
        "messaging-type" => "javax.jms.MessageListener",
        "methods" => {},
        "peak-concurrent-invocations" => 0L,
        "pool-available-count" => 16,
        "pool-create-count" => 0,
        "pool-current-size" => 0,
        "pool-max-size" => 16,
        "pool-name" => "mdb-strict-max-pool",
        "pool-remove-count" => 0,
        "run-as-role" => "Role3",
        "security-domain" => "other",
        "timeout-method" => undefined,
        "timers" => [],
        "transaction-type" => "CONTAINER",
        "wait-time" => 0L,
        "service" => undefined
    }
}
```

5.4. EXCEPTIONS THAT INDICATE AN ENTERPRISE BEAN SUBSYSTEM TUNING MIGHT BE REQUIRED

- **The Stateless Jakarta Enterprise Beans instance pool is not large enough or the timeout is too low**

```
javax.ejb.EJBException: JBAS014516: Failed to acquire a permit within 20 SECONDS
    at org.jboss.as.ejb3.pool.strictmax.StrictMaxPool.get(StrictMaxPool.java:109)
```

- **The enterprise bean thread pool is not large enough, or an enterprise bean is taking longer to process than the invocation timeout**

```
java.util.concurrent.TimeoutException: No invocation response received in 300000
milliseconds
```

5.4.1. Default global timeout values for stateful session beans

In the **ejb3** subsystem, you can configure a default global timeout value for all stateful session beans (SFSBs) that are deployed on your server instance by using the **default-stateful-bean-session-timeout** attribute.

With the **default-stateful-bean-session-timeout** attribute, you can use the following management CLI operations on the **ejb3** subsystem:

- The **read-attribute** operation in the management CLI to view the current global timeout value for the attribute.
- The **write-attribute** operation to configure the attribute by using the management CLI.

Attribute behavior varies according to the server mode. For example:

- When running in the standalone server, the configured value gets applied to all SFSBs deployed on the application server.
- When running a server in a managed domain, all SFSBs that are deployed on server instances within server groups receive concurrent timeout values.

NOTE

When you change the global timeout value for the attribute, the updated settings only apply to new deployments. You must reload the server to apply the new settings to current deployments.

By default, the attribute value is set at **-1**, which means that deployed SFSBs are configured to never time out. However, you can configure two of the following types of valid values for the attribute:

- When you set the attribute value to **0**, the attribute immediately marks eligible SFSBs for removal by the **ejb** container.
- When you set the attribute value greater than **0**, the SFSBs remain idle for the specified time in milliseconds before the **ejb** container removes the eligible SFSBs.

NOTE

You can still use the pre-existing **@StatefulTimeout** annotation or the **stateful-timeout** element, which is located in the **ejb-jar.xml** deployment descriptor, to configure the timeout value for an SFSB. However, setting such a configuration overrides the default global timeout value to the SFSB.

Two methods exist for verifying a new value you set for the attribute:

- Use the **read-attribute** operation in the management CLI.
- Examine the **ejb3** subsystem section of the server's configuration file.

Additional resources

- For more information about viewing the current global timeout value for an attribute, see Display an Attribute Value in the *Management CLI guide*.

- For more information about updating the current global timeout value for an attribute, see Update an Attribute in the *Management CLI guide*.

CHAPTER 6. DATASOURCE AND RESOURCE ADAPTER TUNING

Connection pools are the principal tool that JBoss EAP uses to optimize performance for environments that use datasources, such as relational databases, or resource adapters.

Allocating and deallocating resources for datasource and resource adapter connections is very expensive in terms of time and system resources. Connection pooling reduces the cost of connections by creating a 'pool' of connections that are available to applications.

Before configuring your connection pool for optimal performance, you must monitor the datasource pool statistics or resource adapter statistics under load to determine the appropriate settings for your environment.

6.1. MONITORING POOL STATISTICS

6.1.1. Datasource statistics

When statistics collection is enabled for a datasource, you can view runtime statistics for the datasource.

6.1.1.1. Enabling datasource statistics

By default, datasource statistics are *not* enabled. You can enable datasource statistics collection using the management CLI or the management console.

6.1.1.1.1. Enable datasource statistics using the management CLI

The following management CLI command enables the collection of statistics for the **ExampleDS** datasource.

NOTE

In a managed domain, precede this command with **/profile=*PROFILE_NAME***.

```
/subsystem=datasources/data-source=ExampleDS:write-attribute(name=statistics-
enabled,value=true)
```

Reload the server for the changes to take effect.

6.1.1.1.2. Enable datasource statistics using the management console

Use the following steps to enable statistics collection for a datasource using the management console.

Procedure

1. Navigate to **Configuration** → **Subsystems** → **Datasources & Drivers** → **Datasources**.
2. Select the datasource and click **View**.
3. Click **Edit** under the **Attributes** tab.

4. Set the **Statistics Enabled** field to **ON** and click **Save**. A popup appears indicating that the changes require a reload in order to take effect.

5. Reload the server.

   - For a standalone server, click the **Reload** link from the popup to reload the server.

   - For a managed domain, click the **Topology** link from the popup. From the **Topology** tab, select the appropriate server and select the **Reload** drop down option to reload the server.

6.1.1.2. Viewing datasource statistics

You can view runtime statistics for a datasource using the management CLI or management console.

6.1.1.2.1. View datasource statistics using the management CLI

The following management CLI command retrieves the core *pool* statistics for the **ExampleDS** datasource.

NOTE

In a managed domain, precede these commands with **/host=*HOST_NAME*/server=*SERVER_NAME***.

```
/subsystem=datasources/data-source=ExampleDS/statistics=pool:read-resource(include-
runtime=true)
{
    "outcome" => "success",
    "result" => {
        "ActiveCount" => 1,
        "AvailableCount" => 20,
        "AverageBlockingTime" => 0L,
        "AverageCreationTime" => 122L,
        "AverageGetTime" => 128L,
        "AveragePoolTime" => 0L,
        "AverageUsageTime" => 0L,
        "BlockingFailureCount" => 0,
        "CreatedCount" => 1,
        "DestroyedCount" => 0,
        "IdleCount" => 1,
        ...
}
```

The following management CLI command retrieves the *JDBC* statistics for the **ExampleDS** datasource.

```
/subsystem=datasources/data-source=ExampleDS/statistics=jdbc:read-resource(include-
runtime=true)
{
    "outcome" => "success",
    "result" => {
        "PreparedStatementCacheAccessCount" => 0L,
        "PreparedStatementCacheAddCount" => 0L,
        "PreparedStatementCacheCurrentSize" => 0,
        "PreparedStatementCacheDeleteCount" => 0L,
        "PreparedStatementCacheHitCount" => 0L,
        "PreparedStatementCacheMissCount" => 0L,
        "statistics-enabled" => true
    }
}
```

NOTE

Since statistics are runtime information, be sure to specify the **include-runtime=true** argument.

6.1.1.2.2. View datasource statistics using the management console

To view datasource statistics from the management console, navigate to the **Datasources** subsystem from the **Runtime** tab, select a datasource, and click **View**.

6.1.2. Resource adapter statistics

You can view core runtime statistics for deployed resource adapters. See the *Resource adapter statistics* appendix for a detailed list of all available statistics.

6.1.2.1. Enable resource adapter statistics

By default, resource adapter statistics are *not* enabled. The following management CLI command enables the collection of statistics for a simple resource adapter **myRA.rar** with a connection factory bound in JNDI as **java:/eis/AcmeConnectionFactory**:

NOTE

In a managed domain, precede the command with **/host=*HOST_NAME*/server=*SERVER_NAME*/**.

```
/deployment=myRA.rar/subsystem=resource-adapters/statistics=statistics/connection-
definitions=java\:\/eis\/AcmeConnectionFactory:write-attribute(name=statistics-enabled,value=true)
```

6.1.2.2. View resource adapter statistics

Resource adapter statistics can be retrieved from the management CLI. The following management CLI command returns statistics for the resource adapter **myRA.rar** with a connection factory bound in JNDI as **java:/eis/AcmeConnectionFactory**.

NOTE

In a managed domain, precede the command with **/host=*HOST_NAME*/server=*SERVER_NAME*/**.

```
deployment=myRA.rar/subsystem=resource-adapters/statistics=statistics/connection-
definitions=java\:\/eis\/AcmeConnectionFactory:read-resource(include-runtime=true)
{
    "outcome" => "success",
    "result" => {
        "ActiveCount" => "1",
        "AvailableCount" => "20",
        "AverageBlockingTime" => "0",
        "AverageCreationTime" => "0",
        "CreatedCount" => "1",
        "DestroyedCount" => "0",
        "InUseCount" => "0",
        "MaxCreationTime" => "0",
        "MaxUsedCount" => "1",
        "MaxWaitCount" => "0",
        "MaxWaitTime" => "0",
        "TimedOut" => "0",
        "TotalBlockingTime" => "0",
        "TotalCreationTime" => "0"
    }
}
```

NOTE

Since statistics are runtime information, be sure to specify the **include-runtime=true** argument.

6.2. POOL ATTRIBUTES

This section details advice for selected pool attributes that can be configured for optimal datasource or resource adapter performance.

Minimum Pool Size

The **min-pool-size** attribute defines the minimum size of the connection pool. The default minimum is zero connections. With a zero **min-pool-size**, connections are created and placed in the pool when the first transactions occur.
If **min-pool-size** is too small, it results in increased latency while executing initial database commands because new connections might need to be established. If **min-pool-size** is too large, it results in wasted connections to the datasource or resource adapter.

During periods of inactivity the connection pool will shrink, possibly to the **min-pool-size** value.

Red Hat recommends that you set **min-pool-size** to the number of connections that allow for ideal on-demand throughput for your applications.

Maximum Pool Size

The **max-pool-size** attribute defines the maximum size of the connection pool. It is an important performance parameter because it limits the number of active connections, and thus also limits the amount of concurrent activity.
If **max-pool-size** is too small, it can result in requests being unnecessarily blocked. If **max-pool-size** is too large, it can result in your JBoss EAP environment, datasource, or resource adapter using more resources than it can handle.

Red Hat recommends that you set the **max-pool-size** to at least 15% higher than an acceptable **MaxUsedCount** observed after monitoring performance under load. This allows some buffer for higher than expected conditions.

Prefill

The **pool-prefill** attribute specifies whether JBoss EAP will prefill the connection pool with the minimum number of connections when JBoss EAP starts. The default value is **false**.

When **pool-prefill** is set to **true**, JBoss EAP uses more resources at startup, but there will be less latency for initial transactions.

Red Hat recommends to set **pool-prefill** to **true** if you have optimized the **min-pool-size**.

Strict Minimum

The **pool-use-strict-min** attribute specifies whether JBoss EAP allows the number of connections in the pool to fall below the specified minimum.
If **pool-use-strict-min** is set to **true**, JBoss EAP will not allow the number of connections to temporarily fall below the specified minimum. The default value is **false**.

Although a minimum number of pool connections is specified, when JBoss EAP closes connections, for instance, if the connection is idle and has reached the timeout, the closure may cause the total number of connections to temporarily fall below the minimum before a new connection is created and added to the pool.

Timeouts

There are a number of timeout options that are configurable for a connection pool, but a significant one for performance tuning is **idle-timeout-minutes**.
The **idle-timeout-minutes** attribute specifies the maximum time, in minutes, a connection may be idle before being closed. As idle connections are closed, the number of connections in the pool will shrink down to the specified minimum.

The longer the timeout, the more resources are used but requests might be served faster. The lower the timeout, the less resources are used but requests might need to wait for a new connection to be created.

6.3. CONFIGURING POOL ATTRIBUTES

6.3.1. Configuring datasource pool attributes

You can configure datasource pool attributes using either the management CLI or the management console.

Prerequisites

- Install a JDBC driver.
- Create a datasource.

Procedure

- To use the management console, navigate to **Configuration** → **Subsystems** → **Datasources & Drivers** → **Datasources**, select your datasource, and click **View**. The pool options are configurable under the datasource **Pool** tab. Timeout options are configurable under the datasource **Timeouts** tab.
- To use the management CLI, execute the following command:

```
/subsystem=datasources/data-source=DATASOURCE_NAME/:write-attribute(name=ATTRIBUTE_NAME,value=ATTRIBUTE_VALUE)
```

For example, to set the **ExampleDS** datasource **min-pool-size** attribute to a value of 5 connections, use the following command:

```
/subsystem=datasources/data-source=ExampleDS/:write-attribute(name=min-pool-size,value=5)
```

6.3.2. Configuring resource adapter pool attributes

You can configure resource adapter pool attributes using either the management CLI or the management console.

Prerequisites

- Deploy your resource adapter and add a connection definition.

Procedure

- To use the management console, navigate to **Configuration** → **Subsystems** → **Resource Adapters**, select your resource adapter, click **View**, and select **Connection Definitions** in the left menu. The pool options are configurable under the **Pool** tab. Timeout options are configurable under the **Attributes** tab.

- To use the management CLI, execute the following command:

```
/subsystem=resource-adapters/resource-adapter=RESOURCE_ADAPTER_NAME/connection-definitions=CONNECTION_DEFINITION_NAME:write-attribute(name=ATTRIBUTE_NAME,value=ATTRIBUTE_VALUE)
```

For example, to set the **my_RA** resource adapter **my_CD** connection definition **min-pool-size** attribute to a value of 5 connections, use the following command:

```
/subsystem=resource-adapters/resource-adapter=my_RA/connection-definitions=my_CD:write-attribute(name=min-pool-size,value=5)
```

CHAPTER 7. MESSAGING SUBSYSTEM TUNING

When statistics collection is enabled for a messaging server in the **messaging-activemq** subsystem, you can view runtime statistics for resources on the messaging server.

7.1. ENABLING MESSAGING STATISTICS

Because it can negatively impact performance, statistics collection for the **messaging-activemq** subsystem is *not* enabled by default. You do not need to enable queue statistics to obtain basic information, such as the number of messages on a queue or the number of messages added to a queue. Those statistics are available using queue attributes without requiring that you set **statistics-enabled** to **true**.

You can enable additional statistics collection using the management CLI or the management console.

7.1.1. Enable messaging statistics using the management CLI

The following management CLI command enables the collection of statistics for the **default** messaging server.

```
/subsystem=messaging-activemq/server=default:write-attribute(name=statistics-enabled,value=true)
```

Pooled connection factory statistics are enabled separately from the other messaging server statistics. Use the following command to enable statistics for a pooled connection factory.

```
/subsystem=messaging-activemq/server=default/pooled-connection-factory=activemq-ra:write-attribute(name=statistics-enabled,value=true)
```

Reload the server for the changes to take effect.

7.1.2. Enable messaging statistics using the management console

Use the following steps to enable statistics collection for a messaging server using the management console.

Procedure

1. Navigate to **Configuration** → **Subsystems** → **Messaging (ActiveMQ)** → **Server**.
2. Select the server and click **View**.
3. Click **Edit** under the **Statistics** tab.
4. Set the **Statistics Enabled** field to **ON** and click **Save**.

Pooled connection factory statistics are enabled separately from the other messaging server statistics. Use the following steps to enable statistics collection for a pooled connection factory.

1. Navigate to **Configuration** → **Subsystems** → **Messaging (ActiveMQ)** → **Server**.
2. Select the server, select **Connections**, and click **View**.
3. Select the **Pooled Connection Factory** tab.

4. Select the pooled connection factory and click **Edit** under the **Attributes** tab.
5. Set the **Statistics Enabled** field to **ON** and click **Save**.
6. Reload the server for the changes to take effect.

7.2. VIEWING MESSAGING STATISTICS

You can view runtime statistics for a messaging server using the management CLI or management console.

7.2.1. View messaging statistics using the management CLI

You can view messaging statistics using the following management CLI commands. Be sure to include the **include-runtime=true** argument as statistics are runtime information.

- View statistics for a queue.

```
/subsystem=messaging-activemq/server=default/jms-queue=DLQ:read-resource(include-
runtime=true)
{
    "outcome" => "success",
    "result" => {
        "consumer-count" => 0,
        "dead-letter-address" => "jms.queue.DLQ",
        "delivering-count" => 0,
        "durable" => true,
        ...
    }
}
```

- View statistics for a topic.

```
/subsystem=messaging-activemq/server=default/jms-topic=testTopic:read-resource(include-
runtime=true)
{
    "outcome" => "success",
    "result" => {
        "delivering-count" => 0,
        "durable-message-count" => 0,
        "durable-subscription-count" => 0,
        ...
    }
}
```

- View statistics for a pooled connection factory.

```
/subsystem=messaging-activemq/server=default/pooled-connection-factory=activemq-
ra/statistics=pool:read-resource(include-runtime=true)
{
    "outcome" => "success",
    "result" => {
        "ActiveCount" => 1,
        "AvailableCount" => 20,
            "AverageBlockingTime" => 0L,
            "AverageCreationTime" => 13L,
            "AverageGetTime" => 14L,
            ...
        }
    }
```

NOTE

Pooled connection factory statistics are enabled separately from the other messaging server statistics.

7.2.2. View messaging statistics using the management console

To view messaging statistics from the management console, navigate to the **Messaging (ActiveMQ)** subsystem from the **Runtime** tab, and select the server. Select a destination to view its statistics.

NOTE

The **Prepared Transactions** page is where you can view, commit, and roll back prepared transactions.

7.3. CONFIGURE MESSAGE COUNTERS

You can configure the following message counter attributes for a messaging server.

- **message-counter-max-day-history**: The number of days the message counter history is kept.
- **message-counter-sample-period**: How often, in milliseconds, the queue is sampled. The management CLI command to configure these options uses the following syntax. Be sure to replace `*STATISTICS_NAME*` and `*STATISTICS_VALUE*` with the statistic name and value you want to configure.

```
/subsystem=messaging-activemq/server=default::write-attribute(name=STATISTICS_NAME,value=STATISTICS_VALUE)
```

For example, use the following commands to set the **message-counter-max-day-history** to five days and the **message-counter-sample-period** to two seconds.

```
/subsystem=messaging-activemq/server=default:write-attribute(name=message-counter-max-day-history,value=5)
/subsystem=messaging-activemq/server=default:write-attribute(name=message-counter-sample-period,value=2000)
```

7.4. VIEW MESSAGE COUNTER AND HISTORY FOR A QUEUE

You can view the message counter and message counter history for a queue using the following management CLI operations.

- **list-message-counter-as-json**
- **list-message-counter-as-html**

- **list-message-counter-history-as-json**
- **list-message-counter-history-as-html**

The management CLI command to use display these values uses the following syntax. Be sure to replace `*QUEUE_NAME*` and `*OPERATION_NAME*` with the queue name and operation you want to use.

```
/subsystem=messaging-activemq/server=default/jms-queue=QUEUE_NAME:OPERATION_NAME
```

For example, use the following command to view the message counter for the **TestQueue** queue in JSON format.

```
/subsystem=messaging-activemq/server=default/jms-queue=TestQueue:list-message-counter-as-
json
{
    "outcome" => "success",
    "result" => "
{\"destinationName\":\"TestQueue\",\"destinationSubscription\":null,\"destinationDurable\":true,\"count\":
0,\"countDelta\":0,\"messageCount\":0,\"messageCountDelta\":0,\"lastAddTimestamp\":\"12/31/69
7:00:00 PM\",\"updateTimestamp\":\"2/20/18 2:24:05 PM\"}"
}
```

7.5. RESET MESSAGE COUNTER FOR A QUEUE

You can reset the message counter for a queue using the **reset-message-counter** management CLI operation.

```
/subsystem=messaging-activemq/server=default/jms-queue=TestQueue:reset-message-counter
{
    "outcome" => "success",
    "result" => undefined
}
```

7.6. RUNTIME OPERATIONS USING THE MANAGEMENT CONSOLE

Using the management console you can:

- Perform forced failover to another messaging server
- Reset all message counters for a messaging server
- Reset all message counters history for a messaging server
- View information related to a messaging server
- Close connections for a messaging server
- Roll back transactions
- Commit transactions

7.6.1. Perform forced failover to another messaging server

You can use the management console to perform a forced failover to another messaging server.

Procedure

1. Access the management console and navigate to **Server** using either of the following:
   - **Runtime→ Browse By → Hosts → Host → Server**
   - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server**
3. Click the arrow button next to **View** and click **Force Failover**.
4. On the **Force Failover** window, click **Yes**.

7.6.2. Resetting all message counters for a messaging server

You can use the management console to reset all message counters for a messaging server.

Procedure

1. Access the management console and navigate to **Server** using either of the following:
   - **Runtime→ Browse By → Hosts → Host → Server**
   - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server**
3. Click the arrow button next to **View** and click **Reset**.
4. On the **Reset** window, click the toggle button next to **Reset all message counters** to enable the functionality.
   The button now displays **ON** in a blue background.
5. Click **Reset**.

7.6.3. Resetting message counters history for a messaging server

You can use the management console to reset message counters history for a messaging server.

Procedure

1. Access the management console and navigate to **Server** using either of the following:
   - **Runtime→ Browse By → Hosts → Host → Server**
   - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server**
3. Click the arrow button next to **View** and click **Reset**.
4. On the **Reset** window, click the toggle button next to **Reset all message counters history** to enable the functionality.

The button now displays **ON** in a blue background.

5. Click **Reset**.

7.6.4. View information related to a messaging server

Using the management console you can view a list of the following information related to a messaging server:

- Connections
- Consumers
- Producers
- Connectors
- Roles
- Transactions

To view information related to a messaging server:

Procedure

1. Access the management console and navigate to **Server** using either of the following:
    - **Runtime→ Browse By → Hosts → Host → Server**
    - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server** and then click **View**.
3. Click the appropriate item on the navigation pane to view a list of the item on the right pane.

7.6.5. Close connections for a messaging server

You can close connections by providing an IP address, an ActiveMQ address match or a user name.

To close connections for a messaging server:

Procedure

1. Access the management console and navigate to **Server** using either of the following:
    - **Runtime→ Browse By → Hosts → Host → Server**
    - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server** and then click **View**.
3. On the navigation pane, click **Connections**.
4. On the **Close** window, click the appropriate tab based on which connection you want to close.
5. Based on your selection, enter the IP address, ActiveMQ address match, or the user name, and then click **Close**.

7.6.6. Rolling back transactions for a messaging server

You can use the management console to roll back transactions for a messaging server.

Procedure

1. Access the management console and navigate to **Server** using either of the following:
   - **Runtime→ Browse By → Hosts → Host → Server**
   - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server** and then click **View**.
3. On the navigation pane, click **Transactions**.
4. Select the transaction you want to roll back and click **Rollback**.

7.6.7. Committing transactions for a messaging server

You can use the management console to commit transactions for a messaging server.

Procedure

1. Access the management console and navigate to Server using either of the following:
   - **Runtime→ Browse By → Hosts → Host → Server**
   - **Runtime→ Browse By → Server Groups → Server Group → Server**
2. Click **Messaging ActiveMQ → Server** and then click **View**.
3. On the navigation pane, click **Transactions**.
4. Select the transaction you want to commit and click **Commit**.

7.7. TUNING JAKARTA MESSAGING

If you use the Jakarta Messaging API, review the following information for tips on how to improve performance.

- Disable the message ID.
  If you do not need message IDs, disable them by using the **setDisableMessageID()** method on the **MessageProducer** class. Setting the value to true eliminates the overhead of creating a unique ID and decreases the size of the message.
- Disable the message timestamp.
  If you do not need message timestamps, disable them by using the **setDisableMessageTimeStamp()** method on the **MessageProducer** class. Setting the value to true eliminates the overhead of creating the timestamp and decreases the size of the message.
- Avoid using **ObjectMessage**.
  ObjectMessage is used to send a message that contains a serialized object, meaning the body of the message, or payload, is sent over the wire as a stream of bytes. The Java serialized form of even small objects is quite large and takes up a lot of space on the wire. It is also slow when

compared to custom marshalling techniques. Use **ObjectMessage** only if you cannot use one of the other message types, for example, if you do not know the type of the payload until runtime.

- Avoid **AUTO_ACKNOWLEDGE**.
  The choice of acknowledgement mode in a consumer impacts performance because of the additional overhead and traffic incurred by sending the acknowledgment message sent over the network. **AUTO_ACKNOWLEDGE** incurs this overhead because it requires an acknowledgement to be sent from the server for each message received on the client. If you can, use **DUPS_OK_ACKNOWLEDGE**, which acknowledges messages in a lazy manner, **CLIENT_ACKNOWLEDGE**, meaning the client code will call a method to acknowledge the message, or batch up many acknowledgements with one acknowledge or commit in a transacted session.

- Avoid durable messages.
  By default, Jakarta Messaging messages are durable. If you do not need durable messages, set them to be **non-durable**. Durable messages incur a lot of overhead because they are persisted to storage.

- Use **TRANSACTED_SESSION** mode to send and receive messages in a single transaction.
  By batching messages in a single transaction, the ActiveMQ Artemis server integrated in JBoss EAP requires only one network round trip on the commit, not on every send or receive.

7.8. TUNING PERSISTENCE

- Put the message journal on its own physical volume.
  One of the advantages of an append-only journal is that disk head movement is minimized. This advantage is lost if the disk is shared. When multiple processes, such as a transaction coordinator, databases, and other journals, read and write from the same disk, performance is impacted because the disk head must skip around between different files. If you are using paging or large messages, make sure they are also put on separate volumes.

- Tune the **journal-min-files** value.
  Set the **journal-min-files** parameter to the number of files that fits your average sustainable rate. If you frequently see new files being created on the journal data directory, meaning a lot data is being persisted, you need to increase the minimal number of files. This allows the journal to reuse, rather than create, new data files.

- Optimize the journal file size.
  The journal file size must be aligned to the capacity of a cylinder on the disk. The default value of **10MB** should be enough on most systems.

- Use the **AIO** journal type.
  For Linux operating systems, keep your journal type as **AIO**. **AIO** scales better than Java **NIO**.

- Tune the **journal-buffer-timeout** value.
  Increasing the **journal-buffer-timeout** value results in increased throughput at the expense of latency.

- Tune the **journal-max-io** value.
  If you are using **AIO**, you might be able improve performance by increasing the **journal-max-io** parameter value. Do not change this value if you are using **NIO**.

7.9. OTHER TUNING OPTIONS

This section describes other places in JBoss EAP messaging that can be tuned.

- Use asynchronous send acknowledgements.
  If you need to send non-transactional, durable messages and do not need a guarantee that they have reached the server by the time the call to **send()** returns, do not set them to be sent blocking. Instead use asynchronous send acknowledgements to get your send acknowledgements returned in a separate stream. However, in the case of a server crash, some messages might be lost.

- Use **pre-acknowledge** mode.
  With **pre-acknowledge** mode, messages are acknowledged before they are sent to the client. This reduces the amount of acknowledgment traffic on the wire. However, if that client crashes, messages will not be redelivered if the client reconnects.

- Disable security.
  There is a small performance boost when you disable security by setting the **security-enabled** attribute to false.

- Disable persistence.
  You can turn off message persistence altogether by setting **persistence-enabled** to **false**.

- Sync transactions lazily.
  Setting **journal-sync-transactional** to **false** provides better transactional persistent performance at the expense of some possibility of loss of transactions on failure.

- Sync non-transactional lazily.
  Setting **journal-sync-non-transactional** to **false** provides better non-transactional persistent performance at the expense of some possibility of loss of durable messages on failure.

- Send messages non-blocking.
  To avoid waiting for a network round trip for every message sent, set **block-on-durable-send** and **block-on-non-durable-send** to **false** if you are using Jakarta Messaging and JNDI, or set it directly on the **ServerLocator** by calling the **setBlockOnDurableSend()** and **setBlockOnNonDurableSend()** methods.

- Optimize the **consumer-window-size**.
  If you have very fast consumers, you can increase the **consumer-window-size** to effectively disable consumer flow control.

- Use the core API instead of the Jakarta Messaging API.
  Jakarta Messaging operations must be translated into core operations before the server can handle them, resulting in lower performance than when you use the core API. When using the core API, try to use methods that take **SimpleString** as much as possible. **SimpleString**, unlike **java.lang.String**, does not require copying before it is written to the wire, so if you reuse **SimpleString** instances between calls, you can avoid some unnecessary copying. Note that the core API is not portable to other brokers.

7.10. AVOIDING ANTI-PATTERNS

- Reuse connections, sessions, consumers, and producers where possible.
  The most common messaging anti-pattern is the creation of a new connection, session, and producer for every message sent or consumed. These objects take time to create and may involve several network round trips, so it is a poor use of resources. Always reuse them.

NOTE

Some popular libraries such as the Spring Messaging Template use these anti-patterns. If you are using the Spring Messaging Template, you may see poor performance. The Spring Messaging Template can only safely be used in an application server which caches Jakarta Messaging sessions, for example, using Jakarta Connectors, and only then for sending messages. It cannot safely be used for synchronously consuming messages, even in an application server.

- Avoid fat messages.
  Verbose formats such as XML take up a lot of space on the wire and performance suffers as result. Avoid XML in message bodies if you can.

- Do not create temporary queues for each request.
  This common anti-pattern involves the temporary queue request-response pattern. With the temporary queue request-response pattern, a message is sent to a target, and a reply-to header is set with the address of a local temporary queue. When the recipient receives the message, they process it, and then send back a response to the address specified in the reply-to header. A common mistake made with this pattern is to create a new temporary queue on each message sent, which drastically reduces performance. Instead, the temporary queue should be reused for many requests.

- Do not use message driven beans unless it is necessary.
  Using MDBs to consume messages is slower than consuming messages using a simple Jakarta Messaging message consumer.

CHAPTER 8. LOGGING SUBSYSTEM TUNING

You can further improve upon JBoss EAP logging subsystem performance in production environments by disabling logging to console, configuring appropriate logging levels, and specifying the best location to store log files.

8.1. DISABLING LOGGING TO THE CONSOLE

Disabling console logging can improve JBoss EAP performance. Although outputting logs to the console can be useful in development and testing environments, for production environments it is not necessary in most cases. The JBoss EAP root logger includes a console log handler for all default standalone server profiles except **standalone-full-ha**. The default managed domain profiles do not include a console handler.

To remove the default console handler from the root logger, use the following management CLI command.

```
/subsystem=logging/root-logger=ROOT:remove-handler(name=CONSOLE)
```

8.2. CONFIGURING LOGGING LEVELS

For ideal performance, you must configure the logging levels for your production environment appropriately. For example, although **INFO** or **DEBUG** levels might be appropriate for development or testing environments, in most cases you should set your production environment logging level to something higher, such as **WARN** or **ERROR**.

8.3. CONFIGURING THE LOCATION OF LOG FILES

You should consider the storage location of log files as a potential performance issue. If you save logs to a file system or disk configuration that has poor I/O throughput, it has the potential to affect the whole platform’s performance.

To prevent logging from impacting JBoss EAP performance, it is recommended that you set log locations to high-performance dedicated disks that have a lot of space.

CHAPTER 9. UNDERTOW SUBSYSTEM TUNING

The non-blocking I/O (NIO) **undertow** subsystem introduced in JBoss EAP 7 has greatly improved performance compared to the previous **web** subsystem in JBoss EAP 6. Opportunities for tuning the **undertow** subsystem for your environment include:

- Buffer cache configuration
- Byte buffer pools configuration
- Jakarta Server Pages configuration options
- Listener configuration options
- Session attribute marshalling

9.1. BUFFER CACHE CONFIGURATION

A buffer cache stores static files handled by the **undertow** subsystem. This includes images, static HTML, CSS, and JavaScript files. You can specify a default buffer cache for each Undertow servlet container. Having an optimized buffer cache for your servlet container can improve Undertow performance for serving static files.

Buffers in a buffer cache are allocated in regions and are of a fixed size. There are three configurable attributes for each buffer cache:

buffer-size

The size of an individual buffer, in bytes. The default is 1024 bytes. Set the buffer size to entirely store your largest static file.

buffers-per-region

The number of buffers per region. The default is 1024.

max-regions

The maximum number of regions, which sets a maximum amount of memory allocated to the buffer cache. The default is 10 regions.

You can calculate the maximum amount memory used by a buffer cache by multiplying the buffer size, the number of buffers per region, and the maximum number of regions. For example, the default buffer cache is 1024 bytes * 1024 buffers per region * 10 regions = 10 MB.

Configure your buffer caches based on the size of your static files, and the results from testing expected loads in a development environment. When determining the effect on performance, consider the balance of the buffer cache performance benefit versus the memory used.

9.2. BYTE BUFFER POOLS CONFIGURATION

Undertow byte buffer pools are used to allocate pooled NIO **ByteBuffer** instances. All listeners have a byte buffer pool and you can use different buffer pools and workers for each listener. Byte buffer pools can be shared between different server instances.

The main byte buffer pool attribute that significantly affects performance is **buffer-size**. The default is calculated based on the RAM resources of your system and is sufficient in most cases. If you are configuring this attribute manually, an ideal size for most servers is 16 KB.

9.3. JAKARTA SERVER PAGES CONFIGURATION OPTIONS

The following Jakarta Server Pages configuration options for Undertow servlet containers provide optimizations for how Jakarta Server Pages are compiled into Java bytecode:

generate-strings-as-char-arrays

If your Jakarta Server Pages contain a lot of String constants, enabling this option optimizes scriptlets by converting the String constants to char arrays.

optimize-scriptlets

If your Jakarta Server Pages contain many String concatenations, enabling this option optimizes scriptlets by removing String concatenation for every Jakarta Server Pages request.

trim-spaces

If your Jakarta Server Pages contain a lot of white space, enabling this option trims the white space from HTTP requests and reduces HTTP request payload.

9.3.1. Enabling Jakarta Server Pages options using the management console

To enable the Undertow Jakarta Server Pages configuration options using the management console, complete the following steps:

Procedure

1. Navigate to **Configuration** → **Subsystems** → **Web (Undertow)** → **Servlet Container**.
2. Select the servlet container you want to configure and click **View**.
3. Select **Jakarta Server Pages** and click **Edit**.
4. For each option you want to enable, set the field to **ON**, and then click **Save**.

9.3.2. Enabling Jakarta Server Pages options using the management CLI

To enable the Undertow Jakarta Server Pages configuration options using the management CLI, complete the following steps:

Procedure

- Use the following command:

```
/subsystem=undertow/servlet-container=__SERVLET_CONTAINER__/setting=jsp/:write-attribute(name=__OPTION_NAME__,value=true)
```

For example, to enable **generate-strings-as-char-arrays** for the **default** servlet container, use the following command:

```
/subsystem=undertow/servlet-container=default/setting=jsp/:write-attribute(name=generate-strings-as-char-arrays,value=true)
```

9.4. LISTENER CONFIGURATION OPTIONS

Depending on your applications and environment, you can configure multiple listeners specific to certain types of traffic, for example, traffic on specific ports, and then configure options for each listener.

The following are selected performance-related options that can be configured on HTTP, HTTPS, and AJP listeners.

max-connections

The maximum number of concurrent connections that the listener can handle. By default this attribute is undefined, which results in unlimited connections.
You can use this option to set a ceiling on the number of connections a listener can handle, which might be useful to cap resource usage. In configuring this value you should consider your workload and traffic type. Also see **no-request-timeout** below.

no-request-timeout

The length of time in milliseconds that a connection is idle before it is closed. The default value is 60000 milliseconds (1 minute).
Tuning this option in your environment for optimal connection efficiency can help improve network performance. If idle connections are prematurely closed, there are overheads in re-establishing connections. If idle connections are open for too long, they unnecessarily use resources.

max-header-size

The maximum size of an HTTP request header, in bytes. The default is 1048576 (1024KB).
Limiting the header size can be useful to prevent certain types of denial of service attacks.

buffer-pool

Specifies the buffer pool in the **io** subsystem to use for the listener. By default, all listeners use the **default** buffer pool.
You can use this option to configure each listener to use a unique buffer pool, or have multiple listeners use the same buffer pool.

worker

The **undertow** subsystem relies on the **io** subsystem to provide XNIO workers. This option specifies the XNIO worker that the listener uses. By default, a listener uses the **default** worker in the **io** subsystem.
It might be useful to configure each listener to use a specific worker so you can assign different worker resources to certain types of network traffic.

9.4.1. Configuring listener options using the management console

To configure the listener options using the management console, complete the following steps:

Procedure

1. Navigate to **Configuration** → **Subsystems** → **Web (Undertow)** → **Server**.
2. Select the server you want to configure and click **View**.
3. In the left menu, select **Listener** then select the type of listener to configure, for example **HTTP Listener**, and select the listener in the table.
4. CLick **Edit**, modify the options you want to configure, and click **Save**.

9.4.2. Configuring listener options using the management CLI

To configure the listener options using the management CLI, complete the following steps:

Procedure

- Use the following command:

```
/subsystem=undertow/server=SERVER_NAME/LISTENER_TYPE=LISTENER_NAME:write-
attribute(name=OPTION_NAME,value=OPTION_VALUE)
```

For example, to set **max-connections** to **100000** for the **default** HTTP listener in the **default-server** Undertow server, use the following command:

```
/subsystem=undertow/server=default-server/http-listener=default:write-attribute(name=max-
connections,value=100000)
```

CHAPTER 10. IO SUBSYSTEM TUNING

The **io** subsystem defines XNIO workers and buffer pools that are used by other JBoss EAP subsystems, such as Undertow and Remoting.

10.1. CONFIGURING WORKERS

You can create multiple separate workers that each have their own performance configuration and which handle different I/O tasks. For example, you could create one worker to handle HTTP I/O, and another worker to handle Jakarta Enterprise Beans I/O, and then separately configure the attributes of each worker for specific load requirements.

Worker attributes that significantly affect performance include **io-threads** which sets the total number of I/O threads that a worker can use, and **task-max-threads** which sets the maximum number of threads that can be used for a particular task. The defaults for these two attributes are calculated based on the server's CPU count.

10.1.1. Monitoring worker statistics

You can view a worker's runtime statistics using the management CLI. This exposes worker statistics such as connection count, thread count, and queue size.

The following command displays runtime statistics for the **default** worker:

```
/subsystem=io/worker=default:read-resource(include-runtime=true,recursive=true)
```

NOTE

The number of core threads, which is tracked by the **core-pool-size** statistic, is currently always set to the same value as the maximum number of threads, which is tracked by the **max-pool-size** statistic.

10.2. CONFIGURING BUFFER POOLS

NOTE

IO buffer pools are deprecated, but they are still set as the default in the current release.

A buffer pool in the **io** subsystem is a pooled NIO buffer instance that is used specifically for I/O operations. Like workers, you can create separate buffer pools which can be dedicated to handle specific I/O tasks.

The main buffer pool attribute that significantly affects performance is **buffer-size**. The default is calculated based on the RAM resources of your system, and is sufficient in most cases. If you are configuring this attribute manually, an ideal size for most servers is 16KB.

CHAPTER 11. JGROUPS SUBSYSTEM TUNING

For optimal network performance it is recommended that you use UDP multicast for JGroups in environments that support it.

NOTE

TCP has more overhead and is often considered slower than UDP since it handles error checking, packet ordering, and congestion control itself. JGroups handles these features for UDP, whereas TCP guarantees them itself. TCP is a good choice when using JGroups on unreliable or high congestion networks, or when multicast is not available.

This chapter assumes that you have chosen your JGroups stack transport protocol (UDP or TCP) and communications protocols that JGroups cluster communications will use.

11.1. MONITORING JGROUPS STATISTICS

You can enable statistics for the **jgroups** subsystem to monitor JBoss EAP clustering using the management CLI or through JMX.

NOTE

Enabling statistics adversely affects performance. Only enable statistics when necessary.

Procedure

1. Use the following command to enable statistics for a JGroups channel.

   NOTE

   In a managed domain, precede these commands with ***/profile=PROFILE_NAME***.

   ```
   /subsystem=jgroups/channel=CHANNEL_NAME:write-attribute(name=statistics-enabled,value=true)
   ```

   For example, use the following command to enable statistics for the default **ee** channel.

   ```
   /subsystem=jgroups/channel=ee:write-attribute(name=statistics-enabled,value=true)
   ```

2. Reload the JBoss EAP server.

   ```
   reload
   ```

3. You can now see JGroups statistics using either the management CLI, or through JMX with a JVM monitoring tool:

   - To use the management CLI, use the **:read-resource(include-runtime=true)** command on the JGroups channel or protocol that you want to see the statistics for.

NOTE

In a managed domain, precede these commands with ***/host=HOST_NAME/server=SERVER_NAME***.

For example:

- To see the statistics for the **ee** channel, use the following command:

```
/subsystem=jgroups/channel=ee:read-resource(include-runtime=true)
```

- To see the statistics for the **FD_ALL** protocol in the **ee** channel, use the following command:

```
/subsystem=jgroups/channel=ee/protocol=FD_ALL:read-resource(include-runtime=true)
```

- To connect to JBoss EAP using a JVM monitoring tool, see the Monitoring Performance chapter. You can see the statistics on JGroups MBeans through the JMX connection.

11.2. NETWORKING AND JUMBO FRAMES

Where possible, it is recommended that the network interface for JGroups traffic should be part of a dedicated Virtual Local Area Network (VLAN). This allows you to separate cluster communications from other JBoss EAP network traffic to more easily control cluster network performance, throughput, and security.

Another network configuration to consider to improve cluster performance is to enable jumbo frames. If your network environment supports it, enabling jumbo frames by increasing the Maximum Transmission Unit (MTU) can help boost network performance, especially in high throughput environments.

To use jumbo frames, all NICs and switches in your network must support it.

Additional resources

See the Red Hat Customer Portal for instructions on enabling jumbo frames for Red Hat Enterprise Linux.

11.3. MESSAGE BUNDLING

Message bundling in JGroups improves network performance by assembling multiple small messages into larger bundles. Rather than sending out many small messages over the network to cluster nodes, instead messages are queued until the maximum bundle size is reached or there are no more messages to send. The queued messages are assembled into a larger message bundle and then sent.

This bundling reduces communications overhead, especially in TCP environments where there is a higher overhead for network communications.

11.3.1. Configuring message bundling

JGroups message bundling is configured using the **max_bundle_size** property. The default **max_bundle_size** is 64KB.

The performance improvements of tuning the bundle size depend on your environment, and whether more efficient network traffic is balanced against a possible delay of communications while the bundle is assembled.

Procedure

- Use the following management CLI command to configure **max_bundle_size**.

  ```
  /subsystem=jgroups/stack=STACK_NAME/transport=TRANSPORT_TYPE/property=max_bund
  le_size:add(value=BUNDLE_SIZE)
  ```

  For example, to set **max_bundle_size** to 60K for the default **udp** stack:

  ```
  /subsystem=jgroups/stack=udp/transport=UDP/property=max_bundle_size:add(value=60K)
  ```

11.4. JGROUPS THREAD POOLS

The **jgroups** subsystem uses its own thread pools for processing cluster communication. JGroups contains thread pools for **default**, **internal**, **oob**, and **timer** functions which you can configure individually. Each JGroups thread pool includes configurable attributes for **keepalive-time**, **max-threads**, **min-threads**, and **queue-length**.

Appropriate values for each thread pool attribute depend on your environment, but for most situations the default values should suffice.

11.5. JGROUPS SEND AND RECEIVE BUFFERS

The **jgroups** subsystem has configurable send and receive buffers for both UDP and TCP stacks.

Appropriate values for JGroups buffers depend on your environment, but for most situations the default values should suffice. It is recommended that you test your cluster under load in a development environment to tune appropriate values for the buffer sizes.

NOTE

Your operating system may limit the available buffer sizes and JBoss EAP may not be able to use its configured buffer values.

CHAPTER 12. TRANSACTIONS SUBSYSTEM TUNING

If your environment uses XA distributed transactions, you can tune the transaction manager's log store for better performance.

The default transaction log store uses a simple file store. For XA transactions this type of log store can be inefficient, as it creates one system file for each transaction log. Especially for XA transactions, a journal store is much more efficient as it uses a journal that consists of one file for all transactions.

For better XA transaction performance, it is recommended that you use a journal log store. For Red Hat Enterprise Linux systems, you can additionally enable asynchronous I/O (AIO) on the journal store to further improve performance.

NOTE

For Red Hat Enterprise Linux systems, if you are enabling asynchronous I/O (AIO) on the journal store, ensure that the **libaio** package is installed.

12.1. ENABLE THE JOURNAL LOG STORE USING THE MANAGEMENT CONSOLE

You can use the management console to enable the journal log store.

Procedure

1. Navigate to **Configuration** → **Subsystems** → **Transaction** → and click **View**.
2. In the **Configuration** tab, click **Edit**.
3. Set the **Use Journal Store** field to **ON**.
4. **Optional**: For Red Hat Enterprise Linux systems, set the **Journal Store Enable Async IO**field to **ON**.
5. Click **Save**.

12.2. ENABLE THE JOURNAL LOG STORE USING THE MANAGEMENT CLI

You can use the management CLI to enable the journal log store.

Procedure

1. To enable the journal log store using the management CLI, use the following command:

```
/subsystem=transactions:write-attribute(name=use-journal-store,value=true)
```

2. **Optional**: For Red Hat Enterprise Linux systems, use the following command to enable journal log store asynchronous I/O:

```
/subsystem=transactions:write-attribute(name=journal-store-enable-async-io, value=true)
```

APPENDIX A. REFERENCE MATERIAL

A.1. DATASOURCE STATISTICS

Table A.1. Core pool statistics

Name	Description
ActiveCount	The number of active connections. Each of the connections is either in use by an application or available in the pool.
AvailableCount	The number of available connections in the pool.
AverageBlockingTime	The average time spent blocking on obtaining an exclusive lock on the pool. This value is in milliseconds.
AverageCreationTime	The average time spent creating a connection. This value is in milliseconds.
AverageGetTime	The average time spent obtaining a connection.
AveragePoolTime	The average time that a connection spent in the pool.
AverageUsageTime	The average time spent using a connection.
BlockingFailureCount	The number of failures trying to obtain a connection.
CreatedCount	The number of connections created.
DestroyedCount	The number of connections destroyed.
IdleCount	The number of connections that are currently idle.
InUseCount	The number of connections currently in use.
MaxCreationTime	The maximum time it took to create a connection. This value is in milliseconds.
MaxGetTime	The maximum time for obtaining a connection.
MaxPoolTime	The maximum time for a connection in the pool.
MaxUsageTime	The maximum time using a connection.
MaxUsedCount	The maximum number of connections used.
MaxWaitCount	The maximum number of requests waiting for a connection at the same time.

Name	Description
MaxWaitTime	The maximum time spent waiting for an exclusive lock on the pool.
TimedOut	The number of timed out connections.
TotalBlockingTime	The total time spent waiting for an exclusive lock on the pool. This value is in milliseconds.
TotalCreationTime	The total time spent creating connections. This value is in milliseconds.
TotalGetTime	The total time spent obtaining connections.
TotalPoolTime	The total time spent by connections in the pool.
TotalUsageTime	The total time spent using connections.
WaitCount	The number of requests that had to wait to obtain a connection.
XACommitAverageTime	The average time for an XAResource commit invocation.
XACommitCount	The number of XAResource commit invocations.
XACommitMaxTime	The maximum time for an XAResource commit invocation.
XACommitTotalTime	The total time for all XAResource commit invocations.
XAEndAverageTime	The average time for an XAResource end invocation.
XAEndCount	The number of XAResource end invocations.
XAEndMaxTime	The maximum time for an XAResource end invocation.
XAEndTotalTime	The total time for all XAResource end invocations.
XAForgetAverageTime	The average time for an XAResource forget invocation.
XAForgetCount	The number of XAResource forget invocations.
XAForgetMaxTime	The maximum time for an XAResource forget invocation.
XAForgetTotalTime	The total time for all XAResource forget invocations.
XAPrepareAverageTime	The average time for an XAResource prepare invocation.

Name	Description
XAPrepareCount	The number of XAResource prepare invocations.
XAPrepareMaxTime	The maximum time for an XAResource prepare invocation.
XAPrepareTotalTime	The total time for all XAResource prepare invocations.
XARecoverAverageTime	The average time for an XAResource recover invocation.
XARecoverCount	The number of XAResource recover invocations.
XARecoverMaxTime	The maximum time for an XAResource recover invocation.
XARecoverTotalTime	The total time for all XAResource recover invocations.
XARollbackAverageTime	The average time for an XAResource rollback invocation.
XARollbackCount	The number of XAResource rollback invocations.
XARollbackMaxTime	The maximum time for an XAResource rollback invocation.
XARollbackTotalTime	The total time for all XAResource rollback invocations.
XAStartAverageTime	The average time for an XAResource start invocation.
XAStartCount	The number of XAResource start invocations.
XAStartMaxTime	The maximum time for an XAResource start invocation.
XAStartTotalTime	The total time for all XAResource start invocations.

Table A.2. JDBC statistics

Name	Description
PreparedStatementCacheAccessCount	The number of times that the statement cache was accessed.
PreparedStatementCacheAddCount	The number of statements added to the statement cache.
PreparedStatementCacheCurrentSize	The number of prepared and callable statements currently cached in the statement cache.
PreparedStatementCacheDeleteCount	The number of statements discarded from the cache.
PreparedStatementCacheHitCount	The number of times that statements from the cache were used.

Name	Description
PreparedStatementCacheMissCount	The number of times that a statement request could not be satisfied with a statement from the cache.

A.2. RESOURCE ADAPTER STATISTICS

Table A.3. Resource adapter statistics

Name	Description
ActiveCount	The number of active connections. Each of the connections is either in use by an application or available in the pool
AvailableCount	The number of available connections in the pool.
AverageBlockingTime	The average time spent blocking on obtaining an exclusive lock on the pool. The value is in milliseconds.
AverageCreationTime	The average time spent creating a connection. The value is in milliseconds.
CreatedCount	The number of connections created.
DestroyedCount	The number of connections destroyed.
InUseCount	The number of connections currently in use.
MaxCreationTime	The maximum time it took to create a connection. The value is in milliseconds.
MaxUsedCount	The maximum number of connections used.
MaxWaitCount	The maximum number of requests waiting for a connection at the same time.
MaxWaitTime	The maximum time spent waiting for an exclusive lock on the pool.
TimedOut	The number of timed out connections.
TotalBlockingTime	The total time spent waiting for an exclusive lock on the pool. The value is in milliseconds.
TotalCreationTime	The total time spent creating connections. The value is in milliseconds.
WaitCount	The number of requests that had to wait for a connection.

A.3. IO SUBSYSTEM ATTRIBUTES

NOTE

Attribute names in these tables are listed as they appear in the management model, for example, when using the management CLI. See the schema definition file located at ***EAP_HOME*/docs/schema/wildfly-io_2_0.xsd** to view the elements as they appear in the XML, as there may be differences from the management model.

Table A.4. worker attributes

Attribute	Default	Description
io-threads		The number of I/O threads to create for the worker. If not specified, the number of threads is set to the number of CPUs × 2.
stack-size	0	The stack size, in bytes, to attempt to use for worker threads.
task-keepalive	60000	The number of milliseconds to keep non-core task threads alive.
task-core-threads	2	The number of threads for the core task thread pool.
task-max-threads		The maximum number of threads for the worker task thread pool. If not specified, the maximum number of threads is set to the number of CPUs × 16, taking the **MaxFileDescriptorCount** JMX property, if set, into account.

Table A.5. buffer-pool attributes

Attribute	Default	Description
buffer-size		The size, in bytes, of each buffer slice. If not specified, the size is set based on the available RAM of your system: • 512 bytes for less than 64 MB RAM • 1024 bytes (1 KB) for 64 MB – 128 MB RAM • 16384 bytes (16 KB) for more than 128 MB RAM
buffers-per-slice		How many slices, or sections, to divide the larger buffer into. This can be more memory efficient than allocating many separate buffers. If not specified, the number of slices is set based on the available RAM of your system: * 10 for less than 128 MB RAM * 20 for more than 128 MB RAM

Attribute	Default	Description
direct-buffers		Whether the buffer pool uses direct buffers, which are faster in many cases with NIO. Note that some platforms do not support direct buffers.

NOTE

IO buffer pools are deprecated as of JBoss EAP 7.2. While they are still set as the default in the current release, they will be replaced by Undertow byte buffer pools in a future release.

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