

Oracle Fusion Middleware

Developing Custom Management Utilities Using JMX for Oracle WebLogic Server



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Preface

This document describes how to create JMX clients that monitor and modify WebLogic Server resources.

Audience

This document is a resource for software vendors who develop JMX-compatible management systems. It also contains information that is useful for business analysts and system architects who are evaluating WebLogic Server or considering the use of JMX for a particular application.

It is assumed that the reader is familiar with Jakarta EE and general application management concepts. This document emphasizes a hands-on approach to developing a limited but useful set of JMX management services.

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Diversity and Inclusion

Oracle is fully committed to diversity and inclusion. Oracle respects and values having a diverse workforce that increases thought leadership and innovation. As part of our initiative to build a more inclusive culture that positively impacts our employees, customers, and partners, we are working to remove insensitive terms from our products and documentation. We are also mindful of the necessity to maintain compatibility with our customers' existing technologies and the need to ensure continuity of service as Oracle's offerings and industry standards evolve. Because of these technical constraints, our effort to remove insensitive terms is ongoing and will take time and external cooperation.

Related Documentation

The Oracle Technology Network includes a Web site that provides links to books, white papers, and additional information on JMX: <http://www.oracle.com/technetwork/java/javase/tech/javamanagement-140525.html>.

WebLogic Server supports JMX 1.4 by leveraging the JMX implementation in the JDK on which it is running. To view the JMX 1.4 specification, download it from <https://docs.oracle.com/en/java/javase/17/jmx/index.html>

To view the JMX Remote API 1.0 specification, download it from <http://jcp.org/aboutJava/communityprocess/final/jsr160/index.html>.

You can view the API reference for the `javax.management*` packages from: <https://docs.oracle.com/en/java/javase/17/docs/api/index.html>.

For guidelines on developing other types of management services for WebLogic Server applications, see the following documents:

- *Adding WebLogic Logging Services to Applications Deployed on Oracle WebLogic Server* describes WebLogic support for internationalization and localization of log messages, and shows you how to use the templates and tools provided with WebLogic Server to create or edit message catalogs that are locale-specific.
- *Configuring and Using the Diagnostics Framework for Oracle WebLogic Server* describes how system administrators can collect application monitoring data that has not been exposed through JMX, logging, or other management facilities.

For guidelines on developing and tuning WebLogic Server applications, see the following documents:

- *Developing Applications for Oracle WebLogic Server* is a guide to developing WebLogic Server applications.
- *Developing Manageable Applications Using JMX for Oracle WebLogic Server* describes how to create and register custom MBeans.

New and Changed WebLogic Server Features

For a comprehensive listing of the new WebLogic Server features introduced in this release, see *What's New in Oracle WebLogic Server*.

Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
<i>italic</i>	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
monospace	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

1

Introduction

This document describes creating JMX clients that monitor and modify WebLogic Server resources.

To integrate third-party management systems with the WebLogic Server management system, WebLogic Server provides standards-based interfaces that are fully compliant with the Java Management Extensions (JMX) specification. Software vendors can use these interfaces to monitor WebLogic Server MBeans, to change the configuration of a WebLogic Server domain, and to monitor the distribution (activation) of those changes to all server instances in the domain. While JMX clients can perform all WebLogic Server management functions without using Oracle's proprietary classes, Oracle recommends that remote JMX clients use WebLogic Server protocols (such as T3) to connect to WebLogic Server instances.

2

Understanding WebLogic Server MBeans

This chapter describes the MBeans that WebLogic Server provides that you can use to configure, monitor, and manage WebLogic Server resources, and also explains how WebLogic Server distributes and maintains these MBeans.

This chapter includes the following sections:

The *MBean Reference for Oracle WebLogic Server* provides a detailed reference for all WebLogic Server MBeans.

Basic Organization of a WebLogic Server Domain

A WebLogic Server administration **domain** is a collection of one or more servers and the applications and resources that are configured to run on the servers. Each domain must include a special server instance that is designated as the **Administration Server**. The simplest domain contains a single server instance that acts as both Administration Server and host for applications and resources. This domain configuration is commonly used in development environments. Domains for production environments usually contain multiple server instances (**Managed Servers**) running independently or in groups called clusters. In such environments, the Administration Server does not host production applications. For more information about domains, refer to Understanding Oracle WebLogic Server Domains in *Understanding Domain Configuration for Oracle WebLogic Server*.

Separate MBean Types for Monitoring and Configuring

All WebLogic Server MBeans can be organized into one of the following general types based on whether the MBean monitors or configures servers and resources:

- **Run-time MBeans** contain information about the run-time state of a server and its resources. They generally contain only data about the current state of a server or resource, and they do not persist this data. When you shut down a server instance, all run-time statistics and metrics from the run-time MBeans are destroyed.
- **Configuration MBeans** contain information about the configuration of servers and resources. They represent the information that is stored in the domain's XML configuration documents.
- Configuration MBeans for system modules contain information about the configuration of services such as JDBC data sources and JMS topics that have been targeted at the system level. Instead of targeting these services at the system level, you can include services as modules within an application. These application-level resources share the life cycle and scope of the parent application. However, WebLogic Server does not provide MBeans for application modules. See Supported Deployment Units in *Deploying Applications to Oracle WebLogic Server*.

The Life Cycle of WebLogic Server MBeans

The life cycle of a run-time MBean follows that of the resource for which it exposes run-time data. For example, when you start a server instance, the server instantiates a `ServerRuntimeMBean` and populates it with the current run-time data. Each resource updates

the data in its run-time MBean as its state changes. The resource destroys its run-time MBeans when it is stopped.

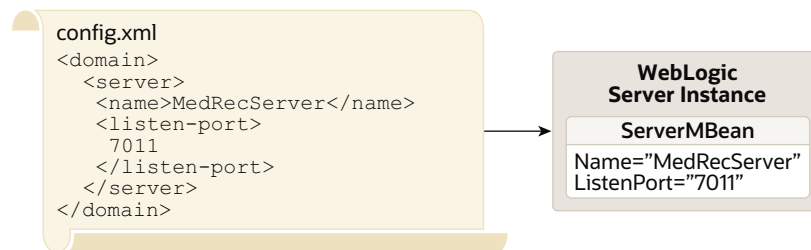
For a configuration MBean, the life cycle is as follows:

1. Each server in the domain has its own copy of the domain's configuration documents (which consist of a `config.xml` file and subsidiary files). During a server's startup cycle, it contacts the Administration Server to update its configuration files with any changes that occurred while it was shut down. Then it instantiates configuration MBeans to represent the data in the configuration documents. (See [Figure 2-1](#).)

Note

By default, a Managed Server will start even if it cannot contact the Administration Server to update its configuration files. This default setting creates the possibility that Managed Servers across the domain might run with inconsistent configurations. For information about changing this default, see *Starting a Managed Server When the Administration Server Is Not Accessible in Administering Server Startup and Shutdown for Oracle WebLogic Server*.

Figure 2-1 Initializing Configuration MBeans on Administration Server



The configuration MBeans enable each server instance in the domain to have an identical in-memory representation of the domain's configuration.

2. To control changes to the domain's configuration, JMX clients have read-only access to these configuration MBeans.

The Administration Server maintains a separate, editable copy of the domain's configuration documents in the domain's `config/pending` directory. It uses the data in these pending documents to instantiate a set of configuration MBeans that JMX clients can modify. After a JMX client modifies one of these configuration MBeans, the client directs the Administration Server to save the modifications in the pending configuration documents. Then the client starts a transactional process that updates the read-only configuration documents and configuration MBeans for all server instances in the domain.

See *Managing Configuration Changes in Understanding Domain Configuration for Oracle WebLogic Server*.

3. Configuration MBeans are destroyed when you shut down the server instance that hosts them.

WebLogic Server MBean Data Model

The JMX specification does not impose a model for organizing MBeans. However, because the configuration of a WebLogic Server domain is specified in an XML document, WebLogic Server organizes its MBeans into a hierarchical model that reflects the XML document structure.

For example, the root of a domain's configuration document is `<domain>` and below the root are child elements such as `<server>` and `<cluster>`. Each domain maintains a single MBean of type `DomainMBean` to represent the `<domain>` root element. Within `DomainMBean`, JMX attributes provide access to the MBeans that represent child elements such as `<server>` and `<cluster>`.

The following sections describe the patterns that WebLogic Server MBeans use to model the underlying XML configuration:

Containment and Reference Relationships

MBean attributes that provide access to other MBeans represent one of following types of relationships:

- Containment, which reflects a parent-child relationship between the corresponding XML elements in the domain's configuration document.
- Reference, which reflects a sibling or other non-ancestor, non-descendant relationship.

Containment Relationship

The XML excerpt in [Example 2-1](#) illustrates a containment relationship between `<domain>` and `<server>` and `<domain>` and `<cluster>`.

Example 2-1 Containment Relationship in XML

```
<domain>
  <server>
    <name>MyServer</name>
  </server>
  <cluster>
    <name>MyCluster</name>
  </cluster>
</domain>
```

To reflect this relationship, `DomainMBean` has two attributes, `Servers` and `Clusters`. The value of the `Servers` attribute is an array of object names `javax.management.ObjectName[]` for all `ServerMBeans` that have been created in the domain. The value of the `Clusters` attribute is an array of object names for all `ClusterMBeans`.

Another aspect of the containment relationship is expressed in a set of MBean operations that follow the design pattern for Java bean factory methods: for each contained (child) MBean, the parent MBean provides a `createChild` and `destroyChild` operation, where *Child* is the short name of the MBean's type. (The short name is the MBean's unqualified type name without the MBean suffix. For example, `createServer`).

Note

JMX clients cannot use `javax.management.MBeanServer.create()` or `register()` to create and register instances of WebLogic Server MBeans because WebLogic Server does not make its MBean implementation classes publicly available.

If you create and register custom MBeans (MBeans you have created to manage your applications), you will have access to your own implementation files and you can use the standard `MBeanServer.create()` or `register()` methods. Custom MBeans are not part of the WebLogic Server data model and do not participate in its factory method model.

In some cases, an MBean's factory methods are not public because of dependencies within a server instance. In these cases the parent manages the life cycle of its children. For example, each `ServerMBean` must have one and only one child `LogMBean` to configure the server's local log file. The factory methods for `LogMBean` are not public, and `ServerMBean` maintains the life cycle of its `LogMBean`.

With a containment relationship, the parent MBean also contains a `lookupChild` operation. If you know the user-supplied name that was used to create a specific server or resource, you can use the lookup operation in the parent MBean to get the object name. For example, `DomainMBean` includes an operation named `lookupServers(String name)`, which takes as a parameter the name that was used to create a server instance. If you named a server `MS1`, you could pass a `String` object that contains `MS1` to the `lookupServers` method and the method would return the object name for `MS1`.

Reference Relationship

The XML excerpt in [Example 2-2](#) illustrates a reference relationship between `<server>` and `<cluster>`.

Example 2-2 Reference Relationship in XML

```
<domain>
  <server>
    <name>MyServer</name>
    <cluster>MyCluster</cluster>
  </server>
  <cluster>
    <name>MyCluster</name>
  </cluster>
</domain>
```

While a server logically belongs to a cluster, the `<server>` and `<cluster>` elements in the domain's configuration file are siblings. To reflect this relationship, `ServerMBean` has a `Cluster` attribute whose value is the object name (`javax.management.ObjectName`) of the `ClusterMBean` to which the server belongs.

MBeans in a reference relationship do not provide factory methods.

WebLogic Server MBean Object Names

All MBeans must be registered in an MBean server under an object name of type `javax.management.ObjectName`. WebLogic Server follows a convention in which object names for child MBeans contain part of its parent MBean object name.

Note

If you learn the WebLogic Server naming conventions, you can understand where an MBean instance resides in the data hierarchy by observing its object name. However, if you use containment attributes or lookup operations to get object names for WebLogic Server MBeans, your JMX applications do not need to construct or parse object names.

WebLogic Server naming conventions encode its MBean object names as follows:

```
com.bea:Name=name,Type=type[,TypeOfParentMBean=NameOfParentMBean]
[,TypeOfParentMBean1=NameOfParentMBean1]...
```

In the preceding MBean object name convention:

- `com.bea:` is the JMX domain name.
For WebLogic Server MBeans, the JMX domain is always `com.bea`. If you create custom MBeans for your applications, name them with your own JMX domain.
- `Name=name,Type=type[,TypeOfParentMBean=NameOfParentMBean]`
`[,TypeOfParentMBean1=NameOfParentMBean1]...` represents a set of JMX key properties.

The order of the key properties is not significant, but the name must begin with `com.bea:`.

[Table 2-1](#) describes the key properties that WebLogic Server encodes in its MBean object names.

Table 2-1 WebLogic Server MBean Object Name Key Properties

This Key Property	Specifies
<code>Name=name</code>	The string that you provided when you created the resource that the MBean represents. For example, when you create a server, you must provide a name for the server, such as <code>MS1</code>. The <code>ServerMBean</code> that represents <code>MS1</code> uses <code>Name=MS1</code> in its JMX object name. If you create an MBean, you must specify a value for this <code>Name</code> component that is unique amongst all other MBeans in a domain.
<code>Type=type</code>	For configuration MBeans and run-time MBeans, the short name of the MBean's type. The short name is the unqualified type name without the MBean suffix. For example, for an MBean that is an instance of the <code>ServerRuntimeMBean</code>, use <code>ServerRuntime</code>. For MBeans that manage services targeted at the system level, the fully qualified name of the MBean's type including any Bean or MBean suffix. For example, for an MBean that manages a system-level JDBC data source, use <code>weblogic.j2ee.descriptor.wl.JDBCDataSourceBean</code>.

Table 2-1 (Cont.) WebLogic Server MBean Object Name Key Properties

This Key Property	Specifies
<i>TypeOfParentMBean=</i> <i>NameOfParentMBean</i>	To create a hierarchical namespace, WebLogic Server MBeans use one or more instances of this attribute in their object names. The levels of the hierarchy are used to indicate scope. For example, a LogMBean at the domain level of the hierarchy manages the domain-wide message log, while a LogMBean at a server level manages a server-specific message log. WebLogic Server child MBeans with implicit creator methods use the same value for the Name property as the parent MBean. For example, the LogMBean that is a child of the MedRecServer Server MBean uses Name=MedRecServer in its object name: medrec:Name=MedRecServer, Type=Log, Server=MedRecServer WebLogic Server cannot follow this convention when a parent MBean has multiple children of the same type. Some MBeans use multiple instances of this component to provide unique identification. For example, the following is the object name for an EJBComponentRuntime MBean in the MedRec sample application: medrec:ApplicationRuntime=MedRecServer_MedRecEAR, Name=MedRecServer_MedRecEAR_Session EJB, ServerRuntime=MedRecServer, Type=EJBComponentRuntime The ApplicationRuntime=MedRecServer_MedRecEAR key property indicates that the EJB instance is a module within the MedRec enterprise application and a child of the MedRecServer_MedRecEAR ApplicationRuntimeMBean. The ServerRuntime=MedRecServer key property indicates that the EJB instance is currently deployed on a server named MedRecServer and a child of the MedRecServer ServerRuntimeMBean.
<i>Location=servername</i>	When you access run-time MBeans or configuration MBeans through the Domain Runtime MBean Server, the MBean object names include a Location=servername key property which specifies the name of the server instance on which that MBean is located. See MBean Servers. Singleton MBeans, such as DomainRuntimeMBean and ServerLifecycleRuntimeMBean exist only on the Administration Server and do not need to include this key property.

MBeanServerInvocationHandler

If you use the MBeanServerInvocationHandler to create a proxy for the MBean, as shown here:

```
Intf proxy = (Intf)
    MBeanServerInvocationHandler.newProxyInstance(mbs,
                                                    name,
                                                    Intf.class,
                                                    false);
```

you should include the WLS extension MBeanServerInvocationHandler instead of javax.management.MBeanServerInvocationHandler, as shown here:

```
import weblogic.management.jmx.MBeanServerInvocationHandler;
```

This ensures that return exceptions are handled correctly.

MBean Servers

At the core of any JMX agent is the MBean server, which acts as a container for MBeans.

The JVM for an Administration Server maintains three MBean servers provided by Oracle and optionally maintains the platform MBean server, which is provided by the JDK itself. The JVM for a Managed Server maintains only one Oracle MBean server and the optional platform MBean server.

[Table 2-2](#) describes each MBean server.

Table 2-2 MBean Servers in a WebLogic Server Domain

This MBean server	Creates, registers, and provides access to...
Domain Runtime MBean Server	MBeans for domain-wide services. This MBean server also acts as a single point of access for MBeans that reside on Managed Servers. You can register your own (custom) MBeans in this MBean server (see <i>Registering Custom MBeans in the Domain Runtime MBean Server in Developing Manageable Applications Using JMX for Oracle WebLogic Server</i>). If your JMX client accesses WebLogic Server MBeans in this MBean server by constructing object names, the client must add a <code>Location=servername</code> key property to the MBean object name. See WebLogic Server MBean Object Names. Only the Administration Server hosts an instance of this MBean server.
Runtime MBean Server	MBeans that expose monitoring, run-time control, and the active configuration of a specific WebLogic Server instance. You can also register your own (custom) MBeans in this MBean server (see <i>Registering Custom MBeans in the Domain Runtime MBean Server in Developing Manageable Applications Using JMX for Oracle WebLogic Server</i>). In this release, the WebLogic Server Runtime MBean Server is configured by default to be the platform MBean server. However, you can configure WebLogic Server to create a separate MBean Server and use it instead of the platform MBean Server. See Using the Platform MBean Server. Each server in the domain hosts an instance of this MBean server.
Edit MBean Server	Pending configuration MBeans and operations that control the configuration of a WebLogic Server domain. It exposes a <code>ConfigurationManagerMBean</code> for locking, saving, and activating changes. Only the Administration Server hosts an instance of this MBean server.
The JVM's platform MBean server	MBeans provided by the JDK that contain monitoring information for the JVM itself. You can register custom MBeans in this MBean server. In this release, WebLogic Server uses the JVM's platform MBean server to contain the WebLogic run-time MBeans by default. As such, the platform MBean server provides access to platform MBeans, WebLogic run-time MBeans, and WebLogic configuration MBeans that are on a single server instance. See Using the Platform MBean Server and <i>Registering MBeans in the JVM Platform MBean Server in Developing Manageable Applications Using JMX for Oracle WebLogic Server</i>.

Connecting to MBean Servers

JMX enables both local and remote access to MBean servers, but JMX clients use different APIs for the two types of access and WebLogic Server MBean servers expose different capabilities to local clients and remote clients.

Local Connections to MBean Servers

JMX clients running within a WebLogic Server JVM can access the server's Runtime MBean Server or Domain Runtime MBean Server directly through JNDI, and authentication is required to access any MBeans that require roles. These are the only WebLogic Server MBean servers that allow local access. When accessed from a local client, the Runtime MBean Server or Domain Runtime MBean Server returns its `javax.management.MBeanServer` interface, which enables clients to access WebLogic Server MBeans and to create, register, and access custom MBeans. See [Make Local Connections to the Runtime MBean Server](#) and [Make Local Connections to the Domain Runtime MBean Server](#).

JMX clients can also access the local JVM's platform MBean server. Any local client can access the MBeans in this MBean server. See Registering MBeans in the JVM Platform MBean Server in *Developing Manageable Applications Using JMX for Oracle WebLogic Server*.

Remote Connections to MBean Servers

Remote JMX clients (clients running in a different JVM from the MBean server) can use the `javax.management.remote` APIs to access any WebLogic MBean server. Clients must authenticate through the WebLogic Server security framework to do so (see [Security for WebLogic Server MBeans](#)). When accessed from a remote client, a WebLogic Server MBean server returns its `javax.management.MBeanServerConnection` interface, which enables clients to only access MBeans; remote clients cannot create and register custom MBeans. See [Make Remote Connections to an MBean Server](#).

You can enable remote access to the platform MBean server. See Registering MBeans in the JVM Platform MBean Server in *Developing Manageable Applications Using JMX for Oracle WebLogic Server*.

Using the Platform MBean Server

In this release of WebLogic Server, the WebLogic Server Runtime MBean Server is configured by default to contain the platform MXBeans for the corresponding server. The Domain Runtime MBean Server contains the platform MXBeans for all of the servers in the domain. The MBean object names for the platform MXBeans will be the same as those provided by the JVM except they will have the additional `Location=servername` key property.

The WLST script in [Example 2-3](#) illustrates using platform MXBeans to monitor the resources of a running domain.

Using the platform MBean server for the Runtime MBean Server is controlled by the [PlatformMBeanServerUsed](#) attribute in the JMX MBean. In previous releases, the default value for the `PlatformMBeanServerUsed` attribute was `false` so the platform MBean server was not used unless explicitly enabled. In this release of WebLogic Server, the default value for the `PlatformMBeanServerUsed` attribute is `true` for domains that are at version 10.3.3.0 or later. See [PlatformMBeanServerEnabled](#) in the *MBean Reference for Oracle WebLogic Server*.

If desired, you can configure WebLogic Server to create a separate MBean Server and use it instead of the platform MBean server by setting the `PlatformMBeanServerEnabled` attribute value to `false` using any of the administration tools listed in *Summary of System Administration Tools and APIs* in *Understanding Oracle WebLogic Server*. In WLST, start an edit session, navigate to the JMX directory for the domain, use `cmo.setPlatformMBeanServerUsed(false)` to change the value, and then activate the changes.

For more information on the Platform MBean Server and Platform MBean, see the following JAVA SDK documentation:

- <https://docs.oracle.com/en/java/javase/17/management/using-platform-mbean-server-and-platform-mbeans.html>
- <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/java/lang/management/package-summary.html>

Example 2-3 Using Platform MBeans

"""

This WLST script demonstrates how to use the Platform MBeans to monitor the resources of a running WLS domain. It uses the `domainCustom` command to retrieve the memory usage for 2 servers in the domain. For information about the available platform MBeans, refer to the following link:

<https://docs.oracle.com/en/java/javase/17/docs/api/java.management/java/lang/management/package-summary.html>

"""

```
connect()
domainCustom()
cd ("java.lang")
# monitor heap and thread usage once a minute for 5 minutes
x = 0
while x < 5:
    # Admin Server
    cd ("java.lang:Location=AdminServer,type=Memory")
    huAdmin = get("HeapMemoryUsage")
    cd ("..")
    cd ("java.lang:Location=AdminServer,type=Threading")
    numThreadsAdmin = get("ThreadCount")
    print "Admin server memory usage = ", huAdmin.get("max"), " number threads: ",
numThreadsAdmin
    cd ("..")
    # m1 server
    cd ("java.lang:Location=m1,type=Memory")
    huM1 = get("HeapMemoryUsage")
    cd ("..")
    cd ("java.lang:Location=m1,type=Threading")
    numThreadM1 = get("ThreadCount")
    cd ("..")
    print "M1 server memory usage = ", huM1.get("max"), " number threads: ", numThreadM1
    Thread.sleep(60000)
    x = x + 1
```

Service MBeans

Within each MBean server, WebLogic Server registers a service MBean under a simple object name. The attributes and operations in this MBean serve as your entry point into the WebLogic Server MBean hierarchies and enable JMX clients to navigate to all WebLogic Server MBeans in an MBean server after supplying only a single object name. See [Table 2-3](#).

JMX clients that do not use the entry point (service) MBean must correctly construct an MBean's object name to get and set the MBean's attributes or invoke its operations. Because the object names must be unique, they are usually long and difficult to construct from a client.

Table 2-3 Service MBeans

MBean Server	Service MBean	JMX object name:
The Domain Runtime MBean Server	DomainRuntimeServiceMBean Provides access to MBeans for domain-wide services such as application deployment, JMS servers, and JDBC data sources. It also is a single point for accessing the hierarchies of all run-time MBeans and all active configuration MBeans for all servers in the domain. See DomainRuntimeServiceMBean in <i>MBean Reference for Oracle WebLogic Server</i> .	com.bea:Name=DomainRuntimeService,Type=weblogic.management.mbeanservers.domainruntime.DomainRuntimeServiceMBean
Runtime MBean Servers	RuntimeServiceMBean Provides access to run-time MBeans and active configuration MBeans for the current server. See RuntimeServiceMBean in <i>MBean Reference for Oracle WebLogic Server</i> .	com.bea:Name=RuntimeService, Type=weblogic.management.mbeanservers.runtime.RuntimeServiceMBean
The Edit MBean Server	EditServiceMBean Provides the entry point for managing the configuration of the current WebLogic Server domain. See EditServiceMBean in <i>MBean Reference for Oracle WebLogic Server</i> .	com.bea:Name=EditService, Type=weblogic.management.mbeanservers.edit.EditServiceMBean

Security for WebLogic Server MBeans

To connect to a WebLogic Server MBean server, a JMX client must supply credentials for a user who has been defined in the WebLogic Server domain's security realm.

To further secure the MBeans that have been registered in an MBean server, WebLogic Server uses security roles and policies. A security **role**, like a security group, grants an identity to a user. Unlike a group, however, membership in a role can be based on a set of conditions that are evaluated at run time. A security **policy** is another set of run-time conditions that specify which users, groups, or roles can access a resource. Oracle provides a default set of roles and policies for WebLogic Server MBeans. (See [Default Security Policies for MBeans](#) in the *MBean Reference for Oracle WebLogic Server*.)

During the startup cycle for a WebLogic Server instance, the server creates a collection of `weblogic.security.service.JMXResource` objects, which are the in-memory representations of the MBean security policies. When a JMX client attempts to get or set an MBean attribute or invoke an operation, the MBean server asks the security realm if the user has sufficient permission. The security realm first determines which role the user is in. (Role assignments are determined at run time.) Then it uses the default policies and any other policies that you have created to determine if the role is allowed access.

You can use the WebLogic Remote Console to change the default access permissions. See [Security Policies and Roles](#) in the *Oracle WebLogic Remote Console Online Help*.

Additional Security Resources for Some Attributes and Operations

For MBean attributes and operations that represent particularly sensitive data or actions, WebLogic Server provides additional security resource objects to limit which users can access

the data or action. For example, the `ServerLifecycleRuntimeMBean`'s `shutdown()` operation is protected by a `JMXResource` object and a `weblogic.security.service.ServerResource` object. For a complete list of attributes and operations that are protected by multiple resources, see Administrative Resources and Server Resources in *Securing Resources Using Roles and Policies for Oracle WebLogic Server*.

The default configuration of roles and security policies for these attributes and operations work together to create a consistent security scheme. You can, however, make modifications that limit access in ways that you do not intend. See *Maintaining a Consistent Security Scheme* in *Securing Resources Using Roles and Policies for Oracle WebLogic Server*.

3

Overview of WebLogic Server Subsystem MBeans

This chapter describes the MBeans that can be used to manage various subsystems of WebLogic Server, including domain and server logging, JMS servers and JMS system module resources, and JDBC resources.

This chapter includes the following sections:

In addition, for a description of MBeans that can be used to manage WebLogic Security, see [Understanding the Hierarchy of Security MBeans](#).

Domain and Server Logging Configuration

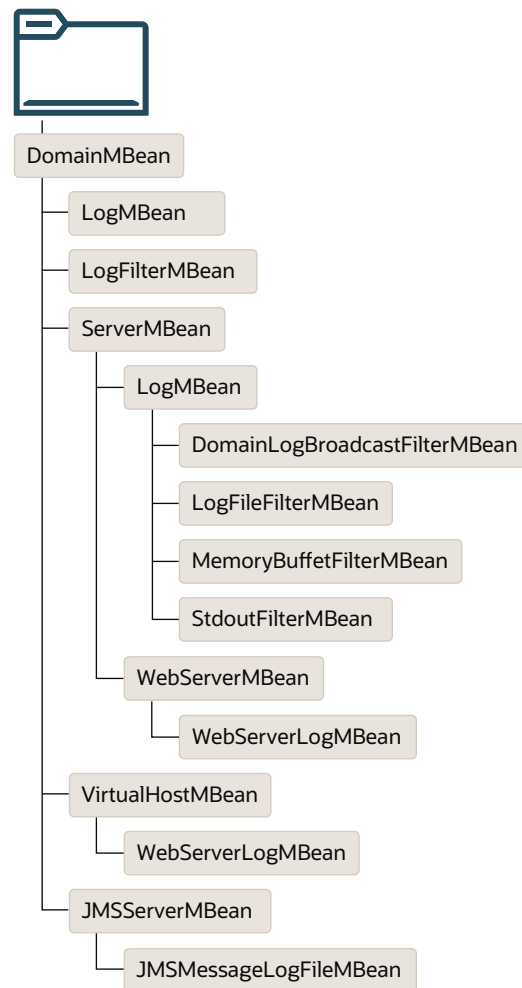
Within a WebLogic Server domain, several MBeans configure logging services. [Table 3-1](#) introduces the MBeans and [Figure 3-1](#) illustrates where the MBeans are located in the configuration MBean hierarchy.

Table 3-1 MBeans for Domain and Server Logging

This MBean...	Configures...
LogMBean	• Threshold severity level and filter settings for logging output. • Whether the server logging is based on the default Java Logging APIs. • Whether to redirect the JVM <code>stdout</code> and <code>stderr</code> output to the registered log destinations. The Administration Server maintains an instance of LogMBean for the domain-wide message log, and each server instance maintains its own instance for its local server log. See LogMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
LogFileMBean	Log file names and the location, file-rotation criteria, and number of files that a WebLogic Server instance uses to store log messages. See LogFileMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
LogFilterMBean	A log filter which determines which messages a server instance sends to the registered log destinations. Each log filter is represented by its own instance of LogFilterMBean. A log filter can be defined at the domain or server level. See LogFilterMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
ServerMBean	Path prefix for the server's JTA transaction log files. See ServerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
WebServerMBean	Logging HTTP requests. See WebServerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.

Table 3-1 (Cont.) MBeans for Domain and Server Logging

This MBean...	Configures...
VirtualHostMBean	Logging HTTP requests for virtual hosts that you define. See VirtualHostMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
JMSServerMBean	Message log file for this JMS Server. See JMSServerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Figure 3-1 Logging MBeans

JMS Server and JMS System Module Configuration

Within a WebLogic Server domain, multiple MBeans configure JMS servers and JMS system module resources. JMS servers are persisted in the domain's config.xml file and multiple JMS servers can be configured on the various WebLogic Server instances in a cluster, as long as they are uniquely named. When a JMS system module is created using JMX, WebLogic Server creates a JMS system module descriptor file in the config\jms subdirectory of the domain

directory, and adds a reference to the module in the domain's `config.xml` file as a `JMSSystemResource` element. This reference includes the path to the JMS system module file and a list of target servers and clusters on which the system module is deployed.

[Table 3-2](#) introduces the MBeans and [Figure 3-2](#) illustrates where the MBeans are located in the configuration MBean hierarchy.

Table 3-2 MBeans for JMS Servers and JMS System Module Resources

This MBean...	Configures...
<code>JMSServerMBean</code>	A JMS server is configuration entity that acts as a management container for targeted destination resources (queues and topics) in a JMS system module. A JMS server's primary responsibility for its destinations is to maintain information on what persistent store is used for any persistent messages that arrive on the destinations, and to maintain the states of durable subscribers created on the destinations. As a container for targeted destinations, any configuration or run-time changes to a JMS server can affect all of its destinations. See JMSServerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
<code>JMSSystemResourceMBean</code>	A JMS system resource is a resource whose definition is part of the system configuration rather than an application. The descriptor for the resource is linked through the WebLogic configuration file, but resides in a separate descriptor file. See JMSSystemResourceMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
<code>SubDeploymentMBean</code>	Subdeployments enable administrators to deploy some resources in a JMS module to a JMS server and other JMS resources to a server instance or cluster. Standalone queues or topics can only be targeted to a single JMS server. Whereas, connection factories, uniform distributed destinations (UDDs), and foreign servers can be targeted to one or more JMS servers, one or more server instances, or to a cluster. Therefore, standalone queues or topics cannot be associated with a subdeployment if other members of the subdeployment are targeted to multiple JMS servers. However, UDDs can be associated with such subdeployments since the purpose of UDDs is to distribute its members to multiple JMS servers in a domain. See SubDeploymentMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
<code>JMSBean</code>	The top of the JMS module bean tree. JMS modules all have a <code>JMSBean</code> as their root bean (a bean with no parent). See JMSBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
<code>DestinationKeyBean</code>	Defines a unique sort order that destinations can apply to arriving messages. By default messages are sorted in FIFO (first-in, first-out) order, which sorts ascending based on each message's unique <code>JMSMessageID</code>. However, you can configure destination key to use a different sorting scheme for a destination, such as LIFO (last-in, first-out). See DestinationKeyBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
<code>DistributedQueueBean</code>	Defines a set of queues that are distributed on multiple JMS servers, but which are accessible as a single, logical topic to JMS clients. Distributed queues can help with load balancing and distribution, and have many of the same properties as standalone queues. See DistributedQueueBean in the <i>MBean Reference for Oracle WebLogic Server</i>.

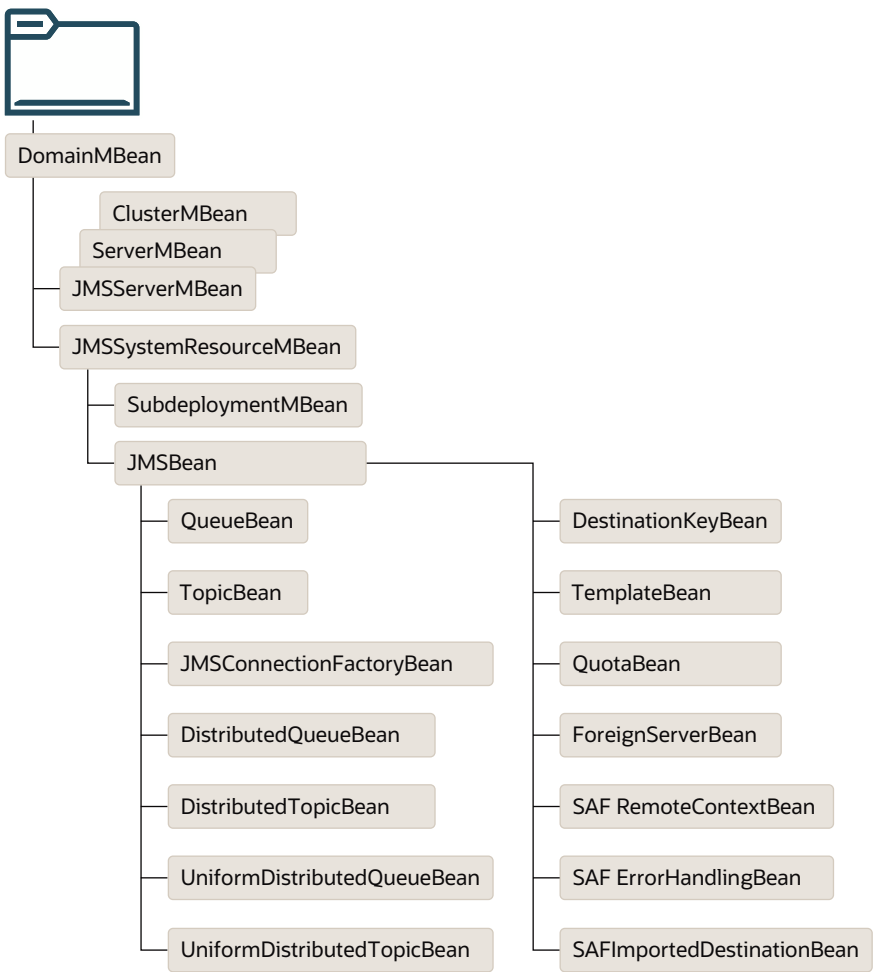
Table 3-2 (Cont.) MBeans for JMS Servers and JMS System Module Resources

This MBean...	Configures...
DistributedTopicBean	Defines a set of topics that are distributed on multiple JMS servers, but which are accessible as a single, logical topic to JMS clients. Distributed topics can help with load balancing and distribution, and have many of the same properties as standalone topics. See DistributedTopicBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
ForeignServerBean	Defines foreign messaging providers or remote WebLogic Server instances that are not part of the current domain. This is useful when integrating with another vendor's JMS product, or when referencing remote instances of WebLogic Server in another cluster or domain in the local WebLogic JNDI tree. See ForeignServerBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
JMSConnectionFactoryBean	Defines a set of connection configuration parameters that are used to create connections for JMS clients. Connection factories can configure properties of the connections returned to the JMS client, and also provide configurable options for default delivery, transaction, and message flow control parameters. See JMSConnectionFactoryBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
QueueBean	Defines a point-to-point destination type, which are used for asynchronous peer communications. A message delivered to a queue is distributed to only one consumer. Several aspects of a queue's behavior can be configured, including thresholds, logging, delivery overrides, and delivery failure options. See QueueBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
QuotaBean	Controls the allotment of system resources available to destinations. For example, the number of bytes a destination is allowed to store can be configured with a Quota resource. See QuotaBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
SAFRemoteContextBean	Defines the URL of the remote server instance or cluster where a JMS destination is exported from. It also contains the security credentials to be authenticated and authorized in the remote cluster or server. See SAFRemoteContextBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
SAFErrorHandlingBean	Defines the action to take when the SAF service fails to forward messages to remote destinations. Configuration options include an Error Handling Policy (Redirect, Log, Discard, or Always-Forward), a Log Format, and sending Retry parameters. See SAFErrorHandlingBean in the <i>MBean Reference for Oracle WebLogic Server</i>.

Table 3-2 (Cont.) MBeans for JMS Servers and JMS System Module Resources

This MBean...	Configures...
SAFImportedDestinationsBean	Defines a collection of imported store-and-forward (SAF) destinations. A SAF destination is a representation of a queue or topic in a remote server instance or cluster that is imported into the local cluster or server instance, so that the local server instance or cluster can send messages to the remote server instance or cluster. All JMS destinations are automatically exported by default, unless the Export SAF Destination parameter on a destination is explicitly disabled. Each collection of SAF imported destinations is associated with a remote SAF context resource, and, optionally, a SAF error handling resource. See SAFImportedDestinationsBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
TemplateBean	Defines a set of default configuration settings for multiple destinations. If a destination specifies a template and does not explicitly set the value of a parameter, then that parameter will take its value from the specified template. See TemplateBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
TopicBean	Defines a publish/subscribe destination type, which are used for asynchronous peer communications. A message delivered to a topic is distributed to all topic consumers. Several aspects of a topic's behavior can be configured, including thresholds, logging, delivery overrides, delivery failure, and multicasting parameters. See TopicBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
UniformDistributedQueueBean	Defines a uniformly configured distributed queue, whose members have a consistent configuration of all distributed queue parameters, particularly in regards to weighting, security, persistence, paging, and quotas. These uniform distributed queue members are created on JMS servers based on the targeting of the uniform distributed queue. Uniform distributed queues can help with message load balancing and distribution, and have many of the same properties as standalone queues, including thresholds, logging, delivery overrides, and delivery failure parameters. See UniformDistributedQueueBean in the <i>MBean Reference for Oracle WebLogic Server</i>.
UniformDistributedTopicBean	Defines a uniformly configured distributed topic, whose members have a consistent configuration of all uniform distributed queue parameters, particularly in regards to weighting, security, persistence, paging, and quotas. These uniform distributed topic members are created on JMS servers based on the targeting of the uniform distributed topic. Uniform distributed topics can help with message load balancing and distribution, and have many of the same properties as standalone topics, including thresholds, logging, delivery overrides, and delivery failure parameters. See UniformDistributedTopicBean in the <i>MBean Reference for Oracle WebLogic Server</i>.

Figure 3-2 JMS Server and JMS System Resource MBeans



JDBC Resource Configuration

When you create a JDBC resource (data source or multi data source) using the WebLogic Remote Console or using the WebLogic Scripting Tool (WLST), WebLogic Server creates a JDBC module in the `config/jdbc` subdirectory of the domain directory, and adds a reference to the module in the domain's configuration file (`config.xml`).

[Table 3-3](#) introduces the MBeans and [Figure 3-3](#) illustrates where the MBeans are located in the configuration MBean hierarchy.

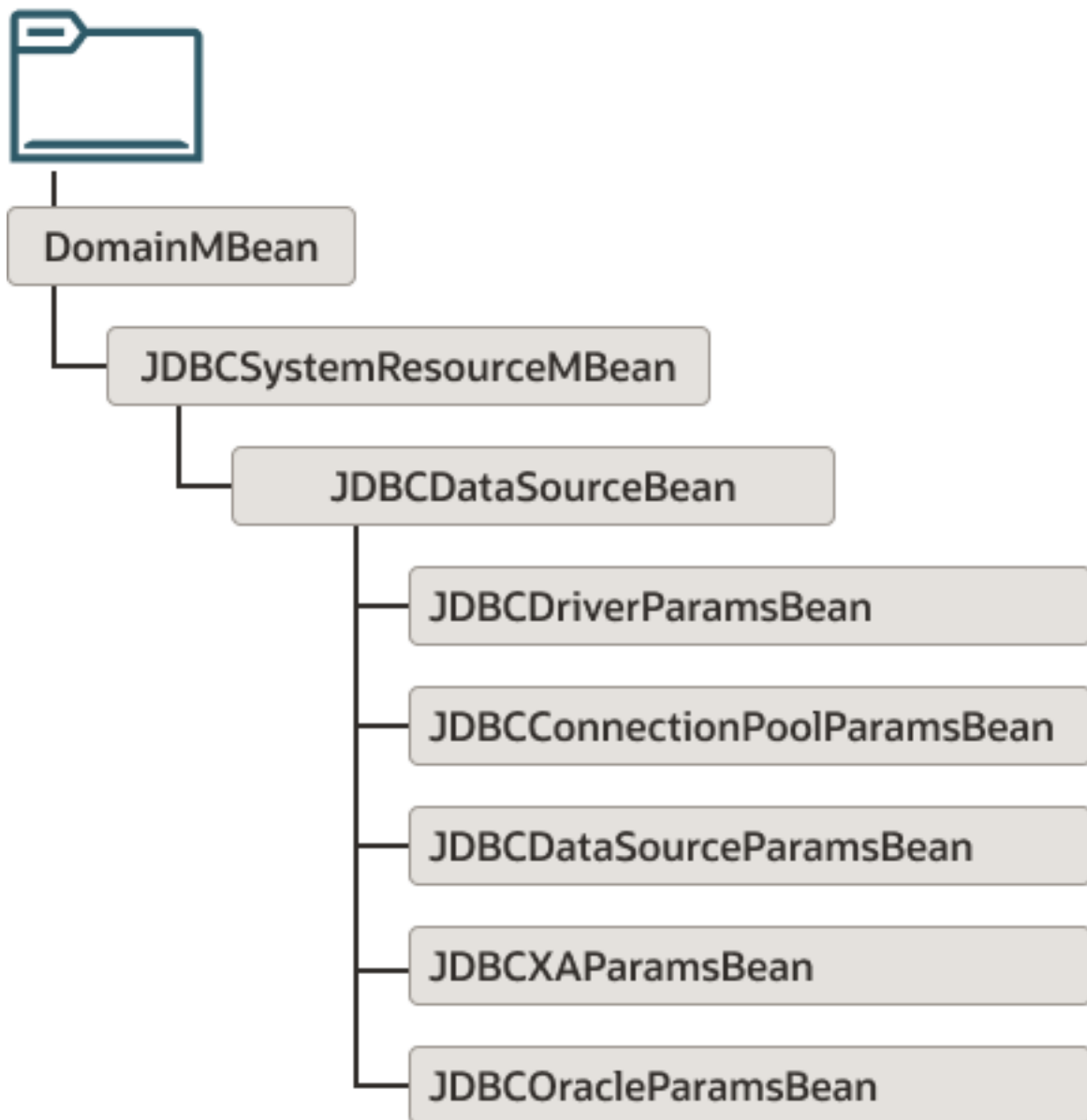
Table 3-3 MBeans for JDBC Resources

This MBean...	Configures...
JDBCSystemResourceMBean	A container for the JavaBeans created from a data source module. However, all JMX access for a JDBC data source is through the JDBCSystemResourceMBean. You cannot directly access the individual JavaBeans created from the data source module. See JDBCSystemResourceMBean in the <i>MBean Reference for Oracle WebLogic Server</i>.

Table 3-3 (Cont.) MBeans for JDBC Resources

This MBean...	Configures...
JDBCDataSourceBean	The top of the JDBC data source bean tree. JDBC data sources all have a JDBCDataSourceBean as their root bean (a bean with no parent). See JDBCDataSourceBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
JDBCDriverParamsBean	Contains the driver parameters of a data source. Configuration parameters for the JDBC Driver used by a data source are specified using a driver parameters bean. See JDBCDriverParamsBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
JDBCConnectionPoolParamsBean	Contains the connection pool parameters of a data source. Configuration parameters for a data source's connection pool are specified using the connection pool parameters bean. See JDBCConnectionPoolBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
JDBCDataSourceParamsBean	Contains the basic usage parameters of a data source. Configuration parameters for the basic usage of a data source are specified using a data source parameters bean. See JDBCDataSourceParamsBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
JDBCXAParamsBean	Contains the XA-related parameters of a data source. See JDBCXAParamsBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
JDBCOracleParamsBean	Contains the Oracle database-related parameters of a data source. See JDBCOracleParamsBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Figure 3-3 JDBC Resource MBeans



Accessing WebLogic Server MBeans with JMX

This chapter describes how to access WebLogic Server MBeans from a JMX client. It explains how to set up the classpath for remote clients; how to make local and remote connections to MBean servers; and how to navigate MBean hierarchies.

This chapter includes the following sections:

Set Up the Classpath for Remote Clients

If your JMX client runs in its own JVM (that is, a JVM that is not a WebLogic Server instance), include the following JAR file in the client's classpath:

```
WL_HOME\server\lib\weblogic.jar
```

where, `WL_HOME` is the directory in which you installed WebLogic Server.

Oracle provides the `wlthint3client.jar` library for remote access, and this library enables connectivity over the T3 or T3S protocol to access MBeans for a WebLogic Server instance or domain. The T3 protocol is an optimized, high-performance protocol for interoperating with WebLogic Server. Oracle recommends that you use the T3 protocol whenever possible.

To use the `wlthint3client.jar`, include the `wlthint3client.jar` in the classpath of your client. A foreign server hosted application can use the `wlthint3client.jar` to act as a remote client to a WebLogic Server instance. To provide access to remote services such as JMS, servlets, EJBs, and start-up classes, deploy any necessary application code along with the `wlthint3client.jar` to your application server. See *Understanding the WebLogic Thin T3 Client*.

Make Remote Connections to an MBean Server

Each WebLogic Server domain includes three types of MBean servers, each of which provides access to different MBean hierarchies. See [MBean Servers](#).

To connect to a WebLogic MBean server:

1. Describe the address of the MBean server by constructing a `javax.management.remote.JMXServiceURL` object.

Pass the following parameter values to the constructor (see `JMXServiceURL` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/remote/JMXServiceURL.html>):

- One of the following values as the protocol for communicating with the MBean server:
`t3`, `t3s`, `http`, `https`, `iiop`, `iiops`
- Listen address of the WebLogic Server instance that hosts the MBean server
- Listen port of the WebLogic Server instance
- Absolute JNDI name of the MBean server. The JNDI name must start with `/jndi/` and be followed by one of the JNDI names described in [Table 4-1](#).

Table 4-1 JNDI Names for WebLogic MBean Servers

MBean Server	JNDI Name
Domain Runtime MBean Server	weblogic.management.mbeanservers.domainruntime
Runtime MBean Server	weblogic.management.mbeanservers.runtime
Edit MBean Server	weblogic.management.mbeanservers.edit

- Construct a `javax.management.remote.JMXConnector` object. This object contains methods that JMX clients use to connect to MBean servers.

The constructor method for `JMXConnector` is:

```
javax.management.remote.JMXConnectorFactory.  
connector(JMXServiceURL serviceURL, Map<String,?> environment)
```

Pass the following parameter values to the constructor (see `JMXConnectorFactory` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/remote/JMXConnectorFactory.html>):

- The `JMXServiceURL` object you created in the previous step.
- A hash map that contains the following name-value pairs:

```
javax.naming.Context.SECURITY_PRINCIPAL, admin-user-name
```

```
javax.naming.Context.SECURITY_CREDENTIALS, admin-user-password
```

```
javax.management.remote.JMXConnectorFactory.PROTOCOL_PROVIDER_PACKAGES,  
"weblogic.management.remote"
```

The `weblogic.management.remote` package defines the protocols that can be used to connect to the WebLogic MBean servers. Remote JMX clients must include the classes in this package on their classpath. See [Set Up the Classpath for Remote Clients](#).

Optionally include the following name-value pair in the hash map:

```
jmx.remote.x.request.waiting.timeout, milliseconds
```

where *milliseconds* is a `java.lang.Long` object that contains the number of milliseconds that your JMX client waits for the invocation of an MBean-server method to return. If a method does not return by the end of the time-out period, the client moves to its next set of instructions. By default, a client waits indefinitely for a method to return; if the MBean server is unable to complete an invocation, the JMX client will hang indefinitely.

- Connect to the WebLogic MBean server by invoking the `JMXConnector.getMBeanServerConnection()` method.

The method returns an object of type `javax.management.MBeanServerConnection`.

The `MBeanServerConnection` object is your connection to the WebLogic MBean server. You can use it for local and remote connections. See `MBeanServerConnection` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/MBeanServerConnection.html>.

- Oracle recommends that when your client finishes its work, close the connection to the MBean server by invoking the `JMXConnector.close()` method.

Example: Connecting to the Domain Runtime MBean Server

Note the following about the code in [Example 4-1](#):

- The class uses global variables, `connection` and `connector`, to represent the connection to the MBean server. The `initConnection()` method, which assigns the value to the `connection` and `connector` variables, should be called only once per class instance to establish a single connection that can be reused within the class.
- The `initConnection()` method takes the username and password (along with the server's listen address and listen port) as arguments that are passed when the class is instantiated. Oracle recommends this approach because it prevents your code from containing unencrypted user credentials. The String objects that contain the arguments will be destroyed and removed from memory by the JVM's garbage collection routine.
- Because the client sets the `jmx.remote.x.request.waiting.timeout` environment parameter to 10000, all of its invocations of MBean server methods will time out if the method does not return within 10000 milliseconds of being invoked.
- When the class finishes its work, it invokes `JMXConnector.close()` to close the connection to the MBean server. (See `JMXConnector` in the in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/remote/JMXConnector.html>.)

Example 4-1 Connecting to the Domain Runtime MBean Server

```
public class MyConnection {

    private static MBeanServerConnection connection;
    private static JMXConnector connector;
    private static final ObjectName service;
    /*
     * Initialize connection to the Domain Runtime MBean Server.
     */
    public static void initConnection(String hostname, String portString,
        String username, String password) throws IOException,
        MalformedURLException {

        String protocol = "t3";
        Integer portInteger = Integer.valueOf(portString);
        int port = portInteger.intValue();
        String jndiroot = "/jndi/";
        String mserver = "weblogic.management.mbeanservers.domainruntime";
        JMXServiceURL serviceURL = new JMXServiceURL(protocol, hostname, port,
            jndiroot + mserver);

        Hashtable h = new Hashtable();
        h.put(Context.SECURITY_PRINCIPAL, username);
        h.put(Context.SECURITY_CREDENTIALS, password);
        h.put(JMXConnectorFactory.PROTOCOL_PROVIDER_PACKAGES,
            "weblogic.management.remote");
        h.put("jmx.remote.x.request.waiting.timeout", new Long(10000));
        connector = JMXConnectorFactory.connect(serviceURL, h);
        connection = connector.getMBeanServerConnection();
    }

    public static void main(String[] args) throws Exception {
        String hostname = args[0];
        String portString = args[1];
        String username = args[2];
        String password = args[3];

        MyConnection c= new MyConnection();
        initConnection(hostname, portString, username, password);
        ...
        connector.close();
    }
}
```

```
}  
}
```

Best Practices: Choosing an MBean Server

A WebLogic Server domain maintains three types of MBean servers, each of which fulfills a specific function. Access MBeans through the MBean server that supports the task you are trying to complete:

- To modify the configuration of the domain, use the Edit MBean Server.
- To monitor changes to the pending hierarchy of configuration MBeans, use the Edit MBean Server.
- To monitor only active configuration MBeans (and not run-time MBeans), use a Runtime MBean Server.

Monitoring through a Runtime MBean Server requires less memory and network traffic than monitoring through the Domain Runtime MBean Server. (WebLogic Server does not initialize the Domain Runtime MBean Server until a client requests a connection to it.)

In most cases, all server instances in the domain have the same set of configuration data and it therefore does not matter whether you monitor the Runtime MBean Server on the Administration Server or on a Managed Server. However, if you make a change that a server cannot consume until it is restarted, the server will no longer accept any changes and its configuration data could become outdated. In this case, monitoring this server's Runtime MBean Server indicates only the configuration for the specific server instance. To understand the process of changing a WebLogic Server domain and activating the changes, see *Managing Configuration Changes in Understanding Domain Configuration for Oracle WebLogic Server*.

- If your client monitors run-time MBeans for multiple servers, or if your client runs in a separate JVM, Oracle recommends that you connect to the Domain Runtime MBean Server on the Administration Server instead of connecting separately to each Runtime MBean Server on each server instance in the domain.

If you register a JMX listener and filter with an MBean in the Domain Runtime MBean Server, the JMX filter runs in the same JVM as the MBean it monitors. For example, if you register a filter with an MBean on a Managed Server, the filter runs on the Managed Server and forwards only messages that satisfy the filter criteria to the listener.

In general, code that uses the Domain Runtime MBean Server is easier to maintain and is more secure for the following reasons:

- Your code only needs to construct a single URL for connecting to the Domain Runtime MBean Server on the Administration Server. Thereafter, the code can look up values for all server instances and optionally filter the results.
- If your code uses the Runtime MBean Server to read MBean values on multiple server instances, it must construct a URL for each server instance, each of which has a unique listen address/listen port combination.
- You can route all administrative traffic in a WebLogic Server domain through the Administration Server's secured administration port, and you can use a firewall to prevent connections to Managed Server administration ports from outside the firewall.

The trade off for directing all JMX requests through the Domain Runtime MBean Server is a slight degradation in performance due to network latency and increased memory usage. Connecting directly to each Managed Servers's Runtime MBean Server to read MBean values eliminates the network hop that the Domain Runtime MBean Server makes to retrieve a value from a Managed Server. However, for most network topologies and

performance requirements, the simplified code maintenance and enhanced security that the Domain Runtime MBean Server enables is preferable.

Note

When JMX notifications are added to MBeans, the Domain Runtime MBean Server can consume large amounts of memory. When JMX notifications are used, two cases exist that cause the Administration Server to keep copies of all JMX object names registered in all Runtime MBean Servers running in all Managed Servers in the domain:

- At the WebLogic Server level, to simulate the unregister MBean notifications when a Managed Server shuts down.
- At the JDK JMX client notification layer.

The likelihood of encountering this issue grows when both of the following conditions exist:

- EM Fusion Middleware Control is being used to manage large domains, as it adds notification listeners to the Domain Runtime MBean Server.
- Fusion Middleware products that significantly increase the number of JMX runtime MBeans are included in the domain. This would include any product with MBeans that are registered in WebLogic Server Runtime MBean Server instances running in the domain; that is, in the Administration Server as well as all Managed Servers. (These products include Coherence, SOA Suite, OSB, and so on.)

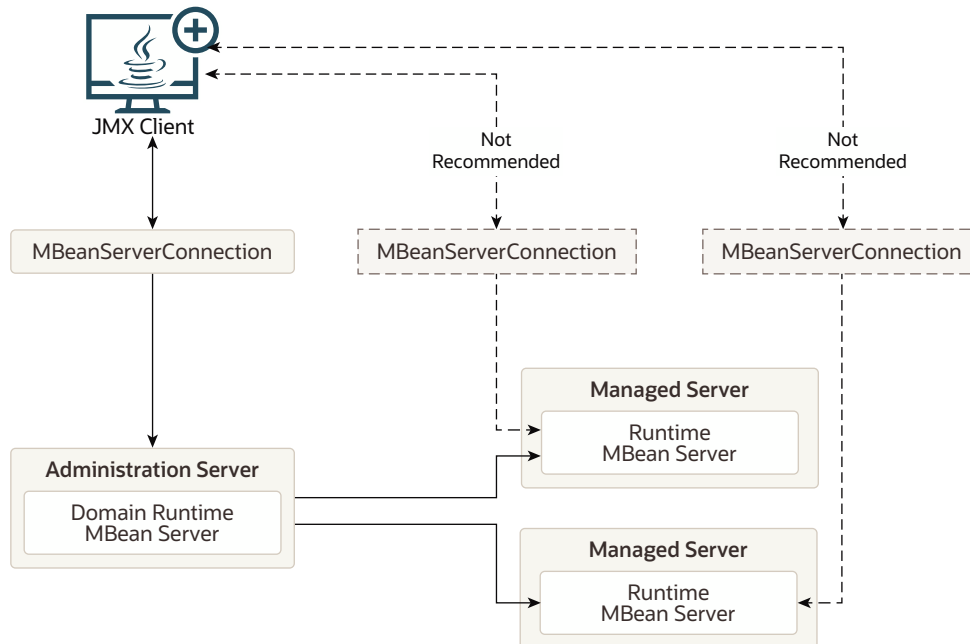
To eliminate this particular scaling issue, disable the `managed-server-notifications-enabled` attribute. This configuration attribute disables the ability to define notifications on MBeans that are contained in the Managed Servers Runtime MBean Servers (these MBeans contain a `Location=key` in the `ObjectName`).

If Managed Server notifications are disabled, then the two sets of `ObjectNames` for MBeans contained in the WebLogic Server and JDK components will not be kept. Notifications listeners can still be defined on the `MBeanServerDelegate` and on MBeans contained in the local Domain Runtime MBean Server. However, notifications listeners cannot be added to the non-local MBeans.

The `managed-server-notifications-enabled` attribute can be set using WLST as follows:

```
edit()
startEdit()
cd("JMX/domain-name")
cmo.setManagedServerNotificationsEnabled(false)
activate()
```

Figure 4-1 Domain Runtime MBean Server versus Runtime MBean Server



Make Local Connections to the Runtime MBean Server

Local clients can access a WebLogic Server instance's Runtime MBean Server through the JNDI tree instead of constructing a `JMXServiceURL` object.

Note

Local clients can also access a WebLogic Server's Domain Runtime MBean Server through the JNDI tree, as described in [Make Local Connections to the Domain Runtime MBean Server](#).

When accessed from JNDI, the Runtime MBean Server returns its `javax.management.MBeanServer` interface. This interface contains all the methods in the `MBeanServerConnection` interface plus additional methods such as `registerMBean()`, which a local process can use to register custom MBeans. (See `MBeanServer` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/MBeanServerConnection.html>.)

If the classes for the JMX client are located in a Jakarta EE module, such as an EJB or Web application, then the JNDI name for the Runtime MBeanServer is:

```
weblogic/jmx/runtime
```

For example:

```
InitialContext ctx = new InitialContext();
server = (MBeanServer)ctx.lookup("weblogic/jmx/runtime");
```

If the classes for the JMX client are not part of a Jakarta EE module, then the JNDI name for the Runtime MBean Server is:

```
java:comp/jmx/runtime
```

Note

The Jakarta EE specification does not allow application servers to create JNDI bindings automatically in `java:comp/env` namespace. Thus, starting WebLogic Server 12.2.1, the following new bindings replaces the existing `java:comp/env/jmx` bindings:

- `weblogic/jmx/runtime` replaces `java:comp/env/jmx/runtime`
- `weblogic/jmx/domainRuntime` replaces `java:comp/env/jmx/domainRuntime`
- `weblogic/jmx/edit` replaces `java:comp/env/jmx/edit`

The `java:comp/env/jmx/runtime`, `java:comp/env/jmx/domainRuntime`, and `java:comp/env/jmx/edit` bindings still exist. However, if you try to list them using JNDI interfaces, you cannot see them. Applications that access these deprecated bindings can find the bindings by performing a lookup of the object bound there.

Make Local Connections to the Domain Runtime MBean Server

Local clients can also access a WebLogic Server instance's Domain Runtime MBean Server through the JNDI tree instead of constructing a `JMXServiceURL` object.

When accessed from JNDI, the Domain Runtime MBean Server returns its `javax.management.MBeanServer` interface. This interface contains all the methods in the `MBeanServerConnection` interface plus additional methods such as `registerMBean()`, which a local process can use to register custom MBeans, and other methods such as `getMBeanCount()`, `instantiate()`, and `getClassLoader()`. (See `MBeanServer` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/MBeanServer.html>.)

Note

As a best practice, Oracle recommends that you use the Domain Runtime MBean Server only for MBeans that perform domain-wide operations. You should ensure that any MBean processing and network activity do not slow down the Administration Server and prevent it from processing administration operations.

If the classes for the JMX client are located in a Jakarta EE module, such as an EJB or Web application, then the JNDI name for the Domain Runtime MBeanServer is:

```
weblogic/jmx/domainRuntime
```

For example:

```
InitialContext ctx = new InitialContext();  
server = (MBeanServer)ctx.lookup("weblogic/jmx/domainRuntime");
```

If the classes for the JMX client are not part of a Jakarta EE module, then the JNDI name for the Domain Runtime MBean Server is:

```
java:comp/jmx/domainRuntime
```

The Domain Runtime MBean Server is present only on the Administration Server. Because the `ctx.lookup()` call returns a reference to the local MBeanServer, the lookup method can only be called when running on the Administration Server. If called when running on a Managed Server, a `NameNotFoundException` is thrown.

Navigate MBean Hierarchies

WebLogic Server organizes its MBeans in a hierarchical data model. (See [WebLogic Server MBean Data Model](#).) In this model, all parent MBeans include attributes that contain the object names of their children. You use the child's object name in standard JMX APIs to get or set values of the child MBean's attributes or invoke its methods.

To navigate the WebLogic Server MBean hierarchy:

1. Initiate a connection to an MBean server.

See the previous section, [Make Remote Connections to an MBean Server](#).

Initiating the connection returns an object of type

```
javax.management.MBeanServerConnection
```

2. Obtain the object name for an MBean at the root of an MBean hierarchy by invoking the `MBeanServerConnection.getAttribute(ObjectName object-name, String attribute)` method where:

- *object-name* represents the object name of the service MBean that is registered in the MBean server. (See [Service MBeans](#).)

[Table 2-3](#) describes the type of service MBeans that are available in each type of MBean server.

- *attribute* represents the name of a service MBean attribute that contains the root MBean.

3. Successively invoke code similar to the following:

```
ObjectName on =  
MBeanServerConnection.getAttribute(object-name, attribute)
```

In the preceding syntax:

- *object-name* represents the object name of the current node (MBean) in the MBean hierarchy.
- *attribute* represents the name of an attribute in the current MBean that contains one or more instances of a child MBean. If the attribute contains multiple children, assign the output to an object name array, `ObjectName[]`.

To determine an MBean's location in an MBean hierarchy, refer to the MBean's description in *MBean Reference for Oracle WebLogic Server*. For each MBean, the *MBean Reference for Oracle WebLogic Server* lists the parent MBean that contains the current MBean's factory methods. For an MBean whose factory methods are not public, the *MBean Reference for Oracle WebLogic Server* lists other MBeans from which you can access the current MBean.

Example: Printing the Name and State of Servers

The code example in [Example 4-2](#) connects to the Domain Runtime MBean Server and uses the `DomainRuntimeServiceMBean` to get the object name for each `ServerRuntimeMBean` in the domain. Then it retrieves and prints the value of each server's `ServerRuntimeMBean` Name and State attributes.

Note the following about the code in [Example 4-2](#):

- In addition to the connection and connector global variables, the class assigns the object name for the WebLogic Server service MBean to a global variable. Methods within the class will use this object name frequently, and once it is defined it does not need to change.
- The `printServerRuntimes()` method gets the value of the `DomainRuntimeServiceMBean` `ServerRuntimes` attribute, which contains an array of all `ServerRuntimeMBean` instances in the domain. (See [DomainRuntimeServiceMBean](#) in *MBean Reference for Oracle WebLogic Server*.)

Example 4-2 Example: Print the Name and State of Servers

```
import java.io.IOException;
import java.net.MalformedURLException;
import java.util.Hashtable;
import javax.management.MBeanServerConnection;
import javax.management.MalformedObjectNameException;
import javax.management.ObjectName;
import javax.management.remote.JMXConnector;
import javax.management.remote.JMXConnectorFactory;
import javax.management.remote.JMXServiceURL;
import javax.naming.Context;

public class PrintServerState {

    private static MBeanServerConnection connection;
    private static JMXConnector connector;
    private static final ObjectName service;

    // Initializing the object name for DomainRuntimeServiceMBean
    // so it can be used throughout the class.
    static {
        try {
            service = new ObjectName(
                "com.bea:Name=DomainRuntimeService,Type=weblogic.management.mbeanservers.domainruntime.DomainRuntimeServiceMBean");
        } catch (MalformedObjectNameException e) {
            throw new AssertionError(e.getMessage());
        }
    }

    /*
     * Initialize connection to the Domain Runtime MBean Server
     */
    public static void initConnection(String hostname, String portString,
        String username, String password) throws IOException,
        MalformedURLException {
        String protocol = "t3";
        Integer portInteger = Integer.valueOf(portString);
        int port = portInteger.intValue();
        String jndiroot = "/jndi/";
        String mserver = "weblogic.management.mbeanservers.domainruntime";
        JMXServiceURL serviceURL = new JMXServiceURL(protocol, hostname,
            port, jndiroot + mserver);
        Hashtable h = new Hashtable();
        h.put(Context.SECURITY_PRINCIPAL, username);
        h.put(Context.SECURITY_CREDENTIALS, password);
        h.put(JMXConnectorFactory.PROTOCOL_PROVIDER_PACKAGES,
            "weblogic.management.remote");
        connector = JMXConnectorFactory.connect(serviceURL, h);
    }
}
```

```

        connection = connector.getMBeanServerConnection();
    }

    /*
    * Print an array of ServerRuntimeMBeans.
    * This MBean is the root of the runtime MBean hierarchy, and
    * each server in the domain hosts its own instance.
    */
    public static ObjectName[] getServerRuntimes() throws Exception {
        return (ObjectName[]) connection.getAttribute(service,
            "ServerRuntimes");
    }

    /*
    * Iterate through ServerRuntimeMBeans and get the name and state
    */
    public void printNameAndState() throws Exception {
        ObjectName[] serverRT = getServerRuntimes();
        System.out.println("got server runtimes");
        int length = (int) serverRT.length;
        for (int i = 0; i < length; i++) {
            String name = (String) connection.getAttribute(serverRT[i],
                "Name");
            String state = (String) connection.getAttribute(serverRT[i],
                "State");
            System.out.println("Server name: " + name + ".    Server state: "
                + state);
        }
    }

    public static void main(String[] args) throws Exception {
        String hostname = args[0];
        String portString = args[1];
        String username = args[2];
        String password = args[3];

        PrintServerState s = new PrintServerState();
        initConnection(hostname, portString, username, password);
        s.printNameAndState();
        connector.close();
    }
}

```

Example: Monitoring Servlets

Each servlet in a Web application provides instance of `ServletRuntimeMBean` which contains information about the servlet's run-time state. (See [ServletRuntimeMBean](#) in *MBean Reference for Oracle WebLogic Server*.)

In the WebLogic Server data model, the path to a `ServletRuntimeMBean` is as follows:

1. The Domain Runtime MBean Server (for all servlets on all servers in the domain), or the Runtime MBean Server on a specific server instance.
2. `DomainRuntimeServiceMBean` or `RuntimeServiceMBean`, `ServerRuntimes` attribute.
3. `ServerRuntimeMBean`, `ApplicationRuntimes` attribute.
4. `ApplicationRuntimeMBean`, `ComponentRuntimes` attribute.

The `ComponentRuntimes` attribute contains many types of component run-time MBeans, one of which is `WebAppComponentRuntimeMBean`. When you get the value of this attribute,

you use the child MBean's Type attribute to get a specific type of component run-time MBean.

5. WebAppComponentRuntimeMBean, ServletRuntimes attribute.

Example 4-3 Monitoring Servlets

```
import java.io.IOException;
import java.net.MalformedURLException;
import java.util.Hashtable;

import javax.management.MBeanServerConnection;
import javax.management.MalformedObjectNameException;
import javax.management.ObjectName;
import javax.management.remote.JMXConnector;
import javax.management.remote.JMXConnectorFactory;
import javax.management.remote.JMXServiceURL;
import javax.naming.Context;

public class MonitorServlets {
    private static MBeanServerConnection connection;
    private static JMXConnector connector;
    private static final ObjectName service;

    // Initializing the object name for DomainRuntimeServiceMBean
    // so it can be used throughout the class.
    static {
        try {
            service = new ObjectName(

"com.bea:Name=DomainRuntimeService,Type=weblogic.management.mbeanservers.domainruntime.Do
mainRuntimeServiceMBean");
        } catch (MalformedObjectNameException e) {
            throw new AssertionError(e.getMessage());
        }
    }

    /*
    * Initialize connection to the Domain Runtime MBean Server
    */
    public static void initConnection(String hostname, String portString,
        String username, String password) throws IOException,
        MalformedURLException {
        String protocol = "t3";
        Integer portInteger = Integer.valueOf(portString);
        int port = portInteger.intValue();
        String jndiroot = "/jndi/";
        String mserver = "weblogic.management.mbeanservers.domainruntime";

        JMXServiceURL serviceURL = new JMXServiceURL(protocol, hostname,
            port, jndiroot + mserver);
        Hashtable h = new Hashtable();
        h.put(Context.SECURITY_PRINCIPAL, username);
        h.put(Context.SECURITY_CREDENTIALS, password);
        h.put(JMXConnectorFactory.PROTOCOL_PROVIDER_PACKAGES,
            "weblogic.management.remote");
        connector = JMXConnectorFactory.connect(serviceURL, h);
        connection = connector.getMBeanServerConnection();
    }

    /*
    * Get an array of ServerRuntimeMBeans
    */
}
```

```

    public static ObjectName[] getServerRuntimes() throws Exception {
        return (ObjectName[]) connection.getAttribute(service,
            "ServerRuntimes");
    }

    /*
    * Get an array of WebAppComponentRuntimeMBeans
    */
    public void getServletData() throws Exception {
        ObjectName[] serverRT = getServerRuntimes();
        int length = (int) serverRT.length;
        for (int i = 0; i < length; i++) {
            ObjectName[] appRT =
                (ObjectName[]) connection.getAttribute(serverRT[i],
                    "ApplicationRuntimes");
            int appLength = (int) appRT.length;
            for (int x = 0; x < appLength; x++) {
                System.out.println("Application name: " +
                    (String)connection.getAttribute(appRT[x], "Name"));
                ObjectName[] compRT =
                    (ObjectName[]) connection.getAttribute(appRT[x],
                        "ComponentRuntimes");
                int compLength = (int) compRT.length;
                for (int y = 0; y < compLength; y++) {
                    System.out.println("  Component name: " +
                        (String)connection.getAttribute(compRT[y], "Name"));
                    String componentType =
                        (String) connection.getAttribute(compRT[y], "Type");
                    System.out.println(componentType.toString());
                    if (componentType.toString().equals("WebAppComponentRuntime")){
                        ObjectName[] servletRTs = (ObjectName[])
                            connection.getAttribute(compRT[y], "Servlets");
                        int servletLength = (int) servletRTs.length;
                        for (int z = 0; z < servletLength; z++) {
                            System.out.println("    Servlet name: " +
                                (String)connection.getAttribute(servletRTs[z],
                                    "Name"));
                            System.out.println("      Servlet context path: " +
                                (String)connection.getAttribute(servletRTs[z],
                                    "ContextPath"));
                            System.out.println("        Invocation Total Count : " +
                                (Object)connection.getAttribute(servletRTs[z],
                                    "InvocationTotalCount"));
                        }
                    }
                }
            }
        }
    }

    public static void main(String[] args) throws Exception {
        String hostname = args[0];
        String portString = args[1];
        String username = args[2];
        String password = args[3];

        MonitorServlets s = new MonitorServlets();
        initConnection(hostname, portString, username, password);
        s.getServletData();
        connector.close();
    }
}

```

The code in [Example 4-3](#) navigates the hierarchy described in the previous paragraphs and gets values of `ServletRuntimeMBean` attributes.

5

Managing a Domain's Configuration with JMX

This chapter describes how to use JMX to manage a WebLogic Server domain's configuration. It explains how to edit MBean attributes; how to list and undo changes; how to track the activation of changes; and how to set and get encrypted MBean attribute values. It also includes best practices for editing and handling exceptions.

This chapter includes the following sections:

To understand the process of changing a WebLogic Server domain and activating the changes, see Managing Configuration Changes in *Understanding Domain Configuration for Oracle WebLogic Server*.

Editing MBean Attributes: Main Steps

To edit MBean attributes:

1. Start an Edit Session.

All edits to MBean attributes occur within the context of an edit session, and within each WebLogic Server domain only one edit session can be active at a time. Once a user has started an edit session, WebLogic Server locks other users from accessing the pending configuration MBean hierarchy. See [Managing Locks](#).

2. Change Attributes or Create New MBeans.

Changing an MBean attribute or creating a new MBean updates the in-memory hierarchy of pending configuration MBeans. If you end your edit session before saving these changes, the unsaved changes will be discarded.

3. Save Changes to the Pending Configuration Files.

When you are satisfied with your changes to the in-memory hierarchy, save them to the domain's pending configuration files. Any changes that you save remain in the pending configuration files until they have been activated or explicitly reverted. If you end your edit session before activating the saved changes, you or someone else can activate them in a subsequent edit session.

You can iteratively make changes and save changes before activating them. For example, you can create and save a server. Then you can configure the new server's listen port and listen address and save those changes. Organizing your code in this way can facilitate correcting any validation errors.

4. Activate Your Saved Changes.

When you activate your changes, WebLogic Server copies the saved, pending configuration files to all servers in the domain. Each server evaluates the changes and indicates whether it can consume them. If it can, then it updates its active configuration files and in-memory hierarchy of configuration MBeans.

5. Restart any server instances that have been updated with changes that require a server restart.

Start an Edit Session

To start an edit session:

1. Initiate a connection to the Edit MBean Server.

The connection returns an object of type `java.management.MBeanServerConnection`.

See [Make Remote Connections to an MBean Server](#).

2. Get the object name for `ConfigurationManagerMBean`.

`ConfigurationManagerMBean` provides methods to start and stop edit sessions, and save, undo, and activate configuration changes. (See [ConfigurationManagerMBean](#) in *MBean Reference for Oracle WebLogic Server*.)

Each domain has only one instance of `ConfigurationManagerMBean` and it is contained in the `EditServiceMBean` `ConfigurationManager` attribute. `EditServiceMBean` is your entry point for all edit operations. It has a simple, fixed object name and contains attributes and operations for accessing all other MBeans in the Edit MBean Server.

To get the `ConfigurationManagerMBean` object name, use the following method:

```
MBeanServerConnection.getAttribute(  
    ObjectName object-name, String attribute)
```

In the preceding method syntax:

- *object-name* represents the literal `"com.bea:Name=EditService,Type=weblogic.management.mbeanservers.edit.EditServiceMBean"`, which is the object name of `EditServiceMBean`.
- *attribute* represents the literal `ConfigurationManager`, which is the name of the attribute in `EditServiceMBean` that contains `ConfigurationManagerMBean`.

3. Start an edit session.

To start an edit session, invoke the `ConfigurationManagerMBean` `startEdit(int waitTime, int timeout)` operation, where:

- *waitTime* represents the number of milliseconds `ConfigurationManagerMBean` waits to establish a lock on the edit MBean hierarchy. You cannot establish a lock if other edits are in progress unless you have administrator privileges (see [Managing Locks](#)).
- *timeout* represents the number of milliseconds you have to complete your edit session. If the time expires before you save or activate your edits, all of your unsaved changes are discarded.

The `startEdit` operation returns either of the following:

- If it cannot establish a lock on the edit tree within the amount of time that you specified, it throws `weblogic.management.mbeanservers.edit.EditTimedOutException`.
- If it successfully locks the edit tree, it returns an object name for `DomainMBean`, which is the root of the edit MBean hierarchy.

Change Attributes or Create New MBeans

To change the attribute values of existing MBeans, create new MBeans, or delete MBeans:

1. Navigate the hierarchy of the edit tree and retrieve an object name for the MBean that you want to edit. To create or delete MBeans, retrieve an object name for the MBean that contains the appropriate factory methods.

See [Make Remote Connections to an MBean Server](#).

2. To change the value of an MBean attribute, invoke the `MBeanServerConnection.setAttribute(object-name, attribute)` method, where:

- `object-name` represents the object name of the MBean that you want to edit.
- `attribute` represents a `javax.management.Attribute` object, which contains the name of the MBean attribute that you want to change and its new value.

To create an MBean, invoke the MBean's create method. For example, the factory method to create an instance of `ServerMBean` is `createServer(String name)` in `DomainMBean`. In *MBean Reference for Oracle WebLogic Server*, each MBean describes the location of its factory methods (see [ServerMBean](#)).

3. (Optional) If you organize your edits into multiple steps, consider validating your changes after each step by invoking the `ConfigurationManagerMBean.validate()` operation.

The validate method verifies that all unsaved changes satisfy dependencies between MBean attributes and makes other checks that cannot be made at the time that you set the value of a single attribute.

If it finds validation errors, the `validate()` operation throws an exception of type `weblogic.management.mbeanservers.edit.ValidationException`. See [Exception Types Thrown by Edit Operations](#).

Validating is optional because the `save()` operation also validates changes before saving.

Save Changes to the Pending Configuration Files

Save your changes by invoking the `ConfigurationManagerMBean.save()` operation.

Activate Your Saved Changes

To activate your saved changes throughout the domain:

1. Invoke the `ConfigurationManagerMBean.activate(long timeout)` operation where `timeout` specifies how many milliseconds the operation has to complete.

The activate operation returns an object name for an instance of `ActivationTaskMBean`, which contains information about the activation request. See [Listing and Undoing Changes](#).

When the activate operation succeeds or times out, it releases your lock on the editable MBean hierarchy.

2. Close your connection to the MBean server by invoking `JMXConnector.close()`.

Exception Types Thrown by Edit Operations

[Table 5-1](#) describes all of the exception types that WebLogic Server can throw during edit operations. When WebLogic Server throws such an exception, the MBean server wraps the exception in `javax.management.MBeanException`. (See `MBeanException` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/MBeanException.html>.)

Table 5-1 Exception Types Thrown by Edit Operations

Exception Type	Thrown When
<code>EditTimeoutException</code>	The request to start an edit session times out.
<code>NotEditorException</code>	You attempt to edit MBeans without having a lock or when an administrative user cancels your lock and starts an edit session.
<code>ValidationException</code>	You set an MBean attribute's value to the wrong data type, outside an allowed range, not one of a specified set of values, or incompatible with dependencies in other attributes.

Listing and Undoing Changes

The following sections describe working with changes that you have made during an edit session:

WebLogic Server describes changes in a `Change` object, which is of type `javax.management.openmbean.CompositeType`. See `CompositeType` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/openmbean/CompositeType.html>.

Through JMX, you can access information about the changes to a domain's configuration that have occurred during the current server session only. WebLogic Server maintains an archive of configuration files, but the archived data and comparisons of archive versions is not available through JMX.

List Unsaved Changes

For each change that you make to an MBean attribute, WebLogic Server creates a `Change` object which contains information about the change. You can access these objects from the `ConfigurationManagerMBean` `Changes` attribute until you save the changes. See [ConfigurationManagerMBean](#) in *MBean Reference for Oracle WebLogic Server*.

Any unsaved changes are discarded when your edit session ends.

To list unsaved changes:

1. Start an edit session and change at least one MBean attribute.
2. Get the value of the `ConfigurationManagerMBean` `Changes` attribute and assign the output to a variable of type `Object[]`.
3. For each object in the array, invoke `Object.toString()` to output a description of the change.

Because `Change` is a `javax.management.openmbean.CompositeType`, you can also cast each item in the array as a `CompositeType` and invoke `CompositeType` methods on the change. See `CompositeType` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/openmbean/CompositeType.html>.

Example 5-1 Example Method that Lists Unsaved Changes

```
public void listUnsaved() throws Exception {
    ObjectName cfgMgr = (ObjectName) connection.getAttribute(service,
        "ConfigurationManager");
    Object[] list = (Object[])connection.getAttribute(cfgMgr, "Changes");
}
```

```

    int length = (int) list.length;
    for (int i = 0; i < length; i++) {
        System.out.println("Unsaved change: " + list[i].toString());
    }
}

```

The code in [Example 5-1](#) creates a method that lists unsaved changes. It assumes that the calling method has already established a connection to the Edit MBean Server.

List Unactivated Changes

When anyone saves changes, WebLogic Server persists the changes in the pending configuration files. The changes remain in these files, even across multiple editing sessions, unless a user who has started an edit session invokes the `ConfigurationManagerMBean.undoUnactivatedChanges()` operation, which reverts all unactivated changes from the pending files.

The `ConfigurationManagerMBean` `UnactivatedChanges` attribute contains `Change` objects for both unsaved changes and changes that have been saved but not activated. (There is no attribute that contains only saved but unactivated changes.) See [ConfigurationManagerMBean Unactivated Changes](#) in *MBean Reference for Oracle WebLogic Server*.

To list changes that you have saved in the current editing session but not activated, or changes that your or others have saved in previous editing sessions but not activated:

1. Start an edit session and change at least one MBean attribute.
2. Get the value of the `ConfigurationManagerMBean` `UnactivatedChanges` attribute and assign the output to a variable of type `Object[]`.
3. For each object in the array, invoke `Object.toString()` to output a description of the change.

Because `Change` is a `javax.management.openmbean.CompositeType`, you can also cast each item in the array as a `CompositeType` and invoke `CompositeType` methods on the change. See `CompositeType` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/openmbean/CompositeType.html>.

Example 5-2 Example Method that Lists Unactivated Changes

```

public void listUnactivated() throws Exception {
    ObjectName cfgMgr = (ObjectName) connection.getAttribute(service,
        "ConfigurationManager");
    Object[] list = (Object[])connection.getAttribute(cfgMgr,
        "UnactivatedChanges");
    int length = (int) list.length;
    for (int i = 0; i < length; i++) {
        System.out.println("Unactivated changes: " + list[i].toString());
    }
}

```

The code in [Example 5-2](#) creates a method that lists unactivated changes. It assumes that the calling method has already established a connection to the Edit MBean Server.

List Changes in the Current Activation Task

When you activate changes, WebLogic Server creates an instance of `ActivationTaskMBean`, which contains one `Change` object for each change that is being activated. You can access these `ActivationTaskMBeans` from either of the following:

- The `ConfigurationManagerMBean activate()` method returns an object name for the `ActivationTaskMBean` that describes the current activation task.
- The `ConfigurationManagerMBean CompletedActivationTasks` attribute can potentially contain a list of all `ActivationTaskMBean` instances that have been created during the current Administration Server instantiation. See [Listing All Activation Tasks Stored in Memory](#).

To list changes in the current activation task only:

1. Start an edit session.
2. Assign the output of the activate operation to an instance variable of type `javax.management.ObjectName`.
3. Get the value of the `ActivationTaskMBean Changes` attribute, and assign the output to a variable of type `Object[]`.
4. For each object in the array, invoke `Object.toString()` to output a description of the change.

Because `Change` is a `javax.management.openmbean.CompositeType`, you can also cast each item in the array as a `CompositeType` and invoke `CompositeType` methods on the change. See `CompositeType` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/openmbean/CompositeType.html>.

Example 5-3 Example Method that Lists Changes in the Current Activation Task

```
public void activateAndList()
    throws Exception {
    ObjectName cfgMgr = (ObjectName) connection.getAttribute(service,
        "ConfigurationManager");
    ObjectName task = (ObjectName) connection.invoke(cfgMgr, "activate",
        new Object[] { new Long(120000) }, new String[] { "java.lang.Long" });
    Object[] changes = (Object[]) connection.getAttribute(task, "Changes");
    int i = (int) changes.length;
    for (int i = 0; i < i; i++) {
        System.out.println("Changes activated: " + changes[i].toString());
    }
}
```

The code in [Example 5-3](#) creates a method that lists all changes activated in the current editing session. It assumes that the calling method has already established a connection to the Edit MBean Server.

Undoing Changes

`ConfigurationManagerMBean` provides two operations for undoing changes made during an editing session:

- `undo`
Reverts unsaved changes.
- `undoUnactivatedChanges`
Reverts all changes, saved or unsaved, that have not yet been activated. If other users have saved changes in a previous editing session but not activated those changes, invoking the `ConfigurationManagerMBean undoUnactivatedChanges()` operation reverts those changes as well.

After you invoke this method, the pending configuration files are identical to the working configuration files that the active servers use.

To undo changes, start an edit session and invoke the `ConfigurationManagerMBean` `undo` or `undoUnactivatedChanges` operation.

For example:

```
connection.invoke(cfgMgr, "undo", null, null);
```

Tracking the Activation of Changes

In addition to maintaining a list of changes, each `ActivationTaskMBean` that WebLogic Server creates when you invoke the `activate` operation describes which user activated the changes, the status of the activation task, and the time at which the changes were activated.

The Administration Server maintains instances of `ActivationTaskMBean` in memory only; they are not persisted and are destroyed when you shut down the Administration Server. Because the `ActivationTaskMBean` instances contain a list of `Change` objects (each of which describes a single change to an MBean attribute), they use a significant amount of memory. To save memory, by default the Administration Server maintains only a few of the most recent `ActivationTaskMBean` instances in memory. To change the default, increase the value of the `ConfigurationManagerMBean` `CompletedActivationTasksCount` attribute.

The following sections describe working with instances of `ActivationTaskMBean`:

Listing the Status of the Current Activation Task

When you invoke the `activate` operation, WebLogic Server returns an `ActivationTaskMBean` instance to represent the activation task.

The `ActivationTaskMBean` `State` attribute describes the status of the activation task. This attribute stores an `int` value and `ActivationTaskMBean` defines constants for each of the `int` values. See [ActivationTaskMBean](#) in *MBean Reference for Oracle WebLogic Server*.

To list the status of the current activation task:

1. Start an edit session and change at least one MBean attribute.
2. Invoke the `ConfigurationManagerMBean` `activate(long timeout)` operation and assign the output to a variable of type `ActivationTaskMBean`.
3. Get the value of the `ActivationTaskMBean` `State` attribute.

Listing All Activation Tasks Stored in Memory

The `ActivationTaskMBean` that the `activate` operation returns describes only a single activation task. The Administration Server keeps this `ActivationTaskMBean` in memory until you purge it (see [Purging Completed Activation Tasks from Memory](#)) or the number of activation tasks exceeds the value of the `ConfigurationManagerMBean` `CompletedActivationTasksCount` attribute.

To access all `ActivationTaskMBean` instances that are currently stored in memory (see [Example 5-4](#)):

1. Connect to the Edit MBean Server. (You do not need to start an edit session.)
2. Get the value of the `ConfigurationManagerMBean` `CompletedActivationTasks` attribute and assign the output to a variable of type `Object[]`.

3. (Optional) For each object in the array, get and print the value of `ActivationTaskMBean` attributes such as `User` and `State`.

See [ActivationTaskMBean](#) in *MBean Reference for Oracle WebLogic Server*.

4. (Optional) For each object in the array, get the value of the `Changes` attribute. Invoke `Object.toString()` to output the value of the `Change` object.

Example 5-4 Example Method that Lists All Activation Tasks in Memory

```
public void listActivated() throws Exception {
    ObjectName cfgMgr = (ObjectName) connection.getAttribute(service,
        "ConfigurationManager");
    ObjectName[] list = (ObjectName[])connection.getAttribute(cfgMgr,
        "CompletedActivationTasks");
    System.out.println("Listing completed activation tasks.");
    int length = (int) list.length;
    for (int i = 0; i < length; i++) {
        System.out.println("Activation task " + i);
        System.out.println("User who started activation: " +
            connection.getAttribute(list[i], "User"));
        System.out.println("Task state: " + connection.getAttribute(list[i],
            "State"));
        System.out.println("Start time: " + connection.getAttribute(list[i],
            "StartTime"));

        Object[] changes = (Object[])connection.getAttribute(list[i], "Changes");
        int l = (int) changes.length;
        for (int y = 0; y < l; y++) {
            System.out.println("Changes activated: " + changes[y].toString());
        }
    }
}
```

Purging Completed Activation Tasks from Memory

Because the `ActivationTaskMBean` instances contain a list of `Change` objects (each of which describes a single change to an `MBean` attribute), they use a significant amount of memory.

If the Administration Server is running out of memory, you can purge completed activation tasks from memory. Then decrease the value of the `ConfigurationManagerMBean` `CompletedActivationTasksCount` attribute.

To purge completed activation tasks from memory, connect to the Edit `MBean` Server and invoke the `ConfigurationManagerMBean` `purgeCompletedActivationTasks` operation.

For example:

```
connection.invoke(cfgMgr, "purgeCompletedActivationTasks", null, null);
```

Managing Locks

To prevent changes that could leave the pending configuration `MBean` hierarchy in an inconsistent state, only one user at a time can edit `MBeans`. When a user invokes the `ConfigurationManagerMBean` `startEdit` operation, the `ConfigurationManagerMBean` prevents other users (locks) from starting edit sessions.

The following actions remove the lock:

- The `ConfigurationManagerMBean` `activate` operation succeeds or times out.

You can use the `ActivationTaskMBean.waitForTaskCompletion` operation to block until the activation process is complete.

- The `ConfigurationManagerMBean.stopEdit` operation succeeds.
- A user with administrator privileges invokes the `ConfigurationManagerMBean.cancelEdit` operation while another user has the lock.

For example, `connection.invoke(cfgMgr, "cancelEdit", null, null);`

- An edit session has been started under a user identity and another process starts an edit session under the same user identity.

For example, if you use the WebLogic Remote Console to start an edit session and shortly afterward, use the WebLogic Scripting Tool (WLST) to start an edit session under the same user identity, the WLST session will remove the lock from your WebLogic Remote Console session.

To prevent another process from starting an edit session under your user identity, get an exclusive lock by passing a boolean of value `true` to the `startEdit` operation. See [startEdit\(waitTimeInMillis, timeOutInMillis, exclusive\)](#) in the *MBean Reference for Oracle WebLogic Server*.

All unsaved changes are lost when the lock is removed.

Best Practices: Recommended Pattern for Editing and Handling Exceptions

Oracle recommends that you organize your editing code into several try-catch blocks. Such an organization will enable you to catch specific types of errors and respond appropriately. For example, instead of abandoning the entire edit session if a change is invalid, your code can save the changes, throw an exception and exit without attempting to activate invalid changes.

JMX agents wrap all exceptions in a generic exception of type `javax.management.MBeanException`. A JMX client can use the `MBeanException.getTargetException()` to unwrap the wrapped exception.

Consider using the following structure (see the pseudo-code in [Example 5-5](#)):

- A try block that connects to the Edit MBean Server, starts an edit session, and makes and saves changes.

After this try block, one catch block for each of the following types of exception wrapped within `MBeanException`:

- `EditTimedOutException`

This exception is thrown if the `ConfigurationManagerMBean.startEdit()` operation cannot get a lock within the amount of time that you specify.

- `NotEditorException`

This exception is thrown if the edit session times out or an administrator cancels your edit session. (See [Managing Locks](#).)

- `ValidationException`

This exception is thrown if you set a value in an MBean that is the wrong data type, outside an allowed range, not one of a specified set of values, or incompatible with dependencies in other attributes.

Within the code that handles `ValidationException`, include a try block that either attempts to correct the validation error or stops the edit session by invoking the `ConfigurationManagerMBean stopEdit()` operation. If the try block stops the edit session, its catch block should ignore the `NotEditorException`. This exception indicates that you no longer have a lock on the pending configuration MBean hierarchy; however, because you want to abandon changes and release your lock anyway, it is not an error condition for this exception to be thrown.

- A try block that activates the changes that have been saved.

The `ConfigurationManager activate(long timeout)` operation returns an instance of `ActivationTaskMBean`, which contains information about the activation task. Oracle recommends that you set the timeout period for `activate()` to a minute and then check the value of the `ActivationTaskMBean State` attribute.

If `State` contains the constant `STATE_COMMITTED`, then your changes have been successfully activated in the domain. You can use a return statement at this point to end your editing work. The lock that you created with `startEdit()` releases after the activation task succeeds.

If `State` contains a different value, the activation has not succeeded in the timeout period that you specified in `activate(long timeout)`. You can get the value of the `ActivationTaskMBean Error` attribute to find out why.

After this try block, one catch block to catch the following type of wrapped exception:

`NotEditorException`

If this exception is thrown while trying to activate changes, your changes were not activated because your edit session timed out or was cancelled by an administrator.

- (Optional) A try block that undoes the saved changes.

If your class does not return in the activation try block, then your activation task was not successful. If you do not want these saved changes to be activated by a future attempt to activate changes, then invoke the `ConfigurationManagerMBean undoUnactivatedChanges()` operation.

Otherwise, the pending configuration files retain your saved changes. The next time any user attempts to activate saved changes, WebLogic Server will attempt to activate your saved changes along with any other saved changes.

After this try block, one catch block to **ignore** the following type of wrapped exception:

`NotEditorException`

- A try block to stop the edit session.

If your activation attempt fails and you are ready to abandon changes, there is no need to wait until your original timeout period to expire. You can stop editing immediately.

After this try block, one catch block to **ignore** the following type of exception:

`NotEditorException`

- Throw the exception that is stored in the `ActivationTaskMBean Error` attribute.

Example 5-5 Code Outline for Editing and Exception Handling

```
try {
    //Initialize the connection and start the edit session
    ...
    ObjectName domainConfigRoot = (ObjectName) connection.invoke(cfgMgr,
        "startEdit",
        new Object[] { new Integer(30000), new Integer(300000) },
```

```

        new String[] { "java.lang.Integer", "java.lang.Integer" });

    // Modify the domain
    ...
    // Save your changes
    connection.invoke(cfgMgr, "save", null, null);

} catch (MBeanException e) {
    Exception targetException = e.getTargetException();
    if (targetException instanceof EditTimeoutException) {
        // Could not get the lock. Notify user
        ...
        throw new MyAppCouldNotStartEditException(e);
    }
    if (targetException instanceof NotEditorException) {
        ...
        throw new MyAppEditSessionFailed(e);
    }
    if (targetException instanceof ValidationException) {
        ...
        try {
            connection.invoke(cfgMgr, "stopEdit", null, null);
            // A wrapped NotEditorException here indicates that you no longer have a
            // lock on the pending configuration MBean hierarchy; however,
            // because you want to abandon changes and release your lock anyway,
            // it is not an error condition for this exception to be thrown
            // and you can safely ignore it.
        } catch (MBeanException e) {
            Exception targetException = e.getTargetException();
            if (targetException instanceof NotEditorException) {
                //ignore
            }
        }
        throw new MyAppEditChangesInvalid(e);
    }
    else {
        throw MBeanException (e);
    }
}

// Changes have been saved, now activate them
try {
    // Activate the changes
    ActivationTaskMBean task = (ObjectName) connection.invoke(cfgMgr,
        "activate",
        new Object[] { new Long(60000) },
        new String[] { "java.lang.Long" });
    // Everything worked, just return.
    String status = (String) connection.getAttribute(task, "State");
    if (status.equals("4"))
        return;
    // If there is an activation error, use ActivationTaskMBean.getError
    // to get information about the error
    failure = connection.getAttribute(task, "Error");
    // If you catch a wrapped NotEditorException, your changes were not activated
    // because your edit session ended or was cancelled by an administrator.
    // Throw the wrapped exception.
} catch (MBeanException e) {
    Exception targetException = e.getTargetException();
    if (targetException instanceof NotEditorException) {
        ...
        throw new MyAppEditSessionFailed(e);
    }
}

```

```

    }
}

// If your class executes the remaining lines, it is because activating your
// saved changes failed.
// Optional: You can undo the saved changes that failed to activate. If you
// do not undo your saved changes, they will be activated the next time
// someone attempts to activate changes.
// try {
//     {
//         connection.invoke(cfgMgr, "undoUnactivatedChanges", null, null);
//     } catch(MBeanException e) {
//         Exception targetException = e.getTargetException();
//         if (targetException instanceof NotEditorException) {
//             ...
//             throw new MyAppEditSessionFailed(e);
//         }
//     }
// }

// Stop the edit session
try {
    connection.invoke(cfgMgr, "stopEdit", null, null);
    // If your activation attempt fails and you are ready to abandon
    // changes, there is no need to wait until your original timeout
    // period to expire. You can stop editing immediately
    // and you can safely ignore any wrapped NotEditorException.
} catch (MBeanException e) {
    Exception targetException = e.getTargetException();
    if (targetException instanceof NotEditorException) {
        //ignore
    }
}
...
// Output the information about the error that caused the activation to
// fail.
throw new MyAppEditSessionFailed(connection.getAttribute(task, "Error"));

```

Setting and Getting Encrypted Values

To prevent unauthorized access to sensitive data such as passwords, some attributes in WebLogic Server configuration MBeans are encrypted. The attributes persist their values in the domain's config.xml file as an encrypted string and represent the in-memory value in the form of an encrypted byte array. The names of encrypted attributes end with Encrypted. For example, the ServerMBean exposes the password that is used to secure access through the IIOP protocol in an attribute named DefaultIIOPPasswordEncrypted. To support backwards compatibility, and to enable remote JMX clients to set passwords for WebLogic Server MBeans, each encrypted attribute provides a less secure means to encrypt and set its value.

The following sections describe how to work with encrypted attributes:

Set the Value of an Encrypted Attribute (Recommended Technique)

To use this technique (see [Example 5-6](#)):

1. In the same WebLogic Server JVM that hosts the MBean attribute, write a value to a byte array.
2. Pass the byte array to the `weblogic.management.EncryptionHelper.encrypt(byte[])` method and pass its return value to the `MBeanServerConnection.setAttribute` method.

Avoid assigning the encrypted byte array to a variable because this causes the unencrypted byte array to remain in memory until it is garbage collected and the memory is reallocated.

3. Clear the original byte array using the `weblogic.management.EncryptionHelper.clear()` method.

Example 5-6 Example: Set the Value of an Encrypted Attribute (Recommended Technique)

```
public void editDefaultIIOPPassword(ObjectName cfgRoot) throws Exception {
    // Get the ServerMBean from the DomainMBean
    ObjectName server = (ObjectName) connection.invoke(cfgRoot,
        "lookupServer", new Object[] { "myserver" },
        new String[] { "java.lang.String" });
    // Get new password from standard in. Assign it to a byte array.
    System.out.println("Enter new password and press enter: ");
    byte userInput[] = new byte[10];
    System.in.read(userInput);
    // Encrypt the byte array and set it as the encrypted
    // attribute value.
    Attribute newPassword = new Attribute("DefaultIIOPPasswordEncrypted",
        weblogic.management.EncryptionHelper.encrypt(userInput));
    connection.setAttribute(server, newPassword);
    System.out.println("New password is set to: " +
        connection.getAttribute(server, "DefaultIIOPPasswordEncrypted"));
    // Clear the byte array.
    weblogic.management.EncryptionHelper.clear(userInput);
}
```

Set the Value of an Encrypted Attribute (Compatibility Technique)

Prior to 9.0, JMX clients used a different technique for setting encrypted values. JMX clients can continue to use this compatibility technique, and if you want to set encrypted values from a remote JMX client, this is the only technique available. The compatibility technique is less secure because it creates a `String` that contains your unencrypted password. Even though WebLogic Server converts the `String` to an encrypted byte array, the `String` will remain in memory until it is garbage collected and the memory is reallocated.

To use the compatibility technique:

1. Write a value to a `String`.
2. Pass the `String` as a parameter to the `MBeanServerConnection.setAttribute` method, but instead of setting the value of the encrypted attribute, set the value for the corresponding non-encrypted attribute.

WebLogic Server converts the `String` to an encrypted byte array and sets it as `CustomIdentityKeyStorePassPhraseEncrypted`. (It does not set a value for `CustomIdentityKeyStorePassPhrase`).

For example, to set the `CustomIdentityKeyStorePassPhraseEncrypted` from a remote JMX client, invoke the `MBeanServerConnection.setAttribute` for an attribute named `CustomIdentityKeyStorePassPhrase`.

For example:

```
public void editDefaultIIOPPassword(ObjectName cfgRoot, String password)
    throws Exception {
    // Get the ServerMBean from the DomainMBean
    ObjectName server = (ObjectName) connection.invoke(cfgRoot, "lookupServer",
        new Object[]{"myserver"}, new String[]{"java.lang.String"});
```

```
Attribute newPassword = new Attribute("DefaultIIOPPassword",  
    "password");  
connection.setAttribute(server, newPassword);  
}
```

Back Up an Encrypted Value

To make a backup copy of a password, use the getter method of the MBean's encrypted value to retrieve the encrypted byte array. Then write the value of the byte array to a file. WebLogic Server does not provide APIs or other utilities for decrypting values that it has encrypted.

If you need to restore the password value, you can load the saved value into a byte array and pass it as a parameter to the `MBeanServerConnection.setAttribute` method (see [Set the Value of an Encrypted Attribute \(Recommended Technique\)](#)).

Note

Because each WebLogic Server domain uses its own encryption algorithm, you must back up and restore passwords separately for each domain even if the unencrypted value for the password is the same for all domains.

Instead of backing up the same encrypted password for each domain, you can use the getter method of an MBean's corresponding **unencrypted** value. This getter unencrypts the password and copies into a `String`. The `String` will not be erased from memory until it is garbage collected and the memory is reallocated.

6

Managing Security Realms with JMX

This chapter describes how to use JMX to manage security realms, which comprise the mechanisms for protecting WebLogic resources. Each security realm consists of a set of configured security providers, which are modular components that handle specific aspects of security. You can create a JMX client that uses the providers in a realm to add or remove security data such as users and groups. You can also create a client that adds or removes providers and makes other changes to the realm configuration.

This chapter includes the following sections:

For more information about WebLogic Security, see *Understanding Security for Oracle WebLogic Server*.

Understanding the Hierarchy of Security MBeans

Like other subsystems, the WebLogic Server security framework organizes its MBeans in a hierarchy that JMX clients can navigate without constructing JMX object names. However, the set of MBean types that are available in a security realm depends on which security providers you have installed in the realm, and the set of services that each security provider enables depends on how the provider was created.

The root of the security realm hierarchy is the `RealmMBean`. It contains all of the providers that have been configured for the realm. For example, its `Authorizers` attribute contains all authorization providers that have been configured for the realm. WebLogic Server installs a default set of security providers; therefore, by default the `RealmMBean` `Authorizers` attribute contains a `DefaultAuthorizerMBean`. However, you can uninstall these default providers and replace them with any number of your own providers or third-party providers. For information about the default security providers, see *Configuring WebLogic Security Providers and Configuring Authorization Providers in Administering Security for Oracle WebLogic Server*.

Base Provider Types and Mix-In Interfaces

Each security provider must extend a base provider type. For example, `DefaultAuthorizerMBean` extends `AuthorizerMBean`, and any custom or third-party authorization provider also extends `AuthorizerMBean`. If a JMX client gets the value of the `RealmMBean` `Authorizers` attribute, the MBean server returns all MBeans in the realm that extend `AuthorizerMBean`. The JMX client can iterate through the list of providers and select one based on the value of its `Name` attribute or other criteria.

Base provider types can be enhanced by extending a set of optional mix-in interfaces. For example, if an authentication provider extends the `UserEditorMBean`, then the provider can add users to the realm.

Security MBeans

WebLogic Server's Security MBeans configure security providers in a security realm. The following tables describe the MBeans that configure different types of security providers.

- [Table 6-1](#) describes the MBeans that configure Authentication security providers, as well as the abstract MBean classes that Authentication providers must extend. In addition to the

MBeans in this table, WebLogic Server includes configuration MBeans for each out-of-the-box Authentication provider.

- [Table 6-2](#) describes the MBeans that configure security providers, other than Authentication security providers.
- [Table 6-3](#) describes optional MBean mixin interfaces that security providers can support for management and utility purposes.

For more information about configuring WebLogic security providers, see *Configuring WebLogic Security Providers and Configuring Authorization Providers in Administering Security for Oracle WebLogic Server*. [Figure 6-1](#) illustrates where the MBeans are located in the configuration MBean hierarchy.

Table 6-1 MBeans for Authentication Security Providers

This MBean...	Configures...
AuthenticationProviderMBean	The base MBean for all MBean implementations that manage Authentication providers. If your Authentication provider uses the WebLogic Security SSPI to provide login services, then your MBean must extend <code>weblogic.management.security.authentication.Authenticator</code> . If your Authentication provider uses the WebLogic Security SPI to provide identity-assertion services, then your MBean must extend <code>weblogic.management.security.authentication.IdentityAsserter</code> . See AuthenticationProviderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
AuthenticatorMBean	The SSPI MBean that all Authentication providers with login services must extend. This MBean provides a <code>ControlFlag</code> to determine whether the Authentication provider is a REQUIRED, REQUISITE, SUFFICIENT, or OPTIONAL part of the login sequence. See AuthenticatorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
IdentityAsserterMBean	The SSPI MBean that all Identity Assertion providers must extend. This MBean enables an Identity Assertion provider to specify the token types for which it is capable of asserting identity. See IdentityAsserterMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
ServletAuthenticationFilterMBean	The SSPI MBean that all Servlet Authentication Filter providers must extend. This MBean is just a marker interface. It has no methods on it. See ServletAuthenticationFilterMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-2 MBeans for Other Security Providers

This MBean...	Configures...
AdjudicatorMBean	The SSPI MBean that all Adjudication providers must extend. See AdjudicatorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DefaultAdjudicatorMBean	Configuration attributes for the WebLogic Adjudication provider. See DefaultAdjudicatorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-2 (Cont.) MBeans for Other Security Providers

This MBean...	Configures...
AuditorMBean	The SSPI MBean that all Auditing providers must extend. See AuditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DefaultAuditorMBean	Configuration attributes for the WebLogic Auditing provider. See DefaultAuditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
AuthorizerMBean	The SSPI MBean that all Authorization providers must extend. See AuthorizerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DeployableAuthorizerMBean	The SSPI MBean that must be extended by all Authorization providers that can store policies created while deploying a Web application or EJB. See DeployableAuthorizerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DefaultAuthorizerMBean	Configuration attributes for the WebLogic Authorization provider. See DefaultAuthorizerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
CredentialMapperMBean	The SSPI MBean that all Credential Mapping providers must extend. See CredentialMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DeployableCredentialMapperMBean	The SSPI MBean that must be extended by all Credential Mapper providers that can store credential maps created while deploying a component. See DeployableCredentialMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DefaultCredentialMapperMBean	Configuration attributes for the WebLogic Credential Mapping provider, a username/password Credential Mapping provider. See DefaultCredentialMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
PKICredentialMapperMBean	Configuration attributes for the PKI Credential Mapping provider, a key pair Credential Mapping provider. See PKICredentialMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
SAMLCredentialMapperMBean	Configuration attributes for the SAML Credential Mapping provider, a Security Assertion Markup Language Credential Mapping provider. See SAMLCredentialMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
CertPathProviderMBean	The base MBean for all certification path providers. See CertPathProviderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
CertPathBuilderMBean	The SSPI MBean that all certification path providers with CertPathBuilder services must extend. See CertPathBuilderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
CertPathValidatorMBean	The SSPI MBean that all certification path providers with CertPathValidator services must extend. See CertPathValidatorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-2 (Cont.) MBeans for Other Security Providers

This MBean...	Configures...
CertificateRegistryMBean	Configures and manages the certificate registry. It is both a builder and a validator. It supports building from the end certificate, the end certificate's subject DN, the end certificate's issuer DN and serial number, and the end certificate's subject key identifier. See CertificateRegistryMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
WebLogicCertPathProviderMBean	The SSPI MBean that all certification path providers with CertPathBuilder services must extend. See WebLogicCertPathProviderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
RoleMapperMBean	The base MBean for Role Mapping providers. A Role Mapping provider for a non-deployable module must extend this MBean directly. A Role Mapping provider for a deployable module must extend the DeployableRoleMapperMBean. See RoleMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DeployableRoleMapperMBean	The SSPI MBean that must be extended by Role Mapping providers that can store roles created while deploying a Web application or EJB. See DeployableRoleMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
DefaultRoleMapperMBean	Configuration attributes for the WebLogic Role Mapping provider. See DefaultRoleMapperMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-3 MBean Mixin Interfaces for Security Providers

This MBean...	Configures...
ContextHandlerMBean	Provides a set of attributes for ContextHandler support. An Auditor provider MBean can optionally implement this MBean. See ContextHandlerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
GroupEditorMBean	Provides a set of methods for creating, editing, and removing groups. An Authentication provider MBean can optionally implement this MBean. See GroupEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
GroupMemberListerMBean	Provides a method for listing a group's members. An Authentication provider MBean can optionally implement this MBean. See GroupMemberListerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
GroupMembershipHierarchyCacheMBean	Provides configuration attributes that are required to support the Group Membership Hierarchy Cache. An Authentication provider MBean can optionally implement this MBean. See GroupMembershipHierarchyCacheMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-3 (Cont.) MBean Mixin Interfaces for Security Providers

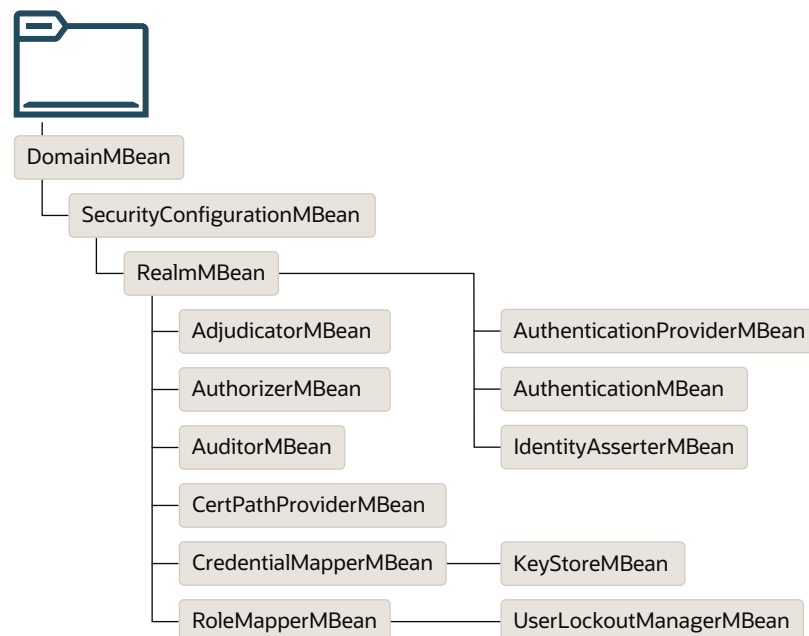
This MBean...	Configures...
GroupReaderMBean	Provides a set of methods for reading data about groups. An Authentication provider MBean can optionally implement this MBean. See GroupReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
MemberGroupListerMBean	Provides a method for listing the groups that contain a member. An Authentication provider MBean can optionally implement this MBean. See MemberGroupListerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserEditorMBean	Provides a set of methods for creating, editing, and removing users. An Authentication provider MBean can optionally implement this MBean. See UserEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserLockoutManagerMBean	Lists and manages lockouts on user accounts. An Authentication provider MBean can optionally implement this MBean. See UserLockoutManagerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserPasswordEditorMBean	Provides two methods for changing a user's password. An Authentication provider MBean can optionally implement this MBean. See UserPasswordEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserReaderMBean	Provides a set of methods for reading data about users. An Authentication provider MBean can optionally implement this MBean. See UserReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserRemoverMBean	Provides a method for removing users. An Authentication provider MBean can optionally implement this MBean. See UserRemoverMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
RoleEditorMBean	Provides a set of methods for creating, editing, and removing roles. A Role Mapping provider MBean can optionally implement this MBean. See RoleEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
RoleListerMBean	Provides a set of methods for listing data about roles. A Role Mapping provider MBean can optionally implement this MBean. See RoleListerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
RoleReaderMBean	Provides a set of methods for reading roles. A Role Mapping provider MBean can optionally implement this MBean. See RoleReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
PolicyEditorMBean	Provides a set of methods for creating, editing, and removing policies. An Authorization provider MBean can optionally implement this MBean. See PolicyEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-3 (Cont.) MBean Mixin Interfaces for Security Providers

This MBean...	Configures...
PolicyListerMBean	Provides a set of methods for listing data about policies. An Authorization provider MBean can optionally implement this MBean. See PolicyListerMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
PolicyReaderMBean	Provides a set of methods for reading policies. An Authorization provider MBean can optionally implement this MBean. See PolicyReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
PKICredentialMapEditorMBean	Provides a set of methods for creating, editing, and removing a credential map that matches users, resources and credential action to keystore aliases and the corresponding passwords. A PKICredentialMapping provider MBean can optionally implement this MBean. See PKICredentialMapEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
PKICredentialMapReaderMBean	Provides a set of methods for reading a credential map that matches users and resources to keystore aliases and their corresponding passwords that can then be used to retrieve key information or public certificate information from the configured keystores. A PKICredentialMapping provider MBean can optionally implement this MBean. See PKICredentialMapReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserPasswordCredentialMapEditorMBean	Provides a set of methods for creating, editing, and removing a credential map that matches WebLogic users to remote user names and their corresponding passwords. A Credential Mapping provider MBean can optionally extend this MBean. See UserPasswordCredentialMapEditorMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserPasswordCredentialMapExtendedReaderMBean	Provides a set of methods for reading credentials and credential mappings. Credential mappings match WebLogic users to remote usernames and passwords. A Credential Mapping provider MBean can optionally extend this MBean. See UserPasswordCredentialMapExtendedReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
UserPasswordCredentialMapReaderMBean	Provides a set of methods for reading credentials and credential mappings. Credential mappings match WebLogic users to remote usernames and passwords. A Credential Mapping provider MBean can optionally extend this MBean. See UserPasswordCredentialMapReaderMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
ImportMBean	Provides a set of methods for importing provider specific data. An optional mixin interface that any security provider may extend. See ImportMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .
ExportMBean	Provides a set of methods for exporting provider specific data. An optional mixin interface that any security provider may extend. See ExportMBean in the <i>MBean Reference for Oracle WebLogic Server</i> .

Table 6-3 (Cont.) MBean Mixin Interfaces for Security Providers

This MBean...	Configures...
ListerMBean	Provides a general mechanism for returning lists. Derived MBeans extend this interface to add methods that access the data of the current object in the list. An optional mixin interface that any security provider may extend. See ListerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>
NameListerMBean	Defines a method used to return lists of names. An optional mixin interface that any security provider may extend. See NameListerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>
LDAPServerMBean	Provides methods to get configuration parameters needed for connecting to an external LDAP server. An optional mixin interface that any security provider may extend. See LDAPServerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>
ApplicationVersionerMBean	The SSPI MBean that security providers extend to indicate that the provider supports versionable applications. An optional mixin interface that a RoleMapper, Authorizer, or CredentialMapper provider MBean may extend. See ApplicationVersionerMBean in the <i>MBean Reference for Oracle WebLogic Server</i>

Figure 6-1 Security MBeans

Choosing an MBean Server to Manage Security Realms

When using JMX to manage security realms, you must use two different MBean servers depending on your task:

- To set the value of a security MBean attribute, you must use the Edit MBean Server.
- To add users, groups, roles, and policies, or to invoke other operations in a security provider MBean, you must use a Runtime MBean Server or the Domain Runtime MBean Server.

In addition, to prevent the possibility of incompatible changes, you cannot invoke operations in security provider MBeans if your client or another JMX client has an edit session currently active.

For example, the value of the `MinimumPasswordLength` attribute in `DefaultAuthenticatorMBean` is stored in the domain's configuration document. Because all modifications to this document are controlled by WebLogic Server, to change the value of this attribute you must use the Edit MBean Server and acquire a lock on the domain's configuration. The `createUser` operation in `DefaultAuthenticatorMBean` adds data to an LDAP server, which is not controlled by WebLogic Server. To prevent incompatible changes between the `DefaultAuthenticatorMBean`'s configuration and the data that it uses in the LDAP server, you cannot invoke the `createUser` operation if you or other users are in the process of modifying the `MinimumPasswordLength` attribute. In addition, because changing this attribute requires you to restart WebLogic Server, you cannot invoke the `createUser` operation until you have restarted the server.

Working with Existing Security Providers

Because security providers can extend optional mix-in interfaces, not all security providers can perform all tasks. This flexibility enables your organization's security architect to design a realm for your security needs. The flexibility also makes the design of your JMX clients dependent upon the design and configuration of each realm.

For example, some realms might contain three types of Authentication providers:

- One that extends `UserEditorMBean` to save administrative users to an LDAP server
- One that extends `UserEditorMBean` to save customers to a database management system
- One that does not extend `UserEditorMBean` and is used only to authenticate existing users

To work with the Authentication providers in this realm, your JMX client must be able to determine which one can add users to the appropriate repository.

[Table 6-4](#) discusses techniques for finding a security provider that is appropriate for your task.

Table 6-4 Finding a Provider in the Realm

Technique	Description
Find by name	Each security provider instance is assigned a short name when an administrator configures it for the realm. Your JMX client can look up all providers of a specific type (such as all Authentication providers) and choose the one that matches a name. If you use this technique, consider saving the name of the security provider in a configuration file instead of hard-coding it in your JMX client. The configuration file enables system administrators to change the providers in the realm and update the properties file instead of requiring you to update and recompile the JMX client.

Table 6-4 (Cont.) Finding a Provider in the Realm

Technique	Description
Find by MBean type	If the system administrator always wants to use the same type of provider for a task, then your JMX client can find the provider MBean that is of the specified type. For example, if the system administrator always wants to use a <code>SQLAuthenticatorMBean</code> to add customers to a realm, your JMX client can find an instance of <code>SQLAuthenticatorMBean</code>. While this technique requires no user input, it assumes: • There will always be an instance of <code>SQLAuthenticatorMBean</code> in the realm and this one instance extends <code>UserEditorMBean</code>. • If there are multiple instances of <code>SQLAuthenticatorMBean</code>, all of them extend <code>UserEditorMBean</code> and it does not matter which instance is used. See Discovering Available Services.
Use any provider that extends the mix-in interface you need	You can create a JMX client that learns about the class hierarchy for each provider MBean instance and chooses an instance that extends the mix-in interface you need for your task. For example, your client can discover which Authentication provider extends <code>UserEditorMBean</code>. See Discovering Available Services. Use this technique if you know that your security realm will contain only one MBean that extends the needed mix-in interface, or if it does not matter which one you use.

Discovering Available Services

To create a JMX client that finds MBeans by type or mix-in interface:

1. Connect to a WebLogic Server Runtime MBean Server.

See [Make Remote Connections to an MBean Server](#).

All WebLogic Server instances maintain their own Runtime MBean Server, and you can connect to any server's Runtime MBean Server.

2. Get all security provider MBeans of a specific type in the realm (for example, get all Authentication provider MBeans):

- a. Use either the `RuntimeServiceMBean` or `DomainRuntimeServiceMBean` to navigate the following path through the WebLogic Server MBean hierarchy:

DomainMBean to SecurityConfigurationMBean to RealmMBean

See [Make Remote Connections to an MBean Server](#).

- b. Get the value of the `RealmMBean` attribute that contains instances of the security provider type.

For example, to get all authentication providers, get the value of the `RealmMBean` `AuthenticationProviders` attribute.

3. For each security provider MBean in the `RealmMBean` attribute, get the name of the MBean's class.

See [Example 6-1](#).

- a. Get the provider MBean's `javax.management.ModelMBeanInfo` object.

Use `MBeanServerConnection.getMBeanInfo(Provider-MBean)`

where *Provider-MBean* is a provider MBean that you retrieved from *RealmMBean*.

- b. Get the MBean info's `javax.management.Descriptor` object, and then get the value of the Descriptor's `interfaceClassName` field.
4. Use the WebLogic Server MBean type service to find all security provider MBean classes that extend a particular base type or mix-in interface.

See [Example 6-1](#).

- a. Determine the fully-qualified interface name of the base type or mix-in interface.

Each entry in the *MBean Reference for Oracle WebLogic Server* lists the fully-qualified interface name of WebLogic Server provider MBeans. If you use a third-party provider, refer to the third-party documentation for this information.

For example, the fully-qualified interface name of the *UserEditorMBean* mix-in interface is `weblogic.management.security.authentication.UserEditorMBean`. (See [UserEditorMBean](#) in *MBean Reference for Oracle WebLogic Server*.)

- b. Construct the MBeanTypeService MBean's object name.

The MBeanTypeService MBean is always registered under the following `javax.management.ObjectName`:

```
com.bea:Name=MBeanTypeService,Type=weblogic.management.mbeanservers.MBeanTypeService
```

- c. Invoke the MBeanTypeService MBean's `getSubtypes(java.lang.String beanInterface)` operation, where *beanInterface* represents the fully-qualified interface name that you determined in Step 1.

The operation returns an array of `java.lang.String` objects.

5. Compare the output of the MBean type service with the class name of each provider MBean instance.

See [Example 6-1](#).

6. If the provider MBean's class implements or extends the interface from step 4a, invoke operations on the provider MBean.

Example 6-1 Example: Determine If a Provider MBean Instance Extends UserEditorMBean Mix-In Interface

```
ObjectName MBTservice = new ObjectName(
    "com.bea:Name=MBeanTypeService,Type=weblogic.management.mbeanservers.
    MBeanTypeService");

for (int p = 0; atnProviders != null && p < atnProviders.length; p++) {
    ModelMBeanInfo info = (ModelMBeanInfo)
        mBeanServerConnection.getMBeanInfo(atnProviders[p]);
    Descriptor desc = info.getMBeanDescriptor();
    String className = (String)desc.getFieldValue("interfaceClassName");
    String[] mba = (String[]) mBeanServerConnection.invoke( MBTservice,
        "getSubtypes", new Object[] {
            "weblogic.management.security.authentication.UserEditorMBean ",
            new String[] { "java.lang.String" } });
    boolean isEditor = false;
    for (int i = 0; i < mba.length; i++) {
        if (mba[i].equals(className)){
            userEditor = atnProviders[p];
            isEditor = true;
            break;
        }
    }
    if (isEditor = true) break;
```

```
    }
}
```

Example: Adding Users to a Realm

The code example in [Example 6-2](#) adds a user to a security realm and adds the user to the Administrators group by searching through all of the authentication providers in the realm and using the first one that extends UserEditorMBean.

Note the following about the code example:

- The user name and password come from a JavaBean that was created from an Apache Struts action.
- The code does not need to lock the domain's configuration because it is not modifying the configuration of the security MBean itself. Instead, it is invoking an operation in the default Authorization provider which saves security data in an LDAP server.

Example 6-2 Example: Adding Users to a Realm

```
public ActionForward createNewAdmin(ActionMapping mapping,
    ActionForm form,
    HttpServletRequest request,
    HttpServletResponse response)
    throws ClientException, Exception {
    logger.info("Create New Admin");
    CreateAdminBean user = (CreateAdminBean) form;
    logger.debug(user.toString());

    MBeanServerConnection mBeanServerConnection =
        this.getDomainMBeanServerConnection(request);
    ObjectName service = new
        ObjectName("com.bea:Name=DomainRuntimeService,"+
            "Type=weblogic.management.mbeanservers.domainruntime.
            DomainRuntimeServiceMBean");
    ObjectName domainMBean =
        (ObjectName) mBeanServerConnection.getAttribute(service,
            "DomainConfiguration");
    ObjectName securityConfiguration =
        (ObjectName) mBeanServerConnection.getAttribute(domainMBean,
            "SecurityConfiguration");
    ObjectName defaultRealm =
        (ObjectName) mBeanServerConnection.
            getAttribute(securityConfiguration, "DefaultRealm");
    ObjectName[] atnProviders =
        (ObjectName[]) mBeanServerConnection.getAttribute(defaultRealm,
            "AuthenticationProviders");

    ObjectName userEditor = null;
    ObjectName MBTservice = new ObjectName(
        "com.bea:Name=MBeanTypeService,Type=weblogic.management.mbeanservers.
        MBeanTypeService");

    for (int p = 0; atnProviders != null && p < atnProviders.length; p++) {
        ModelMBeanInfo info = (ModelMBeanInfo)
            mBeanServerConnection.getMBeanInfo(atnProviders[p]);
        Descriptor desc = info.getMBeanDescriptor();
        String className = (String)desc.getFieldValue("interfaceClassName");
        String[] mba = (String[]) mBeanServerConnection.invoke( MBTservice,
            "getSubtypes", new Object[] {
                "weblogic.management.security.authentication.UserEditorMBean" },
            new String[] { "java.lang.String" });
    }
```

```

        boolean isEditor = false;
        for (int i = 0; i < mba.length; i++) {
            if (mba[i].equals(className)){
                userEditor = atnProviders[p];
                isEditor = true;
                break;
            }
            if (isEditor = true) break;
        }
    }
}

try {
    mBeanServerConnection.invoke(
        userEditor, "createUser",
        new Object[] {user.getUsername(), user.getPassword(),
            "MedRec Admininistator"},
        new String[] {"java.lang.String", "java.lang.String",
            "java.lang.String"}
    );
} catch (MBeanException ex) {
    Exception e = ex.getTargetException();
    if (e instanceof AlreadyExistsException) {
        logger.info("User, " + user.getUsername() + ", already exists.");
        ActionErrors errors = new ActionErrors();
        errors.add("invalidUserName",
            new ActionError("invalid.username.already.exists"));
        saveErrors(request, errors);
        return mapping.findForward("create.new.admin");
    } else {
        logger.debug(e);
        return mapping.findForward("create.new.admin");
    }
}

try {
    mBeanServerConnection.invoke(
        userEditor, "addMemberToGroup",
        new Object[] {"Administrators", user.getUsername()},
        new String [] {"java.lang.String", "java.lang.String"}
    );

    mBeanServerConnection.invoke(
        userEditor, "addMemberToGroup",
        new Object[] {"MedRecAdmins", user.getUsername()},
        new String [] {"java.lang.String", "java.lang.String"}
    );
} catch (MBeanException ex) {
    Exception e = ex.getTargetException();
    if (e instanceof NameNotFoundException) {
        logger.info("Invalid Group Name.");
        ex.printStackTrace();
        return mapping.findForward("create.new.admin");
    } else {
        logger.debug(e);
        return mapping.findForward("create.new.admin");
    }
}
}
logger.info("MedRec Administrator successfully created.");
return mapping.findForward("create.new.admin.successful");
}

```

Modifying the Realm Configuration

While security provider MBeans handle specific aspects of security, such as authentication and authorization, two other MBeans handle general, realm-wide and domain-wide aspects of security:

- `RealmMBean` represents a security realm. JMX clients can use it to add or remove security providers and to specify such behaviors as whether Web and EJB containers call the security framework on every access or only when security is set in the deployment descriptors.
- `SecurityConfigurationMBean` specifies domain-wide security settings such as connection filters and URL-pattern matching behavior for security constraints, servlets, filters, and virtual-hosts in the WebApp container and external security policies.

These two MBeans persist their data in WebLogic Server configuration files. Therefore, to modify attribute values in `RealmMBean` or `SecurityConfigurationMBean`, you must use the Edit MBean Server and `ConfigurationManagerMBean` as described in [Managing a Domain's Configuration with JMX](#).

Using Notifications and Monitor MBeans

This chapter describes how to use JMX to monitor MBeans. JMX provides two ways to monitor MBeans: MBeans can emit notifications when specific events occur (such as a change in an attribute value), or a special type of MBean called a monitor MBean can poll another MBean and periodically emit notifications to describe an attribute value. You create Java classes called **listeners** that listen for these notifications and respond appropriately. For example, your management utility can include a listener that receives notifications when applications are deployed, undeployed, or redeployed. All WebLogic Server configuration MBeans emit notifications when attribute values change, and some run-time MBeans do. This chapter includes the following sections:

Best Practices: Listening Directly Compared to Monitoring

If the MBean that you want to monitor emits notifications, you can choose whether to create a listener object that listens for changes in the MBean or a monitor MBean that periodically polls the MBean and emits notifications only when its attributes change in specific ways. The technique that you choose depends mostly on the complexity of the situations in which you want to receive notifications.

If your requirements are simple, registering a listener directly with an MBean is the preferred technique because the MBean pushes its notifications to your listener and you are notified of a change almost immediately. However, the base classes that you implement for a listener and optional filter (`javax.management.NotificationListener` and `NotificationFilter`) provide few facilities for comparing values with thresholds and other values. (See the `javax.management` package in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/package-summary.html>.)

If your notification requirements are sufficiently complex, or if you want to monitor a group of changes that are not directly associated with a single change in the value of an MBean attribute, use a monitor MBean. (See the `javax.management.monitor` package in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/monitor/package-summary.html>.) The monitor MBeans provide a rich set of tools for comparing data and sending notifications only under specific circumstances. However, the monitor periodically polls the observed MBean for changes in attribute value and you are notified of a change only as frequently as the polling interval that you specify.

Best Practices: Listening for WebLogic Server Events

The WebLogic Server JMX agent and WebLogic Server MBeans emit different types of notification objects for different types of events. Many event types trigger multiple MBeans to emit notifications at different points within the event process. [Table 7-1](#) describes common event types and recommends the MBean with which a JMX monitoring application should register to listen for notifications.

Note

Each JMX notification object contains an attribute named `Type`, which contains a dot-delimited string. Do not confuse discussions of this `Type` attribute with a notification's object type.

The `Type` attribute offers a way to categorize and filter notifications. For example, if your custom MBeans emit notifications, JMX conventions suggest that you set your notification object's `Type` attribute to a string that starts with your company name: `mycompany.myapp.valueIncreased`.

All JMX notification objects extend the `javax.management.Notification` object type. JMX and WebLogic Server define additional notification object types, such as `javax.management.AttributeChangeNotification`. The additional object types contain specialized sets of information that are appropriate for different types of events. (See the list of `Notification` subclasses for `javax.management.Notification` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/Notification.html>. Also see [weblogic.management.logging.WebLogicLogNotification](#) in the *Java API Reference for Oracle WebLogic Server*.)

Table 7-1 Events and Notification Objects

Event	Listening Recommendation
A WebLogic Server instance starts or stops	To receive a notification when a server starts or stops, register a listener with each server's <code>ServerLifecycleRuntimeMBean</code> in the Domain Runtime MBean Server and configure an <code>AttributeChangeNotificationFilter</code>. Each server in a domain provides its own <code>ServerLifecycleRuntimeMBean</code>, which is available through the Domain Runtime MBean Server even if the server itself is not active. When you start a server instance, the server's <code>ServerLifecycleRuntimeMBean</code> updates the value of its <code>State</code> attribute and emits an <code>AttributeChangeNotification</code>. For an example of such a listener and filter, see Listening for Notifications from WebLogic Server MBeans: Main Steps. Note: This recommendation assumes that you start a domain's Administration Server before starting Managed Servers. If a Managed Server starts before the Administration Server, a listener in the Domain Runtime MBean Server (which runs only on the Administration Server) will not be initialized at the time the Managed Server's <code>ServerLifecycleRuntimeMBean</code> changes its state to <code>RUNNING</code>. If you cannot guarantee that the Administration Server starts first, use the JMX timer service to periodically query the Domain Runtime MBean Server for MBeans whose object name contains the <code>Type=ServerRuntime</code> key property. An MBean that matches this query is a <code>ServerRuntimeMBean</code>, which each server instance creates as part of its startup process. If the query finds a newly created <code>ServerRuntimeMBean</code>, you know that a new server instance has been started. See <code>MBeanServerConnection.queryNames</code> (see https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/MBeanServerConnection.html#queryNames(javax.management.ObjectName,%20javax.management.QueryExp)). Prior to WebLogic Server 15.1.1.0.0, the Managed Server JMX notifications are enabled by default. Starting with WebLogic Server 15.1.1.0.0, the Managed Server JMX notifications are changed to be disabled by default. This helps to reduce JMX notifications which occur between the Administration Server and Managed Servers whenever any new servers are added, any states change, and so on. This saves CPU and memory resources if there are large numbers of runtime MBeans and large numbers of servers in the domain. To access the configuration or runtime MBeans from the Managed Servers and the Administration Server in a domain, Oracle recommends the user JMX applications to connect directly to the Runtime MBean Server on the Managed Servers and the Administration Server, and not to rely on the Domain Runtime MBean Server on the Administration Server. To enable the Managed Server JMX notifications, set a flag - <code>Dweblogic.management.disableManagedServerNotifications=false</code> during the Administration Server startup, and not during the Managed Server's startup.

Table 7-1 (Cont.) Events and Notification Objects

Event	Listening Recommendation
A WebLogic Server resource is created or destroyed	When you create a resource such as a server or a JDBC data source, WebLogic Server registers the resource's configuration MBean in the MBean server. When you delete a resource, WebLogic Server unregisters the configuration MBean. To listen for the registration and unregistration of MBeans, register a listener with <code>javax.management.MBeanServerDelegate</code>, which emits notifications of type <code>javax.management.MBeanServerNotification</code> when MBeans are registered or unregistered. If you register a listener with <code>MBeanServerDelegate</code> in the Edit MBean Server, you receive notifications when someone modifies the pending MBean hierarchy. If you register a listener in the Runtime MBean Server or the Domain Runtime MBean Server, you receive notifications only when pending changes have been successfully activated in the domain. If you are interested solely in monitoring configuration data (and are not interested in monitoring run-time statistics), register your listener in only one Runtime MBean Server. See Best Practices: Choosing an MBean Server. See Example: Listening for The Registration of Configuration MBeans.
The configuration of a WebLogic Server resource is modified	All configuration MBeans emit notifications of type <code>AttributeChangeNotification</code> when their attribute values change. To receive this notification, register a listener with the MBean that is in the Domain Runtime MBean Server or Runtime MBean Server (see Best Practices: Choosing an MBean Server). If you register an MBean in the Edit MBean Server, you receive notifications when someone modifies the pending MBean hierarchy. If you register a listener in the Runtime MBean Server or the Domain Runtime MBean Server, you receive notifications only when pending changes have been successfully activated in the domain. If you are interested solely in monitoring configuration data (and are not interested in monitoring run-time statistics), register your listener in only one Runtime MBean Server. See Best Practices: Choosing an MBean Server.
The run-time state of a WebLogic Server resource changes	Some run-time MBeans emit notifications of type <code>AttributeChangeNotification</code> when their attribute values change. To receive this notification, register a listener with the MBean in the Domain Runtime MBean Server. If a run-time MBean does not emit notifications, you can create a monitor MBean that polls the run-time MBean. See Using Monitor MBeans to Observe Changes: Main Steps.

Table 7-1 (Cont.) Events and Notification Objects

Event	Listening Recommendation
A WebLogic Server resource emits a log message	When a WebLogic Server resource generates a log message, the server's <code>weblogic.management.runtime.LogBroadcasterRuntimeMBean</code> emits a notification of type <code>weblogic.management.logging.WebLogicLogNotification</code>, which can be cast as the standard <code>javax.management.Notification</code> class. To listen for log message notifications, register a listener with <code>LogBroadcasterRuntimeMBean</code>. You can listen for the standard JMX notifications, or if you want to retrieve detailed information about the log messages, listen for <code>WebLogicLogNotifications</code>, which contains methods that you can use to retrieve detailed information. Listening for <code>WebLogicLogNotifications</code> requires you to import this WebLogic Server class into your listener class. To see a list of error messages that WebLogic Server resources generate, refer to <i>Error Messages</i>. See WebLogicLogNotification in the <i>Java API Reference for Oracle WebLogic Server</i>.

Best Practices: Listening or Monitoring WebLogic Server Runtime Statistics

WebLogic Server MBeans provide detailed statistics on the run-time state of its services and resources. The statistics in [Table 7-2](#) provide a general overview of the performance of WebLogic Server. You can listen for changes to these statistics by creating a listener and registering it directly with the MBeans that contain the attributes or you can configure monitor MBeans to periodically poll and report only the statistics that you consider to be significant (see [Registering a Notification Listener and Filter](#) and [Registering the Monitor and Listener](#)).

Table 7-2 Commonly Monitored WebLogic Server Runtime Statistics

To track this statistic...	Listen or monitor this MBean attribute...
The current state of server.	MBean Type: ServerLifecycleRuntimeMBean Attribute Name: State
Activity on the server's listen ports.	MBean Type: ServerRuntimeMBean Attribute Name: OpenSocketsCurrentCount MBean Type: ServerMBean Attribute Name: AcceptBacklog Use these two attributes together to compare the current activity on the server's listen ports to the total number of requests that can be backlogged on the ports.
Memory and thread use.	MBean Type: ThreadPoolRuntimeMBean Attribute Name: ExecuteThreadIdleCount Indicates the number of threads in a server's execute queue that are taking up memory space but are not being used to process data.

Table 7-2 (Cont.) Commonly Monitored WebLogic Server Runtime Statistics

To track this statistic...	Listen or monitor this MBean attribute...
Memory and thread use	MBean Type: ThreadPoolRuntimeMBean Attribute Name: PendingUserRequestCount Indicates the number of user requests waiting in a server's execute queue.
Memory and thread use	MBean Type: JVMRuntimeMBean Attribute Name: HeapSizeCurrent Indicates the amount of memory (in bytes) that is currently available in the server's JVM heap.
Database connections	MBean Type: JDBCDataSourceRuntimeMBean Attribute Name: ActiveConnectionsCurrentCount Indicates the current number of active connections in a JDBC connection pool.
Database connections	MBean Type: JDBCDataSourceRuntimeMBean Attribute Name: ActiveConnectionsHighCount The high water mark of active connections in a JDBC connection pool. The count starts at zero each time the connection pool is instantiated.
Database connections	MBean Type: JDBCDataSourceRuntimeMBean Attribute Name: LeakedConnectionCount Indicates the total number of leaked connections. Leaked connections are connections that have been checked out but never returned to the connection pool via a <code>close()</code> call; it is important to monitor the total number of leaked connections, as a leaked connection cannot be used to fulfill later connection requests.
Database connections	MBean Type: JDBCDataSourceRuntimeMBean Attribute Name: ConnectionDelayTime Indicates the average time to connect to a connection pool.
Database connections	MBean Type: JDBCDataSourceRuntimeMBean Attribute Name: FailuresToReconnectCount Indicates when the connection pool fails to reconnect to its data store. Applications may notify a listener when this attribute increments, or when the attribute reaches a threshold, depending on the level of acceptable downtime.

Listening for Notifications from WebLogic Server MBeans: Main Steps

To listen directly for the notifications that an MBean emits:

1. Create a listener class in your application. See [Creating a Notification Listener](#).
2. Create an additional class that registers your listener and an optional filter with the MBean whose notifications you want to receive. See [Configuring a Notification Filter](#) and [Registering a Notification Listener and Filter](#).
3. Package and deploy the listener and registration class. See [Packaging and Deploying Listeners on WebLogic Server](#).

Creating a Notification Listener

To create a notification listener:

1. Create a class that implements `javax.management.NotificationListener`.

See `NotificationListener` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/NotificationListener.html>.

2. Within the class, add a `NotificationListener.handleNotification(Notification notification, java.lang.Object handback)` method.

Note

Your implementation of this method should return as soon as possible to avoid blocking its notification broadcaster.

3. (Optional) In most listening situations, you want to know more than the simple fact that an MBean has emitted a notification object. For example, you might want to know the value of the notification object's `Type` attribute, which is used to classify the type of event that caused the notification to be emitted.

To retrieve information from a notification object, within your `handleNotification` method invoke the object's methods. Because all notification types extend `javax.management.Notification`, the following `Notification` methods are available for all notifications:

- `getMessage()`
- `getSequenceNumber()`
- `getTimeStamp()`
- `getType()`
- `getUserData()`

See `Notification` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/Notification.html>.

Most notification types provide additional methods for retrieving data that is specific to the notification. For example, `javax.management.AttributeChangeNotification` provides `getNewValue()` and `getOldValue()`, which you can use to determine how the attribute value has changed.

Example 7-1 Notification Listener

```
import javax.management.Notification;
import javax.management.NotificationFilter;
import javax.management.NotificationListener;
import javax.management.AttributeChangeNotification;

public class MyListener implements NotificationListener {

    public void handleNotification(Notification notification, Object obj) {

        if(notification instanceof AttributeChangeNotification) {
            AttributeChangeNotification attributeChange =
                (AttributeChangeNotification) notification;
```

```

        System.out.println("This notification is an
                           AttributeChangeNotification");
        System.out.println("Observed Attribute: " +
                           attributeChange.getAttributeName() );
        System.out.println("Old Value: " + attributeChange.getOldValue() );
        System.out.println("New Value: " + attributeChange.getNewValue() );
    }
}
}

```

[Example 7-1](#) is a simple listener that uses `AttributeChangeNotification` methods to retrieve the name of an attribute with a changed value, and the old and new values.

Listening from a Remote JVM

As of JMX 1.2, there are no special requirements for programming a listener that runs in a different JVM from the MBean to which it is listening.

Once you establish a connection to the remote JMX agent (using `javax.management.MBeanServerConnection`), JMX takes care of sharing data between the JVMs. See [Registering a Notification Listener and Filter](#), for instructions on establishing a connection from a remote JVM.

Best Practices: Creating a Notification Listener

Consider the following recommendations while creating your `NotificationListener` class:

- Unless you use a notification filter, your listener receives all notifications (of all notification types) from the MBeans with which it is registered.
Instead of using one listener for all possible notifications that an MBean emits, the best practice is to use a combination of filters and listeners. While having multiple listeners adds to the amount of time for initializing the JVM, the trade-off is ease of code maintenance.
- If your WebLogic Server environment contains multiple instances of MBean types that you want to monitor, you can create one notification listener and then create as many registration classes as MBean instances that you want to monitor.
For example, if your WebLogic Server domain contains three JDBC data sources, you can create one listener class that listens for `AttributeChangeNotifications`. Then, you create three registration classes. Each registration class registers the listener with a specific instance of `JDBCDataSourceRuntimeMBean`.
- While the `handleNotification` method signature includes an argument for a handback object, your listener does not need to retrieve data from or otherwise manipulate the handback object. It is an opaque object that helps the listener to associate information regarding the MBean emitter.
- Your implementation of the `handleNotification` method should return as soon as possible to avoid blocking its notification broadcaster.
- If you invoke a method from a specialized notification type, wrap the method calls in an `if` statement to prevent your listener from invoking the method on notification objects of all types.

Configuring a Notification Filter

The JDK includes two simple filter classes that you can configure to forward notifications that match criteria that you specify. To configure one of the JDK's filter classes:

1. In the class that registers your listener with an MBean create an instance of `javax.management.NotificationFilterSupport` or `AttributeChangeNotificationFilter`.
2. Invoke a filter class method to specify filter criteria.

See `NotificationFilterSupport` (<https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/NotificationFilterSupport.html>) or `AttributeChangeNotificationFilter` (<https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/AttributeChangeNotificationFilter.html>) in the *Java SE 17 API Specification*.

For example, the following lines of code configure an `AttributeChangeNotificationFilter` that forwards only attribute change notifications and only if there is a change in an attribute named `State`:

```
AttributeChangeNotificationFilter filter =  
    new AttributeChangeNotificationFilter();  
filter.enableAttribute("State");
```

Creating a Custom Filter

If the JDK's filter class is too simplistic for your needs, you can create more sophisticated, custom filter classes. (See `NotificationFilter` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/NotificationFilterSupport.html>.) However, Oracle recommends that you use the JDK filter classes whenever possible: using a custom filter complicates the packaging and deployment of your listener and filter. See [Packaging and Deploying Listeners on WebLogic Server](#).

Registering a Notification Listener and Filter

After you implement a notification listener class, you create an additional class that registers your listener (and optionally configures and registers a filter) with an MBean instance.

To register a notification listener and filter with an MBean:

1. Initialize a connection to a Runtime MBean Server or the Domain Runtime MBean Server.
See [Make Remote Connections to an MBean Server](#).
2. To register with a WebLogic Server MBean, navigate the MBean hierarchy and retrieve an object name for the MBean that you want to listen to. See [Make Remote Connections to an MBean Server](#).

To register with a custom MBean, create an `ObjectName` that contains the MBean's JMX object name. See `javax.management.ObjectName` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/ObjectName.html>.

3. Instantiate the listener class that you created.
4. (Optional) Instantiate and configure one of the JDK's filter classes or instantiate a custom class.
5. Register the listener and filter by passing the MBean's object name, listener class, and filter class to the `MBeanServerConnection.addNotificationListener` (`ObjectName name`, `ObjectName listener`, `NotificationFilter filter`, `Object handback`) method.

Example 7-2 Registering a Listener with ServerLifecycleRuntimeMBean

```

import java.util.Hashtable;
import java.io.IOException;
import java.net.MalformedURLException;

import javax.management.MBeanServerConnection;
import javax.management.ObjectName;
import javax.management.MalformedObjectNameException;
import javax.management.remote.JMXConnector;
import javax.management.remote.JMXConnectorFactory;
import javax.management.remote.JMXServiceURL;
import javax.naming.Context;

import javax.management.AttributeChangeNotificationFilter;

public class RegisterListener {
    private static MBeanServerConnection connection;
    private static JMXConnector connector;
    private static final ObjectName service;
    // Initializing the object name for DomainRuntimeServiceMBean
    // so it can be used throughout the class.
    static {
        try {
            service = new ObjectName(
                "com.bea:Name=DomainRuntimeService,Type=weblogic.management.mbeanserv
                ers.domainruntime.DomainRuntimeServiceMBean");
        } catch (MalformedObjectNameException e) {
            throw new AssertionError(e.getMessage());
        }
    }

    /*
     * Initialize connection to the Domain Runtime MBean Server
     * each server in the domain hosts its own instance.
     */
    public static void initConnection(String hostname, String portString,
        String username, String password) throws IOException,
        MalformedURLException {
        String protocol = "t3";
        Integer portInteger = Integer.valueOf(portString);
        int port = portInteger.intValue();
        String jndiroot = "/jndi/";
        String mserver = "weblogic.management.mbeanservers.domainruntime";
        JMXServiceURL serviceURL = new JMXServiceURL(protocol, hostname, port,
            jndiroot + mserver);
        Hashtable h = new Hashtable();
        h.put(Context.SECURITY_PRINCIPAL, username);
        h.put(Context.SECURITY_CREDENTIALS, password);
        h.put(JMXConnectorFactory.PROTOCOL_PROVIDER_PACKAGES,
            "weblogic.management.remote");
        connector = JMXConnectorFactory.connect(serviceURL, h);
        connection = connector.getMBeanServerConnection();
    }

    /*
     * Get an array of ServerLifecycleRuntimeMBeans
     */
    public static ObjectName[] getServerLCRuntimes() throws Exception {
        ObjectName domainRT = (ObjectName) connection.getAttribute(service,
            "DomainRuntime");
        return (ObjectName[]) connection.getAttribute(domainRT,

```

```

        "ServerLifecycleRuntimes");
    }

    public static void main(String[] args) throws Exception {
        String hostname = args[0];
        String portString = args[1];
        String username = args[2];
        String password = args[3];
        try {
            //Instantiating your listener class.
            MyListener listener = new MyListener();
            AttributeChangeNotificationFilter filter =
                new AttributeChangeNotificationFilter();
            filter.enableAttribute("State");

            initConnection(hostname, portString, username, password);
            //Passing the name of the MBeans and your listener class to the
            //addNotificationListener method of MBeanServer.
            ObjectName[] serverLCRT = getServerLCRuntimes();
            int length= (int) serverLCRT.length;
            for (int i=0; i < length; i++) {
                connection.addNotificationListener(serverLCRT[i], listener,
                    filter, null);
                System.out.println("\n[myListener]: Listener registered with"
                    +serverLCRT[i]);
            }

            //Keeping the remote client active.
            System.out.println("pausing.....");
            System.in.read();
        } catch (Exception e) {
            System.out.println("Exception: " + e);
        }
    }
}

```

The example class registers the listener from [Example 7-1](#) and the JDK's `AttributeChangeNotificationFilter` with all `ServerLifecycleRuntimeMBeans` in a domain. The class does not pass a handback object.

In the example, `weblogic` is a user who has permission to view and modify MBean attributes. For information about permissions to view and modify MBeans, refer to *User, Groups, and Security Roles in [Securing Resources Using Roles and Policies for Oracle WebLogic Server](#)*.

The example class also includes some code that keeps the `RegisterListener` class active and not exit the main program. Usually this code is not necessary because a listener class runs in the context of some larger application that is responsible for invoking the class and keeping it active. It is included here so you can easily compile and see the example working.

Packaging and Deploying Listeners on WebLogic Server

You can package and deploy a JMX listener as a remote application, a WebLogic Server startup class (which makes the listener available as soon as a server boots), or within one of your other applications that you deploy on WebLogic Server.

If you use a filter from the JDK, you do not need to package the filter class. It is always available through the JDK.

[Table 7-3](#) describes how to package and deploy your listeners and any custom filters.

Table 7-3 Packaging and Deploying Listeners and Custom Filters

If you deploy the listener...	Do this for the listener...	Do this for a custom filter...
As a remote application	Make the listener's class available on the remote client's classpath.	Make the filter's class available on the remote client's classpath. Also add the filter class to the classpath of each server instance that hosts the monitored MBeans by archiving the class in a JAR file and copying the JAR in each server's <code>lib</code> directory. See Domain Directory Contents in <i>Understanding Domain Configuration for Oracle WebLogic Server</i> .
As a WebLogic Server startup class	Add the listener class to the server's classpath by archiving the class in a JAR file and copying the JAR in the server's <code>lib</code> directory.	Add the filter class to the server's classpath by archiving the class in a JAR file and copying the JAR in the server's <code>lib</code> directory. See Domain Directory Contents in <i>Understanding Domain Configuration for Oracle WebLogic Server</i> .
As part of an application that you deploy on WebLogic Server	Package the listener class with the application.	Package the listener class with the application. Also add the filter class to the classpath of each server instance that hosts the monitored MBeans by doing one of the following: - Archiving the class in a JAR file and copying the JAR in each server's <code>lib</code> directory. See Domain Directory Contents in <i>Understanding Domain Configuration for Oracle WebLogic Server</i>. - Using the JMX MLet service to make the filter class available to the MBean server. See <code>javax.management.loading.MLet</code> in the <i>Java SE 17 API Specification</i> (https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/loading/MLet.html) and the JMX 1.4 specification, which you can download from https://docs.oracle.com/en/java/javase/17/jmx/index.html.

Example: Listening for The Registration of Configuration MBeans

When you create a WebLogic Server resource, such as a server or a JDBC data source, WebLogic Server creates a configuration MBean and registers it in the Domain Runtime MBean Server.

To listen for these events, register a listener with `javax.management.MBeanServerDelegate`, which emits a notification of type

`javax.management.MBeanServerNotification` each time an MBean is registered or unregistered. See `MBeanServerDelegate` in the *Java SE 17 API Specification* (<https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/MBeanServerDelegateMBean.html>)

Note the following about the example listener in [Example 7-3](#):

- To provide information about which type of WebLogic Server MBean has been registered, the listener looks at the object name of the registered MBean. All WebLogic Server MBean object names contain a key property whose name is "Type" and whose value indicates the

type of MBean. For example, instances of `ServerRuntimeMBean` contain the `Type=ServerRuntime` key property in their object names.

- All JMX notifications contain a `Type` attribute, whose value offers a way to categorize and filter notifications. The `Type` attribute in `MBeanServerNotification` contains only one of two possible strings: `"JMX.mbean.registered"` or `"JMX.mbean.unregistered"`. JMX notifications also contain a `getType` method that returns the value of the `Type` attribute.

The listener in [Example 7-3](#) invokes different lines of code depending on the value of the `Type` attribute.

- If a `JDBCDataSourceRuntimeMBean` has been registered, the listener passes the MBeans' object name to a custom method. The custom method registers a listener and configures a filter for the `JDBCDataSourceRuntimeMBean`; this MBean listener emits messages when the MBean's `Enabled` attribute changes.

The implementation of the custom method is located in the **registration** class (not the filter class) so that the method can reuse registration class's connection to the MBean server. Such reuse is an efficient use of resources and eliminates the need to store credentials and URLs in multiple classes.

Example 7-3 Example: Listening for MBeans Being Registered and Unregistered

```
import javax.management.Notification;
import javax.management.NotificationListener;
import javax.management.MBeanServerNotification;
import javax.management.ObjectName;

public class DelegateListener implements NotificationListener {
    public void handleNotification(Notification notification, Object obj) {
        if (notification instanceof MBeanServerNotification) {
            MBeanServerNotification msnotification =
                (MBeanServerNotification) notification;

            // Get the value of the MBeanServerNotification
            // Type attribute, which contains either
            // "JMX.mbean.registered" or "JMX.mbean.unregistered"
            String nType = msnotification.getType();

            // Get the object name of the MBean that was registered or
            // unregistered
            ObjectName mbn = msnotification.getMBeanName();

            // Object names for WebLogic Server MBeans always contain
            // a "Type" key property, which indicates the
            // MBean's type (such as ServerRuntime or Log)
            String key = mbn.getKeyProperty("Type");

            if (nType.equals("JMX.mbean.registered")) {
                System.out.println("A " + key + " has been created.");

                System.out.println("Full MBean name: " + mbn);
                System.out.println("Time: " + msnotification.getTimestamp());
                if (key.equals("JDBCDataSourceRuntime")) {
                    // Registers a listener with a ServerRuntimeMBean.
                    // By defining the "registerWithServerRuntime" method
                    // in the "ListenToDelegate" class, you can reuse the
                    // connection that "ListenToDelegate" established;
                    // in addition to being an efficient way to use resources,
                    // it eliminates the need to store credentials and URLs in
                    // multiple classes.
                    ListenToDelegate.registerWithJDBCDataSourceRuntime(mbn);
                }
            }
        }
    }
}
```

```

    }
    if (nType.equals("JMX.mbean.unregistered")) {
        System.out.println("An MBean has been unregistered");
        System.out.println("Server name: " +
            mbn.getKeyProperty("Name"));
        System.out.println("Time: " + msnotification.getTimeStamp());
        System.out.println("Full MBean name: "
            + msnotification.getMBeanName());
    }
}
}
}
}

```

[Example 7-4](#) shows methods from a registration class. Note the following:

- The JMX object name for MBeanServerDelegate is always "JMImplementation:type=MBeanServerDelegate".
- The main method configures an instance of `javax.management.NotificationFilterSupport` to forward notifications only if value of the notification's `Type` attribute starts with "JMX.mbean.registered" or "JMX.mbean.unregistered".
- The `registerWithJDBCDataSourceRuntime` method registers the listener in [Example 7-1](#) with the specified `JDBCDataSourceRuntimeMBean` instance. The method also configures a `javax.management.AttributeChangeNotificationFilter`, which forwards only `AttributeChangeNotifications` that describe changes to an attribute named `Enabled`.

To compile and run these methods, use the supporting custom methods from [Example 7-2](#) and run the resulting class as a remote JMX client.

Example 7-4 Example: Registering a Listener with MBeanServerDelegate

```

public static void main(String[] args) throws Exception {
    String hostname = args[0];
    String portString = args[1];
    String username = args[2];
    String password = args[3];
    ObjectName delegate = new ObjectName(
        "JMImplementation:type=MBeanServerDelegate");

    try {
        //Instantiating your listener class.
        StartStopListener slistener = new StartStopListener();
        NotificationFilterSupport filter = new NotificationFilterSupport();
        filter.enableType("JMX.mbean.registered");
        filter.enableType("JMX.mbean.unregistered");

        /* Invoke a custom method that establishes a connection to the
         * Domain Runtime MBean Server and uses an instance of
         * MBeanServerConnection to represents the connection. The custom
         * method assigns the MBeanServerConnection to a class-wide, static
         * variable named "connection".
         */
        initConnection(hostname, portString, username, password);

        //Passing the name of the MBeans and your listener class to the
        //addNotificationListener method of MBeanServer.
        connection.addNotificationListener(delegate, slistener, filter,
            null);

        System.out.println("\n[myListener]: Listener registered ...");
        //Keeping the remote client active.
    }
}

```

```

        System.out.println("pausing.....");
        System.in.read();
    } catch (Exception e) {
        System.out.println("Exception: " + e);
    }
}

// Called by the listener if it receives notification of a
// JDBCDataSourceRuntimeMBean being registered.
public static void registerWithJDBCDataSourceRuntime(ObjectName mbean) {
    try {
        MyListener mylistener = new MyListener();
        AttributeChangeNotificationFilter filter =
            new AttributeChangeNotificationFilter();
        filter.enableAttribute("Enabled");

        connection.addNotificationListener(mbean, mylistener,
            filter, null);
    } catch (Exception e) {
        System.out.println("Exception: " + e);
    }
}

```

Using Monitor MBeans to Observe Changes: Main Steps

To configure and use monitor MBeans:

1. Choose the type of monitor MBean type that supports your monitoring needs. See [Monitor MBean Types and Notification Types](#).
2. Create a listener class that can listen for notifications from monitor MBeans. See [Creating a Notification Listener for a Monitor MBean](#).
3. Create a class that creates, registers and configures a monitor MBean, registers your listener class with the monitor MBean, and then starts the monitor MBean. See [Registering the Monitor and Listener](#).

Monitor MBean Types and Notification Types

JMX provides monitor MBeans that are specialized to observe specific types of changes:

- StringMonitorMBean observes attributes whose value is a String.

Use this monitor to periodically observe attributes such as ServerLifecycleRuntimeMBean State.

See `javax.management.monitor.StringMonitor` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/monitor/StringMonitor.html>, which implements StringMonitorMBean.

- GaugeMonitorMBean observes attributes whose value is a Number.

Use this monitor to observe an attribute whose value fluctuates as a result of normal operations. Configure the gauge monitor to emit a notification if the value of the attribute fluctuates outside a specific range. For example, you can use it to monitor the `ThreadPoolRuntimeMBean` `StandbyThreadCount` attribute to verify that the number of unused but available threads in a server falls within an acceptable range.

See `javax.management.monitor.GaugeMonitor` in the *Java SE 17 API Specification* (see <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/monitor/GaugeMonitor.html>), which implements GaugeMonitorMBean.

- CounterMonitorMBean observes attributes whose value is a Number.

Use this monitor to observe an attribute whose value only increases as a result of normal operation. Configure the counter monitor to emit a notification if the value of the attribute crosses an upper threshold. You can also configure the counter monitor to increase the threshold and then reset the threshold at a specified point.

For example, to track the overall number of hits on a server and to be notified each time 100 additional hits have accumulated, use a counter monitor that observes the `ServerRuntimeMBean` `OpenSocketsCurrentCount` attribute.

See `javax.management.monitor.CounterMonitor` in the *Java SE 17 API Specification* (see <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax/management/monitor/CounterMonitor.html>), which implements `CounterMonitorMBean`.

All monitor MBeans emit notifications of type

`javax.management.monitor.MonitorNotification`. When a monitor MBean generates a notification, it describes the event that generated the notification by writing a specific value into the notification's `Type` property. Table 7-4 describes the value of the `Type` property that the different types of monitor MBeans encode. A filter or listener can use the notification's `getType()` method to retrieve the `String` in the `Type` property.

Table 7-4 Monitor MBeans and the MonitorNotification Type Property

A Monitor MBean of This Type	Encodes This String in the MonitorNotification's Type Property
CounterMonitor	<code>jmx.monitor.counter.threshold</code> when the value of the counter reaches or exceeds a threshold known as the comparison level.
GaugeMonitor	<code>jmx.monitor.gauge.high</code> if the observed attribute value is increasing and becomes equal to or greater than the high threshold value. Subsequent crossings of the high threshold value do not cause further notifications unless the attribute value becomes equal to or less than the low threshold value. <code>jmx.monitor.gauge.low</code> if the observed attribute value is decreasing and becomes equal to or less than the low threshold value. Subsequent crossings of the low threshold value do not cause further notifications unless the attribute value becomes equal to or greater than the high threshold value.
StringMonitor	<code>jmx.monitor.string.matches</code> if the observed attribute value matches the string to compare value. Subsequent matches of the string to compare values do not cause further notifications unless the attribute value differs from the string to compare value. <code>jmx.monitor.string.differs</code> if the attribute value differs from the string to compare value. Subsequent differences from the string to compare value do not cause further notifications unless the attribute value matches the string to compare value.

Errors and the MonitorNotification Type Property

If an error occurs, all monitors encode one of the following values in the notification's `Type` property:

- `jmx.monitor.error.mbean`, which indicates that the observed MBean is not registered in the MBean Server. The observed object name is provided in the notification.

- `jmx.monitor.error.attribute`, which indicates that the observed attribute does not exist in the observed object. The observed object name and observed attribute name are provided in the notification.
- `jmx.monitor.error.type`, which indicates that the object instance of the observed attribute value is null or not of the appropriate type for the given monitor. The observed object name and observed attribute name are provided in the notification.
- `jmx.monitor.error.runtime`, which contains exceptions that are thrown while trying to get the value of the observed attribute (for reasons other than the cases described above).

The counter and the gauge monitors can also encode `jmx.monitor.error.threshold` into the `Type` property under the following circumstances:

- For a counter monitor, when the threshold, the offset, or the modulus is not of the same type as the observed counter attribute.
- For a gauge monitor, when the low threshold or high threshold is not of the same type as the observed gauge attribute.

Creating a Notification Listener for a Monitor MBean

When an observed attributes meets the criteria that you specify, a monitor MBean emits a notification. There are no special requirements for creating a listener for a `MonitorNotification`. The steps are the same as those described in [Creating a Notification Listener](#), except:

- You listen for notifications of type `MonitorNotification`.
- Optionally, you can import the `javax.management.monitor.MonitorNotification` class and invoke its methods to retrieve additional information about the event that generated the notification.

See [Example 7-5](#).

Example 7-5 Listener for Monitor Notifications

```
import javax.management.Notification;
import javax.management.NotificationListener;
import javax.management.monitor.MonitorNotification;
public class MonitorListener implements NotificationListener {
    public void handleNotification(Notification notification, Object obj) {
        if(notification instanceof Notification) {
            Notification notif = (Notification) notification;
            System.out.println("Notification type" + notif.getType() );
            System.out.println("Message: " + notif.getMessage() );
        }
        if (notification instanceof MonitorNotification) {
            MonitorNotification mn = (MonitorNotification) notification;
            System.out.println("Observed Attribute: " +
                mn.getObservedAttribute());
            System.out.println("Trigger: " + mn.getTrigger() );
        }
    }
}
```

Registering the Monitor and Listener

Recall that to use a monitor MBean, you first must create and register an instance of the monitor MBean in the MBean server. Then you register a listener with the monitor MBean that you created. You can do all of this in a single class.

To register a monitor MBean, register your listener, and start the monitor MBean:

1. Initialize a connection to the Domain Runtime MBean Server.

See [Make Remote Connections to an MBean Server](#).

2. Create an `ObjectName` for your monitor MBean instance.

See `javax.management.ObjectName` in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/ObjectName.html>.

Oracle recommends that your object name starts with the name of your organization and includes key properties that clearly identifies the purpose of the monitor MBean instance.

For example, `mycompany:Name=SocketMonitor,Type=CounterMonitor`

3. Create and register one of the monitor MBeans.

Use `javax.management.MBeanServerConnection.createMBean(String classname, ObjectName name)` method, where:

- `classname` represents one of the following values:
 - `javax.management.monitor.CounterMonitor`
 - `javax.management.monitor.GaugeMonitor`
 - `javax.management.monitor.StringMonitor`
- `name` represents the object name that you created for the monitor MBean instance.

4. Configure the monitor MBean by setting the value of its attributes.

For guidelines on which attributes to set, see the `javax.management.monitoring` package in the *Java SE 17 API Specification* at <https://docs.oracle.com/en/java/javase/17/docs/api/java.management/javax.management/monitor/package-summary.html>.

5. To specify the MBean that your monitor MBean monitors (the observed MBean), invoke the monitor MBean's `addObservedObject(ObjectName objectname)` and `addObservedAttribute(String attributename)` operations where.

- `objectname` is the `ObjectName` of the observed MBean
- `attributename` is the name of the attribute in the observed MBean that you want to monitor

A single instance of a monitor MBean can monitor multiple MBeans. Invoke the `addObservedObject` and `addObservedAttribute` operation for each MBean instance that you want to monitor.

6. Instantiate the listener object that you created in [Creating a Notification Listener for a Monitor MBean](#).

7. Optionally instantiate and configure a filter.

8. Register the listener and optional filter with the **monitor MBean**. Do not register the listener with the observed MBean.

Invoke the monitor MBean's `addNotificationListener(NotificationListener listener, NotificationFilter filter, Object handback)` method.

9. Start the monitor by invoking the monitor MBean's `start()` operation.

Example: Registering a CounterMonitorMBean and Its Listener

[Example 7-6](#) shows the `main()` method of a class that creates and configures a `CounterMonitorMBean` to observe the `OpenSocketsCurrentCount` attribute in each `ServerRuntimeMBean` instance in a domain. (See [OpenSocketsCurrentCount](#) in *MBean Reference for Oracle WebLogic Server*.)

The code example connects to the Domain Runtime MBean Server so that it can monitor multiple instances of `ServerRuntimeMBean`. Note the following:

- Only one instance of `CounterMonitorMBean` monitors all instances of `ServerRuntimeMBean`. The Domain Runtime MBean Server gives the `CounterMonitorMBean` federated access to instances of `ServerRuntimeMBean` that are running in a different JVM.
- Only one instance of your listener class and the filter class listens and filters notifications from the `CounterMonitorMBean`.

To compile and run this main method, use the supporting custom methods from [Example 7-2](#) and run the resulting class as a remote JMX client.

Example 7-6 Example: Registering a CounterMonitorMBean and Its Listener

```
public static void main(String[] args) throws Exception {
    String hostname = args[0];
    String portString = args[1];
    String username = args[2];
    String password = args[3];

    try {
        /* Invokes a custom method that establishes a connection to the
         * Domain Runtime MBean Server and uses an instance of
         * MBeanServerConnection to represents the connection. The custom
         * method assigns the MBeanServerConnection to a class-wide, static
         * variable named "connection".
         */
        initConnection(hostname, portString, username, password);
        //Creates and registers the monitor MBean.
        ObjectName monitorON =
            new ObjectName("mycompany:Name=mySocketMonitor,Type=CounterMonitor");
        String classname = "javax.management.monitor.CounterMonitor";
        System.out.println("===> create mbean "+monitorON);
        connection.createMBean(classname, monitorON);

        //Configure the monitor MBean.
        Number initThreshold = new Long(2);
        Number offset = new Long(1);
        connection.setAttribute(monitorON,
            new Attribute("InitThreshold", initThreshold));
        connection.setAttribute(monitorON, new Attribute("Offset", offset));
        connection.setAttribute(monitorON,
            new Attribute("Notify", new Boolean(true)));

        //Gets the object names of the MBeans that you want to monitor.
        ObjectName[] serverRT = getServerRuntimes();
        int length= (int) serverRT.length;
        for (int i=0; i < length; i++) {
            //Sets each instance of ServerRuntime MBean as a monitored MBean.
            System.out.println("===> add observed mbean "+serverRT[i]);
            connection.invoke(monitorON, "addObservedObject",
                new Object[] { serverRT[i] },
                new String[] { "javax.management.ObjectName" });
        }
    }
}
```

```
        Attribute attr = new Attribute("ObservedAttribute",
                                      "OpenSocketsCurrentCount");
        connection.setAttribute(monitorON, attr);
    }

    // Instantiates your listener class and configures a filter to
    // forward only counter monitor messages.
    MonitorListener listener = new MonitorListener();
    NotificationFilterSupport filter = new NotificationFilterSupport();
    filter.enableType("jmx.monitor.counter");
    filter.enableType("jmx.monitor.error");

    //Uses the MBean server's addNotificationListener method to
    //register the listener and filter with the monitor MBean.
    System.out.println("==> ADD NOTIFICATION LISTENER TO "+monitorON);
    connection.addNotificationListener(monitorON, listener, filter, null);
    System.out.println("\n[myListener]: Listener registered ...");

    //Starts the monitor.
    connection.invoke(monitorON, "start", new Object[] { }, new String[] { });

    //Keeps the remote client active.
    System.out.println("pausing.....");
    System.in.read();
} catch (Exception e) {
    System.out.println("Exception: " + e);
    e.printStackTrace();
}
}
```

8

Configuring WebLogic Server JMX Services

This chapter describes how to establish and configure the specific set of JMX services that are to be available within a WebLogic Server domain. For example, in a production environment you can disable the WebLogic Server editing service and therefore prevent most run-time changes to the domain.

This chapter includes the following sections:

Determining the JMX Services Available in a Domain

Within a WebLogic domain, you can specify which JMX services are available.

The following attributes of `JMXMBean` determine which JMX services are available in a domain (see [JMXMBean](#) in *MBean Reference for Oracle WebLogic Server*):

- `EditMBeanServerEnabled` controls whether JMX clients, including utilities such as the WebLogic Remote Console and the WebLogic Scripting Tool, can modify a domain's configuration.
- `DomainMBeanServerEnabled` controls whether JMX clients can access all run-time MBeans and read-only configuration MBeans through a single connection to the Domain Runtime MBean Server.
- `RuntimeMBeanServerEnabled` controls whether JMX clients can access a specific server's run-time MBeans and read-only configuration MBeans through the server's Runtime MBean Server.
- `PlatformMBeanServerEnabled` controls whether all WebLogic Server instances initialize the JDK platform MBean server. `PlatformMBeanServerUsed` controls whether all WebLogic server instances start their Runtime MBean Servers as the JDK platform MBean server. This makes it possible to access WebLogic Server MBeans and the JVM platform MBeans from a single MBean server.
- `CompatibilityMBeanServerEnabled` enables JMX clients to use the deprecated `weblogic.management.MBeanHome` interface to access WebLogic Server MBeans.
- `ManagementEJBEnabled` controls whether the current WebLogic Server domain supports the Jakarta Management APIs.

Example: Using WebLogic Scripting Tool to Make a Domain Read-Only

The following example uses the WebLogic Scripting Tool (WLST) to set the `JMXMBean` `EditMBeanServerEnabled` attribute to `false`. It assumes that you are running WLST on a Windows computer, that you created a domain under `c:\mydomain`, and that you have not deleted the scripts that WebLogic Server creates along with your domain.

Note

The following steps prevent JMX clients (including the WebLogic Remote Console and the WebLogic Scripting Tool in online mode) from modifying the domain's configuration. You can still modify the domain configuration through the offline editing feature of WebLogic Scripting Tool.

These steps do not prevent JMX clients from deploying or undeploying modules because the WebLogic Server deployment service does not use JMX.

1. Start the domain's Administration Server.
2. In a command prompt, set up the required environment by running the following script:

```
c:\mydomain\bin\setDomainEnv.cmd
```
3. In the command prompt, enter the following commands:
 - a. `%ORACLE_HOME%\oracle_common\bin\wlst.sh`
 - b. `connect('weblogic','weblogic')`
 - c. `edit()`
 - d. `startEdit()`
 - e. `cd('JMX/mydomain')`
 - f. `set('EditMBeanServerEnabled','false')`
 - g. `activate()`
 - h. `exit()`