



UnboundID[®] Metrics Engine Administration Guide

Version 4.5.1

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Published: 2014-01-28

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Preface

This guide presents the procedures and reference material necessary to install, administer and troubleshoot the UnboundID Metrics Engine in multi-client, high-load production environments.

Purpose of This Guide

The purpose of this guide is to provide valuable procedures and concepts that can be used to manage the UnboundID® Metrics Engine in a multi-client environment. It also provides information to monitor and set up the necessary logs needed to troubleshoot the server's performance.

Audience

The guide is intended for administrators responsible for installing, maintaining, and monitoring servers in large-scale, high load production environments. It is assumed that the reader has the following background knowledge:

- Identity Platforms and LDAPv3 concepts
- System administration principles and practices
- Understanding of Java VM optimization and garbage collection processes
- Application performance monitoring tools

Related Documentation

The following list shows the full documentation set that may help you manage your deployment:

- *UnboundID® Identity Data Store Administration Guide*
- *UnboundID® Identity Data Store Reference Guide (HTML)*
- *UnboundID® Identity Proxy Administration Guide*
- *UnboundID® Identity Proxy Reference Guide (HTML)*
- *UnboundID® Identity Data Sync Administration Guide*
- *UnboundID® Identity Data Sync Reference Guide (HTML)*
- *UnboundID® Metrics Engine Administration Guide*
- *UnboundID® Identity Broker Administration Guide*
- *UnboundID Security Guide*
- *UnboundID® LDAP SDK*
- *UnboundID® Server SDK*

Document Conventions

The following table shows the document convention used in this guide.

Convention	Usage
Monospace	Commands, filenames, directories, and file paths
Monospace Bold	User interface elements, menu items and buttons
<i>Italic</i>	Identifies file names, doc titles, terms, variable names, and emphasized text

Chapter

1

Overview of the Metrics Engine

The UnboundID® Metrics Engine provides collection and storage of performance data from your UnboundID server topology. This chapter introduces the concepts and applications associated with the UnboundID Metrics Engine.

Topics:

- [Overview of the Metrics Engine](#)
- [About Data Collection](#)

Overview of the Metrics Engine

In any large-scale user identity infrastructure, there are expectation and service levels to meet for uptime, scalability transaction response time and throughput. The UnboundID Metrics Engine gives you insight into how your identity infrastructure is performing. It collects data from the internal instrumentation of the UnboundID Identity Data Store, UnboundID Identity Proxy, UnboundID Identity Data Sync, and UnboundID Identity Broker across the instances, replicas, and data centers in your environment.

Using the instantaneous and historical data available from the Metrics Engine, you can now:

- Measure and visualize the performance of the identity infrastructure as a whole service, not just as a collection of individual servers. This data provides the ability to justify and measure the achievement of service-level agreements.
- Identify those client applications and request types that are responsible for the largest resource loads, so that improvement efforts can be applied where they have the greatest impact.
- Determine which servers have the most available capacity, so that requests or request types can be reallocated accordingly.
- Discover a server instance that is under-performing due to resource limitations or misconfiguration.
- Predict the capacity of your infrastructure to accommodate growth in request traffic and identity data.
- Produce detailed analysis of all measurement taken around any abnormal performance event to quickly identify the root cause.

The following diagram illustrates the components of the Metrics Engine and how they interact.

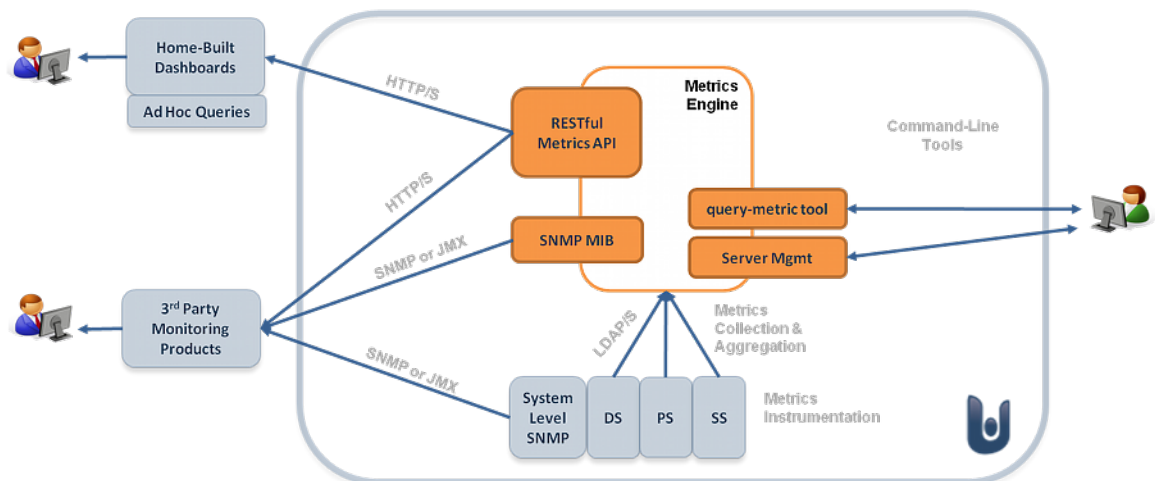


Figure 1: Key Components of the Metrics Engine

The diagram contains the following key components:

- **Metrics Engine.** The Metrics Engine itself is a stand-alone server, just like the other products of the UnboundID Identity Platform. It includes versions of the same configuration, management, and logging tools as the other components of the suite. The Metrics Engine relies on a captive PostgreSQL data store for the collected metrics.
- **Metrics API.** A RESTful API, accessible over HTTPS, gives easy access to the collected metrics and to information about the systems they represent. The API supports parameters for complete control over the data being returned, including filtering, minimum/maximum, average, server types, multiple data series (pivots), historical time periods, units, and histogram data.
- **query-metric tool.** This tool is the primary command-line tool for access to the metric data. In the interactive mode, use the tool to investigate the performance of the service. The query metrics tool also has a parameter-driven command-line mode for automating the extraction of data from the Metrics Engine, ideal for use with shell scripts. It includes an `explore` option that allows you to generate queries that drive the Metrics API, such as adding a specific chart or tabular result to a custom dashboard. It can also generate HTML page output.
- **SNMP access.** Similar to the other UnboundID servers, the Metrics Engine makes its own system-level metrics available over SNMP.
- **Data set.** The Metrics Engine proprietary data set structure is space-optimized and designed for easy interoperability with charting libraries like Highcharts, FusionCharts, or JFreeChart.
- **Charts, Chart Builder and Dashboard Templates.** The Metrics Engine now provides the means to easily produce a user-defined, web-based page of metric charts.

Our customers use a variety of commercial application performance monitoring tools. The Metrics Engine supports integration with third-party products through any of these data access mechanisms:

- Metrics REST API, accessed over HTTP
- SNMP
- Scripted use of `query-metric` tool
- Entries in `cn=monitor` available over LDAP

About Data Collection

The Metrics Engine provides collection and storage of performance data for a set of UnboundID Identity Data Store, UnboundID Identity Proxy, UnboundID Identity Data Sync, and UnboundID Identity Broker servers. The current value of some of this data is accessible via LDAP at `cn=monitor` on the monitored servers. Each monitored server collects and locally stores a limited history of performance data through the use of the Stats Collector plug-in. This history is organized into time-contiguous blocks available via LDAP at `cn=metrics`.

To collect the performance data, the Metrics Engine continuously polls all monitored product servers, fetching any new data and keeping it in a PostgreSQL DBMS. This polling incurs a small load on the product servers, so you should understand the value of collecting the data to make an informed cost/benefit decision. For an in-depth discussion of the data collected by the Metrics Engine and the metrics available, see “Data Collection and Metrics”.

The following figure illustrates the data collection pipeline.

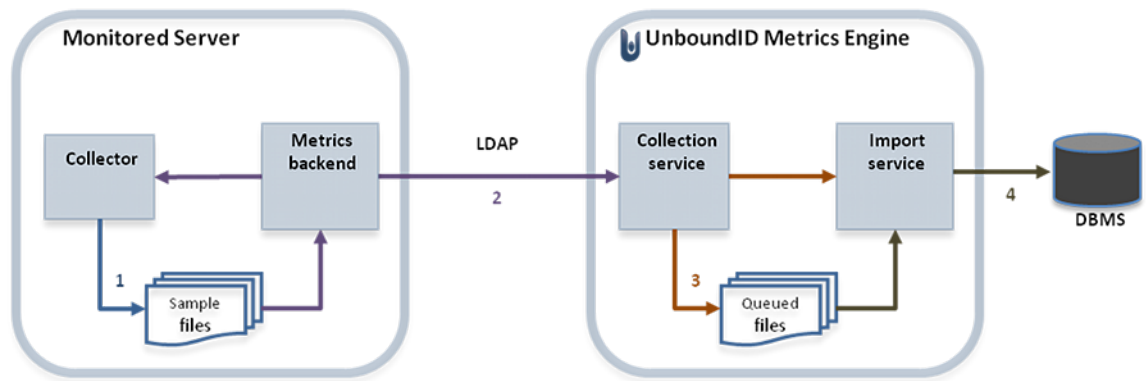


Figure 2: Data Collection Pipeline

Data collection flows in the diagram as follows. The expected delay between steps one and four is about 60 seconds.

1. Samples are taken and stored in time-contiguous blocks on the disk by the monitored server.
2. The Collection Service polls for new sample blocks.
3. New sample blocks are queued to disk on the Metrics Engine.
4. The Import Service loads new blocks into the DBMS.

Chapter

2

Installing the Server

This section describes how to install and configure the Metrics Engine.

Topics:

- [*Before You Begin*](#)
- [*Installation Process Overview*](#)
- [*Configuring the External Servers*](#)
- [*Notes on the PostgreSQL Database Setup*](#)
- [*Installing the Metrics Engine*](#)
- [*Configuring the Metrics Engine*](#)
- [*Running the Metrics Engine*](#)
- [*Installing the Management Console*](#)
- [*Backing Up the Metrics Engine DBMS*](#)
- [*Uninstalling the Metrics Engine*](#)

Before You Begin

This section describes prerequisites for installing the Metrics Engine, including hardware and software requirements.

Supported Operating Platforms

Multi-Platform Support. The UnboundID Metrics Engine is a pure Java application. It is intended to run within the Java Virtual Machine on any Java 6 or 7 Standard Edition (SE) or Enterprise Edition (EE) certified platform. For the list of supported platforms and Java versions, access your Customer Support Center portal or contact your authorized support provider.

The Metrics Engine runs both a Java Application Server and a PostgreSQL[®] RDBMS. Any additional RAM that can be used by PostgreSQL will improve the performance of the `query-metric` tool or the Metrics Engine RESTful API by allowing PostgreSQL to cache data in memory, reducing disk input and output.

Your topology should meet the following hardware requirements:

Table 1: Hardware Requirements

Topology Type	Metrics Engine RAM	DBMS RAM	Disk	CPU	Notes
Small (1 to 6 monitored servers)	8 GB	4 GB	30 GB	4 cores	
Medium (7 to 16 monitored servers)	20 GB	8 GB	60 GB	6 cores	A hardware RAID caching controller with a non-volatile write cache is desirable. Multiple disk spindles is helpful for DBMS data.
Large (17 to 50 monitored servers)	32 GB	16 GB	180 GB	8 cores	A hardware RAID caching controller with a non-volatile write cache is required. Multiple disk spindles is necessary for DBMS data.

The filesystem buffer cache can use any additional system RAM not allocated to the Metrics Engine JVM or PostgreSQL DBMS to cache recently read disk pages. Running other processes on this system will have a detrimental effect on query performance.

The large RAM requirements of the Metrics Engine can be significantly reduced if the DBMS data is kept on SSD-based storage. SSD storage provides sufficient I/O bandwidth that the RAM uses to cache query results and DBMS pages can be reduced without significant performance loss. The Metrics Engine DBMS write data rates are significant and should be a deployment consideration due to the limited number of writes available to SSD devices.

The Metrics Engine installer provides an embedded PostgreSQL server that is installed by default. This server is only available for a limited set of platforms. If you need to run the Metrics Engine on an unsupported platform, you will need to install and configure an external PostgreSQL server and use special arguments in the Metrics Engine installer. We strongly recommend that you use a platform supported by the installer.

Table 2: Support Platforms for the Metrics Engine Installer

Platform	Type	CPU
Linux	x86	64 bit
Solaris 10	x86	64 bit
Solaris 11	x86	64 bit
Solaris 10	sparc	64 bit
Solaris 11	sparc	64 bit
Windows ¹	x86	64 bit
OSX ²	x86	64 bit

Software Requirements

Before you install the Metrics Engine, you need the following:

- Java 6 or Java 7. For more about this requirement, see “Java Software Requirements.”

Installing Java

For optimized performance, the UnboundID Metrics Engine requires Java for 64-bit architectures. You can view the minimum required Java version on your Customer Support Center portal or contact your authorized support provider for the latest software versions supported.

Even if your system already has Java installed, you may want to create a separate Java installation for use by the UnboundID Metrics Engine to ensure that updates to the system-wide Java installation do not inadvertently impact the Metrics Engine. This setup requires that the JDK, rather than the JRE, for the 64-bit version, be downloaded.

On Solaris systems, if you want to use the 64-bit version of Java, you need to install both the 32-bit and 64-bit versions. The 64-bit version of Java on Solaris is not a full stand-alone installation, but instead relies on a number of files provided by the 32-bit installation. Therefore, the 32-bit version should be installed first, and then the 64-bit version installed in the same location with the necessary additional files.

On other platforms (for example, Linux and Microsoft Windows), the 64-bit version of Java contains a complete installation. If you only want to run the 64-bit version of Java, then it is not necessary to install the 32-bit JDK. If you want to have both versions installed, then they should be installed in separate directories, because the files cannot co-exist in the same directory as they can on Solaris systems.

To Install Java (Oracle/Sun)

1. Open a browser and navigate to the following Oracle download site:

<http://www.oracle.com/technetwork/java/javase/downloads/index.html>

¹ Available in the installer but not supported in production.

² Available in the installer but not supported in production.

2. Download the latest version Java JDK. Click the JDK Download button corresponding to the latest Java update.
3. On the Java JDK page, click the Accept Licence Agreement button, then download the version based on your operating system.

To Install Java (IBM)

1. Open a browser and navigate to the following IBM download site:

<http://www.ibm.com/developerworks/java/jdk/>

2. Select the Java version for your operating system. Currently, the minimum supported version for the UnboundID Metrics Engine is IBM Java6 SR-12.

About the PostgreSQL DBMS

The Metrics Engine uses a PostgreSQL DBMS to store the sample data. A traditional table-based DBMS serves the needs of the Metric Engine better than the attribute-based DBMS used by the UnboundID Identity Data Store because the sample data is tabular and the RDBMS system aggregates data efficiently.

To determine the storage requirements of the DBMS, you need to understand the expected data access patterns. The Metrics Engine interacts with the DBMS in four ways:

- Sample import
- Sample aggregation
- Sample age-out
- Sample query

Sample import places a very predictable and steady write load on the DBMS. This single-threaded interaction puts a table-level lock on the target table. Sample imports account for 80% of the writes to the DBMS, so performance benefits from a server-class RAID disk controller with a non-volatile write cache. A Metrics Engine that monitors 20 servers keeps a single 10K RPM disk 70% busy with this single interaction.

Sample aggregation places a very predictable but less frequent read/write load on the DBMS. This interaction is responsible for the aggregation of samples from one time resolution to the next, so it reads from one set of tables and writes to another set. Sample aggregation uses no table-level locks and the ratio of records between read:write is between 60:1 and 24:1. This DBMS interaction is negligible when sample imports are taking place.

Sample age-out occurs at regular intervals and results in a table being dropped and/or added. Age-out occurs every 30 minutes, though some intervals may drop and/or add more than one table.

Sample queries are the least predictable, because they result from clients hitting the public API requesting metric samples. The API allows you to aggregate multiple dimensions and multiple servers in a single request, so a single request may fetch several million rows from the DBMS, though it only returns a few hundred data points to the client. Samples from previous queries are

cached by the Metrics Engine, but initial queries for a given metric may be as slow as several seconds and result in a large amount of disk read activity.

Over time, the storage of samples in the data tables is optimized to match the access patterns of the sample queries. However, the public API supports queries where the results are the aggregate of thousands of different dimension sets, and each dimension set may have thousands of samples within the time range of the query. For example, a query about the throughput of all directory and proxy servers for all applications and all LDAP operations over the last 72 hours might result in 4 to 6 million DBMS records being read into memory, aggregated, and finally reduced to 100 data values. Predicting what samples a future query may want is impossible, and the results from previous queries are cached such that a subsequent request for the same data results in very little DBMS activity. Both disk seek time and rotational delay impact the performance of a first-time query, so disks with faster RPM speeds provide a measurable improvement for first-time queries.

The use of SSD storage for the DBMS files changes the system I/O performance, reducing the need to cache data or DBMS disk blocks in memory to maintain good performance. A Metrics Engine monitoring 20 servers and storing the DBMS files on SSD needs 4GB of RAM for the JVM and 2GB of RAM for Postgres, so a system with 12GB of RAM total provides acceptable performance.

Preparing the Operating System (Solaris)

The UnboundID Metrics Engine has been extensively tested on multiple operating systems. We have found that several operating system optimizations lead to improved performance. These optimizations include using the ZFS filesystem on Solaris systems, restricting ZFS memory consumption, limiting transaction group writes, using compression and disabling access time updates.

Using ZFS

UnboundID strongly recommends the use of ZFS[™] as the underlying filesystem on Solaris 10 and OpenSolaris systems. ZFS is a 128-bit filesystem that can store billions of times more data than traditional 64-bit systems. Based on a storage pool model, ZFS aggregates devices (mirrors, RAID-Z with single or double parity, concatenated or striped storage) into a virtual data source from which filesystems can be constructed. ZFS provides excellent performance, end-to-end data integrity, simple administration management, and unmatched scalability. It also provides many useful features, such as automatic checksum, dynamic striping, variable block sizes, compression, and unlimited constant-time snapshots. ZFS is part of the Solaris 10 and OpenSolaris operating systems.

All of the Metrics Engine's components should be located on a single storage pool (zpool), rather than having separate pools configured for different server components (for example, one pool for the database and a second for log files). Single zpool configurations are the simplest and easiest to manage. From there, you can create multiple filesystems inside the pool and optionally reserve space for one or more of the filesystems.

ZFS's copy-on-write transactional model does not require isolating I/O-intensive components. Therefore, all available disks should be placed in the same zpool, so that as many underlying

spindles as possible can be used to provide the configuration with the greatest number of I/O operations per second.

To Restrict ZFS Memory Consumption

Despite its excellent performance, ZFS does not release memory fast enough for some LDAP operations that might need it. This delay could cause some processes to fail to start while attempting to allocate a large amount of memory for a JVM heap.

To curb memory allocation problems, make sure that the system is configured to limit the amount of memory for caching (for example, up to two gigabytes). The Metrics Engine relies on database caching rather than filesystem caching for its performance. Thus, the underlying system should be configured, so that the memory used by ZFS will not interfere with the memory used by the Metrics Engine. In most environments, we recommend that systems be configured to allow ZFS to use no more than 2 GB of memory for caching.

1. Open the `/etc/system` file.
2. ZFS caches data from all active storage pools in the ARC cache. We can limit its memory consumption by setting the maximum size of the ARC caches using the `zfs_arc_max` property. For example, add the following line to the end of the `/etc/system` file.

```
set zfs:zfs_arc_max= 0x80000000
```

This property sets the maximum size of the ARC cache to 2 GB (0x80000000 or 2147483648 bytes) for ZFS. Note that your system may require a different value.

3. If your system processes large write operations, see the section on Limiting ZFS Transaction Group Writes. Otherwise, reboot the machine for the change to take effect. Also note that this operation requires Solaris 10 update 4 (08/07) and Nevada (build 51) release or later.

To Limit ZFS Transaction Group Writes

UnboundID has found that the Metrics Engine can exhibit uneven throughput performance during continuous write loads for Oracle Berkeley DB Java Edition backends on ZFS systems. We have found that the ZFS Write Throttle feature stalls write operations when transaction groups are flushed to disk. During these periods, operation throughput can drop significantly with these large I/O bursts.

To smooth out write throughput and improve latency, we recommend setting the `zfs_write_limit_override` property in the `etc/system` file to the size of the available disk cache on the system.

1. Open the `/etc/system` file.
2. Add the following line to the end of the file. Set the value to the size of your onboard cache. For example, for a system that has a 32MB cache per disk, set the following parameter:

```
set zfs:zfs_write_limit_override=0x2000000
```

3. For the change to take effect, reboot the machine. Also note that this operation requires Solaris 10 update 4 (08/08) or later.

ZFS Access to Underlying Disks

Storage requirements vary depending on whether ZFS has access to the underlying disks. If possible, ZFS should be given direct access to the underlying disks that will be used to back the storage. Direct access to the underlying disks makes it possible to configure the system with the greatest degree of reliability and flexibility.

To configure the system, ZFS should be given direct access to the underlying disks that will be used to back the storage. In this configuration, the zpool used for the Metrics Engine should have a RAID 1+0 configuration (a stripe across one or more 2-disk mirrors). Although this setup reduces the amount of available space when compared with other configurations, like RAID-Z (ZFS data-parity scheme with full dynamic stripe width) or RAID-Z2 (ZFS dual parity RAID-Z), RAID 1+0 provides dramatically better performance and reliability.

If ZFS cannot get direct access to the underlying disks (for example, the system only has access to a logical unit number, LUN, on a storage area network, SAN), then the provided storage should already include some level of redundancy. Again, the RAID 1+0 configuration is recommended over other schemes like, RAID 5 or RAID 6. If the storage includes redundancy, then the zpool should be created with only that LUN and should not add any additional redundancy. In such a configuration, ZFS is not able to take advantage of its advanced self-healing capabilities when it detects any corruption at the filesystem level. However, ZFS check-summing can still detect those types of problems.

Configuring ZFS Compression

The ZFS filesystem should have compression enabled to improve performance as it reduces the amount of data that needs to be written or read from the underlying disks. In most cases, the reduced costs of the disk I/O outweighs the CPU cost of compressing and decompressing the data.

The following procedure assumes that the ZFS filesystem is named `ds`. The changes take effect immediately with no need to reboot or perform any other action.

Caution:



Knowing the actual size of files is useful when you need to back up files to a non-ZFS filesystem or estimate the amount of memory dedicated to caching. On traditional UNIX filesystems, the `du` command reports the sum of all the specified file sizes. However, on ZFS, `du` reports the amount of disk space consumed, which might not equal the sum of the file sizes if features like compression or multiple copies are enabled. Administrators should be aware of this difference when determining the database size using `du`.

Instead of using `du`, UnboundID Metrics Engine provides a utility, `bin/sum-file-sizes`, that determines the size (in bytes, kilobytes, megabytes, or gigabytes) of the sum of a set of files even if ZFS compression or multiple copies are enabled.

To Configure ZFS Compression

- Turn on ZFS compression by running the `zfs` command.

```
# zfs set compression=on ds
```

Preparing the Operating System (Linux)

The UnboundID Metrics Engine has been extensively tested on multiple operating systems. We have found that several operating system optimizations lead to improved performance. These optimizations include increasing the file descriptor limit on Linux systems, setting filesystem flushes, editing OS-level environment variables, downloading some useful monitoring tools for Redhat Linux systems, and configuring for Huge Page support.

To Set the File Descriptor Limit (Linux)

The Metrics Engine allows for an unlimited number of connections by default but is restricted by the file descriptor limit on the operating system. Many Linux distributions have a default file descriptor limit of 1024 per process, which may be too low for the server if it needs to handle a large number of concurrent connections.

1. Display the current hard limit of your system. The hard limit is the maximum server limit that can be set without tuning the kernel parameters in the `proc` filesystem.

```
ulimit -aH
```

2. Edit the `/etc/sysctl.conf` file. If there is a line that sets the value of the `fs.file-max` property, make sure its value is set to at least 65535. If there is no line that sets a value for this property, add the following to the end of the file:

```
fs.file-max = 65535
```

3. Edit the `/etc/security/limits.conf` file. If the file has lines that sets the soft and hard limits for the number of file descriptors, make sure the values are set to 65535. If the lines are not present, add the following lines to the end of the file (before “#End of file”). Also note that you should insert a tab, rather than spaces, between the columns.

```
* soft nofile 65535
* hard nofile 65535
```

4. Reboot your system, and then use the `ulimit` command to verify that the file descriptor limit is set to 65535.

```
# ulimit -n
```

To Set the Filesystem Flushes

With the out-of-the-box settings on Linux systems running the `ext3` filesystem, the data is only flushed to disk every five seconds. If the Metrics Engine is running on a Linux system using the `ext3` filesystem, consider editing the mount options for that filesystem to include the following:


```
commit=1
```

This variable changes the flush frequency from five seconds to one second.

You should also set the flush frequency to the `/etc/fstab` file. Doing the change via the `mount` command alone will not survive across reboots.

About Editing OS-Level Environment Variables

Certain environment variables can impact the Metrics Engine in unexpected ways. This is particularly true for environment variables that are used by the underlying operating system to control how it uses non-default libraries.

For this reason, the Metrics Engine explicitly overrides the values of key environment variables like `PATH`, `LD_LIBRARY_PATH`, and `LD_PRELOAD` to ensure that something set in the environments that are used to start the server does not inadvertently impact its behavior.

If there is a legitimate need to edit any of these environment variables, the values of those variables should be set by manually editing the `set_environment_vars` function of the `lib/_script-util.sh` script. You will need to stop (`stop-metrics-engine`) and re-start (`start-metrics-engine`) the server for the change to take effect.

Install `sysstat` and `pstack` (Red Hat)

For Red Hat® Linux systems, you should install a couple of packages, `sysstat` and `pstack`, that are disabled by default, but are useful for troubleshooting purposes in the event that a problem occurs. The troubleshooting tool `collect-support-data` uses the `iostat`, `mpstat`, and `pstack` utilities to collect monitoring, performance statistics, and stack trace information on the server's processes.

Install `dstat` (SUSE Linux)

The `dstat` utility is used by the `collect-support-data` tool and can be obtained from the OpenSUSE project website. The following example shows how to install the `dstat` utility on SuSE Enterprise Linux 11 SP2:

1. Login as Root.
2. Add the appropriate repository using the `zypper` tool.

```
$ zypper addrepo http://download.opensuse.org/repositories/server:/monitoring/  
SLE_11_SP2 Monitoring
```

3. Install the `dstat` utility.

```
$ zypper install dstat
```

To Disable Filesystem Swapping

For all deployments, we recommend disabling disk swapping on the filesystem to protect the Metrics Engine JVM process from an overly aggressive filesystem cache.

- Run the following command:

```
% sysctl -w vm.swappiness=0
```

To Set noatime on ext3 and ext 4 Systems

If you are using an `ext3` or `ext4` filesystem, it is recommended that you set `noatime`, which turns off any *atime* updates during read accesses to improve performance. You should also set the flush frequency to the `/etc/fstab` file. Doing the change via the `mount` command alone will not survive across reboots.

- Run the following command on an `ext3` system.

```
# mount -t ext3 -o noatime /dev/fs1
```

- Run the following command on an `ext4` system.

```
# mount -t ext4 -o noatime /dev/fs1
```

Configuring Huge Page Support (Linux)

We recommend configuring Huge Page support to provide a performance gain for your system of about 5–10 percent. Typically, on Linux systems, memory is managed in page sizes of 4096 bytes per page. RedHat Enterprise Linux Server introduced the concept of *huge pages*, where memory is managed in page sizes of 2M or 1 GB per page. Huge Page support is especially useful for virtualized environments using VMWare. If you are configuring a VMWare-based system, you will need to calculate the memory configurations for your particular system. Follow the recommended VMWare Tuning Guidelines presented on their web site.

As a general guideline, on RedHat Enterprise Linux Server 5.x versions, you should ensure that the size of the huge page is set slightly higher than the maximum size of your JVM settings. For example, for a total system memory of 96 GB, you could set the JVM memory to 80GB, then configure your system to provide ~85GB of Huge Page support.

RedHat Enterprise Linux Server 6.0 or later introduces *Transparent Huge Pages*, which is an abstraction layer that simplifies the management of huge pages. By default, Transparent Huge Page support is enabled on RedHat Enterprise Linux Server 6.0 or later and CentOS 6.0 or later.

To Configure Huge Page Support on Releases Prior to Redhat Enterprise Linux Server 6.0

1. Log in as root. For this example, we assume you are using at least Redhat Enterprise Linux Server 5.5.
2. Verify that your kernel supports huge pages. If the contents of `/proc/meminfo` contains "HugePage_Total," "HugePages_Free" or "HugePagesize," then your kernel supports huge pages. Make note of the huge page size of your system, which is dependent on your system architecture.

```
$ cat /proc/meminfo | grep Huge
HugePages_Total: 0
HugePages_Free: 0
HugePages_Rsvd: 0
```

```
HugePagesize: 2048 kB
```

3. Set the maximum amount of memory on the server. For 64-bit JVMs that support huge pages, you need to set the kernel for shared memory to be slightly higher than the maximum size of your JVM. This memory is "pinned" or reserved for the application once the JVM is started. For this example, set the maximum shared memory to 85 GB. In the `/etc/sysctl.conf` file, you need to add a line as follows:

```
kernel.shmmax = <number of bytes>
```

For example, for 85 GB, add the line:

```
kernel.shmmax = 91268055040
```

4. Next, set a virtual memory kernel parameter to tell the OS how many huge pages you want to set aside. In the `/etc/sysctl.conf` file, you need to add the following line:

```
vm.nr_hugepages = <number of pages>
```

For example, we want to set the virtual memory to 85 GB (89128960 kB), which is 85 GB / 2 MB (obtained in step 2 as the size of each huge page). Thus, $89128960 \text{ kB} / 2048 \text{ kB} = 43520$, which is the number of huge pages we want to reserve. This setting only takes effect at boot time.

```
vm.nr_hugepages = 43520
```

To set it without reboot, run one of the following commands:

```
sysctl -w vm.nr_hugepages=43520
```

If you want the setting to be present after reboot, then you have to modify the `/etc/sysctl.conf` file.

5. Reboot the machine. Repeat step 2 to ensure that huge page memory is configured.

```
$ cat /proc/meminfo | grep Huge
HugePages_Total: 44564
HugePages_Free: 44564
HugePages_Rsvd: 0
HugePagesize: 2048 kB
```

6. Finally, go to the Metrics Engine root. Assuming you are using Sun JVM, set the `-XX:+UseLargePages` JVM option in the Metrics Engine's `config/java.properties` file for the `start-ds` tool and `import-ldif` tools. Note that each command should be on a single line. The command options are listed on separate lines for readability purposes.

```
# These JVM arguments can be used to run the Metrics Engine with an
# aggressive memory tuning:

start-ds.java-args=-d64 -server -Xmx80g -Xms80g -XX:+UseConcMarkSweepGC
-XX:+CMSConcurrentMTEnabled -XX:+CMSParallelRemarkEnabled
-XX:+CMSParallelSurvivorRemarkEnabled -XX:+CMSScavengeBeforeRemark
-XX:RefDiscoveryPolicy=1 -XX:ParallelCMSThreads=1
-XX:CMSMaxAbortablePrecleanTime=3600000 -XX:CMSInitiatingOccupancyFraction=80
-XX:+UseParNewGC -XX:+UseMembar -XX:+UseBiasedLocking -XX:+UseCompressedOops
-XX:PermSize=64M -XX:+HeapDumpOnOutOfMemoryError -XX:+UseLargePages

# These JVM arguments can be used to do an offline LDIF import with an aggressive
# memory tuning:
import-ldif.offline.java-args=-d64 -server -Xmx80g -Xms80g
-XX:+UseParallelGC -XX:+UseMembar -XX:NewRatio=8 -XX:+UseNUMA
-XX:+UseCompressedOops -XX:+UseNUMA -XX:+HeapDumpOnOutOfMemoryError
```

```
-XX:+UseLargePages
```

7. On the Metrics Engine, run the `dsjavaproperties` tool to save the JVM settings.

```
$ bin/dsjavaproperties
```

You have successfully set up Huge Page Support on your Linux system.

Running as a Non-Root User

The Metrics Engine installer cannot be run as the root user, and generally the Metrics Engine (and PostgreSQL) should not be run as root. The drawback to not running as root is the inability to use network port numbers below 1024. Some operating systems provide workarounds for this limitation, but the best practice is to install and run the Metrics Engine as a user, other than root, and select port numbers greater than 1024.

On systems running Solaris 10 and OpenSolaris, you can use the User and Process Rights Management subsystem with the Role-Based Access Control (RBAC) mechanisms to grant users or roles only the privileges necessary to accomplish a specific task. Using RBAC avoids the assignment of full super-user (root) privileges to the user. For example, you can grant the `net_privaddr` privilege to a non-root user, or role, that gives him or her the ability to listen on privileged ports (for example, on ports 1024 or below). Similarly, granting the `sys_resource` privilege allows a user to bypass restrictions on resource limits, such as the number of file descriptors a process might use.

The Solaris User and Process Rights Management system can also be used to remove capabilities from users. For example, removing the `proc_info` privilege from a user prevents the user from seeing processes owned by other users. Removing the `file_link_any` privilege can prevent users from creating hard links to files owned by other users. Hard links are not needed by the Metrics Engine and can represent a security risk under certain conditions. The following table summarizes the Solaris privileges that you may want to assign to non-root users.

Privilege	Description
<code>net_privaddr</code>	Provides the ability to listen on privileged network ports.
<code>sys_resource</code>	Provides the ability to bypass restrictions on resource limits (including the number of available file descriptors).
<code>proc_info</code>	Provides the ability for users to see processes owned by other users on the system. This privilege is available to all users by default, but it can pose a security risk in some cases. UnboundID recommends that it be removed from the role used by the Metrics Engine.
<code>file_link_any</code>	Provides the ability to create hard links to files owned by other users on the system. This privilege is available to all users by default, but it can pose a security risk in some cases. UnboundID recommends that it be removed from the role used by the Metrics Engine.

Running as a Non-Root User (Linux)

Linux systems do not provide a direct analog to the Solaris User and Process Rights Management subsystems. As a result, there is no easy way to allow a non-root user to listen on a privileged port.

To run as a non-root user but still allow connections on a privileged port, two options are available:

- **Use a Load-Balancer or Proxy Server.** In many environments, the server can be run on a non-privileged port but can be hidden by a hardware load-balancer or LDAP proxy server.
- **Use `netfilter`.** The `netfilter` mechanism, exposed through the `iptables` command, can be used to automatically redirect any requests from a privileged port to the unprivileged port on which the server is listening.

Creating a Solaris Role

To give multiple administrators access to the Metrics Engine, UnboundID Metrics Engine recommends that a Solaris role be created to run the server and that all necessary administrators be added to that role. The Solaris role provides an audit trail that can be used to identify which administrator performed a given action, while still allowing administrators to run the server, to view and edit files used by the server, and to execute commands as that same user. As with normal user accounts, roles can be assigned privileges. The role used for the Metrics Engine should include the `net_privaddr` and `sys_resource` privileges and should exclude the `proc_info` and `file_link_any` privileges for improved security (that is, to eliminate the need for root access).

To Create a Solaris Role for Multiple Administrators

To give multiple administrators access to the Metrics Engine, UnboundID Metrics Engine recommends that a Solaris role be created to run the server and that all necessary administrators be added to that role. The Solaris role provides an audit trail that can be used to identify which administrator performed a given action, while still allowing administrators to run the server, to view and edit files used by the server, and to execute commands as that same user. As with normal user accounts, roles can be assigned privileges. The role used for the Metrics Engine should include the `net_privaddr` and `sys_resource` privileges and should exclude the `proc_info` and `file_link_any` privileges for improved security (that is, to eliminate the need for root access).

1. Create a Solaris role. Assume the role is named `ds` with all of the appropriate privileges needed to run the Metrics Engine. Make sure to enter the whole command on a single line.

```
# roleadd -d /export/home/ds -m -s /usr/bin/bash \
-K defaultpriv=basic,net_privaddr,sys_resource,-proc_info,-file_link_any ds
```

2. Assign a password.

```
# passwd ds
```

3. For each administrator who is allowed to manage the Metrics Engine, assign the role with the `usermod` command. For example, to give someone with a user name of “john” the ability to assume the `ds` role, issue the following command:

```
# usermod -R ds john
```

If a user is already a member of one or more roles, then the entire list of existing roles, separated by commas, must also be provided or the user will be removed from those roles. For example, if the root account is also a role and the user “john” is also a member of that role, then the command would be:

```
# usermod -R root,ds john
```

4. Log in using a normal user account and then use the `bin/su` command to assume the role created for the Metrics Engine. You cannot log directly into a system as a role. Only users that have been explicitly assigned to a role will be allowed to assume it.

Installation Process Overview

The process for setting up and installing a Metrics Engine involves the following steps:

- Configuring the External Servers: UnboundID Identity Data Store, UnboundID Identity Proxy, and UnboundID Identity Data Sync servers.
- Installing the Metrics Engine using the `setup` tool.
- Configuring the Metrics Engine using the `monitored-servers` tool.

The remainder of this chapter describes each of these steps in detail.

Configuring the External Servers

Before you install the Metrics Engine, you need to configure the servers you will be monitoring: UnboundID Identity Data Store, UnboundID Identity Proxy, and UnboundID Identity Data Sync. The Metrics Engine requires all servers to be version 3.5.0 or later. See the administration guides for each product for installation instructions.

Once you have installed the Metrics Engine, you can use the `dsconfig` tool to make configuration changes for the Metrics Engine. When using the `dsconfig` tool interactively, set the complexity level to Advanced, so that you can make all the necessary configuration changes.

Preparing the Servers Monitored by the Metrics Engine

The Metrics Backend manages the storage of metrics and provides access to the stored blocks of metrics via LDAP. The Metrics Backend is configured to keep a maximum amount of metric history based on log retention policies. The default retention policy uses the Default Size Limit Retention Policy, Free Disk Space Retention Policy, and the File Growth Limit Policy, limiting the total disk space used to 500 MB. This amount of disk typically contains more than 24 hours of metric history, which is ample. The Metrics Engine keeps a metric history so that the Metrics Engine can be down for a period and then catch up when it comes back online.

The following two commands create a Retention Policy that limits the number of files to 2000, and sets the Metrics Backend to flush data to a new file every 30 seconds.

```
$ bin/dsconfig create-log-retention-policy \  
  --policy-name StatsCollectorRetentionPolicy \  
  --type file-count --set number-of-files:2000  
  
$ bin/dsconfig set-backend-prop \  
  --backend-name metrics --set sample-flush-interval:30s \  
  --set retention-policy:StatsCollectorRetentionPolicy
```

These commands configure the Metrics Backend to keep 16 hours of metric history, which consumes about 250 MB of disk, ensuring that captured metrics are available to the Metrics Engine within 30 seconds of when the metric was captured. The value of the `sample-flush-interval` attribute determines the maximum delay between when a metric is captured and when it can be picked up by the Metrics Engine.

The flush interval can be set between 15 seconds and 60 seconds, with longer values resulting in less processing load on the Metrics Engine. However, this flush interval increases the latency between when the metric was captured and when it becomes visible in the Dashboard Application. If you change the `sample-flush-interval` attribute to 60 seconds in the example above, then the Metrics Engine keeps 2000 minutes of history. Because the number of metrics produced per unit of time can vary depending on the configuration, no exact formula can be used to compute how much storage is required for each hour of history. However, 20 MB per hour is a good estimate.

Configuring the Processing Time Histogram Plugin

The Processing Time Histogram plugin is configured on each Metrics Engine and Identity Proxy as a set of histogram bucket ranges. When the bucket ranges for a histogram change, the Metrics Engine notices the change and marks samples differently. This process allows for histograms with the same set of bucket definitions to be properly aggregated and understood when returned in a query. If different servers have different bucket definitions, then a single metric query cannot return histogram data from the servers.

You should try to keep the Processing Time Histogram bucket definitions the same on all servers. Having different definitions restricts the ability of the Metrics Engine API to aggregate histogram data across servers and makes the results of a query asking "What percentage of the search requests took less than 12 milliseconds?" harder to understand.

For each server in your topology, you must set the `separate-monitor-entry-per-tracked-application` property of the processing time histogram plugin to `true`. This property must be set to expose per-application monitoring information under `cn=monitor`. When the `separate-monitor-entry-per-tracked-application` property is set to `true`, then the `per-application-ldap-stats` property must be set to `per-application-only` on the Stats Collector Plugin and vice versa.

For example, the following `dsconfig` command line sets the required properties of the Processing Time Histogram plugin:

```
$ bin/dsconfig set-plugin-prop --plugin-name "Processing Time Histogram" \
--set separate-monitor-entry-per-tracked-application:true
```

The following `dsconfig` command line sets the `per-application-ldap-stats` property of the Stats Collector plugin to `per-application-only`:

```
$ bin/dsconfig set-plugin-prop --plugin-name "Stats Collector" \
--set per-application-ldap-stats:per-application-only
```

Setting the Connection Criteria to Collect SLA Statistics by Application

If you want to collect data about your SLAs, you need to configure connection criteria for each Service Level Agreement that you want to track. The connection criteria are used in many areas within the server. They are used by the client connection policies, but they can also be used when the server needs to perform matching based on connection-level properties, such as filtered logging. For assistance using connection criteria, contact your authorized support provider.

For example, imagine that we are interested in collecting statistics on data that is accessed by clients authenticating as the Directory Manager. We need to create connection criteria on the Metrics Engine that identifies any user authenticating as the Directory Manager. The connection criteria name corresponds to the `application-name` dimension value that clients will specify when accessing the data via the API. When you define the Connection Criteria, change the `included-user-base-dn` property to include the Directory Manager's full LDIF entry.

The following `dsconfig` command line creates connection criteria for the Directory Manager:

```
$ bin/dsconfig create-connection-criteria \  
  --criteria-name "Directory Manager" \  
  --type simple \  
  --set "included-user-base-dn:cn=Directory Manager,cn=Root DNs,cn=config"
```

Updating the Global Configuration

You also need to create Global Configuration-tracked applications for each app (connection criteria) you intend to track. The `tracked-application` property allows individual applications to be identified in the server by connection criteria. The name of the tracked application is the same as the name you defined for the connection criteria.

For example, the following `dsconfig` command line adds the connection criteria we created in the previous step to the list of tracked applications:

```
$ bin/dsconfig set-global-configuration-prop \  
  --set "tracked-application:Directory Manager"
```

The value of the `tracked-application` field corresponds to the value of the `application-name` dimension value that clients will specify when accessing the data via the API.

Notes on the PostgreSQL Database Setup

The Metrics Engine uses an embedded PostgreSQL DBMS database to store and to aggregate server data. The PostgreSQL DBMS server is started and stopped automatically by the Metrics Engine.

About Setting Up the PostgreSQL DBMS Database

The PostgreSQL DBMS imposes its organizational structure on all users of the DBMS:

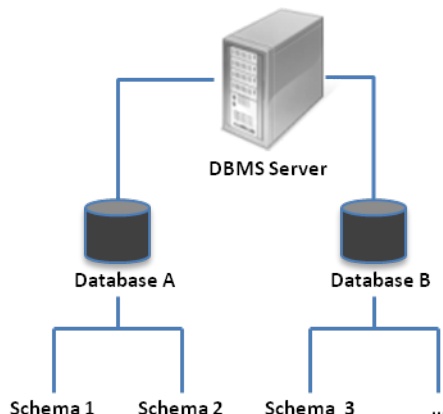


Figure 3: PostgreSQL DBMS Organizational Structure

A PostgreSQL DBMS server is a set of cooperating PostgreSQL processes listening on a single TCP port. The DBMS server is partitioned into one or more databases, and each database is partitioned into one or more schema. Tables are associated with exactly one schema, and indexes are associated with exactly one table. A user (or role, as they are referred to in PostgreSQL) is associated with a database and can be granted access to one or more schema within a database. When a user authenticates to the DBMS server, the resulting session is automatically assigned to a default schema, where each user can specify their own default schema.

The Metrics Engine treats the schema and the users as the same logical idea, creating a schema and a user/role with the same name and assigning the schema as the user's default schema. This is done for the sake of simplicity, not necessity. However, the Metrics Engine requires that the user connecting to the DBMS have the Metrics Engine Schema as the default schema.

The DBMS may be vulnerable to attacks from other processes on the same server. Since the DBMS is only listening on the loopback address, any attack must originate from the same host. If the Metrics Engine and PostgreSQL DBMS are the only processes on this host other than OS processes, then the security risk is greatly diminished. And even if an attacker gets access to the DBMS directly, the Metrics Engine DBMS only contains performance metrics about the operations of the monitored servers and basic configuration information; none of the data stored in the userRoot backend is present in the DBMS. An attacker could modify histogram sample data and alter performance history but could not affect directory data. Finally, even with LDAP hostname and port information for the monitored servers, an attacker would still need to overcome LDAP authentication, and no credential data is stored in the DBMS.

Tuning the PostgreSQL Configuration

The Metrics Engine installer creates the `postgresql.conf` configuration file and the security file, `pg_hba.conf` file. These two files are in the PostgreSQL data directory specified during the install. Based on the size of the monitored installation and the RAM available to PostgreSQL,

you may want to modify two configuration variables to tune the Metrics Engine for optimal performance: `shared_buffers` and `maintenance_work_mem`. The following table provides some guidelines to help you tune your PostgreSQL configuration:

Table 3: Tuning Recommendations Based on Total System Memory

Variable Name	< 4 GB	< 6 GB	< 8 GB	> 8 GB
<code>shared_buffers</code>	128 MB	256MB	512 MB	1 GB
<code>maintenance_work_mem</code>	128 MB	256MB	1 GB	2 GB

Installing the Metrics Engine

Use the `setup` tool for initial setup of the Metrics Engine.

To Install the Metrics Engine

1. Become a user, other than root.
2. To begin the installation process, obtain the latest zip release bundle from UnboundID and unpack it in a folder of your choice. In this example, the release bundle unpacks in the `UnboundID-Metrics-Engine` directory.

```
$ unzip UnboundID-Metrics-Engine-4.5.1.0.zip
```

3. Change to the server root directory.

```
$ cd UnboundID-Metrics-Engine
```

4. Use the `setup` command with the appropriate `JAVA_HOME` environment variable.

```
$ env JAVA_HOME=/ds/java ./setup
```



Note: If your `JAVA_HOME` environment variable is set to an older version of Java, you must explicitly specify the path to the Java JDK installation during setup. You can either set the `JAVA_HOME` environment variable with the Java JDK path or execute the `setup` command in a modified Java environment using the `env` command.

5. Read the UnboundID End-User License Agreement. If you agree to its terms, type `yes` to continue.
6. The tool describes the installation process and the prerequisites. Type `yes` to continue.
7. Type the port number of your local PostgreSQL instance or press **Enter** to accept the default port, which is 5432.
8. Enter the password for the administrative account configured when installing PostgreSQL.

-
9. Next, enter the name and credentials for the user account the Metrics Engine uses to connect to the database. By default, the account name is `metricsengine`. If you want to change the password, select `yes`.
 10. Enter the name of the PostgreSQL database where the Metrics Engine will store its data. By default, the name is `metricsengine`.
 11. Type the root user DN, or press **Enter** to accept the default (`cn=Directory Manager`), and then type and confirm the root user password.
 12. If you want to enable support for HTTP clients, enter 1. If you want to enable HTTPS support, enter 2. To enable both, select 3.

Enter the port number or numbers depending upon the type of HTTP support you select, or press **Enter** to accept the defaults.

13. Type the LDAP port number of your Metrics Engine, or press **Enter** to accept the default port, 1389.



Note: The Metrics Engine process needs special privileges to listen on a port less than 1024.

14. Type `yes` to enable LDAPS. Otherwise, press **Enter** to accept the default value of `no`.

If you answered yes, you will be prompted for certificate options. If you use the Java or the PKCS#12 key store, you will be asked for the key store path, and the key store PIN. If you use the PKCS#11 token, you will be asked for only the key PIN.
15. Type `yes` to enable StartTLS. Otherwise, press **Enter** to accept the default value of `no`. As in the previous step, if you answered `yes`, you will be prompted for certificate options.
16. If you want to specify a particular address on which the server listens for client connections, enter `yes`. Otherwise, accept the default of `no`.
17. Enter whether you want to tune the JVM to maximize memory use. By default, the value is `no`.
18. Type `yes`, or press **Enter** to accept the default to start the Metrics Engine after the configuration has completed.

If you plan to configure additional settings or import data, you can type `no` to keep the server in shutdown mode.
19. When you have finished entering your settings, press 1 to configure the Metrics Engine.

Configuring the Metrics Engine

Once you have finished running the `setup` tool, you need to configure the servers monitored by the Metrics Engine. You can configure the set of monitored servers using the `monitored-servers` tool or configure them individually using `dsconfig`.

About the monitored-servers Tool

The `monitored-servers` command-line tool configures communication between the monitored servers and the Metrics Engine and then bulk adds external server definitions to the Metrics Engine configuration based on a server's administrative data. Before a server is added to the Metrics Engine configuration, the system examines it to determine whether communication needs to be configured. If so, the `cn=Monitoring User` root user is created on the external server with a password you supply.

This tool may be run against the same external server repeatedly, meaning that the server can go through the preparation process again to update the user account or password.

When you run the tool with the `add-servers` subcommand, it creates an external server based on the information discovered about the remote server. It also uses the information located in the `cn=admin` data entry to discover other servers in the topology, which are also added to the configuration.

About Adding Individual Servers Using `dsconfig`

Use the `dsconfig` tool to configure individual servers to be monitored by the Metrics Engine. Only the servers that you specify in the `monitored-server` property of the Monitoring Configuration configuration object will be actively monitored, though historical data may exist for disabled servers. If you want to temporarily disable monitoring and stop the Metrics Engine from collecting statistics, remove the external server from this property. Do not delete the external server object. Add the external server back to the `monitored-server` property when you are ready to re-enable monitoring of the server.

To Configure the Metrics Engine

1. Run the `monitored-servers` tool with the `add-servers` subcommand.

Specify connection information for the Metrics Engine, as well as connection information for any remote servers in use. The engine creates an external server based on the information discovered about the remote server. It also uses the information located in the `cn=admin` data entry to discover other servers in the topology, which are also added to the configuration.

```
$ bin/monitored-servers add-servers --bindDN uid=admin,dc=example,dc=com \  
--bindPassword password --monitoringUserBindPassword password \  
--remoteServerHostname localhost --remoteServerPort 1389 \  
--remoteServerBindPassword password
```

2. Use the `--dry-run` option so that the tool generates output detailing the work that would be done in a live session without actually making changes to the server configuration.

```
$ bin/monitored-servers add-servers --bindDN uid=admin,dc=example,dc=com \
--bindPassword password --monitoringUserBindPassword password \
--remoteServerHostname localhost --remoteServerPort 1389 \
--remoteServerBindPassword password --dry-run
```

To Add Individual Monitored Servers Using dsconfig

1. Run the `dsconfig` tool.

```
$ bin/dsconfig
```

2. Select `Monitoring Configuration` to edit the Metrics Engine configuration.
3. Edit the `monitored-server` property, then enter 2 to add a new server. Only servers specified in this property are monitored.
4. Create a new LDAP external server, and then select the type of server you want to create from the list.
5. Enter the name of the new server.
6. Enter the host name of the server you will monitor. For example, `server.example.com`.
7. Specify the DN used to bind to the target LDAP server. Enter 5 to specify the password used to bind to the server.
8. When you are satisfied with the properties of the external server, enter `f` to create the new external server.
9. When you have finished adding servers to be monitored, enter 1 to accept the new values
10. Enter `f` when you have finished making changes.

Running the Metrics Engine

To start the Metrics Engine, run the `bin/start-metrics-engine` command on UNIX® or Linux systems. Run the `bat/start-metrics-engine` command on Windows systems. The `start-metrics-engine` command starts the Metrics Engine as a background process when no options are specified. To run the Metrics Engine as a foreground process, use the `start-metrics-engine` command with the `--nodetach` option.

Starting the Metrics Engine

When the Metrics Engine starts for the very first time, it downloads new samples from the monitored servers and adds data to the database. Until it has finished this first data collection, the Metrics Engine will not be able to answer metric queries to the database. The Metrics Engine

processes samples from the oldest to the newest, so queries on more recent data may require more start-up time. Note that if the monitored servers have been collecting samples for several days, there may be a significant backlog of data to collect.

To determine if your server is ready to respond to metric queries, you can check the Sample Import Backlog using the `status` tool. The following output shows that the server is available, because the Sample Import Backlog is zero:

```
-- Server Status ---
Server Run Status:    Started 22/Aug/2012:10:35:36.000 -0500
Operational Status:  Available
Open Connections:    2
Sample Import Backlog: 0
Sample Import Delay (ms): 7
Max Connections:     2
Total Connections:   1188

      --- Server Details ---
Host Name:           host.example.com
Administrative Users: cn=Directory Manager
Installation Path:   /UnboundID-Metrics-Engine
Server Version:      UnboundID Metrics Engine 3.6.0.0
Java Version:        1.6.0_31
```

Once the server's Sample Import Backlog is relatively low compared to the number of servers being monitored (no more than five times the number of monitored server), it can answer metric queries for recent data on a particular server, and you can begin to analyze the data.

To Start the Metrics Engine as a Background Process

- Go to the server root directory, and then use `start-metrics-engine`.

```
$ bin/start-metrics-engine
```

To Start the Metrics Engine as a Foreground Process

1. Type `start-metrics-engine` to launch the Metrics Engine as a foreground process.

```
$ bin/start-metrics-engine --nodetach
```

2. You can stop the Metrics Engine by pressing **Ctrl+C** in the terminal window where the server is running or by running the `stop-metrics-engine` utility from another window.

To Start the Metrics Engine at Boot Time

By default, the Metrics Engine does not start automatically when the system is booted. Instead, you must manually start it with the `bin/start-metrics-engine` command. To configure the monitoring server to start automatically when the system boots, use the `create-rc-script` tool to create a run control (RC) script as follows:

1. Create the startup script.

```
$ bin/create-rc-script --outputFile UnboundID-ME.sh \
--userName ds
```

2. As root, move the generated UnboundID-ME.sh script into the `/etc/init.d` directory, and create symlinks to it from the `/etc/rc3.d` (starting with an "S" to ensure that the server is started) and `/etc/rc0.d` directory (starting with a "K" to ensure that the server is stopped).

```
# mv UnboundID-ME.sh /etc/init.d/
# ln -s /etc/init.d/UnboundID-ME.sh /etc/rc3.d/S50-UnboundID-ME.sh
# ln -s /etc/init.d/UnboundID-ME.sh /etc/rc0.d/K50-UnboundID-ME.sh
```

3. Log out as root, and re-assume the `ds` role if you are on a Solaris system.

To Stop the Metrics Engine

Change to the server root directory and use `stop-metrics-engine`.

```
$ bin/stop-metrics-engine
```

To Restart the Metrics Engine

You can restart the Metrics Engine using the `stop-metrics-engine` command with the `--restart` or `-R` option. Running this command is equivalent to shutting down the server, exiting the JVM session, and then starting up again, which requires a re-priming of the JVM cache. To avoid destroying and re-creating the JVM, use an internal restart, which can be issued over LDAP. The internal restart will keep the same Java process and avoid any changes to the JVM options.

Go to the server root directory. Using a loopback interface, run the `stop-metrics-engine` command with the `-R` or `--restart` options.

```
$ bin/stop-metrics-engine --restart \
  --hostname 127.0.0.1
```

Installing the Management Console

The UnboundID Metrics Engine provides a graphical web application tool, the UnboundID Management Console. The Management Console provides configuration and schema management functionality in addition to monitoring and server information. Like the `dsconfig` configuration tool, all changes made using the Management Console are recorded in `logs/config-audit.log`. In addition, anytime a configuration is made to the system, the configuration backend is automatically updated and saved as gzip-compressed files. You can access the changes in the `config/archived-configs` folder.

The Management Console is a web application that must be deployed in a servlet container that supports the servlet API 2.5 or later. An installation using Apache Tomcat is described below for illustration purposes only.



Note: The Management Console supports JBoss 7.1.1 or later. Refer to the JBoss Compatibility section in the `WEB-INF/web.xml` file for specific configuration steps.

To Install the Management Console Out of the Box

1. Download and install the servlet container. For example, download `apache-tomcat-<version>.zip` from <http://tomcat.apache.org/>, and then unzip this file in a location of your choice.
2. Set the appropriate Apache Tomcat environment variables. The `setclasspath.sh` and `catalina.sh` files are in the tomcat bin directory.

```
$ echo "BASEDIR=/path/to/tomcat" >> setclasspath.sh
$ echo "CATALINA_HOME=/path/to/tomcat" >> catalina.sh
```

3. Download the Management Console ZIP file, `metrics-web-console-4.5.1.0-GA-image.zip` and unzip the file on your local host. You should see the following files:

```
3RD-PARTY-LICENSE.TXT
LICENSE.TXT
README
metricsengconsole.war
```

4. Create a `metricsengconsole` directory in `apache-tomcat-<version>/webapps/metricsengconsole`. Then, copy the `metricsengconsole.war` file to `apache-tomcat-<version>/webapps/metricsengconsole`. If the servlet is running and auto-deploy is enabled, copy the `.war` file to the `/webapps` directory and it will install in the directory.

```
$ mkdir apache-tomcat-<version>/webapps/metricsengconsole
$ cp metricsengconsole.war apache-tomcat-<version>/webapps/metricsengconsole
```

5. Go to the `apache-tomcat-<version>/webapps/metricsengconsole` directory to extract the contents of the console. The `jar` command is included with the JDK.

```
$ cd apache-tomcat-<version>/webapps/metricsengconsole
$ jar xvf metricsengconsole.war
```

6. Optional. Edit the `WEB-INF/web.xml` file to point to the correct Metrics Engine instance. Change the host and port to match your server. The parameters in the `web.xml` file appear between `<!--` and `-->` as comments. Uncomment the parameters you need to use. For example, you can specify the server or servers that the console uses to authenticate using the following parameters:

```
<context-param>
  <param-name>ldap-servers</param-name>
  <param-value>localhost:389</param-value>
</context-param>
```



Note: If the `ldap-servers` parameter is left as-is (i.e., undefined by default), the web console displays a form field for the user to enter the server host and port.

- Optional. With the default configuration, Tomcat will time out sessions after 30 minutes of inactivity, forcing the user to log back in again. This can be changed on a servlet container wide basis by editing `apache-tomcat-<version>/conf/web.xml`, and updating the value of this configuration parameter:

```
<session-config>
  <session-timeout>120</session-timeout>
</session-config>
```

The session expires after the specified number of minutes. Changing the value to 120, for example, will extend the expiration to two hours. Changes to this setting might not take effect until the servlet container is restarted, so consider changing the value before starting the server for the first time.

- Start the Metrics Engine if it is not already running, and then start the Management Console using the `apache-tomcat-<version>/bin/startup.sh` script. Use `shutdown.sh` to stop the servlet container. (On Microsoft Windows, use `startup.bat` and `shutdown.bat`.) Note that the `JAVA_HOME` environment variable must be set to specify the location of the Java installation to run the server.

```
$ env JAVA_HOME=/ds/java bin/startup.sh
Using CATALINA_BASE:   /apache-tomcat-<version>
Using CATALINA_HOME:   /apache-tomcat-<version>
Using CATALINA_TMPDIR: /apache-tomcat-<version>/temp
Using JRE_HOME:        /ds/java
```

- Open a browser to `http://hostname:8080/metricsengconsole`. By default, Tomcat listens on port 8080 for HTTP requests.



Note: If you re-start the Metrics Engine, you must also log out of the current Management Console session and then log back in to start a new console session.

Logging into the Management Console

To log into the console, you can either use a DN (for example, `cn=Directory Manager`) or provide the name of an administrator, which is stored under `cn=admin` data. The `dsframework` command can be used to create a global administrator, for example:

```
$ dsframework create-admin-user \
--hostname server1.example.com \
--port 1389 --bindDN "cn=Directory Manager" \
--bindPassword secret \
--userID someAdmin --set password:secret
```

To Log into the Management Console

- Go to the server root directory.

```
$ cd UnboundID-Metrics-Engine
```

- Start the Metrics Engine.

```
$ start-metrics-engine
```

3. Start the Apache Tomcat application server.

```
$ /apache-tomcat-<version>/bin/startup.sh
```

4. Open a browser to `http://hostname:8080/metricsengconsole/`.
5. Type the root user DN (or any authorized administrator user name) and password, and then click **Login**.
6. On the Management Console, click **Configuration**.
7. View the Configuration menu. By default, the console displays the Basic object type properties. You can change the complexity level of the object types using the **Object Types** drop-down list.

Fine-Tuning the Management Console

The Management Console uses a `web.xml` descriptor file for its configuration and deployment settings. Instead of specifying the host name and port on the Login page, you can configure one or more primary servers in the `web.xml` file as well as configure security and truststore settings for your Metrics Engine console. If you specify any servers using the `web.xml` file, the Login page will no longer display the LDAP Server field. It will automatically attempt to connect to the primary server(s) specified in the `web.xml` file in the order in which they are specified until one of the servers can authenticate the username and password. The console also uses this server to "discover" other servers in the topology, making them available for monitoring and management in the console.

To Configure One or More Primary Servers for the Console

1. Open the `metricsengconsole/WEB-INF/web.xml` file in a text editor to specify the server(s) that the console uses to authenticate. First, remove the comment tags (`<!--` and `-->`) in the `ldap-servers` section.
2. Next, specify the servers as `host:port` (e.g., `server1.example.com:389`) or using the LDAPS protocol to specify security information (e.g., `ldaps://server1.example.com:389`). If you specify more than one server, you must separate them using a space. For example, if you have two servers: one using standard LDAP communication, the other using SSL, you would see the following:

```
<context-param>
  <param-name>ldap-servers</param-name>
  <param-value>localhost:389 ldaps://svr1.example.com:389</param-value>
</context-param>
```

3. Save the file.

To Configure SSL for the Primary Console Server

You can configure the console so that it will communicate with all of its primary servers over SSL or StartTLS. See the previous section on how to specify one or more primary servers.

1. Open the `metricsengconsole/WEB-INF/web.xml` file in a text editor to specify the type of communication to authenticate. First, remove the comment tags (`<!--` and `-->`) in the security section.
2. Specify `none`, `ssl`, or `starttls` for the type of security that you are using to communicate with the Metrics Engine.

```
<context-param>
  <param-name>security</param-name>
  <param-value>ssl</param-value>
</context-param>
```

3. Save the file.

To Configure a Truststore for the Console

For SSL and StartTLS communication, you can specify your truststore and its password (or password file) in the `web.xml` file. If no truststore is specified, all server certificates will be blindly trusted.

1. Open the `metricsengconsole/WEB-INF/web.xml` file in a text editor to specify the truststore. First, remove the comment tags (`<!--` and `-->`) in the truststore section.
2. Specify the path to your truststore.

```
<context-param>
  <param-name>trustStore</param-name>
  <param-value>/path/to/truststore</param-value>
</context-param>
```

3. Next, specify the password or the path to the password pin file.

```
<context-param>
  <param-name>trustStorePassword</param-name>
  <param-value>password</param-value>
</context-param>

<context-param>
  <param-name>trustStorePasswordFile</param-name>
  <param-value>/path/to/truststore/pin/file</param-value>
</context-param>
```

4. Save the file.

Upgrading the Management Console

You can easily upgrade the Management Console by first moving the `web.xml` file to another location, unpacking the latest Management Console distribution, and then replacing the newly deployed `web.xml` file with the previous build.

To Upgrade the Management Console

1. Shut down the console and servlet container.
2. In the current deployment of the Management Console, move the `webapps/metricsengconsole/WEB-INF/web.xml` file to another location.
3. Download and deploy the latest version for the Management Console. Follow steps 2–5 outlined in the section "To Install the Console Out of the Box".
4. Assuming you had not renamed the `.war` file when you originally deployed the Management Console, run a diff between the previous and newer version of the `web.xml` file to determine any changes that should be applied to the new `web.xml` file. Make those changes to the new file, and then replace the newly deployed Management Console's `web.xml` to `webapps/metricsengconsole/WEB-INF/web.xml`.
5. Start the servlet container.

Backing Up the Metrics Engine DBMS

This section provides information about why you may need to backup the DBMS, and then how to plan and execute your backup strategy. Understanding what happens during the backup process is important because executing a DBMS backup requires taking the Metrics Engine offline for the duration of the backup.

About Backing Up DBMS Data

The Metrics Engine stores all historical metric samples in the PostgreSQL DBMS, along with several other data tables that are used for bookkeeping and normalization of the sample data. Even a small Metrics Engine installation, which monitors three to four servers, will use sample tables that occupy 95% of the total DBMS space used. While a functional backup must capture a consistent view of several tables, the size of the sample tables dictates the desired approach to a regular backup strategy.

The historical samples allow you to:

- Diagnose performance problems that occurred in the past.
- Provide historical data for capacity planning and historical reporting.
- Provide the data needed for a revenue stream, such as when Metrics Engine data is used for billing and chargeback.

Evaluating the parts of the data that are important to you determines your backup strategy. For example, in the case of billing and chargeback, the data needed for these sorts of tasks is typically small compared to the total population of the DBMS, and you can use the API to extract the data on a regular basis and archive it in a set of CSV files. This may be all the data you need, and the planning and resources required to backup the DBMS will be minimal.

However, in other circumstances, you may not be able to determine what data will be important to you in the future, in which case backing up all DBMS data is the safest approach.

About Historical Data Storage

The Metrics Engine DBMS stores all historical sample data starting from when the Metrics Engine first started collecting sample data. It can store time-aggregated data for up to twenty years, and the data in the DBMS is continually changing as long as the Metrics Engine is running.

The system that feeds data to the Metrics Engine is designed to allow the Metrics Engine to be offline for hours at a time without dropping any data. The collection points hold the data for hours, giving the Metrics Engine ample time for maintenance tasks. The collection points do have a limit on how long they hold data, so the Metrics Engine cannot be offline for an indeterminate time.

If the Metrics Engine is offline so long that the collection points start to delete data that has not yet been captured, then there will be gaps in the data. Aggregation still works, even with these gaps. If the data gap is four hours, four time samples will be missing in the one hour aggregation level, and no data will be missing in the one day aggregation level. However, the one day aggregation level will use only 20 hours of data rather than 24.

The Metrics Engine responds to queries that result in data with time gaps. The resulting data differentiates between data with zero value and missing data.

By default, the Metrics Engine can be offline for about eight hours before any data is lost. If you target a backup that lasts less than two hours, you do not compromise the data.

Determining What Data to Backup

Sample data comprises about 95% of the DBMS by volume. It is broken evenly into four groups:

- > One Second
- > One Minute
- > One Hour
- > One Day

Each of these groups changes over time, with new samples flowing in and being aggregated and with old samples being deleted. The data in the One Second group data changes much faster than the other groups. Using the default settings, 100% of the data in this group is replaced every 8 hours. So, even if you have a backup of this group, it will be completely out of date eight hours after you completed the backup. With such a short period of usefulness, we have omitted this group from the backup, saving both time and space.

The group that contains One Minute data changes every seven days by default, though it can be as long as every five weeks. The data from this group can be useful if you back it up every week. Remember that if the One Minute tables fully age out every week, then a backup from 5 days ago is not very useful.

The One Hour data ages out every year by default, and the One Day data never ages out. Both of these groups are good candidates for backup.

From a planning perspective, we need to backup three of the four sample groups, if we backup at a frequency between daily and weekly. If we backup less often, then we may want to exclude the One Minute data as well, and back up only the One Hour and One Day data groups.

Implications of Restoring Data

If you have a catastrophic storage failure, when you restore the data that was captured and aggregated between the most recent backup and now will be lost. For example, imagine we take weekly backups on Sunday night. If we have to restore from backup on the following Friday in a worst-case scenario, we will have a six day gap in our data. This gap represents six samples from the one day group, 144 samples from the one hour group, and 8640 samples for the one minute group. The collection points are still caching samples, so after the backup is restored, the Metrics Engine will immediately reclaim the most recent eight hours of data.

However, configuring the collection points to retain the data for an entire backup period, while providing 100% recovery of the data, comes at a high price. The Metrics Engine has a modest upper limit on how fast it can get data into the DBMS, approximately 500k samples per minute. If you presented a seven day backlog of data to the Metrics Engine, it will take several days for it to process the backlog, and the Metrics Engine would be unable to answer queries for current data until the backlog finished processing.

We recommend having a gap in the data rather than losing the ability to use the data at all for an extended period of time. Avoid any approach that results in more than two hours of catchup time.

Planning for Periodic Backups

When you plan for a periodic backup, you must choose a time window during which the Metrics engine can be offline and ensure that you have enough disk space to hold the new backup image. The exact size of a DBMS table and its corresponding backup is difficult to predict because it depends on factors that change at each installation. These factors include the number of monitored servers, the number of tracked applications, the collected metrics, and the retention duration for each of the aggregation levels. The following table provides values from installations used during testing. These values reflect backing up three of the four sample groups: one minute, one hour, and one day data.

Table 4: Data from Sample Deployments

Data	For 25 Monitored Servers	For 50 Monitored Servers
Number of tracked applications	20	20
1 second data resolution	8 hours	8 hours
1 minute data retention	14 days	14 days
1 hour data retention	52 weeks	52 week
1 day data retention	20 years	20 years
1 second table size	22 G	42 G
1 minute table size	8 G	18 G
1 hour table size	4 G (estimated)	9 G (estimated)

Data	For 25 Monitored Servers	For 50 Monitored Servers
1 day data retention	4 G (estimated)	7 G (estimated)
time to backup	15 minutes (estimated)	30 minutes (estimated)
time for import catchup	10 minutes	42 minutes
size of compressed backup image	3 G (estimated)	5.5 G (estimated)
time to restore	1 hour (estimated)	2 h (estimated)

If you choose to not make a backup and you lose your DBMS completely, you can always re-initialize the DBMS, restart the Metrics Engine, and start collecting data again. You will lose all collected metric data and all collected event data, but retain the configuration required to start collecting data again. If you have a fixed set of metrics that are historically important, simply taking snapshots of these metrics periodically (using the Metric engine RESTful API) and saving them as .csv files protects you if the DBMS is lost.

Before You Begin Your Backup

Before you attempt a backup or restore, you must shut down the Metrics Engine. If you backup or restore with the Metrics Engine running, you will end up with a corrupted backup or corrupted database.

You need the following information to complete a backup:

- **Database name.** This name was specified during Metrics Engine installation and is available through the `dsconfig` tool. The default value is `metricsengine`.
- **Schema name.** This name was specified during Metrics Engine installation and is available through the `dsconfig` tool. The default value is `metricsengine`.
- **PostgreSQL data base administrator login.** This value is set during the Metrics Engine setup and defaults to `postgres`.
- **PostgreSQL data base administrator password.** This information was provided during the Metrics Engine setup and has no default.

The PostgreSQL login and password must have DBA superuser level privileges. Because you are running PostgreSQL tools from the command line, you need to know how to authenticate to the DBMS using these tools. Typically, you can use the following options to authenticate and prompt for the password:

```
-U dbms login -W
```

These options are omitted from the following examples to improve clarity.

How to Backup the Database

To backup the entire DBMS, excluding the one second data, use the following command:

```
$ pg_dump -v -c -n schema --no-unlogged-table-data database > backup-file-name
```

If you installed the Metrics Engine with the default settings, the command appears as follows:

```
$ pg_dump -v -c -n metricsengine --no-unlogged-table-data metricsengine > backup-file-name
```

The backup command takes the following arguments and options:

- *schema* The schema name used. By default, the value is `unboundid`.
- *database* The database name used. By default, the value is `unboundid`.
- *backup-file-name* The name of the file where the backup is stored.
- `-n` This option specifies that only the schema we are using be backed up.
- `-v` This option specifies to use the verbose mode.



Note: You cannot backup and restore parts of the schema beyond the sample tables. The Metrics Engine application code creates implicit relationships between different tables that are not enforced by the DBMS. If you backup the DBMS with the Metrics Engine running, restoring that backup may corrupt the sample tables, aligning sample data with the wrong metric meta data. The backup must be on a DBMS that has been stopped, and it must capture all of the tables you intend to restore. Any tables not included in the backup must be truncated when you restore from the backup, otherwise these implicit relationships will be broken.

How to Restore the Database

Use the following command to restore the backup created above:

```
$ psql -d database < backup-file-name
```

Executing this command takes between 10 minutes and two hours, depending on the size of the backup. The command drops and recreates each backed up table and index, and then reloads all data for the table stored in the backup.

Excluding Data from Specific Aggregation Levels

The default backup command skips only the unlogged tables, which is the one second data we concluded should not be backed up because it would be stale before the backup could be used. However, you can skip other aggregation levels. To skip an aggregation level, the `-T` option of the `pg_dump` tool should be used. For example, the following command skips the one second and one minute data:

```
$ pg_dump -v -c -n schema --no-unlogged-table-data \  
-T schema.histo_1l -T schema.histo_d* \  
-T schema.scalar_1l -T schema.scalar_d* \  
schema > backup-file-name
```

The following tables describe the names of the specific aggregation levels

Table 5: Aggregation Level Table Names

Aggregation Level	Table Names
1 second	histo_10, histo_h*, scalar_l0, scalar_h*
1 minute	histo_l1, histo_d*, scalar_l1, scalar_d*
1 hour	histo_l2, histo_m*, scalar_l2, scalar_m*
1 day	histo_l3, histo_y*, scalar_l3, scalar_y*

If you explicitly use the `-T` option, then you must prepare the DBMS before you can restore, otherwise the restore will report errors. Every table that is excluded by the `-T` option during backup must be dropped before the restore is attempted.

Performing a Full Backup

You may want a full DBMS backup and restore, rather than exclude the most recent data tables. A full DBMS backup can be used to load the data into a different DBMS server or into another database in the current server. Or, you may want to send the DBMS image to your support provider for analysis of a performance problem.

To create a full backup, use the following command:

```
$ pg_dump -v -c -n schema database > backup-file-name
```

To restore the full backup to a new database, use the following command:

```
$ psql -d new-database-name < backup-file-name
```

How to Export and Import the Database

You may want to export the full database, including the tables that should normally be excluded. For example, you may want to export the database to import the entire schema into another database, perhaps to do further analysis on it without the Metrics Engine continuing to import, aggregate, and trim the data. Below are the commands to export the full database, and then to import it into a new database for further processing or analysis:

```
$ pg_dump -n schema -Fc database > full-backup-file-name
$ createdb -T template0 new-database-name
$ pg_restore -d new-database-name full-backup-file-name
```

You may also want to export the full database if you need to send a Metrics Engine database image in for support to analyze.

Uninstalling the Metrics Engine

The Metrics Engine provides an uninstall command-line utility for quick and easy removal of the code base. You can uninstall the Metrics Engine using one of the following modes:

- **Interactive command-line mode.** This mode is a text-based interface. The utility prompts you for input if more data is required.

- **Non-interactive command-line mode.** This mode suppresses progress information from being provided in standard output during processing, except for fatal errors. This mode is convenient for scripting and is invoked with the `--no-prompt` option.

To Uninstall the Metrics Engine in Interactive Mode

Interactive mode uses a text-based, command-line interface to help you remove your Metrics Engine instance. If `uninstall` cannot remove all of the Metrics Engine files, the server generates a message with a list of the files and directories that must be manually deleted. The `uninstall` command must be run as either the root user or the same user (or role) that installed the Metrics Engine.

1. Go to the server root directory.

```
$ cd UnboundID-Metrics-Engine
```

2. Use the `uninstall` command.

```
$ ./uninstall
```

3. Select the components to be removed. If you want to remove all components, press **Enter** to accept the default.
4. If the Metrics Engine is running, press **Enter** to shutdown the server before continuing the `uninstall` process.
5. Complete the `uninstall`, and view the logs for any remaining files. Manually remove any remaining files or directories, if required.

Uninstalling the Metrics Engine in Non-Interactive Mode

The `uninstall` utility provides a `--no-prompt` option that you can enter on the command line or use in a script. Use the `--forceOnError` option to continue the `uninstall` process even when an error is encountered. If an option is incorrectly entered or if a required option is omitted and the `--forceOnError` option is not used, the command will fail and abort.

To Uninstall the Metrics Engine in Non-Interactive Mode

1. Go to the server root directory.

```
$ cd UnboundID-Metrics-Engine
```

2. Use the `uninstall` command.

```
$ ./uninstall
```

3. Use `uninstall` with the `--remove-all` option to remove all of the Metrics Engine's libraries. The `--quiet` option suppresses output information and is optional.

```
$ ./uninstall --remove-all --no-prompt --forceOnError
```

4. If any files or directories remain, manually remove them.

To Uninstall Selected Components in Non-Interactive Mode

1. Go to the server root directory.

```
$ cd UnboundID-Metrics-Engine
```

2. Use `uninstall` with the `--backup-files` option to remove the Metrics Engine's backup files. Use the `uu--help` or `-H` option to view the other options available to remove specific components.

```
$ ./uninstall \
--backup-files \
--no-prompt \
--quiet \
--forceOnError
```

Uninstalling the Management Console

You can easily remove the existing Management Console by removing the `webapps/metricsengconsole` directory when no longer needed on your system.

To Uninstall the Management Console

1. Close the Management Console, and shut down the servlet container. (On Microsoft Windows, use `shutdown.bat`).

```
$ apache-tomcat-<version>/bin/shutdown.sh
```

2. Remove the `webapps/metricsengconsole` directory.

```
$ rm -rf webapps/metricsengconsole
```

3. Restart the servlet container instance if necessary. Alternatively, if no other applications are installed in the servlet instance, then the entire servlet installation can be removed by deleting the servlet container directory.

Cleaning Up the PostgreSQL DBMS After Uninstall

The Metrics Engine stores metric samples and bookkeeping information in the DBMS. After the Metrics Engine has been uninstalled this data may no longer be useful. If there is a chance that the Metrics Engine may be reinstalled and the existing metric sample data may be useful, then you do not need to cleanup the DBMS. However, if the Metrics Engine will not be reinstalled, or if you just want to get rid of all of the old data before you reinstall, use this procedure.

- Shutdown the Metrics Engine.

```
$ bin/stop-metrics-engine
```

Chapter

3

Configuring Charts

This chapter presents procedures to configure Metrics Engine charts, whether appearing on the Metrics Engine or on the UnboundID Identity Broker Dashboard.

Topics:

- [*Customizing the Identity Broker Dashboard*](#)

Customizing the Identity Broker Dashboard

The UnboundID Identity Broker is a high-performance, highly-scalable, highly secure server, providing a centralized Policy engine, OAuth2 authentication/authorization service, and OpenID Connect service to power your identity infrastructure. The Identity Broker provides a Metrics Tab on its Broker Console that displays a dashboard that tracks key performance metrics (image shown below).

The Metrics Dashboard page is powered by an UnboundID Metrics Engine instance, monitoring activity on the UnboundID Identity Broker. Each chart itself is fully customizable in terms of its data collection and its look-and-feel. Any configuration of the Identity Broker's dashboard charts can be made using the *Chart Builder* tool, and then editing a properties file on the Metrics Engine.

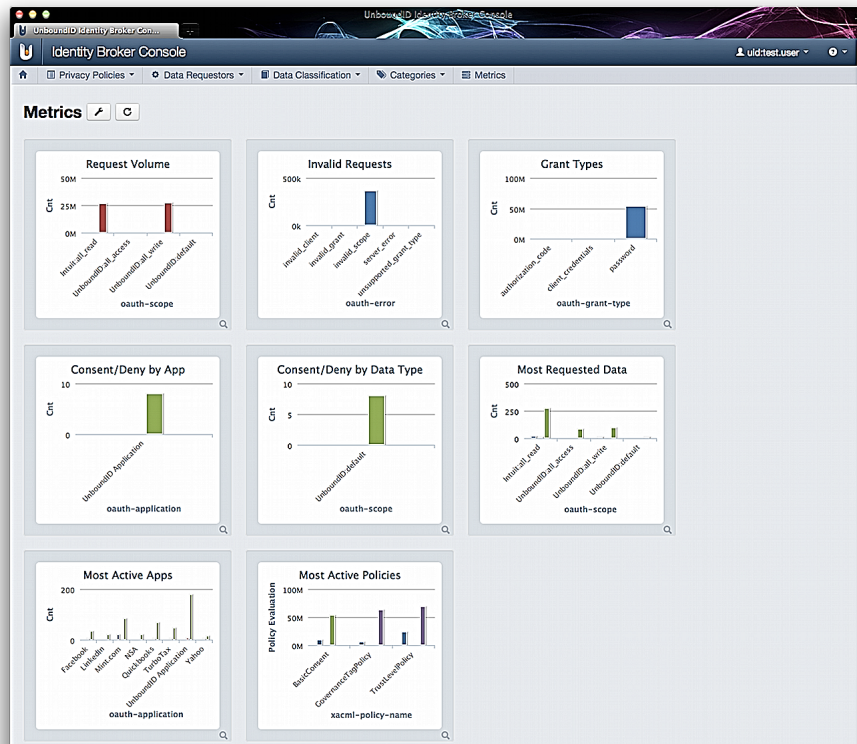


Figure 4: UnboundID Identity Broker Dashboard

Metrics charting in the Chart Builder and the Identity Broker Dashboard use the same library, so that a chart rendered in the Chart Builder will render exactly the same in the Dashboard if the properties produced by the Chart Builder are used. As you change the settings in the Chart Builder, the builder will re-fetch the metric data from the Metrics Engine using the Metrics Engine REST API.

When the Identity Broker Dashboard displays a set of charts, the dashboard page will asynchronously fetch the metric data for all charts in parallel, with each chart rendering when its data is returned. While most metric queries respond quickly (50-100ms), some queries may take longer, which will result in a longer lag between making a change in the Chart Builder (or

refreshing the Identity Broker dashboard) and the chart being rendered. If the lag seems too long, consider making changes to the query to reduce the amount of data it needs to gather. Selecting specific Instances and using Dimension Filters often helps with slow queries.

The Chart Builder tool and the underlying libraries constrain a chart to a single metric. This constraint is in place to simplify the configuration of the chart and the dashboard. When two different metrics need to be compared, the best solution is to produce a chart for each metric and place them in proximity to each other in the dashboard. The layout of charts in the Identity Broker dashboard uses a left-to-right, top-to-bottom flow with a minimum viewport size. The size of each chart is determined by the library default size (300x300) and overridden by values in the chart properties file. Sometimes the legends and labeling of a chart dictate the minimum size for a chart, especially when the values in the legend are long. When certain data values result in charts that are unwieldy, the actual labels used for specific data series can be overridden to be shorter, improving the use of dashboard screen real estate.

About the Metrics Engine Documentation

The Metrics Engine comes with a complete online reference documentation that developers or administrators can use to implement their custom charts. This Documentation page is designed to be a configuration starting point for those wanting to customize their metric charts. After you have successfully installed the UnboundID Identity Broker, backend data store servers, and the UnboundID Metrics Engine, you can access the documentation at the following URL:

```
https://<metrics-engine-host>:<port>/docs/doc-index.html
```

The Metrics Engine Documentation page provides links to a Metrics Documentation page, a reference file that details every metric available per product, a Metrics Engine REST API documentation that explains the endpoints, and the Metrics Engine Chart Builder tool to customize any chart.

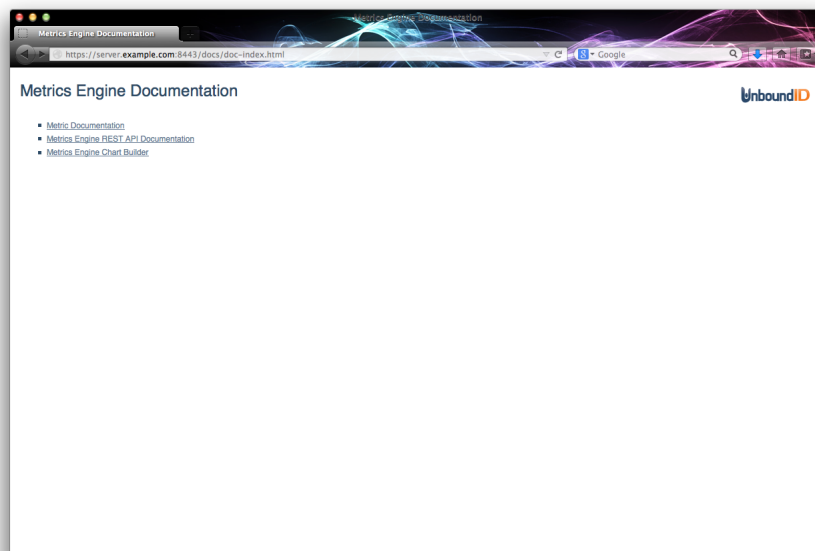
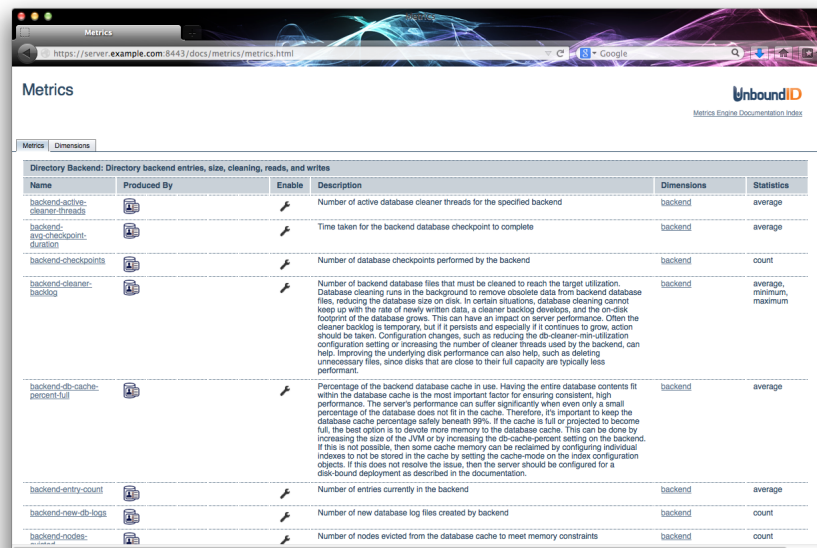


Figure 5: Metrics Engine Documentation

The Metric Documentation link opens to a reference file that lists all of the metrics available on the system. The page displays the following columns:

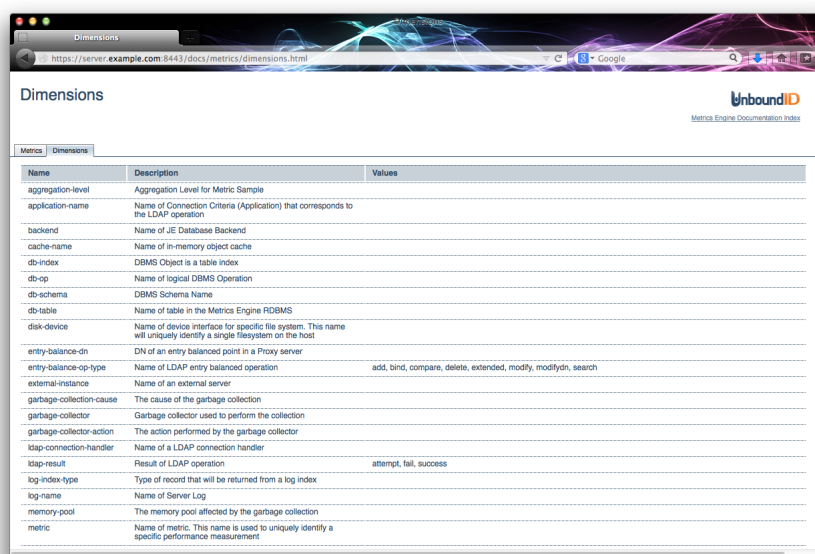
- The **Name** column provides a link to a given metric, which you can click to launch the Chart Builder tool. The Chart Builder tool will display a preview chart for that specific metric. For example, if you click the `backend-active-cleaner-threads` link, you will see the chart for that parameter.
- The **Produced By** column indicates the UnboundID product source that is generating the metric.
- The **Enable** column provides the corresponding `dsconfig` command-line instruction to enable the metric on the producing monitored server. Simple hover over the icon (i.e., the wrench icon) to view the `dsconfig` command.
- The **Description** column provides a brief description of the metric.
- The **Dimensions** column displays the type of data on the chart.
- The **Statistics** column displays the type of measurement taken for the metric.



Name	Produced By	Enable	Description	Dimensions	Statistics
backend-active-cleaner-threads	UnboundID		Number of active database cleaner threads for the specified backend	backend	average
backend-avg-checkpoint-duration	UnboundID		Time taken for the backend database checkpoint to complete	backend	average
backend-checkpoints	UnboundID		Number of database checkpoints performed by the backend	backend	count
backend-cleaner-backlog	UnboundID		Number of backend database files that must be cleaned to reach the target utilization. Database cleaning runs in the background to remove obsolete data from backend database files, reducing the database size on disk. In certain situations, database cleaning cannot keep up with the rate of newly written data, a cleaner backlog develops, and the on-disk footprint of the database grows. This can have an impact on server performance. Often the cleaner backlog is temporary, but if it persists and especially if it continues to grow, action should be taken. Configuration changes, such as reducing the db-cleaner-min-utilization configuration setting or increasing the number of cleaner threads used by the backend, can help. Improving the underlying disk performance can also help, such as deleting unnecessary files, since disks that are close to their full capacity are typically less performant.	backend	average, minimum, maximum
backend-db-cache-percent-full	UnboundID		Percentage of the backend database cache in use. Having the entire database contents fit within the database cache is the most important factor for ensuring consistent, high performance. The server's performance can suffer significantly when even only a small percentage of the database does not fit in the cache. Therefore, it's important to keep the database cache percentage safely beneath 99%. If the cache is full or projected to become full, the best option is to devote more memory to the database cache. This can be done by increasing the size of the JVM or by increasing the db-cache-percent setting on the backend. If this is not possible, then some cache memory can be reclaimed by configuring individual indexes to not be stored in the cache by setting the cache-mode on the index configuration objects. If this does not resolve the issue, then the server should be configured for a disk-bound deployment as described in the documentation.	backend	average
backend-entry-count	UnboundID		Number of entries currently in the backend	backend	average
backend-new-db-logs	UnboundID		Number of new database log files created by backend	backend	count
backend-nodes-evicted	UnboundID		Number of nodes evicted from the database cache to meet memory constraints	backend	count

Figure 6: Metric Documentation

The Metrics page also provides a Dimensions tab, showing the type of dimensions available for a customized chart.



Name	Description	Values
aggregation-level	Aggregation Level for Metric Sample	
application-name	Name of Connection Criteria (Application) that corresponds to the LDAP operation	
backend	Name of J.E Database Backend	
cache-name	Name of in-memory object cache	
db-index	DBMS Object is a table index	
db-op	Name of logical DBMS Operation	
db-schema	DBMS Schema Name	
db-table	Name of table in the Metrics Engine RDBMS	
disk-device	Name of device interface for specific file system. This name will uniquely identify a single filesystem on the host	
entry-balance-dn	DN of an entry balanced point in a Proxy server	
entry-balance-op-type	Name of LDAP entry balanced operation	add, bind, compare, delete, extended, modify, modifydn, search
external-instance	Name of an external server	
garbage-collection-cause	The cause of the garbage collection	
garbage-collector	Garbage collector used to perform the collection	
garbage-collector-action	The action performed by the garbage collector	
ldap-connection-handler	Name of a LDAP connection handler	
ldap-result	Result of LDAP operation	attempt, fail, success
log-index-type	Type of record that will be returned from a log index	
log-name	Name of Server Log	
memory-pool	The memory pool affected by the garbage collection	
metric	Name of metric. This name is used to uniquely identify a specific performance measurement	

Figure 7: Metric Dimensions Tab

About the Chart Builder Tool

The UnboundID Metrics Engine provides a Chart Builder user interface (UI) to preview and customize any type of chart. Each chart is supported by underlying Velocity Template files that generate the Metrics Dashboard on the UnboundID Identity Broker.

The Chart Builder tool (`chart-builder.vm`) is shipped with the UnboundID Metrics Engine distribution and is enabled by default at the following URL (after you have installed the Metrics Engine):

```
https://<metrics-engine-host>:<port>/view/chart-builder
```

Once you have launched the Chart Builder tool, you will see a web page that allows you to configure the specific metric chart that you want to track. You can adjust the chart parameters to suit your tastes and deployment, then you can simply copy-and-paste the generated Chart Properties, shown on the bottom left of the page, into your own properties file. The instructions on how to customize a chart is presented at [To Create a New Dashboard Chart Definition](#) on page 57.

Table 6: Chart Builder Parameters

Parameters	Description
Metric Group	Selects a specific group of metrics to be considered for charting.
Metric	Displays the specific metric. If you open the drop-down list and hover over a metric, you can view a description of the particular metric.
Pivot	Splits the chart result into multiple series based on the pivot dimension chosen.
Dimension Filter	Filters the data based on the dimension(s) entered.
Statistic	Displays the type of "measurement" that may exist for each metric. For example, each response-time sample contains:

Parameters	Description
	<ul style="list-style-type: none"> ➤ # of operations (count) ➤ average time-per-op (average) ➤ histogram-of-operation-time (histogram) <p>On a per-sample basis, the Metrics Engine stores the following: count, average, minimum, maximum, and histogram. Any metric can have all five statistics but not all statistics are equally valuable. Note the following points:</p> <ul style="list-style-type: none"> ➤ The minimum and maximum statistics may be of limited value, because as you time-average them, they go to extremes (min of minimums and max of maximums). ➤ The count and histogram statistics have high fidelity over time because they time-aggregate perfectly. ➤ The average statistic loses fidelity over time, because as the time-window for averaging gets larger, the highs and lows get clipped. <p>You must determine the applicability of these statistics for your particular chart.</p>
Number of Points	If the number of points is set to 1, all chart types, except time series, may be used. If the number of points is > 1, then only time series charts may be used.
Chart Type	<p>Displays the chart based on the type:</p> <ul style="list-style-type: none"> ➤ Area Time Series ➤ Bar Chart ➤ Column Chart ➤ Pie Chart ➤ Stacked Bar Chart ➤ Stacked Column Chart ➤ Time Series
Chart Properties	Displays the generated chart properties for your customization. You must then manually copy-and-paste these properties into your properties files.

For example, in the figure below, the Metric Query Qualifier Count metric is selected to display an aggregated set of query results to monitor the backend servers. Each set has a unique set of data for each dimension in the query. If you select the "metric" pivot and hover your cursor over a specific point on the graph, you can see the set of dimensions in the query.



Figure 8: Chart Builder Pivot Metric View

You can filter the set of dimensions using the **Dimension Filter** field on the right of the chart. For example, if you enter "metric:throughput, response-time," you can filter out the other dimensions to only show the throughput and response-time series. Compare the chart above with the one below, you can see that the dimension filter allowed two of the data series in the upper chart to remain. Again, if you hover your cursor over some point, you can see the dimensions and their values for that sampling point as seen below.

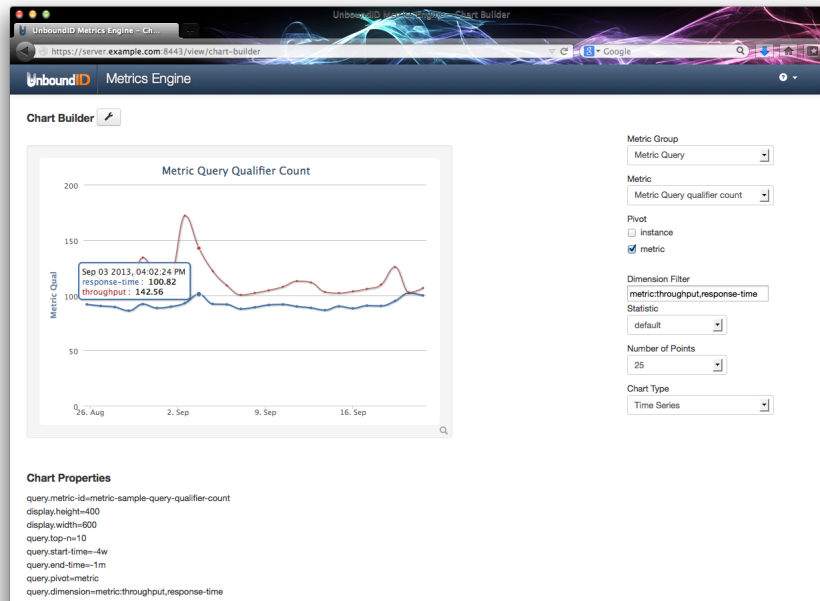


Figure 9: Chart Builder Dimension Filter

Chart Builder allows you to view the metrics data in a variety of different formats, depending your requirements. For example, if you set the number of points to "1" and remove the dimension filter, you can change the chart type to "Area Time Series" on the **Chart Type** drop-down list (shown below).



Note: If the **Number of Points** field is set to any value other than 1, a time series chart is produced. You must choose "1" point to try charts other than the Time Series chart.

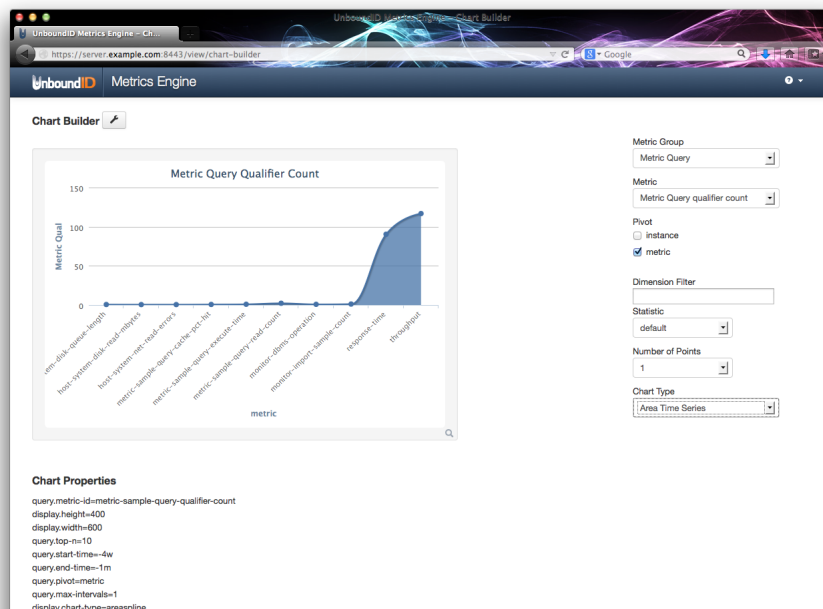


Figure 10: Chart Builder Area Time Series View

The **Chart Type** drop-down list also provides options to change the chart type to a Bar Chart (shown below) or a Stacked Bar Chart (not shown).

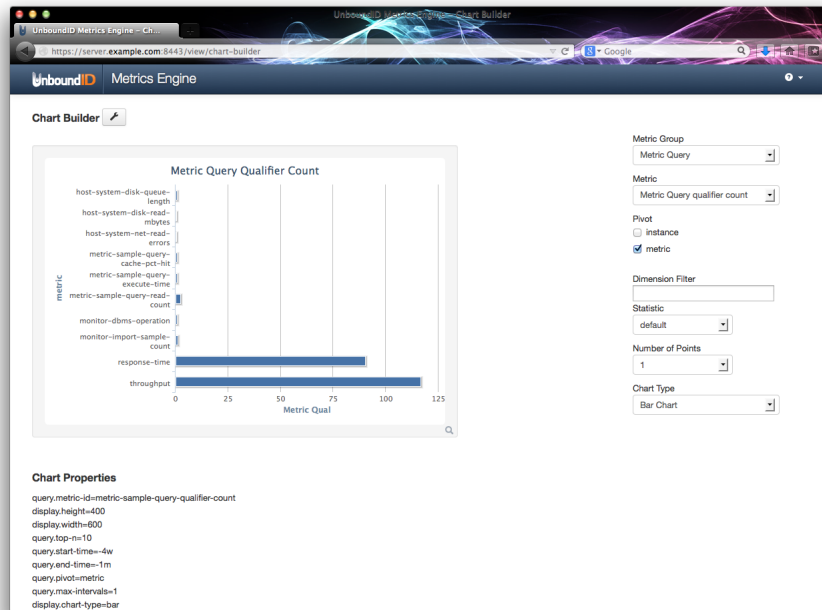


Figure 11: Chart Builder Bar Chart View

You can change the chart type to a Column Chart (shown below) or a Stacked Column Chart (not shown).

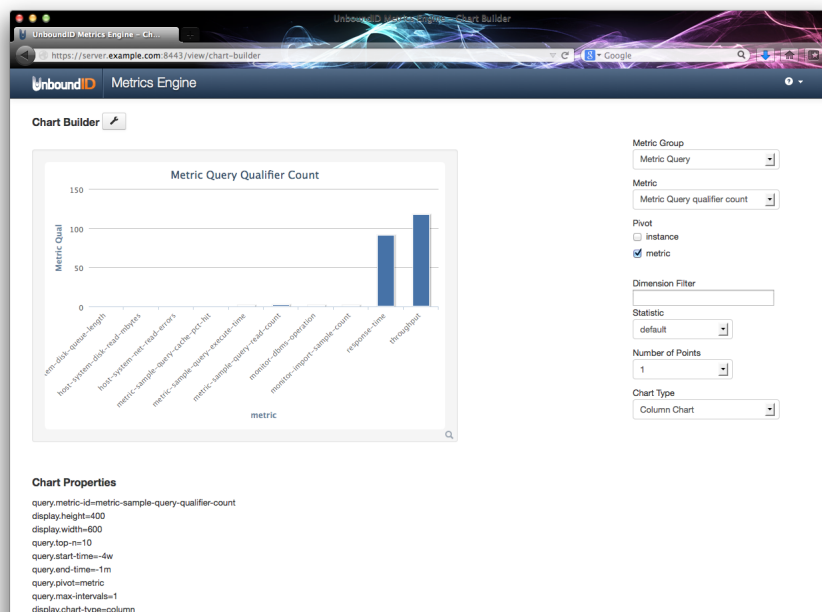


Figure 12: Chart Builder Column Chart View

You can also change the chart type to a Pie Chart.



Figure 13: Chart Builder Pie Chart View

Or, you can change the chart type to a Time Series chart.

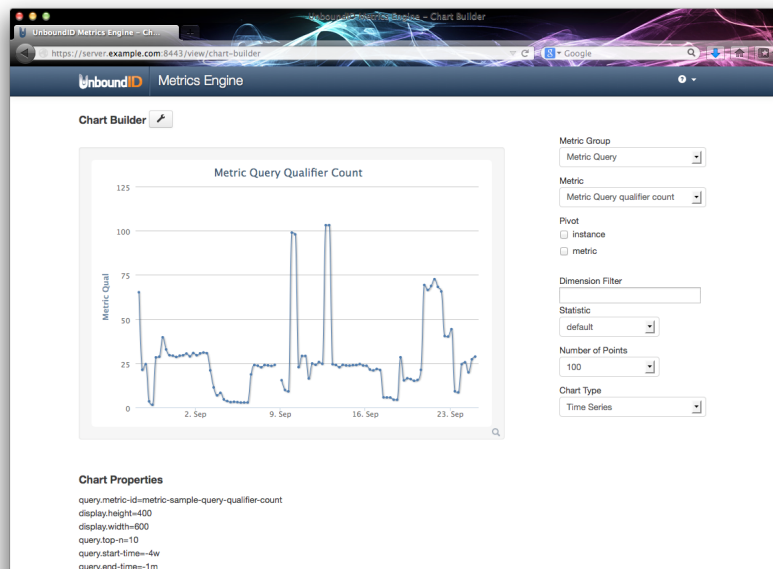


Figure 14: Chart Builder Time Series View

The Chart Builder tool also provides an editor to customize the number of displayed series, the time line and range for each series as well as customizable chart labels and colors. If you click the Chart Builder icon (i.e., the wrench icon), you can make more customizations to your default chart. The following image shows the Chart Builder Editor page and its fields.

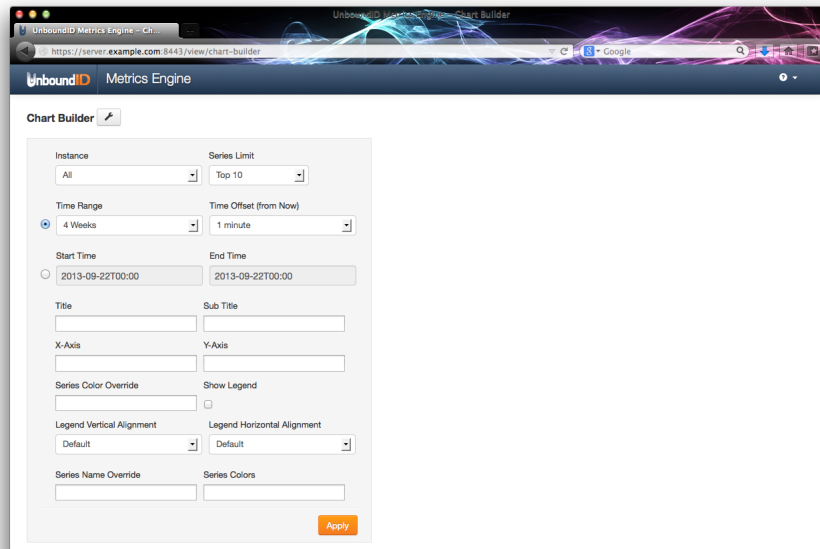


Figure 15: Chart Builder Editor

You can edit the chart title, add a sub-title, and label the X-Axis and Y-Axis. For example, change the chart title to "Throughput & ResponseTime," add a Sub Title "For All Instances," label the Y-Axis as "Metric Qualifier Count" and click the Show Legend box to show a description of the displayed metrics.

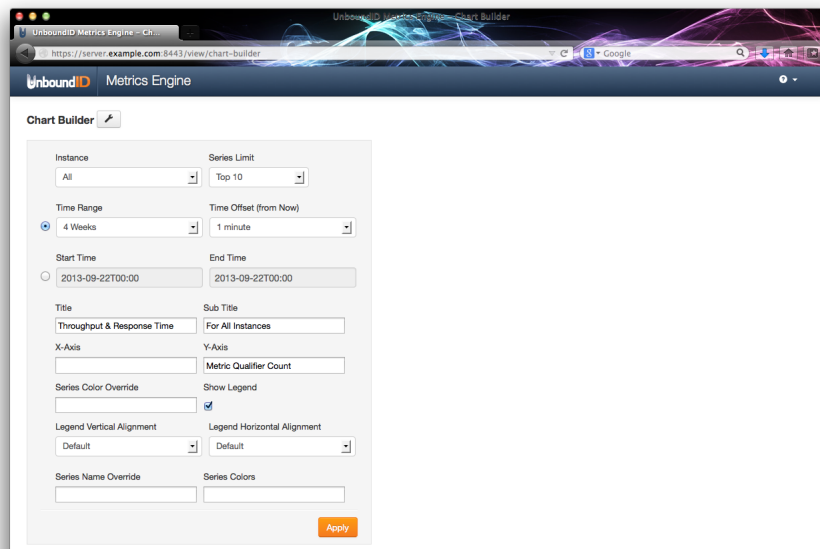


Figure 16: Adding a New Title, Sub-Title, Axis Labels & Legend

After you click the **Apply** button, the resulting changes appear on the chart.

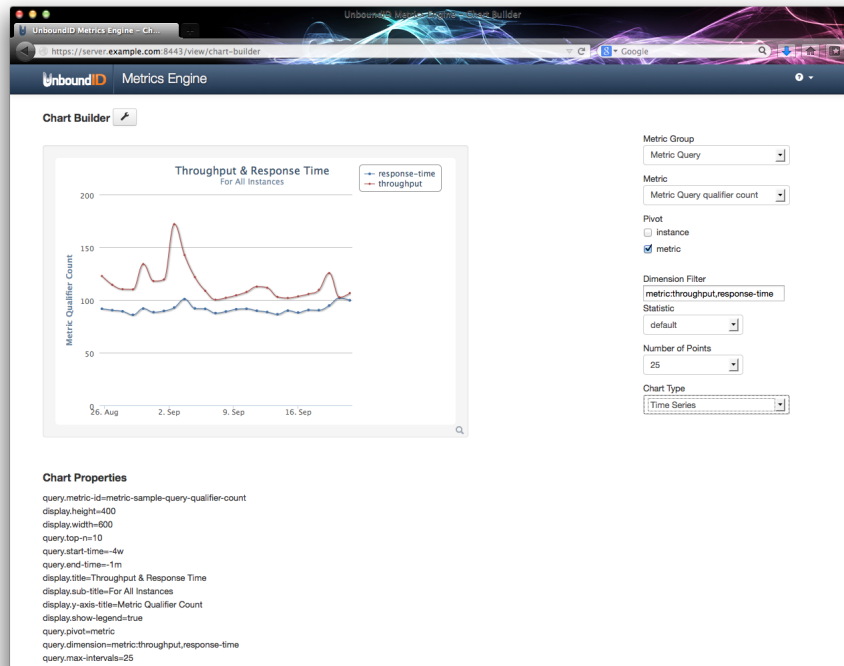


Figure 17: Adding a New Title, Sub-Title, Axis Labels & Legend Resulting Page

You can customize the color of the given chart series line by using the "<dimension-name>=#<Hex RGB Color>" format in the **Series Color Override** field. For example, change the color of the throughput line from the default maroon color to red (i.e., `throughput=#ff0000`) in the **Series Color Override** field. The hover text for that particular dimension also changes to the specified color. The result is shown after the following figure.

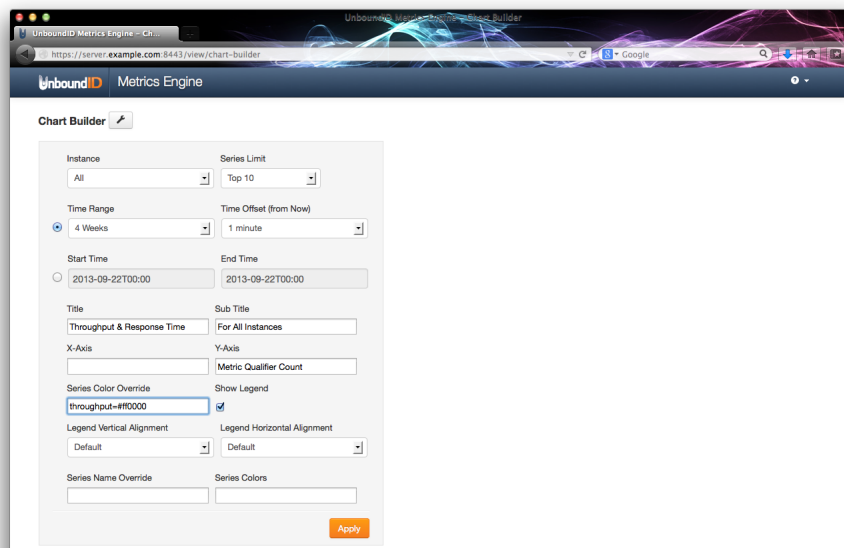


Figure 18: Series Color Override

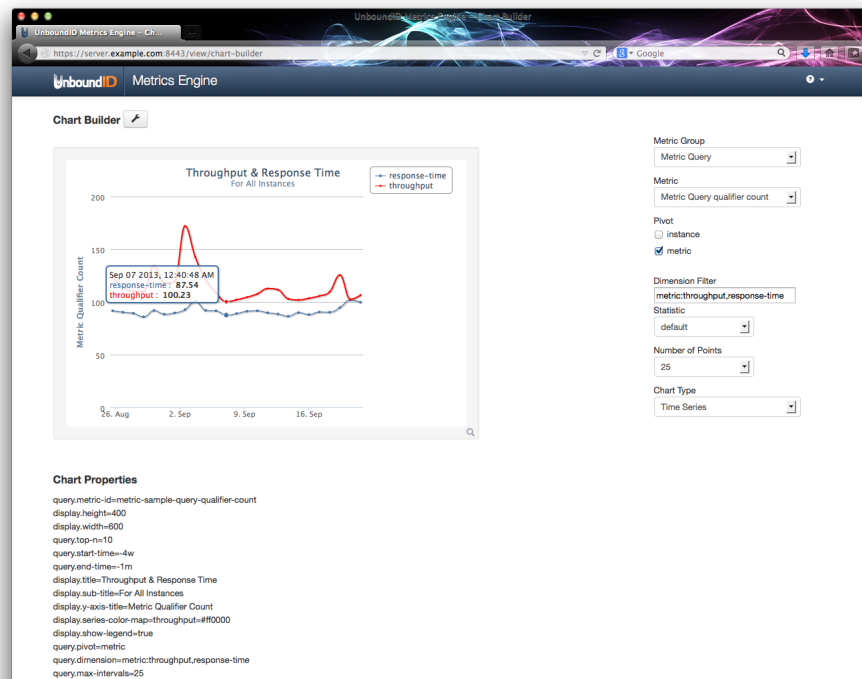


Figure 19: Chart Builder Series Color Override Resulting Page

The **Series Name Override** field allows you to change the series label. For example, you can change the throughput series to "DS-Throughput" and the response-time series to "DS-ResponseTime" by entering "throughput=DS-Throughput,response-time=DS-ResponseTime" in the **Series Name Override** field.

Chart Builder

Instance: All | Series Limit: Top 10

Time Range: 4 Weeks | Time Offset (from Now): 1 minute

Start Time: 2013-09-22T00:00 | End Time: 2013-09-22T00:00

Title: Throughput & Response Time | Sub Title: For All Instances

X-Axis: | Y-Axis: Metric Qualifier Count

Series Color Override: throughput=#ff0000 | Show Legend: ☒

Legend Vertical Alignment: Default | Legend Horizontal Alignment: Default

Series Name Override: throughput=DS-Throughput,response-time=DS-ResponseTime | Series Colors:

Apply

Figure 20: Series Name Override

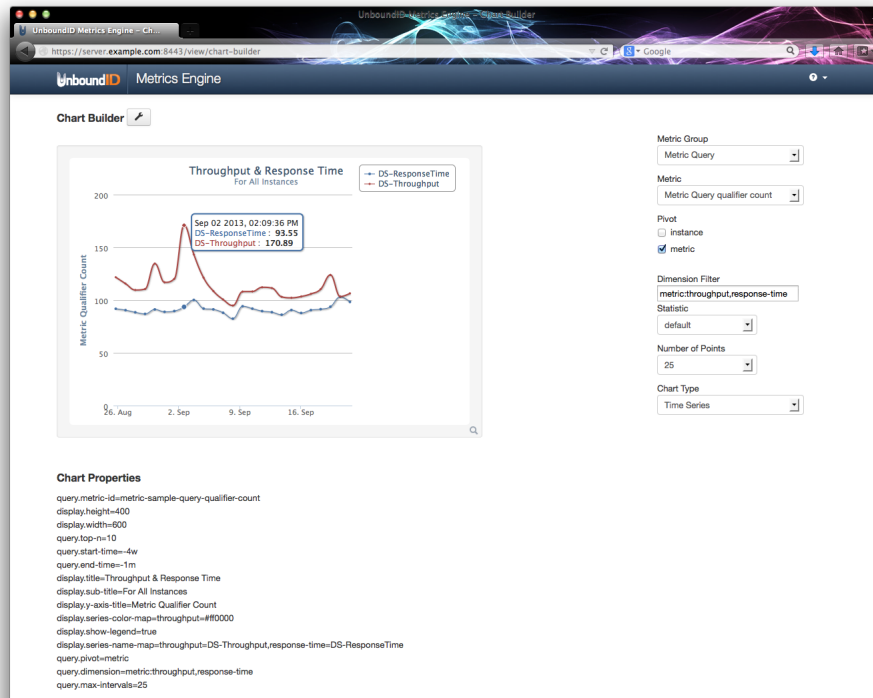


Figure 21: Chart Builder Series Name Override Resulting Page

The **Series Colors** field allows you to set up a pre-determined set of colors for each series line. For example, you can enter the colors, green, fuchsia, blue and lime (#00ff00, #ff00ff, #0000ff, #32cd32) in the **Series Colors** field. The resulting page is displayed in the next figure. Because there are only two series lines, the first two colors, green and fuchsia, are used.

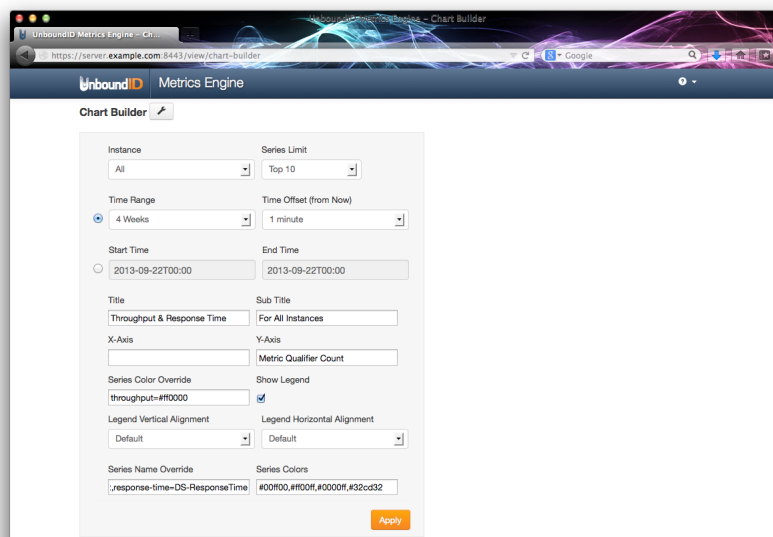


Figure 22: Chart Builder Series Colors



Figure 23: Chart Builder Series Colors Resulting Page

After you have configured a specific chart to suit your taste, you can simply copy-and-paste the chart properties in a properties file on the Metrics Engine. See the section on how to customize a chart at [To Create a New Dashboard Chart Definition](#) on page 57.

About the Dashboard Files

Charts on the UnboundID Identity Broker Dashboard can be created using the Chart Builder previewing tool to customize a particular chart that you want to change. The Chart Builder Tool generates the parameters needed for administrators to copy-and-paste into a properties file. The properties files are located in the `config/dashboard` of the Metrics Engine installation. Although you can directly edit these property files yourself, we recommend that you use the Chart Builder tool exclusively to customize your chart, and then copy the generated parameters into the properties file.

The following is a description of the files present in this directory:

In the `config/dashboard/charts` directory:

- **_chart-definition.template** -- The properties file for creating new chart definitions with descriptions of the available parameters.
- **.properties files** -- The chart definitions that specify their parameter values. These definition files are read in by the `DashboardConfiguration` `VelocityContextProvider` object and made available to the Velocity templates using the `$dashboard.chartDefinitionsByFileName` accessor.

In the **config/velocity/statics** directory:

- **js/dashboard.js** -- Contains the reusable dashboard JavaScript logic. This file is customizable using an extension but should be used as is, out-of-the-box by most templates.
- **css/dashboard.css** -- The default dashboard template styles.
- **vendor/highcharts-2.3.3/js/highcharts.js** -- The Highcharts JavaScript charting package used to render the charts.

In the **config/velocity/templates** directory:

- **broker-dashboard.vm** -- The out-of-the-box Identity Broker Dashboard Velocity template.
- **chart_builder.vm** -- The Chart Builder tool that constructs a chart.
- **_builder-user-input.vm** -- Configuration controls used by the Chart Builder too.
- **_chart.vm** -- The chart definition partial view Velocity template. This file is customizable but should be used as is, out-of-the-box by most dashboard templates.
- **_user-input.vm** -- Provides controls that affect all charts in the Dashboard, unless a chart specifically overrides the value.

About the Chart Properties File

The Identity Broker Dashboard uses a Velocity template (`broker-dashboard.vm`) and a set of chart properties files to render the chart. When you use the Chart Builder tool to create your metrics charts, the tool generates the corresponding properties for each customized item in your chart, which you then copy-and-paste into your properties file. If no values are specified, the property will use a default value.

The properties in the chart definition file are broken into two groups: properties that start with "chart" affect the display of the data, and properties that start with "query" affect the metric query.

Table 7: Default Dashboard Properties

Property	Default Value
display.title	Metric "short name display"
display.height	CSS defined chart height
display.width	CSS defined chart width
display.y-axis-title	Metric count or value units
display.y-axis-min	Auto-calculated value
display.y-axis-max	Auto-calculated value
display.show-legend	true/false. Defaults to false for time intervals and true for category
display.line-type	line, spline, area (time interval only). Defaults to spline.
query.metric-id	Required. Displays the type of metric used for the chart.
query.instance-type	The product instance types to match. If not specified all instance types are matched. To match more than one instance type, specify this parameter multiple times. A list of valid instance types will be returned in an error message if an invalid value is provided.

Property	Default Value
query-instance-group	The product instance groups to match. If not specified all instance groups are matched. This parameter is currently not implemented.
query-instance-location	The product instance locations to match. If not specified all instance locations are matched. To match more than one location, specify this parameter multiple times. Valid locations are contained in the location attribute of the result from resource InstancesResource.
query.instance-hostname	The product instance hostnames to match. If not specified all instance hostnames are matched. To matched more than one hostname, specify this parameter multiple times. Valid hostnames are contained in the hostname attribute of the result from resource InstancesResource.
query.instance-version	The product instance versions to match or null to match all instance versions. Valid version strings are contained in the version attribute of the result from resource InstancesResource.
query.instance	The specific product instance IDs to match. If not specified all instances are used. Valid instance IDs are contained in the id attribute of the result from resource InstancesResource.
query.start-time	Start time relative to the query.end-time. Format is -NmhdwMy (e.g., -2h starts two hours from the end-time) or absolute in ISO8601 format YYYY-MM-DDThh:mm:ss (where fields at the right are optional)
query.end-time	End time relative to the current time. Format is -NmhdwMy (e.g., -2d starts two hours ago) or absolute as described in query.start-time.
query.max-intervals	An integer that specifies the maximum number of time intervals to include in the result, which controls how much time each data point in the result represents.
query.statistic	Defaults to the primary statistic for the metric (typically average or count)
query.dimension	Chart dimension. For example, application-name:SSO Application,ERP Application
query.pivot	instance, histogram, or dimension name
query.top-n	An integer limit on the number of data series in the chart. Positive values will limit the results to the series with the N largest average value, negative values will be limited to the N smallest.

To Create a New Dashboard Chart Definition

For this example procedure, it is assumed that you have properly installed an UnboundID Metrics Engine and UnboundID Identity Broker and its backend external servers.

1. Open a browser and go to: <https://<metrics-engine-host>:<port>/docs/doc-index.html>
2. On the Metrics Engine Documentation page, click the Metric Documentation link, and select a metric to chart, or click the Metrics Engine Chart Builder tool to create a chart.
3. On the Chart Builder tool, configure your chart to meet your requirements. Once you are done, make note of the Chart Properties on the bottom left of the page. You will need to copy-and-paste these properties into a properties file.
4. Create a properties file and copy-and-paste the Chart Properties on the Chart Builder page into the file, and then save the file with a descriptive name, for example, my-

`chart.properties`. The property file directly correlates the listed parameters to the Metrics Engine REST API `DataSetResource.getDataSet` method, which is accessed via GET at `"/metrics/{metric-id}/dataset"`. If no values are specified for a property, then the default values will be used. If you want to exclude a parameter, use `IGNORE` as a value (e.g., `display.title=IGNORE`). Only the `query.metric-id` property is required.

```
query.metric-id=metric-sample-query-qualifier-count
display.height=400
display.width=600
query.top-n=10
query.start-time=-4w
query.end-time=-1m
display.title=Throughput & Response Time
display.sub-title=For All Instances
display.y-axis-title=Metric Qualifier Count
display.series-color-map=throughput=#ff0000
display.show-legend=true
display.series-name-map=throughput=DS-Throughput,response-time=DS-ResponseTime
display.series-colors=#008000,#ff00ff,#0000ff,#00ff00
query.pivot=metric
query.dimension=metric:throughput,response-time
query.max-intervals=25
```



Note: All edits to existing files may be overwritten in future upgrades. To ensure your edits are preserved, create new files with the prefix `"my_"`.

5. Change to the `<server-root>/config/velocity/templates` directory, and copy the `broker-dashboard.vm` file to `my-broker-dashboard.vm`. Modify the following section by adding your file reference. For multiple charts, you can remove the comments and add your chart name to the `$includedCharts` list. For this example, add a single chart definition after the `#end` statement shown below:

```
##
## Only include the charts we want to render...
##

#set ($includedCharts = ["oauth-token-request", "oauth-exceptions", "oauth-grant-
type", "my-chart"])

#foreach( $chartDefinitionFileName in $includedCharts )
#  set($chartDefinition =
    $dashboard.chartDefinitionsByFileName.get($chartDefinitionFileName))
#  parse("_chart.vm")
#end

set($chartDefinitionFileName = "my-chart")
set($chartDefinition =
    $dashboard.chartDefinitionsByFileName.get($chartDefinitionFileName))
parse("_chart.vm")
```

6. Change the `dashboard_url` property on the Broker Admin Console web application to reflect the new template name from step 3.

```
$ bin/dsconfig set-web-application-extension-prop \
--extension-name Broker-Admin-Console \
--set dashboard-url:https://example.com:8443/view/my-broker-dashboard
```

7. If you make more changes, reload the Dashboard page to see the changes. You do *not* have to restart the server for the changes to take effect.

Testing the Dashboard Changes

After you make edits to the chart definition files and the dashboard template file, you can quickly test your changes using a browser. Open a browser and point to URL:

```
https://<metrics-engine>:<https-port>/view/<template-file-name>
```

The URL renders the dashboard in a browser (where `<template-file-name>` does not include the `.vm` file suffix). This approach allows testing of new charts and chart options without impacting the dashboard currently used by the Identity Broker Console web app, assuming `<template-file-name>` is not the same template referenced in the `dashboard-url` configuration property for the web app.

Chapter

4

Data Collection and Metrics

This chapter describes how data is collected, how to tune the data collection, and how to access the data.

Topics:

- [*Overview of Metrics Concepts*](#)
- [*Overview of Query Concepts*](#)
- [*About the Data Collection Process*](#)
- [*About the Collection of System Monitoring Data*](#)
- [*About Monitored Server Clock Skew*](#)
- [*Tuning Data Collection*](#)
- [*About Data Processing on the Metrics Engine*](#)
- [*Accessing Monitoring Data*](#)
- [*Monitoring Service Level Agreements*](#)

Overview of Metrics Concepts

A metric corresponds to a single measurement made within the server. The Metrics Engine collects three types of metrics:

- **Count metrics.** These metrics represent the number of times a specific event happens within the server. Examples of count metrics include number of LDAP operations performed, network packets received, or new connections established.
- **Discrete metrics.** These metrics correspond to measurements that have both a value and a weight. For example, the duration of an LDAP operation or the average duration of a checkpoint.
- **Continuous-valued metrics.** These metrics measure things that always have a value. For example, these metrics include the amount of free disk space, the current number of connected clients, and the number of operations pending in the work queue.

Each metric collected by the Metrics Engine is of only one of these types, and the type is determined by what is measured and how it is measured. The statistics that can be applied when reading values depend on the metric type. Only count statistics are available for count metrics. Discrete metrics have count, average, and histogram statistics available, which expose a count of the values broken down into bucket ranges. Average, minimum, and maximum statistics are available for continuous-valued metrics.

The metric type also plays a role in how samples are aggregated. Aggregation occurs when multiple metric samples taken over time are collapsed into a single sample.

About Analyzing Aggregated Data

We think of metrics as having dimension because the dimension are a convenient way to organize the fact that a single metric may have several different values at the same time. Another way to think of the sample data is as independent data values, where each value is associated with exactly one set of dimensions. It can be more convenient to examine the data with certain dimensions aggregated, rather than pivoted or split. The aggregation helps us form a more simplified mental image of the data, which in turn helps us understand it more quickly.

Because the sample data stored in the DBMS is actually unaggregated, we need to understand the mathematics of aggregation. The following table shows data for a one-dimensional example:

Table 8: Example One-Dimensional Data

Dimension Value	T0	T1	T2	T3	T4	T5	T6	T7
a	5.0	5.0	5.1	5.2	5.1	5.2	5.1	NaN
b	5.0	5.0	NaN	5.2	5.1	5.2	5.1	NaN
c	5.0	5.0	5.1	5.2	5.1	5.2	5.1	NaN
d	6.0	6.0	6.1	6.2	5.1	6.2	6.1	NaN

If we aggregate dimension value (a:d) at time T0, we get different values depending on what statistic we request:

```
MINIMUM(aggregate((a:d)@T0) == 5.0
MAXIMUM(aggregate((a:d)@T0) == 6.0
AVERAGE(aggregate((a:d)@T0) == 21.0/4
COUNT(aggregate((a:d)@T0) == 21.0
```

If we aggregate dimension value (a:d) at time T2, we get different values depending on what statistic we requested:

```
MINIMUM(aggregate((a:d)@T2) == 5.1
MAXIMUM(aggregate((a:d)@T2) == 6.1
AVERAGE(aggregate((a:d)@T2) == 16.3/3
COUNT(aggregate((a:d)@T2) == 16.3
```

Note that the NaN values do not count as a zero, so missing data does not adversely affect aggregation. However, the COUNT statistic looks very different at T2 than it did at T0, even though the raw data only changed by 25%.

If we aggregate dimension value (a:d) at time T7, we get different values again. Here, we have no data to work with, so the aggregates are all NaN.

```
MINIMUM(aggregate((a:d)@T7) == NaN
MAXIMUM(aggregate((a:d)@T7) == NaN
AVERAGE(aggregate((a:d)@T7) == NaN
COUNT(aggregate((a:d)@T7) == NaN
```

The second axis of aggregation is across time. Normally, you would not think of time as an aggregation, but the DBMS only contains four different time resolutions for the samples. So, unless you want one of those four resolutions, you have to aggregate time. Using the same data as above, we aggregate time into two samples, such that T0-T3 are sample 1 and T4-T7 are sample 2. We will not aggregate by dimension. The results are given in the following table.

Table 9: Example Time Aggregation Data

Dimension Value	S1	S2
a	20.3/4	15.4/3
b	15.2/3	15.4/2
c	20.3/4	15.4/3
d	24.3/4	17.4/3

Note how again the NaN values do not affect the computations, and that the time aggregation is always the average of all actual values.

Next, we aggregate over time where the samples do not fit evenly into the new time intervals. In this example, we aggregate our eight time intervals into three as follows:

```
T0,T1,T2 -> S1
T3,T4,T5 -> S2
T6,T7 -> S3
```

The resulting aggregation follows.

Table 10: Aggregating Over Time with Uneven Samples

Dimension Value	S1	S2	S3
a	15.1/3	15.4/3	5.1

Dimension Value	S1	S2	S3
b	10/2	15.5/3	5.1
c	15.1/3	15.5/d	5.1
d	18.1/3	17.5/3	6.1

However, the results can be skewed if you have an outlier value in the wrong place. If the dimension value d at time T6 was 1.0, then the dim value d at sample time S3 would be 1.0 because it would not have any other data to average with.

Averaging that occurs during aggregation can result in misleading data when taken out of context. Generally, it is not wise to aggregate the raw data, isolate a single point in the aggregate results, and draw any conclusions. An outlier value in an aggregate should be examined along the different pivot dimensions before you can infer real meaning from the data, as missing data can influence the aggregates.

About the Types of Metrics

A count metric indicates the number of times a specific event happens within the server. The exact length of the measurement interval is not important. For example, the number of packets received on a network interface during a measurement interval is a count metric. Each measurement returns the count of the number of packets received during that measurement interval only. The sample contains the number of occurrences, whether the measurement interval is 5 seconds or 2 minutes. Another example of a count metric is the number of megabytes of data written to a disk device during the measurement interval. Using the COUNT statistic when querying for a count metric will return the sum of the counts. If the query has a time-based pivot, then it returns the sum of the counts split into time quanta. Count metrics can often be converted into a rate. Using the examples above, the per-minute rates would be packets per minute and Megabytes per minute, which ensures that the time quant is 1 minute in duration.

A continuous metric is a measurement of a value where the thing being measured always has a valid value at each measurement point. For example, CPU percent busy is a continuous metric; for every sample interval, a valid CPU percent busy measurement can be taken. A continuous metric differs from a count metric in that you cannot sum continuous metric samples across time in a meaningful way. For example, if we have a 1 second measurement of CPU percent busy and the CPU is 25% busy for 10 seconds, summing these samples would show the CPU is 250% busy, which is not meaningful. Instead, continuous metric samples use average, minimum, and maximum statistics. If you want to know how busy the CPU has been since midnight, you average, rather than sum, the samples since midnight.

A discrete metric is a measurement that has both a value and a weight. A value with a higher weight means more samples within the sample period for that value. A discrete metric is analogous to a weighted average and requires that multiple measurements be taken within a single sample interval. For example, response time is a discrete metric, where the actual response time of each LDAP operation is averaged and the number of LDAP operations is provided as the weight. Discrete metrics are different from continuous metrics because each measurement is weighted. If no LDAP operations occur in a sample interval, the value would be zero and the weight would be zero.

Some continuous and discrete metrics may also report a minimum/maximum value if the measurement is composed of multiple sub-measurements. The minimum/maximum values are

aggregated by averaging rather than using a `min()`/`max()` function, so the aggregated values do not automatically push to the extremes but rather reflect the median of the minimum/maximum values.

Some discrete metrics may also convey histogram data. Histogram data represents an additional set of measurements that take individual measurements and place them into buckets, where each bucket is defined by a value range. The Metrics Engine supports histograms with up to 15 buckets. Histogram valued samples are unique because they give a picture of the distribution of the values, and because they more precisely answer the question of "How many samples are greater than X?". When multiple measurements are reduced to a single number (average), then the sample value distribution is lost. This loss occurs at the fine-grained measurement level, and during time-based aggregation. However, a histogram representation does not lose the distribution information. Histograms can be added over time so that we can always answer the question "How many samples are greater than X?" exactly (if the value of X is a histogram bucket boundary).

About Dimensions

Dimensions provide a means of aggregating and subdividing metric sample values in a way that logically follows what is actually measured. For example, metrics that measure disk activity have a `disk-device` dimension. Aggregating on the `disk-device` dimension shows the average disk activity for all disks, where pivoting (splitting) by the `disk-device` dimension shows the activity for specific disks.

Every metric has a logical `instance` dimension, which corresponds to the server that the sample was created on. Beyond that, each metric may have up to three dimensions, which are defined in the metric definition.

For example, the `sync-pipe-completed-ops` metric has two dimensions, the `pipe-name` and `pipe-result`. The `pipe-name` is the name of the sync pipe as configured on the UnboundID Synchronization Server. The `pipe-result` is one of the following set of values:

- > `exception`
- > `failed`
- > `failed-at-resource`
- > `failed-during-mapping`
- > `match-multiple-at-dest`
- > `no-match-at-dest`
- > `already-exists-at-dest`
- > `no-change-needed`
- > `out-of-scope`
- > `success`
- > `aborted-by-plugin`
- > `failed-in-plugin`

At each measurement interval for each sync pipe on each sync server, there will be a value for each of the `pipe-result` values. So, for a single Synchronization Server with two sync pipes, `pipe-one` and `pipe-two`, the samples generated for each sample period look like the following. Note that the timestamp is constrained to time-only for brevity.

```
08:15:05, sync-pipe-completed-ops, pipe-one, exception, 1
08:15:05, sync-pipe-completed-ops, pipe-one, failed, 7
08:15:05, sync-pipe-completed-ops, pipe-one, failed-at-resource, 1
08:15:05, sync-pipe-completed-ops, pipe-one, failed-during-mapping, 1
08:15:05, sync-pipe-completed-ops, pipe-one, match-multiple-at-dest, 3
08:15:05, sync-pipe-completed-ops, pipe-one, no-match-at-dest, 0
08:15:05, sync-pipe-completed-ops, pipe-one, already-exists-at-dest, 0
08:15:05, sync-pipe-completed-ops, pipe-one, no-change-needed, 1
08:15:05, sync-pipe-completed-ops, pipe-one, out-of-scope, 1
08:15:05, sync-pipe-completed-ops, pipe-one, success, 125
08:15:05, sync-pipe-completed-ops, pipe-one, aborted-by-plugin, 1
08:15:05, sync-pipe-completed-ops, pipe-one, failed-in-plugin, 0
08:15:05, sync-pipe-completed-ops, pipe-two, exception, 3
08:15:05, sync-pipe-completed-ops, pipe-two, failed, 9
08:15:05, sync-pipe-completed-ops, pipe-two, failed-at-resource, 2
08:15:05, sync-pipe-completed-ops, pipe-two, failed-during-mapping, 1
08:15:05, sync-pipe-completed-ops, pipe-two, match-multiple-at-dest, 4
08:15:05, sync-pipe-completed-ops, pipe-two, no-match-at-dest, 0
08:15:05, sync-pipe-completed-ops, pipe-two, already-exists-at-dest, 0
08:15:05, sync-pipe-completed-ops, pipe-two, no-change-needed, 1
08:15:05, sync-pipe-completed-ops, pipe-two, out-of-scope, 1
08:15:05, sync-pipe-completed-ops, pipe-two, success, 217
08:15:05, sync-pipe-completed-ops, pipe-two, aborted-by-plugin, 1
08:15:05, sync-pipe-completed-ops, pipe-two, failed-in-plugin, 0
```

First, we compare how busy pipe-one is compared to pipe-two by pivoting on `pipe-name`. We do not pivot on `pipe-result`, allowing all twelve results to aggregate to a single value. This results in the following:

```
pipe-one 141
pipe-two 239
```

However, failures would get double-counted, once in the failed result and again in the specific failure mode. So, we can filter specific dimension values into the result by considering only samples with `success` or `failed` `pipe-result` values in the aggregation. This results in the following:

```
pipe-one 132
pipe-two 226
```

These values provide the real sync pipe operation count. Next, we can pivot by `pipe-result`, not `pipe-name`, to get a set of counts that show the distribution of the counts of the specific error types, as well as the success and failure. This data provides a quick way of assessing the kinds of problems being encountered by the sync pipes.

The dimensions give us a way to pivot or aggregate along a metric-specific axis. All metrics have the `instance` pivot and the `time` pivot. Metrics that support the histogram statistic can also have a `histogram` pivot. The following diagram illustrates a response time histogram pivot.

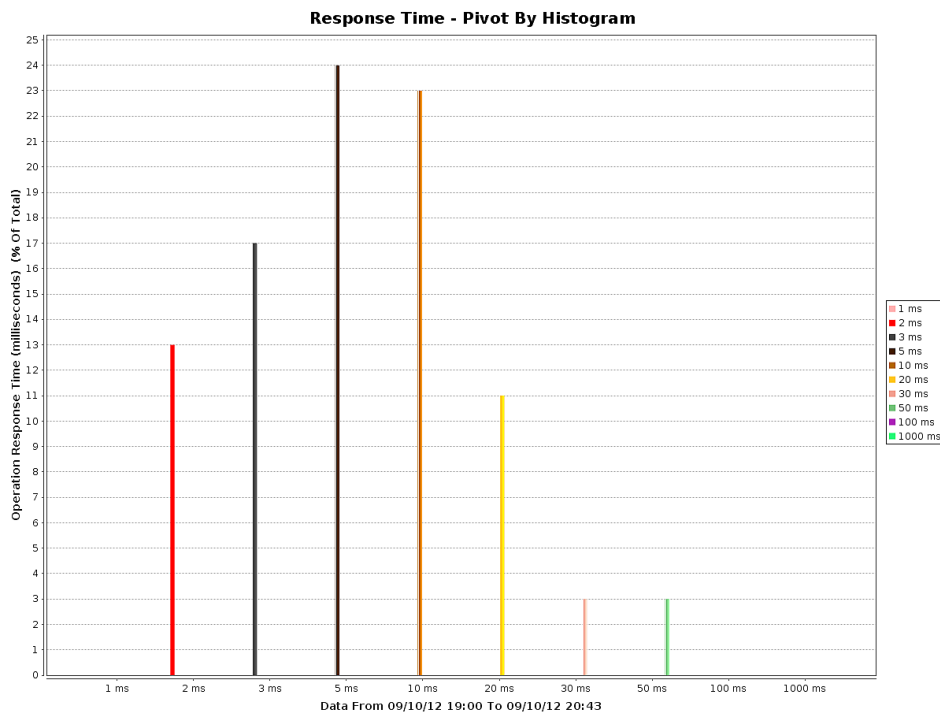


Figure 24: Pivot by Histogram

A time pivot allows the results to show time as a dimension, which breaks the samples that correspond to the requested time range into time quanta. Commonly, you specify N samples across range R, filling in a time-series chart that shows the metric value as a function of time. The following diagram illustrate a response time pivot by time.

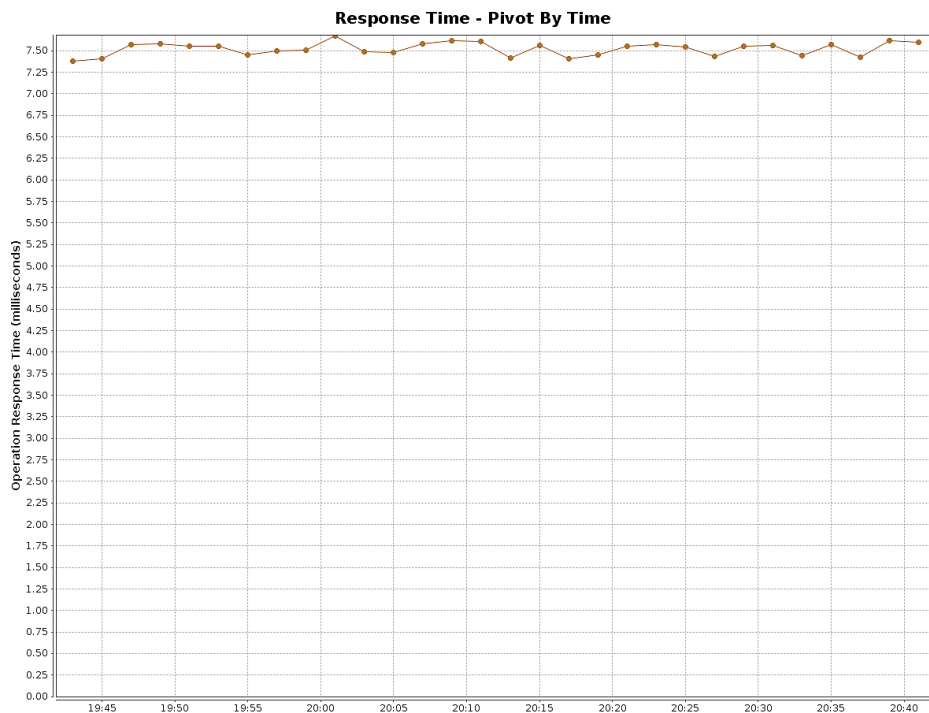


Figure 25: Pivot by Time

An instance pivot allows the results to be pivoted, or split, by server instance, allowing us to compare servers against each other. We can see how busy each server's CPU is by looking at the `host-system-cpu-used` with an instance pivot. The following diagram illustrates response time pivoted by time and instance.

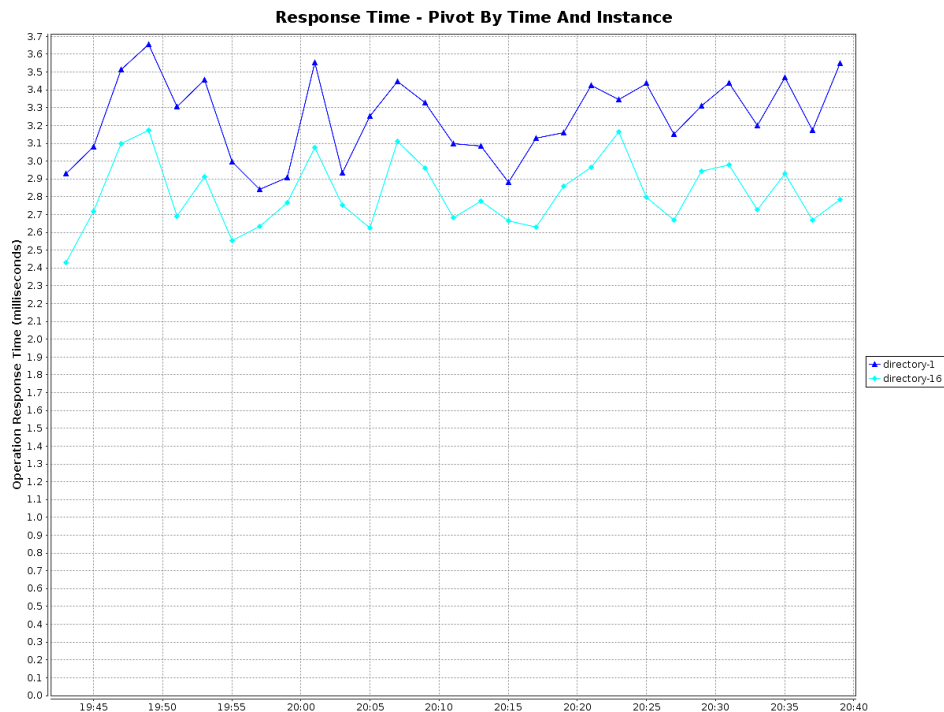


Figure 26: Pivot by Time and Instance

A histogram pivot requires a metric that supports the histogram statistic, and discriminates the results by histogram bucket boundaries. For example, LDAP response time with a histogram pivot shows how many LDAP operations fell into each of the histogram buckets. The following diagram illustrate throughput pivoted by time, instance, and application.

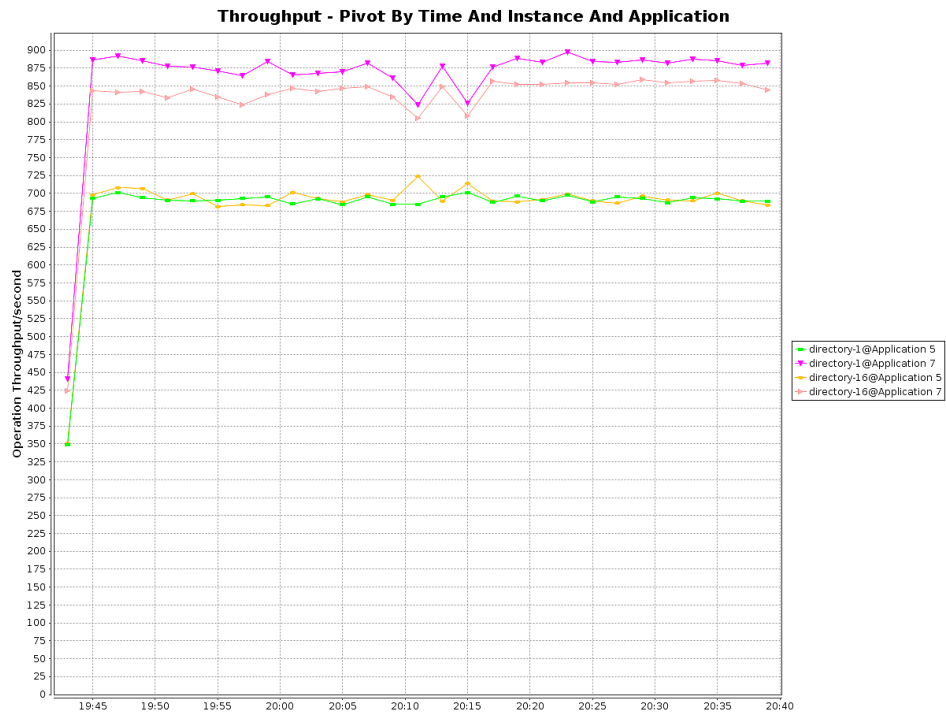


Figure 27: Throughput Pivot

Overview of Query Concepts

A metric query consists of three components:

- The data used to calculate the query results
- The aggregation method used on the data to calculate the query result
- The format of the query result

The remainder of this section describes each of these components in more detail.

Selecting Query Data

The data used to generate the results of a metric query are driven by the following factors:

- Metric and statistic
- Time range
- Server instances included in the result (optional)
- Included dimension values (optional)
- Histogram range (optional)

Every query returns results for a single statistic, such as the average, and of a single metric, such as response time.

A query must include the time range used to generate the results. Time ranges can either be absolute dates (in ISO-8601 format) or relative dates (such as -30m). A relative start time offset

is relative to the end time. A relative end time offset is relative to the current time. When no end time is specified, the server includes results up to the current time.

The time range and the desired number of points, if you have selected pivot by time, dictates the resolution of data used to process the query. For example, the finest granularity of data, one second resolution, is only kept for a few hours. It will not be used to satisfy a query spanning multiple days.

By default, all server instances that produce the metric are used to calculate the query results. However, the metric query can be restricted to one of the following:

- > A specific list of servers
- > Servers of a given type, such as identity data stores
- > Servers within a specific location

For metrics that include one or more dimensions, a query can be evaluated across a subset of dimension values. For example, the results returned for the response-time metric can be restricted to just the `search` and `modify` values of the `op-type` dimension.

For discrete-valued metrics that break their values down into histogram ranges, you can query the count statistic applied to a subset of histogram buckets by specifying a minimum and/or maximum histogram value. For example, a query on the response-time metric could return a count of operations that took longer than 100 milliseconds.

Aggregating the Query Result

You may want a metric query to return the full, raw data that matches the query parameters, so that the server can aggregate metric results across time, server instance, dimension value, or histogram value. The server aggregates results, except when the query indicates not to, by using a pivot. The mechanism for aggregating the data depends on the type of metric, as described earlier. A pivot directs the query processor to not aggregate one component of the query data. A pivot can be one of the following:

- > Time
- > Server instance
- > A specific dimension
- > Histogram buckets

Zero or more pivots can be specified in the query with the following results:

- If no pivot is specified, then the query returns a single number that represents the aggregation of all matched data. For example, a query with no pivot might return the total number of operations that have completed today.
- A single pivot results in one-dimensional data, such as a time-based chart with a single line or a simple bar chart.
- Using two pivots results in two-dimensional data, such as a time-based chart with a separate line for each server instance, or a stacked bar chart that shows the number of completed operations broken down by server and operation type.

- Using three pivots results in three-dimensional data, such as a stacked, grouped bar chart that shows completed operations broken down by server, operation type, and result.

Beyond aggregating multiple samples into one, the data returned by a metric query can be further manipulated to make it more consumable by the client. For example, queries can be scaled on the count statistic to return the count of events per second, per minute, or per hour. Counts of histogram values can be returned by a percentage of the total. For example, instead of returning the raw count of operations that took longer than 50 milliseconds to complete, the results could be returned as the percentage of all operations that took longer than 50 milliseconds to complete. A value of 0.02% is more meaningful than a value of 40.

Formatting the Query Result

The final step of query processing is to convert the results into the format requested by the client. Results can be returned in one of the following formats:

- > A CSV spreadsheet
- > A PNG or a JPG chart
- > XML format
- > JSON format

About the Data Collection Process

The Metrics Engine polls all the monitored servers over LDAP to fetch alert, status, and performance data. Status data indicates the most current status of each monitored server. Alert data reflects the alerts emitted by each server. Performance data exposes the `cn=monitor` entry of each product server.

For a complete summary of the metrics and dimensions that can be exposed through the RESTful Metrics API, see the reference files located in the `docs/metrics-guide` directory. Most metrics have a count, minimum, maximum, and average.

The following sections describe the types of data collected in more detail.

About Performance Data

Performance data represents a majority of the data collected by the Metrics Engine. Depending on how you configure the servers in your topology, each may produce hundreds of kilobytes of performance data per minute, and the Metrics Engine stores performance data for 20 years. You must configure the volume of performance data collected by each monitored server so that the Metrics Engine can keep up with the flow. Ideally, the amount of data captured has little to no impact on the performance of the monitored system.

The performance data model is a dimensional data model, meaning that a measurement may be taken on multiple simultaneous values that are distinguished by dimension values. For example, a response time metric provides the time in milliseconds it took a server to respond to an LDAP request. This response-time metric has two dimensions: application name and operation

type. The application name reflects the connection criteria of the request. The operation type corresponds to the LDAP operation, such as add, bind, or search. So, if a server has 20 different connection criteria, each response-time sample may have 140 different values, one for each of the applications multiplied by the number of operation types.

The performance data captured on the monitored server has a record with the following fields:

Name	Data Type	Description
Timestamp	Date	Time of measurement, using clock on the monitored server
Metric	String	Name of metric
Dimension	String[3]	Values of dimensions 1 - 3
Count	Int	Number of measurements represented by this sample
Average	Double	Average value of this sample
Minimum	Double	Optional minimum value of this sample
Maximum	Double	Optional maximum value of this sample
Buckets	Int[]	Optional histogram data associated with this sample

When a performance record is imported into the Metrics Engine, it is normalized to reduce the size of the record. The normalized record contains the following information in the Metrics Engine:

Name	Data Type	Description
batchID	Int	The ID of the batch of data to which this record belongs
sampleTime	Timestamp	The time the sample was captured or equivalent information after aggregation
metric_qual	Int	The ID of a structure that reflects the metric and all dimension values
definitionID	Int	ID of the histogram definition, if the data belong to a histogram-valued sample
count	Int	Number of measurements represented by this sample
avg_val	Real	Average value for this sample
min_val	Real	Minimum value for this sample
max_val	Real	Maximum value for this sample
val1-15	Long	Histogram bucket values

About the Collection of System Monitoring Data

All UnboundID servers have the capability to monitor the health of the server and host system they run on for diagnostic review and troubleshooting. Initially, the servers do not collect any performance data until they are prepared for monitoring by an UnboundID Metrics Engine using the `monitored-servers add-servers` tool or an administrator enables system health data collection for real-time inspection and querying. At a high level, all of the important server and machine metrics which can be monitored are available in the `cn=monitor` backend.



Note: Windows is not a supported monitoring platform. Host system monitor data is unavailable on Windows.

The Stats Collector plugin is the primary driver of performance data collection for LDAP, server response, replication, local JE databases, and host system machine metrics. Stats Collector configuration determines the sample and collection intervals, granularity of data (basic, extended, verbose), types of host system collection (cpu, disk, network) and what kind of data aggregation occurs for LDAP application statistics. The Stats Collector plugin ensures that an UnboundID Metrics Engine is able to gather all of the detailed data required for a comprehensive diagnostic review.

The Stats Collector plugin relies exclusively on entries in the `cn=monitor` backend to sample data using LDAP queries. In order for real-time host system monitoring data to be present, the Host System Monitor Provider populates the monitor backend with specific real-time attributes about CPU and memory utilization. You can also configure the Host System Monitor Provider to collect real-time utilization data for specific disk subsystems and network interfaces on the host. Configuration of the Host System monitor provider enables the low-level generation of performance data through system-specific System Utilization monitor modules.

The System Utilization Monitors interface directly with the host operating system to gather statistics about CPU utilization and idle states, memory consumption, disk input and output rates, and queue depths, as well as network packet transmit and receive activity.

Utilization metrics are gathered via externally invoked OS commands, such as `iostat` and `netstat`, using platform-specific arguments and version-specific output parsing.

Enabling the Host System monitor provider automatically gathers CPU and memory utilization but only optionally gathers disk and network information. Disk and network interfaces are enumerated in the configuration by device names (e.g., `eth0` or `lo`), and by disk device names (e.g., `sd1`, `sdab`, `sda2`, `scsi0`).

About the External Collector Daemon

The System Utilization monitor contains an embedded collector daemon that runs on systems affected by a Java process fork memory issue, RFE 5049299 (i.e., when a process attempts to fork a child process, Solaris attempts to allocate the same amount of memory for the child process, which will likely fail when the parent process consumes a large amount of memory). The embedded collector daemon is started automatically for the UnboundID server via the startup script named `_start-collector-helper.sh`. The `start-collector-helper` inspects the Host System Monitor provider configuration to conditionally determine whether the external daemon process is required.



Note: On Linux, no OS external commands are forked. Instead, the `/proc` filesystem is accessed directly using file input/output to read the latest CPU, memory, disk, and network I/O data.

The external collector daemon operates by having an internal table of repeatable commands that run on a schedule. The collector creates a simulated filesystem in the `<server-root>/logs` directory for each command type so that the Host System Monitor Provider can find the output of the most recently collected data. The `<server-root>/logs` directory is the default folder for these files.



Note: You can override the default `<server-root>/logs` directory by running the following command:

```
$ bin/dsconfig set-monitor-provider-prop \  
--provider-name "Host System" \  
--set system-utilization-monitor-log-directory:/tmp
```

Commands that are repeated on an interval are executed on a thread at a 2x interval sampling rate. The filename of the output contains the sample timestamp, such as `iostats-[sample-timestamp]`. Repeating commands use a subdirectory for each command type to keep results isolated from other command types and to help organize file cleanup. If the collector daemon fails for any reason, the Host System Monitor provider is not left reading stale system data because the expected timestamp files will be missing. To handle clock-edge timing, the monitor sampler will also look for data in a filename of the previous second. Samples cannot be reused, because timestamp files are deleted once their data have been collected.

The collector daemon runs with no inter-process communication. However the collector daemon monitors a process PID file provided by the startup script and waits for the process PID file to be created and/or waits for an `empty-file-to-active` process PID transition. Once an active server process PID is acquired, the collector daemon monitors the contents of the process PID file as well as the file's existence, to determine whether the UnboundID server is active. If the process PID file is deleted, the process PID contained within the PID file changes, or the process PID becomes inactive, the UnboundID server has stopped and the monitor daemon exits within one second. The daemon also monitors the Host System Monitor provider configuration and exits within one second if the provider is disabled in the server.

Because of the cooperative nature of the external collector daemon files and the output file readers in the System Utilization monitor, the collector daemon can be safely killed by a system administrator. If the collector daemon is terminated, host system machine diagnostic metrics are not available for monitoring until the UnboundID server is restarted.

About Monitored Server Clock Skew

Correlating metric samples from multiple servers as a function of time requires that the timestamp associated with each sample (which is provided by the monitored server) is in sync. The monitored servers need to have their system clocks synchronized. The more time skew there is between monitored servers and the Metrics Engine, the less accurate is the time correlation across samples from different servers. If you have a five second spike in a metric on Server A and a similar six second spike on Server B, if the system clocks on Server A and Server B are not synchronized, you will not know which came first or if they were truly concurrent.

The Metrics Engine does not actively do anything to help synchronize the system clocks, but it does track that information and make it visible in the `cn=Monitored Server <server-name>,cn=monitor` entry.

The `system-clock-skew-seconds` attribute indicates the difference between the Metrics Engine system clock and the monitored server clock, in seconds. The larger this skew value, the less precision you have when comparing changes in data across servers.

While it is not necessary to keep the Metrics Engine clock synchronized with all of the monitored servers, it can be convenient when issuing metric queries with time ranges specified by offsets. Because the offset will be computed using the Metrics Engine system clock, if this clock is very different from the monitored servers' system clocks, then the start/end time of a metric query will not match the expected boundaries.

Tuning Data Collection

Collecting all of the performance data at the most granular level from all of the servers may not be possible without a significant investment in hardware for the Metrics Engine. Instead, you can tune your data collection to fit within the limits of your existing Metrics Engine hardware. The remainder of this section describes several strategies for tuning data collection.

Reducing the Data Collected

You may not require all of the metrics produced by the Metrics Engine. If not, tune the sets of metrics collected by using the `dsconfig` command-line tool to update the Stats Collector Plugin's `entry-cache` property. For example, to omit all metrics related to the entry cache set the `entry-cache-info` group as follows:

```
$ bin/dsconfig set-plugin-prop --plugin-name "Stats Collector" \  
--set entry-cache-info:none
```



Note: The `dsconfig` commands in this section are to be run on each monitored server, not necessarily on the Metrics Engine server.

The server collects information for eight different info groups. In this example, we set the `entry-cache-info` group to none, meaning that none of the metrics from that info group are produced. Limit data collection to the devices of actual interest.

Reducing the Frequency of Data Collection

The monitored servers produce metric samples as quickly as every second, which is useful for short-duration changes. However, these samples are less useful hours later, after the per-second data is aggregated to per-minute data. The following example illustrates how to use the `dsconfig` tool to change the base sample production rate from the default of 1 second to 10 seconds.

```
$ bin/dsconfig set-plugin-prop --plugin-name "Stats Collector" \  
--set "sample-interval:10 seconds"
```

This change reduces the total data volume by about 90 percent.

Reducing the Frequency of Sample Block Creation

You can also reduce the number of sample blocks processed by the Metrics Engine in a given time. By default, the monitored servers produce a new block of samples every 30 seconds. Increasing this to 60 seconds, while reducing the Metrics Engine's polling rate to 60 seconds, reduces the sample processing overhead. For example, you can change the frequency at which the monitored servers create sample blocks using the following `dsconfig` command:

```
$ bin/dsconfig set-backend-prop --backend-name metrics \
  --set sample-flush-interval:60s
```

Reducing Metrics Engine Impact on Performance

The UnboundID Identity Data Store, UnboundID Identity Proxy, and UnboundID Identity Data Sync servers all expose performance data through the `cn=monitor` DN. Performance penalties arise only when this data is read, either directly by an LDAP client, or by enabling either the Periodic Stats Logger or Stats Collector plugins.

The Periodic Stats Logger plugin reads the configured monitors and writes the resulting values to a CSV file that contains human-readable column titles and several value columns per line. The output is suitable for human consumption, typically through a spreadsheet application.

The Stats Collector plugin also reads the configured monitors and writes the resulting values to a CSV file, but this file is made available for LDAP clients at the `cn=metrics` DN. The Stats Collector CSV files are suitable for use by the Metrics Engine, and contain one metric value per line.

If you do not want to monitor performance, you can disable both the Periodic Stats Logger (disabled by default) and the Stats Collector (disabled by default) plugins using `dsconfig`. Each of these plugins adds an approximate 3% CPU utilization penalty, plus a negligible amount of disk I/O and JVM heap usage.

For example, to enable the Stats Collector plugin, use `dsconfig` as follows:

```
$ bin/dsconfig set-plugin-prop --plugin-name "Stats Collector" \
  --set enabled:true
```



Note: The `monitored-servers` tool will enable the Stats Collector plugin on the monitored server.

About Data Processing on the Metrics Engine

When blocks of samples arrive at the Metrics Engine, they are queued on disk and loaded into the database on a FIFO basis. Samples from a single server are processed in time-order, so that sample blocks with older data are always processed before a sample block containing newer data. The Metrics Engine does not do time-correlation between blocks coming from different

servers. So, server A samples from 2 hours ago may be loaded immediately after server B samples from two minutes ago. This flexibility allows different monitored servers to become unavailable to the Metrics Engine, for example, by going off line, without affecting the overall system monitoring. Also, a query for data from server A and B may return data for server B but not server A, until the data queued for server A has been collected and imported.



Note: Samples collected from the Metrics Engine itself are processed ahead of all other servers.

Data Importing

The Metrics Engine polls all of the monitored servers at a regular interval, looking for blocks of samples that have not already been collected. When new samples are available, the Metrics Engine fetches them via LDAP, queues them to disk, and adds an import record to the FIFO import queue. The Metrics Engine has one dedicated thread draining the import queue, taking each block of samples and converting them to the normalized form stored in the DBMS. The import queue's size is normally near zero, but under certain conditions it may become large.

For example, if a monitored server becomes unavailable for an extended period of time, perhaps for several hours, it will continue to queue blocks of samples locally. When it becomes available again, the Metrics Engine collection poll of that server will capture hundreds or even thousands of sample blocks. The Metrics Engine captures the sample blocks at a much faster speed than it can import them, causing the queue to grow for a period of time. If the Metrics Engine is stopped, this problem is compounded because all monitored servers will then have a backlog of sample blocks to be imported.

When the Metrics Engine first starts, it will queue (for import) all sample blocks still on disk. All sample blocks on disk at server startup are first checked for maximum sample age. Blocks that are older than two hours are discarded.

Data Aggregation

To maintain a size-limited DBMS while accumulating data over a period of years, the Metrics Engine aggregates data into four different levels. Each level contains data with less time-granularity, but covering a larger period of time. Data is aggregated from a lower (greater time granularity) to a higher level as soon as enough data for aggregation is available. For example, the level 0 data has one second granularity, and the level 1 data has 1 minute granularity. After level 0 has collected one minute's worth of data, the data from that minute can be aggregated to level 1.

The monitored servers generate three types of metrics, and each type is aggregated differently:

- **Counts.** Samples are aggregated by a sum of the values.
- **Continuous.** Samples are aggregated by an average of the values.
- **Discrete.** Samples are aggregated by a weighted average of the values.

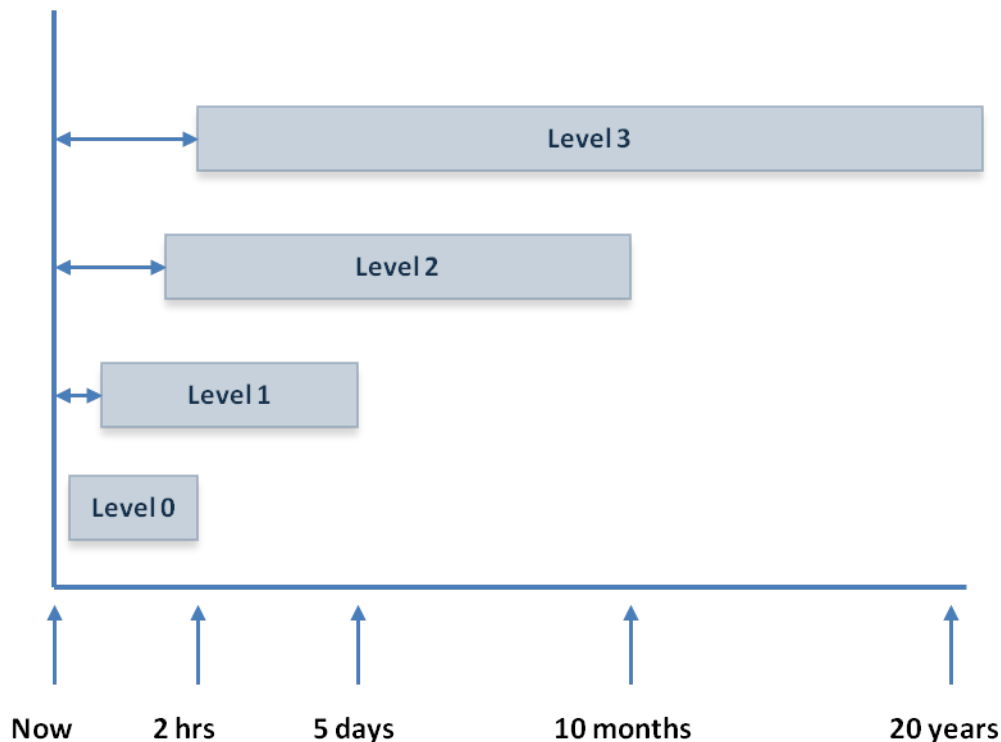
To keep the data tables for each aggregation level at a constrained size, each aggregation level has a maximum age for the samples. When the samples are older than this age, they are deleted from the level. While aggregation occurs soon after the samples arrive in the level, pruning occurs only after all samples in a block have passed their age limit.

The Metrics Engine attempts to collect data from all configured servers as efficiently as possible. However, Monitored Server availability, DBMS backlog, and Metrics Engine load can all cause the data pipeline to slow down. The data aggregation system is designed to correctly handle gaps in the data.

The resolution of the aggregation levels cannot be changed, but you can configure the maximum age of each level. The following table describes the aggregation levels:

Level	Resolution	Default Maximum Age	Max Age
0	1 second	2 hours	48 hours
1	1 minute	7 days	34 days
2	1 hour	12 months	5 years
3	1 day	20 years	20 years

The raw data from the Metrics Engine is initially put in level 0. After a period of time, the newest data in level 0 is aggregated and put into level 1. This aggregation process carries on up to level 3. To keep the DBMS at a fixed upper bound, as the data ages out of each level it is deleted. Consider the following diagram. Note that the x-axis time scale is non-linear:



Level 0 data holds the most recent 2 hours of data. When data in level 0 is older than 2 hours, it is deleted. Because the data in the lower levels have greater time resolution, transient data issues are more visible in lower levels than in upper levels. The aggregation process results in a type of averaging or data smoothing.

A second feature of this type of aggregation is that a gap exists between now and the newest available data for each level. This gap results from aggregation occurring on the boundary of the time resolution of the data. Level 3 data has one day resolution, so the newest data point it could have would need to aggregate an entire day's worth of data. If the aggregation occurs at midnight, then at 12:01 AM, the level 3 data would include yesterday. However, it will not include today until after 12:01 AM tomorrow.

The pruning of data from each level can fall behind at times, so that a given level has more data than it should. However, pruning occurs often enough to ensure that the storage for the data does not grow without bound.

Accessing Monitoring Data

The Metrics Engine stores the data it collects in a DBMS, accessed via JDBC. The default configuration uses a DBMS server located on the same host as the Metrics Engine, with JDBC access limited to loopback connections. Within the DBMS server itself, the Metrics Engine uses a distinct database instance and distinct schema within the database. To access this schema, the Metrics Engine uses a DMBMS user with rights to the specified schema. A user can access the metric data over an HTTP port using the `query-metric` tool. This tool uses the Metrics Engine REST API, which is also available to custom applications

The data collected by the Metrics Engine does not contain any of the data in the LDAP entries of the monitored servers, so there is no risk of customer data being inadvertently exposed. The Metrics Engine does collect monitored server configuration data, most commonly exposed in the dimension values.

Monitoring Service Level Agreements

The Metrics Engine provides the ability to aggregate and track performance data for one or more service level agreements (SLAs). The server aggregates the data using an SLA object that tracks the current and historical performance of LDAP operations (i.e., throughput and response times) that are tied to specifically monitored applications. The SLA object consists of a tracked application name, one or more LDAP operations to be considered, a set of servers that contributes performance data to the SLA and optionally, thresholds to generate alerts should the server exceed these limits.

Thresholds are optional configuration settings but are extremely useful in tracking server performance when enabled. If a threshold is not configured, the performance data is not monitored. Each threshold sets a limit that indicates a *warning* condition where the server's performance is nearing the critical threshold limit and/or a *critical* condition where the server's performance has *exceeded* the critical threshold value. Whenever the monitored server has entered either the warning or critical state, or when it has returned to its non-alerted state, the Metrics Engine generates an alert. The generated alerts are the same types as those created by the Identity Data Store and Identity Proxy servers and can be routed via the same configurable mechanisms for SNMP and SMTP (via the Alert Handler), such that a monitoring console or administrator can be notified when the tracked application performance goes out of tolerance. Although it is possible to gather this metric data using existing monitoring consoles, the SLA

object provides an added advantage in that it can report the aggregate performance of *all* servers involved, which is difficult to configure using external monitoring tools, since aggregate metrics can come from multiple values across multiple servers.

The SLA object provides a few additional features that make monitoring application performance a bit simpler.

- **Designating Servers that Contribute to SLA Tracking.** The SLA object includes a reference to a Server Query component that is used to designate the monitored servers that contribute to the SLA measurements. If your deployment has 10 Identity Data Store servers and 3 Identity Proxy servers, but only five of Identity Data Stores are used to provide service for a tracked application, the SLA object can be configured to remember which servers are involved.
- **REST API.** The Metrics Engine provides a REST API that allows you to list configured SLA objects and their current status, and to drill into any SLA object to get historical performance data across any desired time range. The Metrics Engine REST API also allows you to list alerts generated by SLA thresholds, blending the alert information with the threshold information in a way that gives a more contextual view of the tracked applications performance during (plus before and after) the period when it exceeded its configured limits.

About the Monitoring Thresholds

The Metrics Engine uses a Monitoring Threshold mechanism that has two subcomponents that you can select for your threshold configurations:

- **Spike Monitoring Threshold.** Used to configure a set of operational performance limits on a specific measurement where the limit is specified as a percent change from the most recent measurement average value. The Metrics Engine continually monitors the specified measurements and compares them to configured limits, producing alerts if the performance limits are not met. A Spike Monitoring Threshold has warning and critical limits, and will enter or leave an alerted state when the monitored value exceeds either of the limits. The Spike Monitoring Threshold is configured with limits that are percentages of the recent average value of the measurement, and is therefore useful when the valid range of the measurement is *not known* in advance. This type of limit is useful in detecting short-term changes in a measurement that fluctuates broadly over time. The limit is applied in both positive and negative directions, so that this type of threshold can detect an upward or downward spike in the value. The figure below shows an example of the spike monitoring threshold, where the red line is the average throughput/second and the green lines are the limits, showing the average window for the throughput.

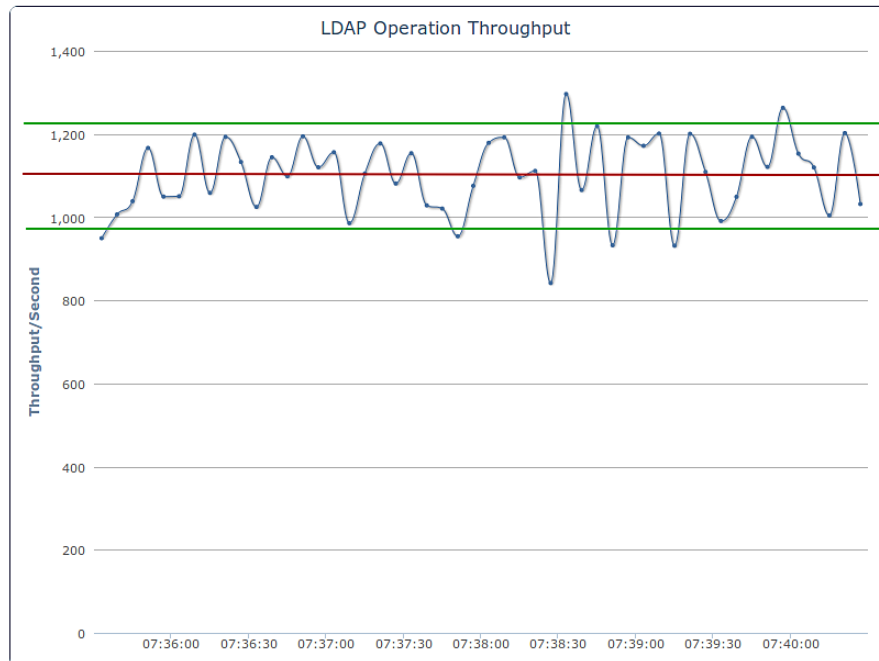


Figure 28: Spike Monitoring Threshold

- **Static Level Monitoring Threshold.** Used to configure performance limits on a specific measurement, where the specified limits are fixed values that do not change over time. The Metrics Engine continually monitors the specified measurements and compares them to configured limits, producing alerts if the performance limits are not met. A Static Level Monitoring Threshold has warning and critical limits, and will enter or leave an alerted state when the monitored value exceeds any of the limits. The Static Level Monitoring Threshold is configured with static numeric limits, and is useful when the expected valid range of the measurement *is known* in advance.

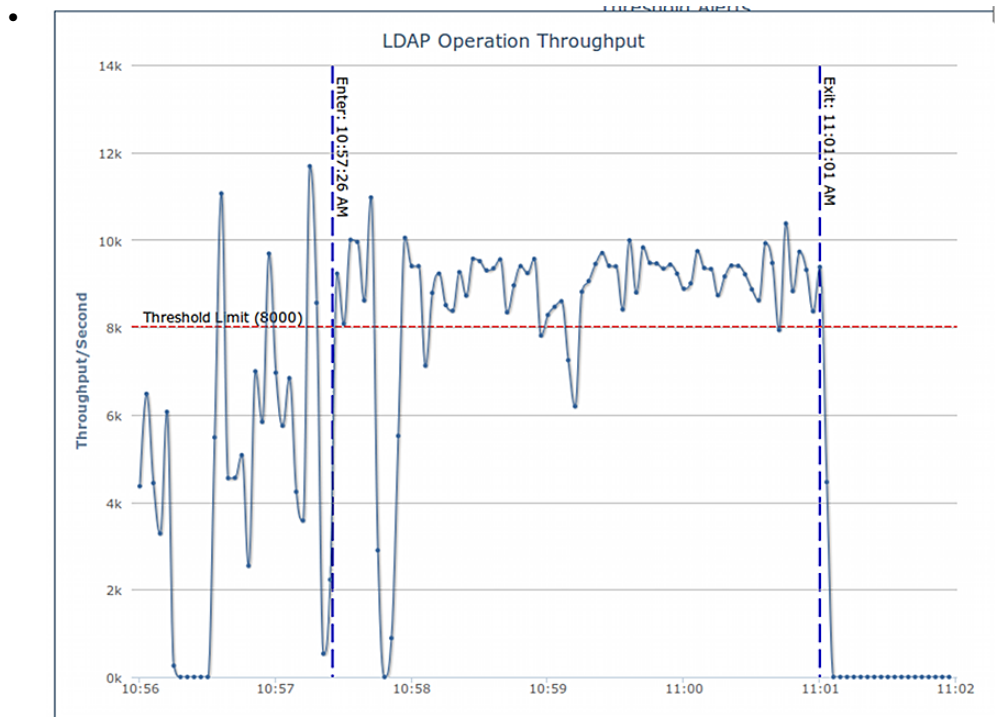


Figure 29: Static Level Monitoring Threshold

The Metrics Engine periodically evaluates each Threshold, computing new values for its current value, current average, and alerted state. The default evaluation period is 30 seconds, and it can be changed using the `threshold-poll-frequency` property of the "Monitoring Configuration" entry.

It is important to understand the timeline of the data used during the Threshold evaluation, so that you can make sense of the delay between the time when a performance change occurs on the monitored servers and when the SLA object reflects the change and alerts are subsequently issued. Using the figure below, a Threshold is evaluated at time 'Now'. The most recent data that Threshold uses is 1 minute old (i.e., Newest Data). Each Threshold evaluation requires at least 1 minute of new data (i.e., Minimum Data), so that at time 'Now' the Threshold is working with data that is between 1 and 2 minutes old (between Minimum Data and Newest Data).

Decreasing the `threshold-poll-frequency` so that Thresholds evaluate more frequently does not change these data limits, the Metrics Engine only checks to see if there is sufficient data more often. The 1 minute delay between 'Now' and 'Newest Data' is not configurable. This delay ensures the Metrics Engine has had enough time to poll the monitored servers and get the most recent data. The 1 minute delay between 'Newest Data' and 'Minimum Data' is configurable on a per-Threshold basis for Spike-valued Thresholds using the `average-value-window` property, but 1 minute is the minimum window. What this means from a practical perspective is that the time between when a monitored performance anomaly occurs on a monitored system, and when an alert is created will be between 2 and 3 minutes.

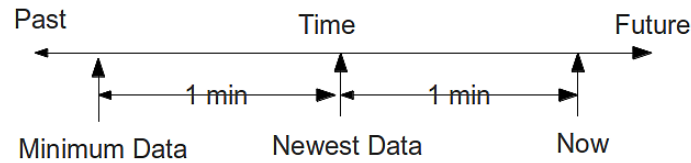


Figure 30: Threshold Time Line

Note also that, because the Metrics Engine can capture metrics data with a very fine time resolution (1 second data is the default), the data is often very "noisy," meaning that there is a lot of variation between samples. By default, the data is time-averaged (e.g., using 5 consecutive 1-second samples to produce a single 5-second value), and time-averaging will ultimately reduce the noise. However, "noisy" data can make it harder to choose an appropriate threshold limit value. If the limit value is too close to the noise levels, the threshold will alert due to values that have a very short time duration, which is usually not desirable or necessary.

To reduce the probability of a false threshold alert due to a short data spike, each threshold is configured with a `minimum-time-to-trigger` property, which determines the minimum time allowed to exceed the threshold before an alert is generated, and a `minimum-time-to-exist` property that determines the time required for the threshold to exit an alerted state. The following figure shows the low resolution response time monitoring for an LDAP operation.

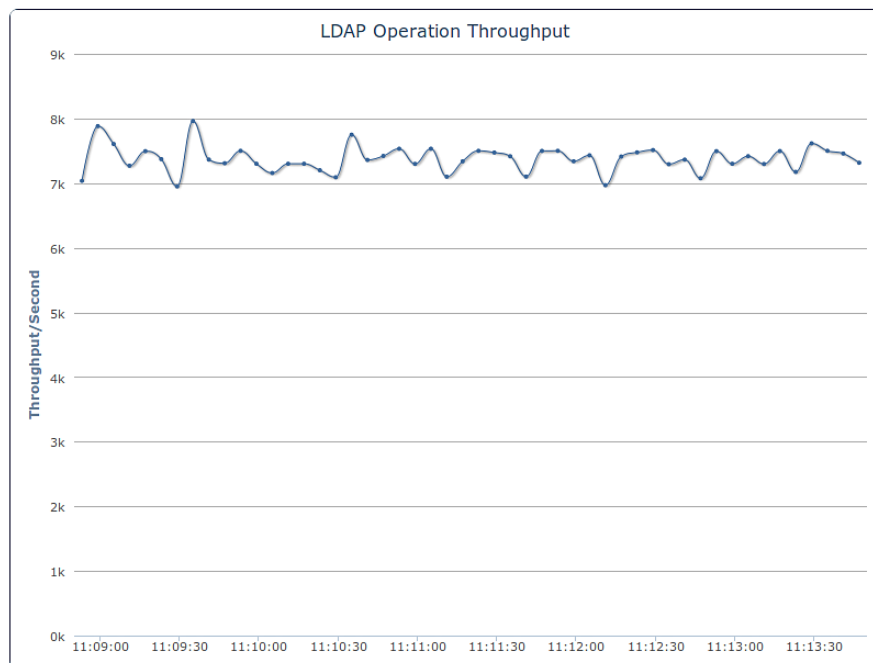


Figure 31: Response Time Monitoring - Low Resolution

The Metrics Engine also provides the option to display a high resolution view for the response time.

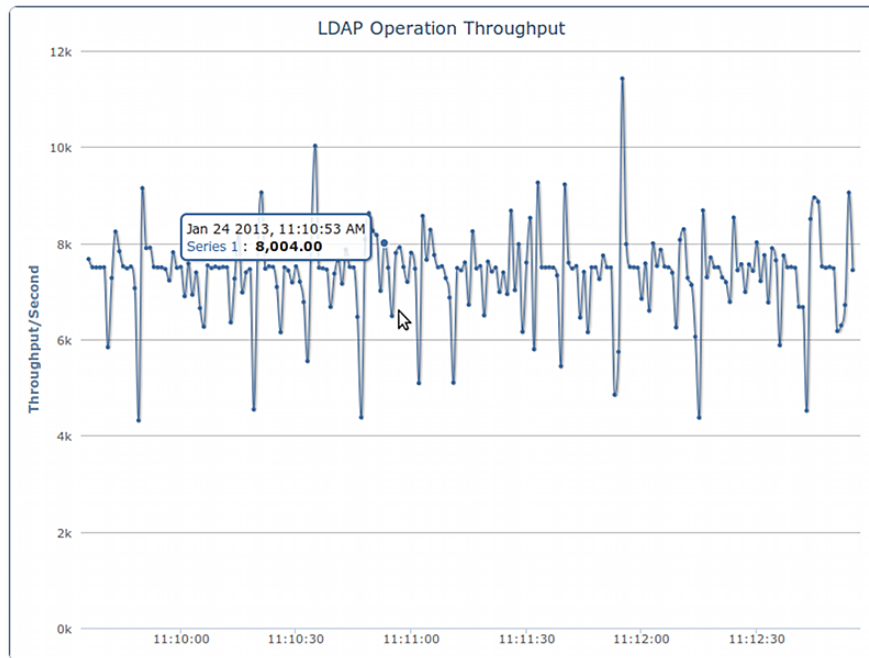


Figure 32: Response Time Monitoring - High Resolution

To Configure a Service Level Agreement (SLA)

Before you configure your SLA object, you must have the Metrics Engine up-and-running and monitoring your servers. The SLA object relies on existing performance metrics and only aggregates the data for specific SLAs. You can configure any number of SLA objects. For more information, see the *Metrics Engine Configuration Reference (HTML)*.

1. Use `dsconfig` to create a server query that specifies which servers will contribute to SLA monitoring. In this example, the command specifies the proxy servers located in Austin.

```
$ bin/dsconfig create-server-query \  
--query-name "Austin Proxy Servers" \  
--set server-instance-type:proxy \  
--set server-instance-location:Austin
```

2. Use `dsconfig` to set up a static-level monitoring threshold called "15ms response time." The alert condition is set to "entry", which means that the server will enter an alerted state (`alert-condition:entry`) and generate an alert if the server enters a warning state (`alert-on-warn:true` and `warn-if-above:12`) or critical state (`critical-if-above:15`). When the server leaves its alerted state, an alert will be generated indicating this condition (`alert-condition:exit`). The minimum amount of time that the threshold can be exceeded before an alert is generated is set to 15 seconds (`min-time-for-trigger:15s`).

```
$ bin/dsconfig create-monitoring-threshold \  
--threshold-name "15ms response time" \  
--type static-level \  
--set alert-condition:entry \  
--set alert-condition:exit \  
--set alert-on-warn:true \  
--set min-time-for-trigger:15s \  

```



```
--set min-time-for-exit:15s \
--set warn-if-above:12 \
--set critical-if-above:15
```

3. Use `dsconfig` to set up a static-level monitoring threshold called "5k ops/sec." The alert condition is set to "entry", which means that the server will enter an alerted state (`alert-condition:entry`) and generate an alert if the server enters a warning state (`alert-on-warn:true` and `warn-if-above:4`) or critical state (`critical-if-above:5`). When the server leaves its alerted state, an alert will be generated indicating this condition (`alert-condition:exit`). The minimum amount of time that the threshold can be exceeded before an alert is generated is set to 15 seconds (`min-time-for-trigger:15s`).

```
$ bin/dsconfig create-monitoring-threshold \
--threshold-name "5k ops/sec" \
--type static-level \
--set alert-condition:entry \
--set alert-condition:exit \
--set alert-on-warn:true \
--set min-time-for-trigger:15s \
--set min-time-for-exit:15s \
--set warn-if-above:4 \
--set critical-if-above:5
```

4. Use `dsconfig` to create an SLA that targets an SSO application and monitors the response and throughput times for LDAP bind operations. The response time threshold is set to 15ms. The throughput threshold is set to 5k operations per second. The targeted servers are the set of proxy servers, located in Austin.

```
$ bin/dsconfig create-ldap-sla \
--sla-name "SSO Application" \
--set enabled:true \
--set "application-name:SSO Application" \
--set "response-time-threshold-ms:15ms response time" \
--set "throughput-threshold-ops-per-second:5k ops/sec" \
--set ldap-op:bind \
--set "sla-server-query:Austin Proxy Servers"
```



Note: An SLA can be disabled, which prevents the Metrics Engine from evaluating the thresholds and generating alerts.

Chapter

5

Accessing the Metrics Engine Data

The data collected by the UnboundID Metrics Engine is available through two main interfaces, the Metrics Engine RESTful API and the query-metric command-line tool. This chapter contains information about how to use these tools to access your monitored data, including API reference materials.

This chapter includes the following topics:

Topics:

- [*About the query-metric tool*](#)
- [*Using the Query Metric Tool*](#)
- [*About the Metrics Engine API*](#)
- [*Metrics Engine API Reference*](#)

About the query-metric tool

The query-metric tool can be used to view the data in a more interactive way than the API itself permits. The tool is a client application of the Metrics Engine API. It features subcommands that can help you understand how to form an API query, as well as tell you what values are permissible.

The query-metric tool features a non-interactive mode as well as an interactive mode that prompts you for information like a wizard. In addition to the subcommands for listing metrics, server instances, and dimension values, you can form queries using the following subcommands:

- **explore** subcommand. This command creates a series of hyper-linked HTML files containing charts for a broad range of metrics. The tool generates these files by making a series of API queries for a set of servers and metrics. The tool helps you understand the breadth of available metrics and look for patterns or anomalies across multiple metrics. In interactive mode, the tool prompts you for the servers and the metrics using a menu.
- **query** subcommand. This command help you refine a query for specific data of interest. In interactive mode, the tool prompts you for the server, metrics, dimensions, statistics, and pivot values using menus. The tool can be used to request a server generated chart image file or data formatted in XML, JSON, or CSV.

Using the Query Metric Tool

The query-metric tool gives you access to all the metrics being gathered by the server. This tool allows you to explore the full breadth of the collected data, examining any metric and dimension.

This tool runs in both interactive and non-interactive modes. Interactive mode presents options in a wizard-like way, allowing you to choose values from menus of options. To start the tool in interactive mode, simply invoke the tool with no parameters:

```
$ query-metric
```

You will be shown a menu allowing you to choose the subcommand you want to invoke. Once the subcommand is finished, you will be given the opportunity to choose another subcommand or quit. You may invoke a subcommand in interactive mode by specifying it on the command line.

For example, the following command starts the `explore` subcommand in interactive mode:

```
$ query-metric explore
```

The `explore` subcommand of the query-metric tool will capture results from several metrics. All metrics can be pivoted by 'instance', but beyond that most metrics have different dimensions. The pseudo-dimensions `dim1/dim2/dim3` may be used to instruct the tool to query on the metrics 1st/2nd/3rd dimension (if available). The following command will will pivot all metrics by instance and the first two dimension of each metric:

```
$ query-metric explore --pivot instance --pivot dim1 --pivot dim2
```

In non-interactive mode, the tool generates charts based on command-line input. For example, the following command requests information from the local Metrics Engine listening on port 8080 and generates response-time and throughput charts for Proxy Server instances in Austin for the previous two weeks:

```
$ query-metric explore --httpPort 8080 --instanceType proxy \  
  --instanceLocation Austin --metric response-time --metric throughput \  
  --startTime -2w
```

The following command line can be used to obtain a JSON formatted data table that shows average throughput for all Proxy Server instances in the topology over time with 100 data points. Each line in the chart represents either an application's search or modification throughput. Throughput values are represented as operations per second:

```
$ query-metric query --hostname localhost --httpPort 8080 \  
  --username cn=user1,cn=api-users --password secret --table json \  
  --metric throughput --instanceType proxy --statistic average \  
  --pivot op-type --pivot application-name \  
  --dimension op-type:search,modify --rateScaling second \  
  --maxIntervals 100 --startTime 2012-09-01T17:41Z \  
  --endTime 2012-09-30T17:41Z
```

To see a list of all supported subcommand and global tool options, invoke the tool's help as follows:

```
$ query-metric -?
```

To get detailed information about a particular subcommand, invoke the subcommand's help as follows:

```
$ query-metric explore -?
```

About the Query Metric Explore Command HTML Pages

The `query-metric` tool's `explore` subcommand generates queries that drive the Metrics API, such as adding a specific chart or tabular result to a custom dashboard. It also generate HTML page output. This section provides some examples of the HTML page output you can expect from the `explore` subcommand.

For example, the `explore` subcommand can generate an index page that shows tables of all the metrics that were collected:

Generated: Fri Sep 07 12:13:40 CDT 2012

[View page of all metrics](#)

Directory Entry Cache - Directory entry cache updates, hit count, and size	
Metric	Description
Entry Cache Hit Count	Number of times the server successfully read an entry from the entry cache
Entry Cache Hit Ratio	Percentage of times an entry was found in the entry cache
Entry Cache Percent Full	Number of entries in the entry cache relative to the maximum number of entries that can be in the cache
Entry Cache Read Attempts	Number of times the server tried to read an entry from the entry cache
Entry Cache Size	Number of entries in entry cache
Entry Cache Updates	Number of times an entry was added or updated within the entry cache
Remaining Entry Cache Memory	Percentage of available JVM memory available to Entry Cache

Directory Backend - Directory backend entries, size, cleaning, reads, and writes	
Metric	Description
Active Cleaner Threads	Number of active database cleaner threads for the specified backend
Backend Checkpoint Duration	Time taken for the backend database checkpoint to complete
Backend Checkpoints	Number of database checkpoints performed by the backend
Backend Cleaner Backlog	Number of backend database files that must be cleaned to reach the target utilization
Backend Entry Count	Number of entries currently in the backend
Backend Nodes Evicted	Number of nodes evicted from the database cache to meet memory constraints
Database Cache Percent Full	Percentage of the backend database cache in use
New Backend Database Log Files	Number of new database log files created by backend
Random Disk Reads	Number of Random IO Disk reads made by backend
Random Disk Writes	Number of Random IO Disk writes made by backend
Sequential Disk Reads	Number of Sequential IO Disk reads made by backend
Sequential Disk Writes	Number of Sequential IO Disk writes made by backend
Size On Disk	Total size of database files on disk for this backend
Time Since Last Checkpoint	Time since backend last completed a checkpoint

External Server - External server health and operations	
Metric	Description
External LDAP Operation Throughput	Number of LDAP operations performed on the external server
External Server Available Connections	Number of connections to an external server that are established but not in use
External Server Failed Connections	Number of connection attempts to an external server that failed

Clicking the "View page of all metrics" link on the index page display a page that contains all the generated charts. This view allows you to easily scroll through all of the charts collected:



Clicking one of the links in the Metric column of the index page or clicking on a chart itself displays a new page. This page contains the chart, links for making requests from the Metrics Engine API for the same data in chart and data formats, as well as other information about the collected data:

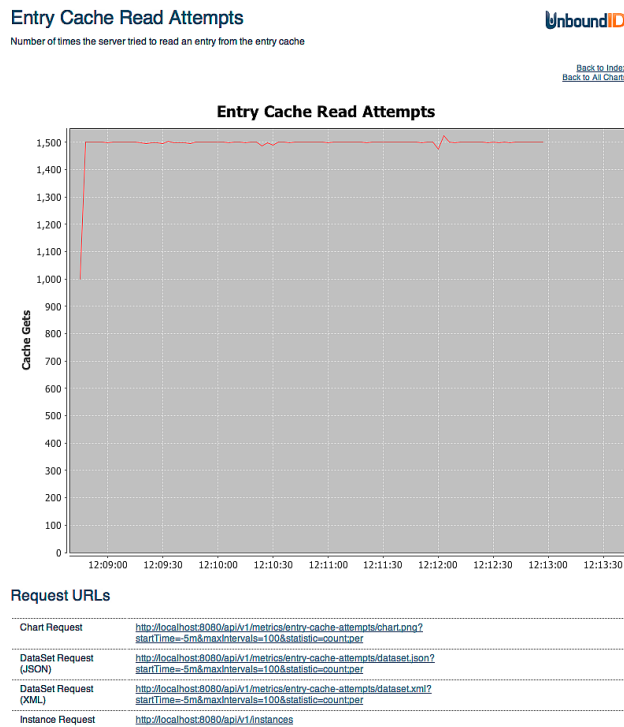


Figure 35: Metric Details Page

About the Metrics Engine API

The Metrics Engine API can be used to build custom dashboards and other applications for exploring the data. It features a RESTful interface that can be accessed using standard, off-the-shelf tools and charting packages, such as the Google Chart Tools. The Metrics Engine API can also be easily accessed from a Web browser.

Metrics Engine API Reference

This section provides reference information for using the RESTful API of the UnboundID Metrics Engine.

Connection Security and Authentication

As discussed in the section "Setting Up the Database," no sensitive user data is collected by the Metrics Engine and stored in the DBMS. However, if you wish to secure access to the Metrics Engine REST API, you may enable secure HTTPS connections and require authentication. A

secure HTTPS Connection Handler may be created during setup, and authentication can be enabled using `dsconfig`.

Metrics Engine REST API authentication is disabled by default. When enabled, the REST API service requires HTTP basic authentication to be used with each request. Requests will be authenticated against entries in the `api-users` LDIF backend or entries in "cn=Root DNs,cn=config". Because Root DN users possess many privileges by default, we strongly recommend that you authenticate with users in the `api-users` backend instead, to prevent the unnecessary use of more privileged account credentials.

To Enable REST API Authentication

Enable REST API authentication by setting the `require-api-authentication` property of the Monitoring Configuration object.

- Set this property as follows:

```
$ bin/dsconfig set-monitoring-configuration-prop --set require-api-  
authentication:true
```

To Add a REST API User

1. Create a file name `api-user1.ldif` containing one or more user entries with no privileges. Below is a sample user entry.

```
dn: cn=app-user1,cn=api-users  
changeType: add  
objectClass: inetOrgPerson  
objectClass: person  
objectClass: top  
cn: app-user1  
uid: app-user1  
sn: User1  
userpassword: ap11  
ds-pwp-password-policy-dn: cn=Default Password Policy,cn=Password Policies,cn=config
```



Note: The password is in clear text. It will be encrypted during the next step.

2. Load the entry using `ldapmodify`.

```
$ bin/ldapmodify --filename api-user1.ldif
```

3. You can now authenticate using either the `cn` or the `uid` of the users added, in this case `api-user1`.

Tuning the RESTful API Service

By default, the Metrics Engine can open up to 20 simultaneous connections to its PostgreSQL RDBMS. The number of connections allowed is set by the `max-db-connections` property of the Monitoring Database configuration object. The HTTP Connection Handler, which runs the REST Servlet, has a default `num-request-handlers` value of 15. This value must be less than

the maximum number of connections. If the RESTful API service is handling its maximum number of concurrent requests, this leaves at least five database connections available for other components, such as the import service.



Note: If the Metrics Engine services requests through multiple HTTP Connection Handlers, such as to support both HTTP and HTTPS, then you must ensure that the total number of request handlers for both HTTP Connection Handlers does not exceed the maximum number of DB connections.

Listing Monitored Instances

Get a list of all monitored instances along with their current status. The default format will be JSON if none is specified. The servlet will use the HTTP Accept header as a hint if no specific format is specified. Results may be filtered using the various `instance` query params.

URL	/api/v1/instances
Method	GET
Formats	JSON, XML
Query Parameters	<ul style="list-style-type: none"> • instanceHostname (multi-valued) - Hostname(s) of the servers to get data from. Multiple values are evaluated as logical ORs. • instanceLocation (multi-valued) - Location(s) of the servers to get data from. Multiple values are evaluated as logical ORs. • instanceType (multi-valued) - Types of server(s) to get data from. Possible values are: <ul style="list-style-type: none"> > directory > proxy > sync > metrics-engine • instanceVersion (multi-valued) - Version(s) of the servers to get data from. Multiple values are evaluated as logical ORs.

EXAMPLES: All instances in JSON format.

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/instances.json
```

All directory and proxy instances in XML format:

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/instances.xml?
instanceType=directory&instanceType=proxy
```

Response Code	200 OK
Response Body	{ "found" : 2,

```

"offset" : 0, #
"instances" : [ {
  "type" : "directory",
  "id" : "unboundid4510",
  "hostname": "unboundid4510.example.com",
  "displayName" : "unboundid4510",
  "version": "UnboundID Directory Server 4.5.1.0",
  "operatingSystem": "Solaris",
  "status": {
    "state": "ONLINE"
  }
}, {
  "type" : "directory",
  "id" : "unboundid3500",
  "hostname": "unboundid3500.example.com",
  "displayName" : "unboundid3500",
  "version": "UnboundID Directory Server 3.5.0.0",
  "operatingSystem": "Linux",
  "status": {
    "state": "DEGRADED",
    "unavailableAlerts": [
      "replication-backlogged"
    ]
  }
}
]
}
}

```

Retrieving a Monitored Instance

Get a specific monitored instance along with its status. The default format will be JSON if none is specified. The servlet will use the HTTP Accept header as a hint if no specific format is specified.

URL	/api/v1/instances/{instance}{.format}
Method	GET
Formats	JSON, XML
Query Parameters	N/A

Server State	<p>The Metrics Engine returns the server state status of the monitored instance, which is displayed by the <code>status</code> parameter:</p> <p>The <code>status</code> parameter can have one of the following values:</p> <ul style="list-style-type: none"> • OFFLINE. The server cannot be contacted at all. • STARTING_UP. The server is starting. • ONLINE. The server is available and apparently normal. • DEAD_LOCKED. The server has detected that it is deadlocked and unable to process more operations. • UNAVAILABLE. The server is unavailable although not necessarily offline. This may be due to the server being in lock-down mode but may be online for administrative purposes. • DEGRADED. The server is available but is in a state that renders it incapable of providing services. • CONNECTION_ERROR. The server could not connect or has lost connection to the host.
---------------------	---

EXAMPLE: Instance with ID `metrics-engine` in JSON format.

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/instances/metrics-engine.json
```

Response Code	200 OK
Response Body	<pre>{ "displayName": "metrics-engine", "hostname": "metrics-engine.example.com", "id" : "metrics-engine", "operatingSystem": "Solaris", "status" : { "state" : "ONLINE" }, "type" : "metrics-engine", "version": "UnboundID Metrics Engine 4.5.1.0" }</pre>

Listing Available Metrics

Get a list of metric definitions along with their the units, dimensions, names, and so on. The default format will be JSON if none is specified. The servlet will use the HTTP Accept header as a hint if no specific format is specified.

URL	/api/v1/metrics{.format}
Method	GET
Formats	JSON, XML
Query Parameters	<ul style="list-style-type: none"> • name - Limits the results to metrics whose names contain a matching substring. The search is not case-sensitive. • type (multi-valued) - Limits the results to the metrics of the specified type. Possible values are: <ul style="list-style-type: none"> > discreteValued > continuousValued > count • group (multi-valued) - Limits the results to the metrics with the specified group. Possible values are: <ul style="list-style-type: none"> > Directory Backend > Monitoring Data Cache > Java Virtual Machine > LDAP > Entry Balancing > Directory Entry Cache > External Server > Host System > Metric Query > Monitoring DBMS > Monitoring Data Processing > Replication > Sync Pipe


	<ul style="list-style-type: none">• instanceType (multi-valued) - Limits the result to metrics that uses the specified instance types as sources. Possible values are:<ul style="list-style-type: none">> directory> proxy> sync> metrics-engine• statistic (multi-valued) - Limits the results to metrics that provides the specified statistics. Possible values are:<ul style="list-style-type: none">> count> average> maximum> minimum> histogram
--	---

EXAMPLES:All metrics in JSON format.

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics.json
```

All count type metrics in the “directory backend” group providing either count or average statistics in JSON format:

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics.json?type=count&group=directory%20backend&statistic=count&statistic=average
```

 **Note:** Spaces in parameter values may be encoded as %20 or t.

Response Code	200 OK
Response Body	<pre>{ "found": 7, "metrics": [{ "countUnit": { "abbreviatedName": "Chkpt", "pluralName": "Checkpoints", "singularName": "Checkpoint" }, "description": "Number of database checkpoints performed by the backend", "dimensions": [{ "id": "backend", "values": ["userroot"] }], "group": "Directory Backend", "id": "backend-checkpoints", "instanceTypes": ["directory"], "name": "Backend Checkpoints", "shortName": "Checkpoints", "statistics": ["count"], "type": "count" }], }</pre>

```

{
  "countUnit": {
    "abbreviatedName": "Evicted",
    "pluralName": "Evicted",
    "singularName": "Evicted"
  },
  "description": "Number of nodes evicted from the
    database cache to meet memory constraints",
  "dimensions": [
    {
      "id": "backend",
      "values": [
        "userroot"
      ]
    }
  ],
  "group": "Directory Backend",
  "id": "backend-nodes-evicted",
  "instanceTypes": [
    "directory"
  ],
  "name": "Backend Nodes Evicted",
  "shortName": "Nodes Evicted",
  "statistics": [
    "count"
  ],
  "type": "count"
},
{
  "countUnit": {
    "abbreviatedName": "JE File",
    "pluralName": "JE Files/Logs",
    "singularName": "JE File/Log"
  },
  "description": "Number of new database log files
    created by backend",
  "dimensions": [
    {
      "id": "backend",
      "values": [
        "userroot"
      ]
    }
  ],
  "group": "Directory Backend",
  "id": "backend-new-db-logs",
  "instanceTypes": [
    "directory"
  ],
  "name": "New Backend Database Log Files",
  "shortName": "New Log Files",
  "statistics": [
    "count"
  ],
  "type": "count"
},
{
  "countUnit": {
    "abbreviatedName": "RandRead",
    "pluralName": "Random Reads",
    "singularName": "Random Read"
  },
  "description": "Number of Random I/O Disk reads
    made by backend",
  "dimensions": [
    {
      "id": "backend",
      "values": [
        "userroot"
      ]
    }
  ],
  "group": "Directory Backend",
  "id": "backend-random-reads",
  "instanceTypes": [
    "directory"
  ],
  "name": "Random Disk Reads",
  "shortName": "Random Reads",

```

	<pre> "statistics": ["count"], "type": "count" }, { "countUnit": { "abbreviatedName": "Rand Wr", "pluralName": "Random Writes", "singularName": "Random Write" }, "description": "Number of Random I/O Disk writes made by backend", "dimensions": [{ "id": "backend", "values": ["userroot"] }], "group": "Directory Backend", "id": "backend-random-writes", "instanceTypes": ["directory"], "name": "Random Disk Writes", "shortName": "Random Writes", "statistics": ["count"], "type": "count" }, { "countUnit": { "abbreviatedName": "Seq Rd", "pluralName": "Sequential Reads", "singularName": "Sequential Read" }, "description": "Number of Sequential I/O Disk reads made by backend", "dimensions": [{ "id": "backend", "values": ["userroot"] }], "group": "Directory Backend", "id": "backend-sequential-reads", "instanceTypes": ["directory"], "name": "Sequential Disk Reads", "shortName": "Sequential Reads", "statistics": ["count"], "type": "count" }, { "countUnit": { "abbreviatedName": "Seq Wr", "pluralName": "Sequential Writes", "singularName": "Sequential Write" }, "description": "Number of Sequential I/O Disk writes made by backend", "dimensions": [{ "id": "backend", "values": ["userroot"] }], "group": "Directory Backend", "id": "backend-sequential-writes", </pre>
--	---

	<pre> "instanceTypes": ["directory"], "name": "Sequential Disk Writes", "shortName": "Sequential Writes", "statistics": ["count"], "type": "count" }], "offset": 0 }</pre>
--	---

Retrieving a Metric Definition

Get a specific metric definition. The default format will be JSON if none is specified. The servlet will use the HTTP Accept header as a hint if no specific format is specified.

URL	/api/v1/metrics/{metricId}.{format}
Method	GET
Formats	JSON, XML
Query Parameters	N/A

EXAMPLE: Metric with ID backend-sequential-writes in XML format.

```

curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics/backend-sequential-writes.xml
```

Response Code	200 OK
Response Body	<p>Count type metric.</p> <pre> <?xml version="1.0" encoding="utf-8" standalone="yes"?> <countMetric xmlns="com.unboundid.directory.mon.api.v1" id="backend-sequential-writes" name="Sequential Disk Writes" shortName="Sequential Writes" group="Directory Backend"> <description>Number of Sequential I/O Disk writes made by backend</description> <instanceTypes> <instanceType>directory</instanceType> </instanceTypes> <statistics> <statistic>count</statistic> </statistics> <dimensions> <dimension id="backend"> <values> <value>userroot</value> </values> </dimension> </dimensions> <countUnit singularName="Sequential Write" pluralName="Sequential Writes" abbreviatedName="Seq Wr" /> </countMetric></pre>
Response Body (JSON format)	<p>Discrete valued metric:</p> <pre> { "countUnit": { "abbreviatedName": "Cluster Operation", "pluralName": "Cluster Operations", "singularName": "Cluster Operation" }, "description": "Time spent performing a cluster operation on a DBMS partition", "dimensions": [{</pre>

	<pre> "id": "aggregation-level", "values": ["level0", "level1", "level2"] }, { "group": "Monitoring DBMS", "id": "monitor-cluster-time", "instanceTypes": ["metrics-engine"], "name": "DBMS Cluster", "shortName": "DBMS Cluster", "statistics": ["average", "count"], "type": "discreteValued", "valueUnit": { "abbreviatedName": "Msec", "pluralName": "Milliseconds", "singularName": "Millisecond" } } } </pre>
Response Body (JSON format)	<p>Continuous valued metric.</p> <pre> { "description": "Number of active database cleaner threads for the specified backend", "dimensions": [{ "id": "backend", "values": ["userroot"] }], "group": "Directory Backend", "id": "backend-active-cleaner-threads", "instanceTypes": ["directory"], "name": "Active Cleaner Threads", "shortName": "Active Cleaner Threads", "statistics": ["average"], "type": "continuousValued", "valueUnit": { "abbreviatedName": "Cleaner", "pluralName": "Cleaner Threads", "singularName": "Cleaner Thread" } } </pre>

Performing a Metric Query

A metric query will return the collected sample data from the various monitored instances. The data returned by the query may be presented several different ways depending on client requirements.

Common Query Parameters	<ul style="list-style-type: none"> • instanceType (multi-valued) - Type(s) of instances to get data from. Possible values are: <ul style="list-style-type: none"> > directory > proxy > sync
--------------------------------	---

	<p>> metrics-engine</p> <ul style="list-style-type: none"> • instanceLocation (multi-valued) - Location(s) of the instances from which data is collected. • instanceHostname (multi-valued) - Names of the machines hosting the instances. • instanceVersion (multi-valued) - Version(s) of the instances providing the data. • instance (multi-valued) - ID(s) of the instances from which data is collected. Note that the instance ID is the <code>cn</code> of the external server. It is the same name as the name displayed by the <code>status</code> command. • startTime - Include samples on or after the specified time. The time is either an absolute time in ISO 8601 format (such as 2012-08-13T19:36:00Z) or a time relative to the <code>endTime</code> (such as -5m or -4h). By default, the start time is -5m. • endTime - Include samples on or before this time. The end time is either an absolute time in ISO 8601 format or a time relative to now (such as -5m or -4h). The default end time is now. Note that offset time values are relative to the current system clock time on the Metrics Engine. • maxIntervals - The number of separate intervals, between the start and end times, returned. This value may be thought of as the “resolution” of the data over time. By default, the maximum number of intervals is 1, which means all samples collected between the start and end times will be aggregated into one result according to the statistic selected. • statistic - Retrieve and apply this statistic to the data. Default for count based metrics is count and average for other metric types. Possible values are: <ul style="list-style-type: none"> > count > average > minimum > maximum > histogram • dimension (multi-valued) - Include only these dimension values. A colon separates the dimension name and values, which are separated by commas (for example, <code>op-type:add,delete</code>). • pivot (multi-valued) - Pivot by these dimensions. A pivot keeps the data separated along different dimensional values. The value “instance” may be used to keep the data separate between different instances. For metrics that have the histogram statistic, the histogram pivot may also be used to keep the values of each histogram bucket separate. • tz (timezone) - Specifies the timezone to be used when displaying dates. By default, GMT. The timezone is specified in Java <code>TimeZone</code> format, so “US/Central” specifies CST in the United States.
Sub-parameters for the count and average statistics	<p>Both the count and average statistics of count type metrics may have a rate scale applied to occurrences over a period of time using the <code>per</code> sub-parameter. The valid rate scaling values are:</p> <p>> s or second</p>

	<ul style="list-style-type: none"> > m or minute > h or hour
Sub-parameters for the histogram statistic	<p>By default, the histogram statistic includes all buckets and keeps the raw value for each bucket. However, you can configure graphs that show the percentage of all operations above a given threshold, such as 50 ms. These graphs are useful for focusing on the small percentage of operations in a given category. We recommend that this value be a histogram bucket boundary. If the value falls between boundaries, then the buckets where it falls will be included in the data. The possible values are:</p> <ul style="list-style-type: none"> > min - Includes in the calculation only the histogram data above the given threshold > max - Provides an upper bound on the histogram value > percent - Allows the histogram values to be reported as a percentage of the overall values. Instead of returning raw counts, the value is a fraction of the total. This percentage is calculated within a pivot. <p>Note that if both min and max are specified, the returned value is the sum of all buckets between min and max (including the max).</p>

Data Set Structure

The data set structure is a proprietary data structure that is space-optimized and designed for easy interoperability with charting libraries like Highcharts, FusionCharts, or JFreeChart. This format is ideal for clients capable of performing some simple manipulation of the returned data to fit the target use case. The default format will be JSON if none is specified. The servlet will use the HTTP Accept header as a hint if no specific format is specified.

URL	/api/v1/metrics/{metricId}/dataset{.format}
Method	GET
Formats	JSON, XML



Note: All of the Common Query parameters apply to this resource.

Get the average response time metric for add and delete operations from 7/7/2012 for all identity data stores and identity proxies in two locations, Austin and Houston:

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics/response-time/dataset?
instanceType=directory
&instanceType=proxy&instanceLocation=austin&instanceLocation=houston&startTime=-1d
&endTime=2012-07-07&pivot=instance&dimension=op-type:add,delete
```

Get the new connections metric and scale the value per hour in the last 5 minutes:

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics/new-connections/dataset?
statistic=count;per:hour
```

Get the percentage of all occurrences in the last hour where the response-time metric has a value above 50ms:

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics/response-time/dataset?
statistic=histogram;min:50;percent&startTime=-1h
```


Response Code	200 OK
Response Body	<p>When only one time interval is requested, a category dataset is returned where the first pivoted dimension values are listed as categories and each data point corresponds to a category. Subsequent pivots and histogram buckets are included as a series and sub-series. This example is the result of two pivots, op-type and instance:</p> <pre> { "type" : "category", "firstSampleTime" : 1344090300000, "lastSampleTime" : 1344090600000, "metric" : { "type" : "discreteValued", "id" : "response-time", "name" : "Response Time", "shortName" : "Response Time", "description" : "Time for server to process an LDAP operation and send a response to the client", "group" : "LDAP", "instanceTypes" : ["directory", "proxy"], "statistics" : ["average", "count", "histogram"], "dimensions" : [{ "id" : "application-name" }, { "id" : "op-type", "values" : ["Search", "ModifyDN", "Add", "Delete", "Compare", "Bind", "Modify"] }], "countUnit" : { "singularName" : "Operation Response Time", "pluralName" : "Operation Response Time", "abbreviatedName" : "Response Time" }, "valueUnit" : { "singularName" : "Millisecond", "pluralName" : "Milliseconds", "abbreviatedName" : "Msec" } }, "series" : [{ "label" : "unboundid35", "data" : ["0", "0", "0", "0", "0", "0", "0"] }, { "label" : "unboundid3", "data" : ["0", "0", "0", "0", "0", "0", "0"] }], "label" : "op-type", "categories" : ["Search", "Delete", "Bind", "Modify", "Add", "ModifyDN", "Compare"] } </pre>
Response Body	<p>For queries that request more than one time interval, a timeInterval data set will be returned. Each data point corresponds to the consecutive time interval. Pivoted dimensional values and histogram buckets are included as a series and sub-series.</p> <pre> { "type" : "timeInterval", "firstSampleTime" : 1344089954000, "lastSampleTime" : 1344090254000, "metric" : { "type" : "discreteValued", "id" : "response-time", "name" : "Response Time", "shortName" : "Response Time", "description" : "Time for server to process an LDAP operation and send a response to the client", "group" : "LDAP", "instanceTypes" : ["directory", "proxy"], "statistics" : ["count", "average", "histogram"], "dimensions" : [{ "id" : "application-name" }, { "id" : "op-type", "values" : ["search", "modifydn", "add", "delete", "compare", "bind", "modify"] }], "countUnit" : { </pre>

	<pre>"singularName" : "Operation Response Time", "pluralName" : "Operation Response Time", "abbreviatedName" : "Response Time" }, "valueUnit" : { "singularName" : "Millisecond", "pluralName" : "Milliseconds", "abbreviatedName" : "Msec" } }, "series" : [{ "label" : "unboundid3", "data" : ["0", "0", "0", "0", "0", "0", "0", "0", "0", "0"] }, { "label" : "unboundid35", "data" : ["0", "0", "0", "0", "0", "0", "0", "0", "0", "0"] }], "resolutionInSeconds" : 30 }</pre>
--	---

Chart Image

This API is the simplest way to retrieve and visualize the collected metrics data. The server will generate a chart of the query result. PNG is the default format if no format is specified.

URL	/api/v1/metrics/{metricId}/chart{.format}
Method	GET
Formats	PNG, JPEG
Query Parameters	<ul style="list-style-type: none">> width - The width of the image. Default value is 800.> height - The height of the image. Default value is 600.> showLegend - Whether to include the chart legend. Default value is true.> title - A custom title of the chart. Default value is the metric name.



Note: All of the Common Query parameters apply to this resource.

For example, to get the percent CPU used by all servers over the last week, pivot by server instance as follows:

```
curl -s -o chart.png https://<MetricsEngineHost>8080/api/v1/metrics/host-system-cpu-used/chart?maxIntervals=50&startTime=-1w&pivot=instance:
```

This results in the following chart.

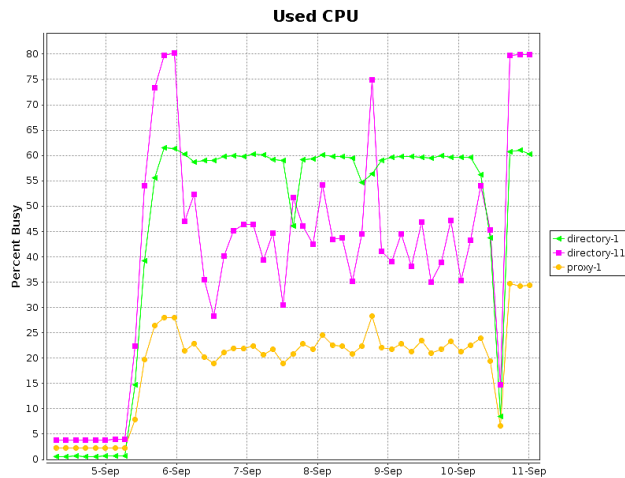


Figure 36: CPU Percent Busy

Google Chart Tools Datasource Protocol

Metrics data may also be requested and presented in tabular format that is fully compatible with Google's Chart Tools Datasource protocol (https://developers.google.com/chart/interactive/docs/dev/implementing_data_source). However, the Google Visualization API query language (the `tq` request parameter) is not supported. The standard metric query parameters as outlined above will still be used instead. The Metrics Engine supports JSON, HTML, CSV, and TSV data formats as outlined by the Datasource protocol.

URL	/api/v1/metrics/{metricId}/datatable
Method	GET
Formats	JSON, HTML, CSV, and TSV
Query Parameters	<ul style="list-style-type: none"> > tqx=out:html - HTML formatted output. > tqx=out:csv - CSV formatted output. > tqx=out:tsv-excel - TSV formatted output. > tz (timezone) - Specifies the timezone to be used when displaying dates. The Google Visualization API has no notion of time zones and always assumes that the times returned are in local time. The Metrics Engine stores all time stamps in GMT and this is the time that is returned by default. This parameter allows you to configure how the Metrics Engine presents the times in the specified timezone. Usually, the client will pass the user's local timezone in IANA Time Zone Database format, so "US/Central" specifies CST in the United States.



Note: All of the Common Query parameters apply to this resource.

Get the average response time metric for the last 5 minutes with 30 second ($5 * 60 / 10$) resolution and pivoted by op-type and then instance in CSV format:

```
curl \
-X GET \
https://<metricsEngineHost>:8080/api/v1/metrics/response-time/datatable?
tqx=out:csv&maxIntervals=10
&pivot=op-type&pivot=instance&tz=US/Central
```

Response Code	200 OK
Response Body	<p>When only one time interval is requested, the first pivoted dimension values form the first column. For queries that request more than one time interval, the start of each time interval forms the first column. Combinations of subsequent pivoted dimension values and/or histogram buckets are included as additional columns. The CSV format will be shown for readability. All date and time values are under the GMT time zone.</p> <pre>"Time","unboundid35 AVERAGE Milliseconds","unboundid3 AVERAGE Milliseconds" "2012-08-04T14:38:00Z","0","0" "2012-08-04T14:39:00Z","0","0" "2012-08-04T14:40:00Z","0","0" "2012-08-04T14:41:00Z","0","0" "2012-08-04T14:42:00Z","0","0"</pre>

The following sample code illustrates using Google chart tools:

```
<html>
<head>
  <!--Load the AJAX API-->
  <script type="text/javascript" src="https://www.google.com/jsapi"></script>
  <script type="text/javascript">

    // Load the Visualization API and the line chart package.
    google.load('visualization', '1.0', {'packages':['corechart']});

    // Set a callback to run when the Google Visualization API is loaded.
    google.setOnLoadCallback(drawChart);

    function drawChart() {
      var query = new google.visualization.Query('https://<metricsEngineHost>:8080/
api/v1/metrics/response-time/datatable?maxIntervals=10&pivot=op-
type&pivot=instance');
      query.send(handleQueryResponse);
    }

    function handleQueryResponse(response) {
      if (response.isError()) {
        alert('Error in query: ' + response.getMessage() + ' '
          + response.getDetailedMessage());
        return;
      }

      var data = response.getDataTable();

      var visualization = new
google.visualization.LineChart(document.getElementById('chart_div'));
      visualization.draw(data, null);
    }
  </script>
</head>
<body>
  <!--Div that will hold the chart-->
  <div id="chart_div"></div>
</body>
</html>
```

Accessing Alerts Collected by the Metrics Engine

The eventTypes and event APIs can be used to retrieve information and alerts from monitored servers. The eventTypes API provides the range of alert types that have occurred. The events API provides detail about individual alerts.

Retrieving Event Types

The range of alerts that have been generated by monitored servers can be retrieved, with optional filtering, based on the following API definition.

URL	/api/v1/eventTypes/[?query-parameters] - gets a list of event types
Method	GET
Formats	JSON, XML
Query Parameters	<ul style="list-style-type: none"> instance, instanceType, startTime, and endTime. See Performing a Metric Query for a description of each parameter.
Response Code	200 OK
Response Body	["health-check-available-to-degraded" , "health-check-degraded-to-available"]

Retrieving Events

The detailed information for one or more events can be retrieved, with optional filtering, based on the following API definition.

URL	/api/v1/events/[?query-parameters] - gets a list of events /api/v1/events/{eventId} - gets a single event
Method	GET
Formats	JSON, XML
Query Parameters	<ul style="list-style-type: none"> type (multi-valued) - Limits the result to include only events of the specified types. Valid values are presented below. severity (multi-valued) - Limits the result to include only events that have the matching severity. Valid "severity" values are: INFO, WARNING, ERROR, and FATAL. instance, instanceType, instanceLocation, instanceHostname, instanceVersion, startTime, and endTime. See Performing a Metric Query for a description of each parameter. limit, offset. See Pagination for a description of each parameter.

Response Code	200 OK
Response Body	<pre>{ "found" : 2, "offset" : 0, "events" : [{ "id": "9bdfdlb8-3811-4a84-b779-93553ff35f83", "creationDate": 1351274815559, "eventType": "server-starting", "eventSeverity": "INFO", "sourceProductInstance": "lockdown-test", "summary": "Server Starting", "detail": "The Directory Server is starting" }, { "id": "9bdfdlb8-3811-4a84-b779-93553ff35f83", "creationDate": 1351274815559, "eventType": "server-starting", "eventSeverity": "INFO", "sourceProductInstance": "directory-3", "summary": "Server Starting", "detail": "The Directory Server is starting" }] }</pre>

The `type` query parameter can take the following values:

- > access-control-change
- > access-control-disabled
- > access-control-enabled
- > access-control-parse-failure
- > access-log-criteria-matched
- > backend-disabled
- > backend-initialization-failed
- > backup-failed
- > cannot-acquire-shared-backend-lock
- > cannot-copy-schema-files
- > cannot-decode-entry
- > cannot-find-recurring-task
- > cannot-register-backend
- > cannot-release-shared-backend-lock
- > cannot-rename-current-task-file
- > cannot-rename-new-task-file
- > cannot-restore-backup
- > cannot-schedule-recurring-task-iteration
- > cannot-write-configuration
- > cannot-write-new-schema-files
- > cannot-write-server-state-file
- > cannot-write-task-backing-file
- > config-change
- > deadlock-detected
- > duplicate-alerts-suppressed
- > duplicate-fatal-alerts-suppressed
- > duplicate-error-alerts-suppressed
- > duplicate-warning-alerts-suppressed
- > duplicate-info-alerts-suppressed
- > entering-lockdown-mode
- > external-config-file-edit-handled
- > external-config-file-edit-lost

- > external-server-initialization-failed
- > force-gc-complete
- > force-gc-starting
- > health-check-available-to-degraded
- > health-check-available-to-unavailable
- > health-check-degraded-to-available
- > health-check-degraded-to-unavailable
- > health-check-unavailable-to-available
- > health-check-unavailable-to-degraded
- > index-degraded
- > index-rebuild-completed
- > index-rebuild-in-progress
- > invalid-privilege
- > je-background-sync-failed
- > je-daemon-thread-exception
- > je-recovery-required
- > large-attribute-update-failure
- > lba-no-available-servers
- > ldap-connection-handler-cannot-listen
- > ldap-connection-handler-consecutive-failures
- > ldap-connection-handler-uncaught-error
- > ldif-backend-cannot-write
- > ldif-connection-handler-parse-error
- > ldif-connection-handler-io-error
- > leaving-lockdown-mode
- > logging-error
- > low-disk-space-error
- > low-disk-space-warning
- > offline-config-change-detected
- > out-of-disk-space-error
- > proxy-entry-balancing-operation-failure
- > proxy-entry-rebalancing-admin-action-required
- > replication-backlogged
- > replication-missing-changes
- > replication-monitor-data-unavailable
- > replication-replay-failed
- > replication-server-changelog-failure
- > replication-server-listen-failure
- > replication-unresolved-conflict
- > replication-unsent-changes
- > restricted-subtree-accessibility
- > schema-checking-disabled
- > server-jvm-paused
- > server-shutting-down
- > server-started
- > server-starting
- > sync-resource-connection-error
- > sync-resource-operation-error
- > sync-pipe-initialization-error
- > sync-pipe-backlog-above-threshold

- > sync-pipe-backlog-below-threshold
- > system-nanotime-stopped
- > system-current-time-shifted
- > thread-exit-holding-lock
- > threshold-warning-entry
- > threshold-warning-exit
- > threshold-critical-entry
- > threshold-critical-exit
- > uncaught-exception
- > unique-attribute-sync-conflict
- > unique-attribute-sync-error
- > unrecognized-alert-type
- > user-defined-error
- > user-defined-fatal
- > user-defined-info
- > user-defined-warning
- > worker-thread-caught-error
- > work-queue-backlogged
- > work-queue-full
- > work-queue-no-threads-remaining

LDAP SLA API

The LDAP SLA API provides a means to list the LDAP SLA objects (configuration data) and to query any single LDAP SLA object. The query of an LDAP SLA object results in the aggregated LDAP SLA configuration plus scalar data that contains the current values for the LDAP SLA plus time-series data. The "current" data comes from the Threshold object, and the historical data comes from a metric query. Thus, historical data is significantly more expensive to fetch and is only included in the results if the client requests it. This allows an LDAP SLA query to get the configuration and current data very efficiently for clients that only need the current data. A client that needs both current and historical data can include the appropriate query parameter and get all the data in a single call.

Retrieving the SLA Object

List the LDAP SLA objects (configuration data) and query any single LDAP SLA object. The default format will be JSON if none is specified. The servlet will use the HTTP Accept header as a hint if no specific format is specified.

URL	<code>/api/v1/sla/ldap-sla</code> - Returns a list of all LDAP SLA configuration objects in name-order. This includes current values and status as held by the Threshold objects, but will only include any historical data. <code>/api/v1/sla/ldap-sla/{sla-name}</code> - Returns a single LDAP SLA configuration object plus optional historical data.
Method	GET
Formats	JSON, XML
Query Parameters	For the 1st URL:

- **instance** - Returns LDAP SLA's that reference the specified instance.
 - **application-name** - Returns LDAP SLA's that reference this application name.
 - **ldap-op** - Returns LDAP SLA's that reference this LDAP operation.
- For the 2nd URL:**
- **historical** (multi-valued, optional)
 - time (includes time series data)
 - limits (includes % of time thresholds limits have been exceeded - requires Threshold)
 - alerts (includes all Threshold alerts - requires Thresholding)
 - histogram (includes response-time histogram as column data)
 - nines (includes response time values that correlate to 99%, 99.9%, 99.99%, and 99.999% response-time measurements)
 - **startTime** - (optional, default - 1 hr). The time at which the historical data starts.
 - **endTime** - (optional, default - 5m). The time at which the historical data ends.
 - **pivot** - (optional, multi-valued). Historical time-series pivots by this dimension.
 - instance - pivot by producing server.
 - ldap-op - pivot by LDAP operation.
 - histogram - pivot response-time time series by histogram buckets.
 - **maxIntervals** - (optional, default=100). Number of points to include in the historical time series.

When the API requests historical data, the API server implementation constructs and issues one or more metric queries as necessary to fetch the resulting data. The API allows a client to enumerate all LDAP SLA objects and to get a broad set of measurement data for the LDAP SLA. If no historical data is needed, the "instantaneous" data is effectively all in memory (in the Threshold objects) and will be a very quick response. Some historical data will be quite a bit slower to fetch (multiple seconds), and clients should be able to manage that fact.

EXAMPLE: Retrieving an SLA object.

```
curl -X GET http://x3550-09:8080/api/v1/sla/ldap/Acme+Identity+Portal?historical=time
&historical=nines&pivot=instance&startTime=-15m
```

Response Code	200 OK
Response Body (JSON format)	<p>Response (JSON):</p> <pre>{ "name": "Acme Identity Portal", "applicationName": "Application 5", "ldapOps": ["search"], "servers": ["x2270-08.unboundid.lab:1389"], "enabled": true, "responseTimeState": "NORMAL", "throughputState": "normal", "currentResponseTime": 6.002752, "currentThroughput": 7032.794, "averageResponseTime": 6.212055, "averageThroughput": 5517.1323, "responseTimeWarnLimit": 8.0, "responseTimeCriticalLimit": 10.0, "throughputWarnLimit": 8000.0, }</pre>

```

"throughputCriticalLimit":10000.0,
"responseTimeSeries":{
  "type":"timeInterval",
  "firstSampleTime":1359045070000,
  "lastSampleTime":1359045970000,
  "rateScaling":"NONE",
  "statistic":"AVERAGE",
  "metric":{
    "type":"discreteValued",
    "id":"response-time",
    "name":"Response Time",
    "shortName":"Response Time",
    "description":"Time for server to process an
      LDAP operation and send a response to the
      client.",
    "group":"LDAP",
    "instanceTypes":["identity-data-store","proxy"],
    "statistics":["average","count","histogram"],
    "dimensions":[{"id":"application-name",
      "values":["unidentified directory application",
        "unidentified proxy application","application 9",
        "application 5","root user","admin user",
        "application 6"]},{id:"op-type","values":
        ["search","modifydn","add","delete","compare",
        "bind","modify"]}],
    "countUnit":{"singularName":"Operation Response Time",
      "pluralName":"Operation Response Time",
      "abbreviatedName":"Response Time"},
    "valueUnit":{"singularName":"Millisecond",
      "pluralName":"Milliseconds","abbreviatedName":"Msec"}
  },
  "series":[
    {
      "label":"x2270-08.unboundid.lab:1389",
      "data":[3.0120885,3.7983484,5.8223324,6.9673944,
        3.7627347,7.8599353,6.4741855,7.1965156,4.642965,
        6.4567575,7.5919747,7.315942,5.5505323,7.676259,
        6.7929792,6.0238724,6.258689,6.918475,7.6584263,
        4.507659,7.7891426,7.7237306,6.003436,6.562086,
        6.5203643,6.3706737,6.766388,6.5930696,7.3876667,
        4.6867347,6.7640586,4.671808,7.1373825,7.2503524,
        7.500583,5.219624,7.4529514,4.440301,7.1102366,
        6.0021896,7.3931694,6.520522,5.547696,6.8611526,
        5.1369443,6.4802103,6.0406966,7.163752,5.3269434,
        6.9904456,5.055998,5.8450484,4.972494,9.763915,
        5.778041,6.201931,6.1402993,5.118754,6.781435,
        7.224573,7.258575,5.4384823,6.7813044,5.820621,
        7.671158,6.168999,5.638104,7.785232,4.797556,
        6.4578395,5.4489355,8.33236,5.5137024,7.273964,
        5.4661403,8.303381,6.2553997,7.1138144,5.845391,
        6.718696,6.9525356,6.2418604,7.1721854,6.0303135,
        6.869038,5.6402783,7.8097477,4.5565543,5.8214054,
        5.8906417,7.159979,7.709213,5.1525316,7.363583,
        5.2055826,8.589983,0.0,0.0,0.0,0.0],
      "lastCompleteIndex":99
    }
  ],
  "resolutionInSeconds":9
},
"throughputSeries":{
  "type":"timeInterval",
  "firstSampleTime":1359045070000,
  "lastSampleTime":1359045970000,
  "rateScaling":"NONE",
  "statistic":"COUNT",
  "metric":{
    "type":"count",
    "id":"throughput",
    "name":"LDAP Operation Throughput",
    "shortName":"LDAP Op Throughput",
    "description":"Number of LDAP operations that have
      been processed.",
    "group":"LDAP",
    "instanceTypes":["identity-data-store","proxy"],
    "statistics":["count"],
    "dimensions":[{"id":"application-name",
      "values":["unidentified directory application",
        "unidentified proxy application","application 9",
        "application 5","root user","admin user",
        "application 6"]},{id:"op-type","values":

```

	<pre> ["search", "modifydn", "add", "delete", "compare", "bind", "modify"]], "countUnit": { "singularName": "Operation Throughput", "pluralName": "Operation Throughput", "abbreviatedName": "Throughput" } }, "series": [{ "label": "x2270-08.unboundid.lab:1389", "data": [7809.953, 7997.222, 6878.337, 5426.2446, 8132.547, 4636.0234, 5249.1113, 5068.4443, 7488.769, 5792.971, 4668.297, 4968.804, 6005.3145, 4304.648, 5328.3774, 6413.66, 5791.5547, 5333.196, 4717.5093, 6262.7993, 4396.8, 4757.9023, 5703.421, 5226.5156, 5780.211, 5628.8447, 4708.0103, 5173.0947, 4726.222, 6214.1113, 5456.183, 7179.8926, 5424.388, 5174.8135, 5110.048, 6766.5894, 4946.5664, 7754.889, 5552.245, 5062.4204, 5660.222, 5493.3477, 5691.1113, 5179.0, 6422.778, 6003.4443, 5229.5557, 5313.6665, 6114.7197, 5476.549, 7345.8345, 6471.737, 6628.267, 3626.0579, 7189.512, 5525.778, 3491.94, 5849.9946, 6055.7065, 5264.3853, 5298.0, 5548.689, 5919.0967, 5246.632, 5120.217, 5890.6953, 5783.586, 4664.3945, 6613.474, 5255.0903, 6440.4443, 4829.505, 6022.874, 4979.2, 6389.972, 4667.748, 5969.5557, 5506.889, 5759.395, 5648.9956, 5226.778, 5394.1816, 5154.8853, 6078.421, 5436.0024, 6174.4443, 4902.453, 5881.0, 5678.8975, 5661.264, 4843.2363, 4998.3545, 6603.6006, 4352.532, 6533.7295, 2974.6267, "NaN", "NaN", "NaN"], "lastCompleteIndex": 95 }, { "resolutionInSeconds": 9 }, { "responseTimeNines": ["100 ms", "1000 ms", "1000 ms", "1000 ms"], "startTime": 1359045070863, "endTime": 1359045970863 }] </pre>
--	---

Pagination

Pagination is supported for both the metrics and instances listing URLs.

Query Parameters	<ul style="list-style-type: none"> > limit - Specifies the maximum number of results to return. Default is to return all results. > offset - Specifies how many results to skip for the first results to return.
Response Parameters	<ul style="list-style-type: none"> > found - The number of results that satisfied the query params. > offset - The index into the total result set where the current response begins.

Response Codes

The following response codes are available.

Response Code	Description
200 OK	The request was processed successfully and the requested data returned.
400 Bad Request	The request contained an error. Refer to the error message to resolve the issue.
404 Not Found	The requested resource is not found or no samples are collected for the metric.
500 Internal Server Error	An unexpected server error occurred. Refer to the error message for more info.

Response Code	Description
503 Service Not Available	The metric query service is temporary offline. Refer to the error message for more info.

Response Body	<pre><?xml version="1.0" encoding="UTF-8"?> <errorResponse> <message>There are no metrics defined with id response-tme. Available metrics may be found at /metrics </message> </errorResponse></pre>
---------------	--

Chapter

6

Managing the Metrics Engine

This chapter provides information about managing the UnboundID® Metrics Engine. It includes information about working with logs, notifications, and alerts, as well as information about the command-line tools included with the Metrics Engine.

Topics:

- [*Working With Logs*](#)
- [*The Monitor Backend*](#)
- [*Monitoring with JMX*](#)
- [*Managing Notifications and Alerts*](#)
- [*Command-Line Tools*](#)

Working With Logs

UnboundID Metrics Engine provides error loggers that provide information about warnings, errors, or significant events that occur within the server. The remainder of this section describes how to create new log publishers, how to configure log rotation and retention, how to manage the file-based error log publisher and how to manage the syslog-based error log publisher.

Creating New Log Publishers

The UnboundID Metrics Engine provides customization options to help you create your own log publishers with the `dsconfig` command.

When you create a new log publisher, you must also configure the log retention and rotation policies for each new publisher. For more information, see [Configuring Log Rotation and Configuring Log Retention](#).

To Create a New Log Publisher

1. Use the `dsconfig` command in non-interactive mode to create and configure the new log publisher. This example shows how to create a logger that only logs disconnect operations.

```
$ bin/dsconfig create-log-publisher \  
  --type file-based-access --publisher-name "Disconnect Logger" \  
  --set enabled:true \  
  --set "rotation-policy:24 Hours Time Limit Rotation Policy" \  
  --set "rotation-policy:Size Limit Rotation Policy" \  
  --set "retention-policy:File Count Retention Policy" \  
  --set log-connects:false \  
  --set log-requests:false --set log-results:false \  
  --set log-file:logs/disconnect.log
```

Note: To configure compression on the logger, add the option to the previous command:



```
--set compression-mechanism: gzip
```

Compression cannot be disabled or turned off once configured for the logger. Therefore, careful planning is required to determine your logging requirements including log rotation and retention with regards to compressed logs.

2. View the Log Publishers.

```
$ bin/dsconfig list-log-publishers
```

Log Publisher	: Type	: enabled
-----	-----	-----
Disconnect Logger	: file-based-access	: true
File-Based Access Logger	: file-based-access	: true
File-Based Audit Logger	: file-based-access	: false
File-Based Debug Logger	: file-based-debug	: false
File-Based Error Logger	: file-based-error	: true

```
Replication Repair Logger : file-based-error : true
```

To Create a Log Publisher Using dsconfig Interactive Command-Line Mode

1. On the command line, type `bin/dsconfig`.
2. Authenticate to the server by following the prompts.
3. On the Configuration Console main menu, select the option to configure the log publisher.
4. On the **Log Publisher Management** menu, select the option to create a new log publisher.
5. Select the Log Publisher type. In this case, select **File-Based Access Log Publisher**.
6. Type a name for the log publisher.
7. Enable it.
8. Type the path to the log file, relative to the Metrics Engine root. For example, `logs/disconnect.log`.
9. Select the rotation policy you want to use for your log publisher.
10. Select the retention policy you want to use for your log publisher.
11. On the Log Publisher Properties menu, select the option for `log-connects:false`, `log-disconnects:true`, `log-requests:false`, and `log-results:false`.
12. Type `f` to apply the changes.

Configuring Log Rotation

The Metrics Engine allows you to configure the log rotation policy for the server. When any rotation limit is reached, the Metrics Engine rotates the current log and starts a new log. If you create a new log publisher, you must configure at least one log rotation policy.

You can select the following properties:

- **Time Limit Rotation Policy.** Rotates the log based on the length of time since the last rotation. Default implementations are provided for rotation every 24 hours and every 7 days.
- **Fixed Time Rotation Policy.** Rotates the logs every day at a specified time (based on 24-hour time). The default time is 2359.
- **Size Limit Rotation Policy.** Rotates the logs when the file reaches the maximum size for each log. The default size limit is 100 MB.
- **Never Rotate Policy.** Used in a rare event that does not require log rotation.

To Configure the Log Rotation Policy

- Use `dsconfig` to modify the log rotation policy for the access logger.

```
$ bin/dsconfig set-log-publisher-prop \  
--publisher-name "File-Based Access Logger" \  
--remove "rotation-policy:24 Hours Time Limit Rotation Policy" \  
--add "rotation-policy:7 Days Time Limit Rotation Policy"
```

Configuring Log Retention

The Metrics Engine allows you to configure the log retention policy for each log on the server. When any retention limit is reached, the Metrics Engine removes the oldest archived log prior to creating a new log. Log retention is only effective if you have a log rotation policy in place. If you create a new log publisher, you must configure at least one log retention policy.

- **File Count Retention Policy.** Sets the number of log files you want the Metrics Engine to retain. The default file count is 10 logs. If the file count is set to 1, then the log will continue to grow indefinitely without being rotated.
- **Free Disk Space Retention Policy.** Sets the minimum amount of free disk space. The default free disk space is 500 MBytes.
- **Size Limit Retention Policy.** Sets the maximum size of the combined archived logs. The default size limit is 500 MBytes.
- **Custom Retention Policy.** Create a new retention policy that meets your Metrics Engine's requirements. This will require developing custom code to implement the desired log retention policy.
- **Never Delete Retention Policy.** Used in a rare event that does not require log deletion.

To Configure the Log Retention Policy

- Use `dsconfig` to modify the log retention policy for the access logger.

```
$ bin/dsconfig set-log-publisher-prop \  
--publisher-name "File-Based Access Logger" \  
--set "retention-policy:Free Disk Space Retention Policy"
```

Managing the File-Based Error Log Publisher

The Error Log reports errors, warnings, and informational messages about events that occur during the course of the Metrics Engine's operation. Each entry in the error log records the following properties (some are disabled by default and must be enabled):

- **Time Stamp.** Displays the date and time of the operation. Format: DD/Month/YYYY:HH:MM:SS <offset from UTC time>

- **Category.** Specifies the message category that is loosely based on the server components.
- **Severity.** Specifies the message severity of the event, which defines the importance of the message in terms of major errors that need to be quickly addressed. The default severity levels are: fatal-error, notice, severe-error, severe-warning.
- **Message ID.** Specifies the numeric identifier of the message.
- **Message.** Stores the error, warning, or informational message.

Error Log Example

The following example displays the error log for the Metrics Engine. The log is enabled by default and is accessible in the <server-root>/logs/errors file.

```
[21/Oct/2012:05:15:23.048 -0500] category=RUNTIME_INFORMATION severity=NOTICE
msgID=20381715 msg="JVM Arguments: '-Xmx8g', '-Xms8g', '-XX:MaxNewSize=1g',
'-XX:NewSize=1g', '-XX:+UseConcMarkSweepGC', '-XX:+CMSConcurrentMTEnabled',
'-XX:+CMSParallelRemarkEnabled', '-XX:+CMSParallelSurvivorRemarkEnabled',
'-XX:+CMSScavengeBeforeRemark', '-XX:RefDiscoveryPolicy=1',
'-XX:ParallelCMSThreads=4', '-XX:CMSMaxAbortablePrecleanTime=3600000',
'-XX:CMSInitiatingOccupancyFraction=80', '-XX:+UseParNewGC', '-XX:+UseMembar',
'-XX:+UseBiasedLocking', '-XX:+UseLargePages', '-XX:+UseCompressedOops',
'-XX:PermSize=128M', '-XX:+HeapDumpOnOutOfMemoryError',
'-Dcom.unboundid.directory.server.scriptName=setup'"
[21/Oct/2012:05:15:23.081 -0500] category=EXTENSIONS severity=NOTICE
msgID=1880555611 msg="Administrative alert type=server-starting
id=4178daee-ba3a-4be5-8e07-5ba17bf30b71
class=com.unboundid.directory.server.core.MetricsEngine
msg='The Metrics Engine is starting'"
[21/Oct/2012:05:15:23.585 -0500] category=CORE severity=NOTICE
msgID=1879507338 msg="Starting group processing for backend api-users"
[21/Oct/2012:05:15:23.586 -0500] category=CORE severity=NOTICE
msgID=1879507339 msg="Completed group processing for backend api-users"
[21/Oct/2012:05:15:23.586 -0500] category=EXTENSIONS severity=NOTICE
msgID=1880555575 msg="'Group cache (2 static group(s) with 0 total
memberships and 0 unique members, 0 virtual static group(s),
1 dynamic group(s))' currently consumes 7968 bytes and can grow to a maximum
of an unknown number of bytes"
[21/Oct/2012:05:16:18.011 -0500] category=CORE severity=NOTICE
msgID=458887 msg="The Metrics Engine (UnboundID Metrics Engine 4.5.1.0
build 20121021003738Z, R12799) has started successfully"
```

To Modify the File-Based Error Logs

- Use dsconfig to modify the default File-Based Error Log.

```
$ bin/dsconfig set-log-publisher-prop \
--publisher-name "File-Based Error Logger" \
--set include-product-name:true --set include-instance-name:true \
--set include-startup-id:true
```

The Monitor Backend

The Metrics Engine exposes its monitoring information under the cn=monitor entry. Administrators can use various means to monitor the servers, including the UnboundID Metrics Engine, through SNMP, the Management Console, JConsole, LDAP command-line tools, and the Periodic Stats Logger.

The Monitor Backend contains an entry per component or activity being monitored. The list of all monitor entries can be seen using ldapsearch as follows:

```
$ bin/ldapsearch --hostname server1.example.com --port 1389 \
--bindDN "uid=admin,dc=example,dc=com" --bindPassword secret \
--baseDN "cn=monitor" "(objectclass=*)" cn
```

The following table describes a subset of the monitor entries:

Table 11: Metrics Engine Monitoring Components

Component	Description
Active Operations	Provides information about the operations currently being processed by the Metrics Engine. Shows the number of operations, information on each operation, and the number of active persistent searches.
Backends	Provides general information about the state of an a Metrics Engine backend, including the entry count. If the backend is a local database, there is a corresponding database environment monitor entry with information on cache usage and on-disk size.
Client Connections	Provides information about all client connections to the Metrics Engine. The client connection information contains a name followed by an equal sign and a quoted value (e.g., connID="15", connectTime="20100308223038Z", etc.)
Connection Handlers	Provides information about the available connection handlers on the Metrics Engine, which includes the LDAP and LDIF connection handlers. These handlers are used to accept client connections and to read requests and send responses to those clients.
Disk Space Usage	Provides information about the disk space available to various components of the Metrics Engine.
General	Provides general information about the state of the Metrics Engine, including product name, vendor name, server version, etc.
Index	Provides on each index. The monitor captures the number of keys preloaded, and counters for read/write/remove/open-cursor/read-for-search. These counters provide insight into how useful an index is for a given workload.
HTTP/HTTPS Connection Handler Statistics	Provides statistics about the interaction that the associated HTTP connection handler has had with its clients, including the number of connections accepted, average requests per connection, average connection duration, total bytes returned, and average processing time by status code.
JVM Stack Trace	Provides a stack trace of all threads processing within the JVM.
LDAP Connection Handler Statistics	Provides statistics about the interaction that the associated LDAP connection handler has had with its clients, including the number of connections established and closed, bytes read and written, LDAP messages read and written, operations initiated, completed, and abandoned, etc.
Processing Time Histogram	Categorizes operation processing times into a number of user-defined buckets of information, including the total number of operations processed, overall average response time (ms), number of processing times between 0ms and 1ms, etc.
System Information	Provides general information about the system and the JVM on which the Metrics Engine is running, including system host name, operation system, JVM architecture, Java home, Java version, etc.
Version	Provides information about the Metrics Engine version, including build ID, version, revision number, etc.
Work Queue	Provides information about the state of the Metrics Engine work queue, which holds requests until they can be processed by a worker thread, including the requests

Component	Description
	rejected, current work queue size, number of worker threads, number of busy worker threads, etc.

Monitoring Disk Space Usage

The disk space usage monitor provides information about the amount of usable disk space available for Metrics Engine components. It also provides the ability to generate administrative alerts, as well as take additional action if the amount of usable space drops below the defined thresholds.

You can configure three thresholds for this monitor:

- **Low space warning threshold.** This threshold is defined as either a percentage or absolute amount of usable space. If the amount of usable space drops below this threshold, then the Metrics Engine will generate an administrative alert but will remain fully functional. It will generate alerts at regular intervals that you configure (such as once a day) unless action is taken to increase the amount of usable space. The Metrics Engine will also generate additional alerts as the amount of usable space is further reduced (e.g., each time the amount of usable space drops below a value 10% closer to the low space error threshold). If an administrator frees up disk space or adds additional capacity, then the server should automatically recognize this and stop generating alerts.
- **Low space error threshold.** This threshold is also defined as either a percentage or absolute size. Once the amount of usable space drops below this threshold, then the server will generate an alert notification and will begin rejecting all operations requested by non-root users with "UNAVAILABLE" results. The server should continue to generate alerts during this time. Once the server enters this mode, then an administrator will have to take some kind of action (e.g., running a command to invoke a task or removing a signal file) before the server will resume normal operation. This threshold must be less than or equal to the low space warning threshold. If they are equal, the server will begin rejecting requests from non-root users immediately upon detecting low usable disk space.
- **Out of space error threshold.** This threshold may also be defined as a percentage or absolute size. Once the amount of usable space drops below this threshold, then the UnboundID Metrics Engine will generate a final administrative alert and will shut itself down. This threshold must be less than or equal to the low space error threshold. If they are equal, the server will shut itself down rather than rejecting requests from non-root users.

The threshold values may be specified either as absolute sizes or as percentages of the total available disk space. All values must be specified as absolute values or as percentages. A mix of absolute values and percentages cannot be used. The low space warning threshold must be greater than or equal to the low space error threshold, the low space error threshold must be greater than or equal to the out of space error threshold, and the out of space error threshold must be greater than or equal to zero.

If the out of space error threshold is set to zero, then the server will not attempt to automatically shut itself down if it detects that usable disk space has become critically low. If the amount of usable space reaches zero, then the database will preserve its integrity but may enter a state in which it rejects all operations with an error and requires the server (or at least the affected backends) to be restarted. If the low space error threshold is also set to zero, then the server will

generate periodic warnings about low available disk space but will remain fully functional for as long as possible. If all three threshold values are set to zero, then the server will not attempt to warn about or otherwise react to a lack of usable disk space.

Monitoring with JMX

The UnboundID Metrics Engine supports monitoring the JVM™ through a Java Management Extensions (JMX™) management agent, which can be accessed using JConsole or any other kind of JMX client. The JMX interface provides JVM performance and resource utilization information for applications running Java. You can monitor generic metrics exposed by the JVM itself, including memory pools, threads, loaded classes, and MBeans, as well as all the monitor information that the Metrics Engine provides. You can also subscribe to receive JMX notifications for any administrative alerts that are generated within the server.

Running JConsole

Before you can access JConsole, you must configure and enable the JMX Connection Handler for the Metrics Engine using the `dsconfig` tool. See [Configuring the JMX Connection Handler and Alert Handler](#).

To invoke the JConsole executable, type `jconsole` on the command line. If `JDK_HOME` is not set in your path, you can access JConsole in the `bin` directory of the `JDK_HOME` path.

Monitoring the Metrics Engine Using JConsole

You can set up JConsole to monitor the Metrics Engine using a remote process. Make sure to enable the JMX Connection Handler and to assign at least the `jmx-read` privilege to a regular user account (the `jmx-notify` privilege is required to subscribe to receive JMX notifications). Do not use a root user account, as this would pose a security risk.

Managing Notifications and Alerts

The UnboundID Metrics Engine provides delivery mechanisms for account status notifications and administrative alerts using SMTP, JMX, or SNMP in addition to standard error logging. Alerts and events reflect state changes within the server that may be of interest to a user or monitoring service. Notifications are typically the delivery of an alert or event to a user or monitoring service. Account status notifications are only delivered to the account owner notifying a change in state in the account.

This chapter presents the following topics:

Working with Administrative Alert Handlers

The UnboundID Metrics Engine provides mechanisms to send alert notifications to administrators when significant problems or events occur during processing, such as problems during server startup or shutdown. The Metrics Engine provides a number of alert handler implementations, including:

- **Error Log Alert Handler.** Sends administrative alerts to the configured server error logger(s).
- **Exec Alert Handler.** Executes a specified command on the local system if an administrative alert matching the criteria for this alert handler is generated by the Metrics Engine. Information about the administrative alert will be made available to the executed application as arguments provided by the command.
- **Groovy Scripted Alert Handler.** Provides alert handler implementations defined in a dynamically-loaded Groovy script that implements the `ScriptedAlertHandler` class defined in the Server SDK.
- **JMX Alert Handler.** Sends administrative alerts to clients using the Java Management Extensions (JMX) protocol. UnboundID uses JMX for monitoring entries and requires that the JMX connection handler be enabled.
- **SMTP Alert Handler.** Sends administrative alerts to clients via email using the Simple Mail Transfer Protocol (SMTP). The server requires that one or more SMTP servers be defined in the global configuration.
- **SNMP Alert Handler.** Sends administrative alerts to clients using the Simple Network Monitoring Protocol (SNMP). The server must have an SNMP agent capable of communicating via SNMP 2c.
- **SNMP Subagent Alert Handler.** Sends SNMP traps to a master agent in response to administrative alerts generated within the server.
- **Third Party Alert Handler.** Provides alert handler implementations created in third-party code using the Server SDK.

Administrative Alert Types

If enabled, the Metrics Engine can generate administrative alerts when the events occur. The Alert types are presented in the table below.

Table 12: Administrative Alert Types

Alert Type	Severity	Description
access-control-change	Info	Indicates that access control configuration has been changed.
access-control-disabled	Warning	Indicates that access control evaluation has been disabled.
access-control-enabled	Info	Indicates that access control evaluation has been enabled.

Alert Type	Severity	Description
access-control-parse-failure	Error	Indicates that an error occurred while attempting to parse an access control rule.
access-log-criteria-matched	Info	Indicates that an access log message matched the criteria for the admin alert access log publisher.
backend-end-initialization-failed	Error	Indicates that an attempt to initialize the backend failed.
cannot-acquire-shared-backend-lock	Error	Indicates that an error occurred while attempting to acquire a shared backend lock.
cannot-copy-schema-files	Error	Indicates that an error occurred while attempting to copy schema files during a schema update.
cannot-decode-entry	Error	Indicates that an error occurred while attempting to decode an entry stored in a backend.
cannot-find-recurring-task	Error	Indicates that the definition for a recurring task could not be found.
cannot-register-backend	Error	Indicates that an error occurred while trying to register a backend.
cannot-register-shared-backend-lock	Error	Indicates that an error occurred while trying to release a shared backend lock.
cannot-rename-current-task-file	Error	Indicates that an error occurred while trying to rename the current task backing file.
cannot-rename-new-task-file	Error	Indicates that an error occurred while trying to rename the new task backing file.
cannot-restore-backup	Error	Indicates that an error occurred while trying to restore a backup.
cannot-schedule-recurring-task-iteration	Error	Indicates that an error occurred while trying to schedule a recurring task iteration.
cannot-write-configuration	Error	Indicates that an error occurred while trying to write the updated server configuration.
cannot-write-new-schema-files	Error	Indicates that an error occurred while trying to update schema files.
cannot-write-server-state-file	Error	Indicates that an error occurred while attempting to write the server status file.
cannot-write-task-backing-file	Error	Indicates that an error occurred while trying to write the task backing file.
config-change	Info	Indicates the a configuration change has been made in the server.
deadlock-detected	Error	Indicates that a deadlock has been detected in the JVMTM in which the Metrics Engine is running.
duplicate-alerts-suppressed	Error	Indicates that duplicate alert notifications have been suppressed.
entering-lockdown-mode	Warning	Indicates that the server is entering lockdown mode, in which it will only allow operations from root users.
external-config-file-edit-handled	Warning	Indicates that the server has detected an external edit to the configuration file with the server online, but that it was able to copy the modifications into a separate file without applying them.
external-config-file-edit-handled	Warning	Indicates that the server has detected an external edit to the configuration file with the server online, but that it was

Alert Type	Severity	Description
		able to copy the modifications into a separate file without applying them.
external-config-file-edit-lost	Error	Indicates that the server has detected an external edit to the configuration file with the server online and was unable to copy the modifications into a separate file.
external-server-initialization-failed	Error	Indicates that an attempt to initialize an external server failed.
force-gc-complete	Info	Indicates that the server has completed a forced garbage collection.
force-gc-starting	Info	Indicates that the server is about to force a synchronous garbage collection.
index-degraded	Warning	Indicates that a backend is operating with a degraded index that needs to be rebuilt before that index may be used.
index-rebuild-completed	Info	Indicates that a backend is in the progress of rebuilding one or more indexes.
index-rebuild-in-progress	Info	Indicates that a backend is in the progress of rebuilding one or more indexes.
invalid-privilege	Warning	Indicates that a user has been configured with an invalid privilege.
je-recovery-required	Fatal	Indicates that a backend using the Oracle Berkeley DB Java Edition (JE) has encountered a server error and requires recovery.
ldap-connection-handler-cannot-listen	Fatal	Indicates that an error occurred when the LDAP connection handler tried to start listening for client connections and therefore the connection handler will be disabled.
ldap-connection-handler-consecutive-failures	Fatal	Indicates that the LDAP connection handler has experienced consecutive failures and will be disabled.
ldap-connection-handler-uncaught-error	Fatal	Indicates that the LDAP connection handler has encountered an uncaught error and will be disabled.
ldif-backend-cannot-write	Error	Indicates that an error occurred while trying to write the backing file for the LDIF backend.
ldif-connection-handler-io-error	Error	Indicates that the LDIF connection handler encountered an I/O error that prevented it from processing.
ldif-connection-handler-parse-error	Error	Indicates that the LDIF connection handler encountered an I/O error that has prevented it from processing.
leaving-lockdown-mode	Info	Indicates that the server is leaving lockdown mode and resuming normal operation.
logging-error	Error	Indicates that an error occurred while attempting to log a message.
low-disk-space-error	Error	Indicates that the amount of usable disk space has dropped below the low space error threshold.
low-disk-space-warning	Warning	Indicates that the amount of usable disk space has dropped below the configured low space warning threshold.

Alert Type	Severity	Description
low-disk-space-warning	Warning	Indicates that the amount of usable disk space has dropped below the configured low space warning threshold.
out-of-disk-space-error	Fatal	Indicates that the amount of usable disk space has dropped below the configured out of space error threshold.
replication-backlogged	Warning	Indicates that the replication backlog has exceeded the replication backlog count alert threshold for longer than the replication backlog duration alert threshold.
replication-backlog	Warning	Indicates that a replication server has known changes that have not been applied yet.
replication-monitor-data-unresolved	Warning	Indicates that replication monitor data is unavailable from cn=monitor.
replication-unresolved-conflict	Error	Indicates that the multi-master replication cannot automatically resolve a conflict.
replication-plugin-message-serialization-failure	Warning	Indicates that the replication plug-in failed to serialize or de-serialize a replication message.
replication-replay-failed	Error	Indicates that the server has failed to replay a replication operation.
replication-server-changelog-failure	Error	Indicates that the replication server encountered an error while accessing the replication changelog database.
replication-server-listen-failure	Error	Indicates that the replication server encountered an error while trying to listen on the configured replication port. There may be another application listening on the same port or the replication server host name may not be resolvable. Check the replication server configuration.
replication-unresolved-conflict	Error	Indicates that the server has detected a replication conflict that could not be resolved.
server-jvm-paused	Warning	Indicates that the server's JVM paused for some reason possibly due to misconfiguration.
server-shutting-down	Info	Indicates that the server has begun the shutdown process.
server-started	Info	Indicates that the server has completed that startup process.
server-starting	Info	Indicates that the server is starting.
system-nanotime-stopped	Error	Indicates that System.nanoTime() has stopped advancing.
thread-exit-holding-lock	Error	Indicates that a thread has exited while still holding one or more locks.
uncaught-exception	Error	Indicates that the server has detected an uncaught exception that may have caused a thread to terminate.
unique-attribute-sync-conflict	Error	Indicates that the server has detected a unique attribute conflict that was introduced from synchronization.
unique-attribute-sync-error	Error	Indicates that the server has encountered an error while attempting to detect unique attribute conflicts via synchronization.
unrecognized-alert-type	Error	Indicates that an unrecognized alert type was encountered. This should never be used for any alert that is generated, but only for cases in which the server needs to create an alert type from a string but the string does not match any recognized type.

Alert Type	Severity	Description
user-defined-error	Error	Indicates that an error alert notification has been generated by third-party code.
user-defined-fatal	Fatal	Indicates that a fatal error alert notification was generated by third-party code.
user-defined-info	Info	Indicates that an informational alert notification was generated by third-party code.
user-defined-warning	Warning	Indicates that a warning alert notification was generated by third-party code.
worker-thread-caught-error	Error	Indicates that a worker thread caught an unexpected error.
work-queue-backlogged	Error	Indicates that the work queue has become significantly backlogged and operations have been required to wait a significant length of time to be processed.
work-queue-full	Error	Indicates that the work queue is full and has rejected a client request.
work-queue-no-threads-remaining	Fatal	Indicates that all worker threads have been terminated due to errors and the server must shut down.
worker-thread-caught-error	Error	Indicates that a worker thread has caught an unexpected error that has caused it to be terminated.

Configuring the JMX Connection Handler and Alert Handler

You can configure the JMX connection handler and alert handler respectively using the `dsconfig` tool. Any user allowed to receive JMX notifications must have the `jmx-read` and `jmx-notify` privileges. By default, these privileges are not granted to any users (including root users or global administrators). For security reasons, we recommend that you create a separate user account that does not have any other privileges but these. Although not shown in this section, you can configure the JMX connection handler and alert handler using `dsconfig` in interactive command-line mode, which is visible on the "Standard" object menu.

To Configure the JMX Connection Handler

1. Use `dsconfig` to enable the JMX Connection Handler.

```
$ bin/dsconfig set-connection-handler-prop \
  --handler-name "JMX Connection Handler" \
  --set enabled:true \
  --set listen-port:1689
```

2. Add a new non-root user account with the `jmx-read` and `jmx-notify` privileges. This account can be added using the `ldapmodify` tool using an LDIF representation like:

```
dn: cn=JMX User,cn=Root DNs,cn=config
changetype: add
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: ds-cfg-root-dn-user
givenName: JMX
sn: User
cn: JMX User
userPassword: password
```

```
ds-cfg-inherit-default-root-privileges: false
ds-cfg-alternate-bind-dn: cn=JMX User
ds-privilege-name: jmx-read
ds-privilege-name: jmx-notify
```

To Configure the JMX Alert Handler

- Use `dsconfig` to configure the JMX Alert Handler.

```
$ bin/dsconfig set-alert-handler-prop --handler-name "JMX Alert Handler" \
--set enabled:true
```

Configuring the SMTP Alert Handler

By default, there is no configuration entry for an SMTP alert handler. To create a new instance of an SMTP alert handler, use the `dsconfig` tool.

Configuring the SMTP Alert Handler

- Use the `dsconfig` tool to configure the SMTP Alert Handler.

```
$ bin/dsconfig create-alert-handler \
--handler-name "SMTP Alert Handler" \
--type smtp \
--set enabled:true \
--set "sender-address:alerts@example.com" \
--set "recipient-address:administrators@example.com" \
--set "message-subject:Directory Admin Alert \%%alert-type\%" \
--set "message-body:Administrative alert:\n\%%alert-message\%"
```

Configuring the SNMP Subagent Alert Handler

You can configure the SNMP Subagent alert handler using the `dsconfig` tool, which is visible at the "Standard" object menu. Before you begin, you need an SNMP Subagent capable of communicating via SNMP2c. For more information on SNMP, see [Monitoring Using SNMP](#).

To Configure the SNMP Subagent Alert Handler

- Use `dsconfig` to configure the SNMP subagent alert handler. The `server-host-name` is the address of the system running the SNMP subagent. The `server-port` is the port number on which the subagent is running. The `community-name` is the name of the SNMP community that is used for the traps.

The Metrics Engine also supports a SNMP Alert Handler, which is used in deployments that do not enable an SNMP subagent.

```
$ bin/dsconfig set-alert-handler-prop \
--handler-name "SNMP Subagent Alert Handler" \
--set enabled:true \
--set server-host-name:host2 \
--set server-port:162 \
--set community-name:public
```

Working with the Alerts Backend

The Metrics Engine stores recently generated admin alerts in an Alerts Backend under the `cn=alerts` branch. The backend makes it possible to obtain admin alert information over LDAP for use with remote monitoring. The backend's primary job is to process search operations for alerts. It does not support add, modify, or modify DN operations of entries in the `cn=alerts` backend.

The alerts persist on disk in the `config/alerts.ldif` file so that they can survive server restarts. By default, the alerts remain on disk for seven days before being removed. However, administrators can configure the number of days for alert retention using the `dsconfig` tool. The administrative alerts of Warning level or worse that have occurred in the last 48 hours are viewable from the output of the status command-line tool and in the Management Console.

To View Information in the Alerts Backend

- Use `ldapsearch` to view the admin alerts.

```
$ bin/ldapsearch --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword secret --baseDN cn=alerts "(objectclass=*)"

dn: cn=alerts
objectClass: top
objectClass: ds-alert-root
cn: alerts

dn: ds-alert-id=3d1857a2-e8cf-4e80-ac0e-ba933be59eca,cn=alerts
objectClass: top
objectClass: ds-admin-alert
ds-alert-id: 3d1857a2-e8cf-4e80-ac0e-ba933be59eca
ds-alert-type: server-started
ds-alert-severity: info
ds-alert-type-oid: 1.3.6.1.4.1.32473.2.11.33
ds-alert-time: 20110126041442.622Z
ds-alert-generator: com.unboundid.directory.server.core.metrics.engine
ds-alert-message: The Metrics Engine has started successfully
```

""""

To Modify the Alert Retention Time

1. Use `dsconfig` to change the maximum time information about generated admin alerts is retained in the Alerts backend. After this time, the information gets purged from the Metrics Engine. The minimum retention time is 0 milliseconds, which immediately purges the alert information.

```
$ bin/dsconfig set-backend-prop --backend-name "alerts" \
  --set "alert-retention-time: 2 weeks"
```

2. View the property using `dsconfig`.

```
$ bin/dsconfig get-backend-prop --backend-name "alerts" \
  --property alert-retention-time
```

```
Property : Value(s)
-----:-----
```

```
alert-retention-time : 2 w
```

To Configure Duplicate Alert Suppression

- Use `dsconfig` to configure the maximum number of times an alert is generated within a particular timeframe for the same condition. The `duplicate-alert-time-limit` property specifies the length of time that must pass before duplicate messages are sent over the administrative alert framework. The `duplicate-alert-limit` property specifies the maximum number of duplicate alert messages should be sent over the administrative alert framework in the time limit specified in the `duplicate-alert-time-limit` property.

```
$ bin/dsconfig set-global-configuration-prop \  
--set duplicate-alert-limit:2 \  
--set "duplicate-alert-time-limit:3 minutes"
```

Command-Line Tools

The UnboundID Metrics Engine provides a full suite of command-line tools necessary to administer the server. The command-line tools are available in the `bin` directory for UNIX or Linux systems and `bat` directory for Microsoft Windows systems.

This chapter presents the following topics:

Using the Help Option

Each command-line utility provides a description of the subcommands, arguments, and usage examples needed to run the tool. You can view detailed argument options and examples by typing `--help` with the command.

```
bin/dsconfig --help
```

For those utilities that support additional subcommands (for example, `dsconfig`), you can get a list of the subcommands by typing `--help-subcommands`.

```
bin/dsconfig --help-subcommands
```

You can also get more detailed subcommand information by typing `--help` with the specific subcommand.

```
bin/dsconfig list-log-publishers --help
```



Note: For detailed information and examples of the command-line tools, see the *UnboundID Metrics Engine Command-Line Tool Reference*.

Available Command-Line Utilities

The Metrics Engine provides the following command-line utilities, which can be run directly in interactive, non-interactive, or script mode.

Table 13: Command-Line Utilities

Command-Line Tools	Description
backup	Run full or incremental backups on one or more Metrics Engine backends. This utility also supports the use of a properties file to pass predefined command-line arguments. See Managing the tools.properties File for more information.
base64	Encode raw data using the base64 algorithm or decode base64-encoded data back to its raw representation.
collect-support-data	Collect and package system information useful in troubleshooting problems. The information is packaged as a ZIP archive that can be sent to a technical support representative.
create-rc-script	Create an Run Control (RC) script that may be used to start, stop, and restart the Metrics Engine on UNIX-based systems.
dsconfig	View and edit the Metrics Engine configuration.
dsframework	Manage administrative server groups or the global administrative user accounts that are used to configure servers within server groups.
dsjavaproperties	Configure the JVM arguments used to run the Metrics Engine and associated tools. Before launching the command, edit the properties file located in <code>config/java.properties</code> to specify the desired JVM options and <code>JAVA_HOME</code> environment variable.
ldapmodify	Perform LDAP modify, add, delete, and modify DN operations in the Metrics Engine.
ldappasswordmodify	Perform LDAP password modify operations in the Metrics Engine.
ldapsearch	Perform LDAP search operations in the Metrics Engine.
ldif-diff	Compare the contents of two LDIF files, the output being an LDIF file needed to bring the source file in sync with the target.
ldifmodify	Apply a set of modify, add, and delete operations against data in an LDIF file.
manage-extension	Install or update extension bundles. An extension bundle is a package of extension(s) that utilize the Server SDK to extend the functionality of the UnboundID Metrics Engine. Extension bundles are installed from a zip archive or file system directory. The Metrics Engine will be restarted if running to activate the extension(s).
metric-engine-schema	Show current and required UnboundID Metrics Engine DBMS schema version information.
monitored-servers	Configure the set of servers to be monitored by this Metrics Engine and prepare external servers for monitoring.
query-metric	Explore collected monitoring data by forming queries for charts and data.
queryrate	Execute metric queries.
restore	Restore a backup of the Metrics Engine backend.
revert-update	Returns a server to the version before the last update was performed.
review-license	Review and/or indicate your acceptance of the product license.

Command-Line Tools	Description
server-state	View information about the current state of the Metrics Engine process.
setup	Perform the initial setup for the Metrics Engine instance.
start-metrics-engine	Start the Metrics Engine.
status	Display basic server information.
stop-metrics-engine	Stop or restart the Metrics Engine.
sum-file-sizes	Calculate the sum of the sizes for a set of files.
summarize-config	Generate a configuration summary of either a remote or local Metrics Engine instance. By default, only basic components and properties will be included. To include advanced components, use the <code>--advanced</code> option.
uninstall	Uninstall the Metrics Engine.
update	Update the Metrics Engine to a newer version by downloading and unzipping the new server install package on the same host as the server you wish to update. Then, use the <code>update</code> tool from the new server package to update the older version of the server. Before upgrading a server, you should ensure that it is capable of starting without severe or fatal errors. During the update process, the server is stopped if running, then the update performed, and a check is made to determine if the newly updated server starts without major errors. If it cannot start cleanly, the update will be backed out and the server returned to its prior state. See the <code>revert-update</code> tool for information on reverting an update.

Managing the tools.properties File

The UnboundID Metrics Engine supports the use of a tools properties file that simplifies command-line invocations by reading in a set of arguments for each tool from a text file. Each property is in the form of name/value pairs that define predetermined values for a tool's arguments. Properties files are convenient when quickly testing the Metrics Engine in multiple environments.

The Metrics Engine supports two types of properties file: default properties files that can be applied to all command-line utilities or tool-specific properties file that can be specified using the `--propertiesFilePath` option. You can override all of the Metrics Engine's command-line utilities with a properties file using the `config/tools.properties` file.

Creating a Tools Properties File

You can create a properties file with a text editor by specifying each argument, or option, using standard Java properties file format (name=value). For example, you can create a simple properties file that define a set of LDAP connection parameters as follows:

```
hostname=server1.example.com
port=1389
bindDN=cn=Directory\ Manager
bindPassword=secret
```

Next, you can specify the location of the file using the `--propertiesFilePath /path/to/File` option with the command-line tool. For example, if you save the previous properties file as `bin/mytool.properties`, you can specify the path to the properties file with `ldapsearch` as follows:


```
$ bin/ldapsearch --propertiesFilePath bin/mytools.properties "(objectclass=*)"
```

Properties files do not allow quotation marks of any kind around values. Any spaces or special characters should be escaped. For example,

```
bindDN=cn=QA\ Managers,ou=groups,dc=example,dc=com
```

The following is not allowed as it contains quotation marks:

```
bindDN=cn="QA Managers,ou=groups,dc=example,dc=com"
```

Tool-Specific Properties

The Metrics Engine also supports properties for specific tool options using the format: `tool.option=value`. Tool-specific options have precedence over general options. For example, the following properties file uses `ldapsearch.port=2389` for `ldapsearch` requests by the client. All other tools that use the properties file uses `port=1389`.

```
hostname=server1.example.com
port=1389
ldapsearch.port=2389
bindDN=cn=Directory\ Manager
```

Another example using the `dsconfig` configuration tool is as follows:

```
hostname=server1.example.com
port=1389
bindDN=cn=Directory\ Manager
dsconfig.bindPasswordFile=/ds/config/password
```



Note: The `.bindPasswordFile` property requires an absolute path. If you were to specify `~/ds/config/password`, where `~` refers to the home directory, the server does not expand the `~` value when read from the properties file.

Specifying Default Properties Files

The Metrics Engine provides a default properties files that apply to all command-line utilities used in client requests. A default properties file, `tools.properties`, is located in the `<server-root>/config` directory.

If you place a custom properties file that has a different filename as `tools.properties` in this default location, you need to specify the path using the `--propertiesFilePath` option. If you make changes to the `tools.properties` file, you do not need the `--propertiesFilePath` option. See the examples in the next section.

Evaluation Order Summary

The Metrics Engine uses the following evaluation ordering to determine options for a given command-line utility:

- All options used with a utility on the command line takes precedence over any options in any properties file.
- If the `--propertiesFilePath` option is used with no other options, the Metrics Engine takes its options from the specified properties file.
- If no options are used on the command line including the `--propertiesFilePath` option (and `--noPropertiesFile`), the Metrics Engine searches for the `tools.properties` file at `<server-root>`
- If no default properties file is found and a required option is missing, the tool generates an error.
- Tool-specific properties (for example, `ldapsearch.port=3389`) have precedence over general properties (for example, `port=1389`).

Evaluation Order Example

Given the following properties file that is saved as `<server-root>/bin/tools.properties`:

```
hostname=server1.example.com
port=1389
bindDN=cn=Directory\ Manager
bindPassword=secret
```

The Metrics Engine locates a command-line options in a specific priority order.

1. All options presented with the tool on the command line take precedence over any options in any properties file. In the following example, the client request is run with the options specified on the command line (port and baseDN). The command uses the `bindDN` and `bindPassword` arguments specified in the properties file.

```
$ bin/ldapsearch --port 2389 --baseDN ou=People,dc=example,dc=com \
--propertiesFilePath bin/tools.properties "(objectclass=*)"
```

2. Next, if you specify the properties file using the `--propertiesFilePath` option and no other command-line options, the Metrics Engine uses the specified properties file as follows:

```
$ bin/ldapsearch --propertiesFilePath bin/tools.properties \
"(objectclass=*)"
```

3. If no options are presented with the tool on the command line and the `--noPropertiesFile` option is not present, the Metrics Engine attempts to locate any default `tools.properties` file in the following location:

```
<server-root>/config/tools.properties
```

Assume that you move your `tools.properties` file from `<server-root>/bin` to the `<server-root>/config` directory. You can then run your tools as follows:

```
$ bin/ldapsearch "(objectclass=*)"
```

The Metrics Engine can be configured so that it does not search for any properties file by using the `--noPropertiesFile` option. This options tells the Metrics Engine to use only those options specified on the command line. The `--propertiesFilePath` and `--noPropertiesFile` options are mutually exclusive and cannot be used together.

4. If no default `tools.properties` file is found and no options are specified with the command-line tool, then the tool generates an error for any missing arguments.

Chapter

7

Managing Security

The UnboundID Metrics Engine provides a full suite of security features to secure communication between the client and the server, to establish trust between components (for example, for replication and administration), and to secure data. Internally, the Metrics Engine uses cryptographic mechanisms that leverage the Java JRE's Java Secure Sockets Extension (JSSE) implementation of the SSL protocol using Key Manager and Trust Manager providers for secure connection integrity and confidentiality, and the Java Cryptography Architecture (JCA) for data encryption.

This chapter presents procedures to configure security and covers the following topics:

Topics:

- [*Summary of the UnboundID Metrics Engine Security Features*](#)
- [*Metrics Engine SSL and StartTLS Support*](#)
- [*Managing Certificates*](#)
- [*Configuring the Key and Trust Manager Providers*](#)
- [*Configuring SSL in the Metrics Engine*](#)
- [*Configuring StartTLS*](#)
- [*Authentication Mechanisms*](#)
- [*Working with SASL Authentication*](#)
- [*Configuring Pass-Through Authentication*](#)
- [*Adding Operational Attributes that Restrict Authentication*](#)
- [*Configuring Certificate Mappers*](#)

Summary of the UnboundID Metrics Engine Security Features

The UnboundID Metrics Engine supports a strong set of cryptographic and other mechanisms to secure communication and data. The following security-related features are available:

- **SSL/StartTLS Support.** The Metrics Engine supports the use of SSL and StartTLS to encrypt communication between the client and the server. Administrators can configure different certificates for each connection handler, or use the same certificate for all connection handlers. Additionally, the server allows for more fine-grained control of the key material used in connecting peers in SSL handshakes and trust material for storing certificates.
- **Message Digest/Encryption Algorithms.** The Metrics Engine supports the use of a number of one-way message digests (e.g., CRYPT, 128-bit MD5, 160-bit SHA-1, and 256-bit, 384-bit, and 512-bit SHA-2 digests with or without salt) as well as a number of reversible encryption algorithms (BASE64, 3DES, AES, RC4, and Blowfish) for storing passwords. Note that even if passwords are encoded using reversible encryption, that encryption is intended for use only within the server itself, and the passwords will not be made available to administrators in unencrypted form. It is generally recommended that encrypted password storage only be used if you anticipate using an authentication mechanism that requires the server to have access to the clear-text representation of passwords, like CRAM-MD5 or DIGEST-MD5.
- **SASL Mechanism Support.** The Metrics Engine supports a number of SASL mechanisms, including ANONYMOUS, CRAM-MD5, DIGEST-MD5, EXTERNAL, PLAIN, and GSSAPI. In some vendors' directory servers, the use of CRAM-MD5 and DIGEST-MD5 requires that the server have access to the clear-text password for a user. In this case, the server supports reversible encryption to store the passwords in a more secure encoding than clear text. The server also supports two types of one-time password (OTP) mechanisms for multi-factor authentication: UNBOUNDID-TOTP SASL and UNBOUNDID-DELIVERED-OTP SASL. The proprietary UNBOUNDID-TOTP SASL mechanism allows multi-factor authentication to the server using the time-based one-time password (TOTP) code. The proprietary UNBOUNDID-DELIVERED-OTP SASL mechanism allows multi-factor authentication to the server by delivering a one-time password to the the end user through some out-of-band channel, such as email or SMS.
- **Password Policy Support.** The Metrics Engine provides extensive password policy support including features, like customizable password attributes, maximum password age, maximum password reset age, multiple default password storage schemes, account expiration, idle account lockout and others. The server also supports a number of password storage schemes, like one-way digests (CRYPT, MD5, SMD5, SHA, SSHA, SSHA256, SSHA384, SSHA512) and reversible encryption (BASE64, 3DES, AES, RC4, BLOWFISH). Administrators can also use a number of password validators, like maximum password length, similarity to current password and the set of characters used. See the chapter on *Password Policies* for more information.
- **Full-Featured Access Control System.** The Metrics Engine provides a full-featured access control subsystem that determines whether a given operation is allowable based on a wide

range of criteria. The access control system allows administrators to grant or restrict access to data, restrict the use of specific types of controls and extended operations and provides strong validation for access control rules before accepting them. See the chapter on *Access Control* for more information.

- **Client Connection Policies Support.** The Metrics Engine provides the ability to control which clients get connected to the server, how they can get connected to the system, and what resources or operations are available to them. For example, administrators can set up client connection criteria that blacklists IP addresses or domains that are known to attempt brute force attacks. Likewise, client connection policies can be configured to restrict the type of operations, controls, extended-operations, SASL mechanisms, search filters and resource limits available to the client. For example, you can configure a client connection policy that limits the number of concurrent connections or rejects all requests on unsecured connections.
- **Backup Protection.** The Metrics Engine provides the ability to protect the integrity of backup contents using cryptographic digests and encryption. When generating a backup, the administrator has an option to generate a cryptographic digest of the backup contents and also optionally to digitally sign that digest. The server also has options to compress and/or encrypt the contents of the backup. When restoring the backup, the server can verify that the digest matches the content of the backup and generates an error if the backup has been changed from when it was initially written, making it tamper-evident. The server also provides the ability to verify the integrity of a backup without actually restoring it. See chapter on *Backing Up and Restoring Data* for more information.

Metrics Engine SSL and StartTLS Support

The UnboundID Metrics Engine supports the use of SSL and/or StartTLS to secure communication with clients and other components in your environment.



Note: Although the term "SSL" (Secure Sockets Layer) has been superseded by "TLS" (Transport-Layer Security), the older term "SSL" will continue to be used in this document to make it easier to distinguish between the use of TLS as a general mechanism for securing communication and the specific use of the StartTLS extended operation.

The supported versions of SSL or StartTLS are determined by what the underlying JVM supports. The server will automatically look at the supported protocols and attempt to determine the best one to use.

When using Oracle Java SE 1.7, version TLSv1.2 is preferred by the server. A particular protocol can be specified by setting the `com.unboundid.util.SSLUtil.defaultSSLProtocol` property

LDAP-over-SSL (LDAPS)

The Metrics Engine provides the option of using dedicated connection handlers for LDAPS connections. LDAPS differs from LDAP in that upon connect, the client and server establish an SSL session before any LDAP messages are transferred. LDAPS connection handlers with SSL enabled may only be used for secure communication, and connections must be closed when the SSL session is shut down.

StartTLS Support

The StartTLS extended operation provides a means to add SSL encryption to an existing plain-text LDAP connection. The client opens an unencrypted TCP connection to the server and, after processing zero or more LDAP operations over that clear-text connection, sends a StartTLS extended request to the server to indicate that the client-server communication should be encrypted.

To require the use of SSL for client connections accepted by a connection handler, set `use-ssl` to true for that connection handler. To allow clients to use StartTLS on a connection handler, the administrator must configure that connection handler to allow StartTLS. Because SSL and StartTLS are mutually exclusive, you cannot enable both SSL and StartTLS for the same connection handler (although you can have some connection handlers configured to use SSL and others configured to use StartTLS).

Managing Certificates

You can generate and manage certificates using a variety of commonly available tools, such as the Java `keytool` utility, which is a key and certificate management utility provided with the Java SDK. The `keytool` utility can be used to create keystores, which hold key material used in the course of establishing an SSL session, and truststores, which may be consulted to determine whether a presented certificate should be trusted.

Because there are numerous ways to create or obtain certificates, the procedures in this section will only present basic steps to set up your certificates. Many companies have their own certificate authorities or have existing certificates that they use in the servers, and in such environments you should follow the guidelines specific to your company's implementation.

The UnboundID Metrics Engine supports three keystore types: Java Keystore (JKS), PKCS#12, and PKCS#11.

- **Java Keystore (JKS).** In most Java SE implementations, the JKS keystore is the default and preferred keystore format. JKS keystores may be used to hold certificates for other Java-based applications, but such keystores are likely not compatible with non-Java-based applications.
- **PKCS#12.** This keystore type is a well-defined standard format for storing a certificate or certificate chain, and may be used to hold certificates already in use for other types of

servers. Most other servers that provide a proprietary format for storing certificates provide a mechanism for converting those certificates to PKCS#12.

- **PKCS#11.** Also, known as Cryptoki (pronounced "crypto-key") is a format for cryptographic token interfaces for devices, such as cryptographic smart cards, hardware accelerators, and high performance software libraries. PKCS#11 tokens may also offer a higher level of security than other types of keystores, and many of them have been FIPS 140-2 certified and may be tamper-evident or tamper-resistant.

Authentication Using Certificates

The Metrics Engine supports two different mechanisms for certificate-based authentication:

- **Client Certificate Validation.** The Metrics Engine can request the client to present its own certificate for client authentication during the SSL or StartTLS negotiation process. If the client presents a certificate, then the server will use the trust manager provider configured for the associated connection handler to determine whether to continue the process of establishing the SSL or StartTLS session. If the client certificate is not accepted by the trust manager provider, then the server will terminate the connection. Note that even if the client provides its own certificate to the server during the process of establishing an SSL or StartTLS session, the underlying LDAP connection may remain unauthenticated until the client sends an LDAP bind request over that connection.
- **SASL EXTERNAL Certificate Authentication.** The SASL EXTERNAL mechanism is used to allow a client to authenticate itself to the Metrics Engine using information provided outside of LDAP communication. In the Metrics Engine, that information must come in the form of a client certificate presented during the course of SSL or StartTLS negotiation. Once the client has established a secure connection to the server in which it provided its own client certificate, it may send a SASL EXTERNAL bind request to the server to request that the server attempt to identify the client based on information contained in that certificate. The server will then use a certificate mapper to identify exactly one user entry that corresponds to the provided client certificate, and it may optionally perform additional verification (e.g., requiring the certificate the client presented to be present in the `userCertificate` attribute of the user's entry). If the certificate mapper cannot identify exactly one user entry for that certificate, or if its additional validation is not satisfied, then the bind attempt will fail and the client connection will remain unauthenticated.

Creating Server Certificates using Keytool

You can generate and manage certificates using the `keytool` utility, which is available in the Java 1.6 SDK. The `keytool` utility is a key and certificate management utility that allows users to manage their public/private key pairs, x509 certificate chains and trusted certificates. The utility also stores the keys and certificates in a keystore, which is a password-protected file with a default format of JKS although other formats like PKCS#12 are available. Each key and trusted certificate in the keystore is accessed by its unique alias.

To Create a Server Certificate using Keytool

1. Change to the directory where the certificates will be stored.

```
$ cd /ds/UnboundID-Metrics-Engine/config
```

2. Use the `keytool` utility to create a private/public key pair and a keystore. The `keytool` utility is part of the Java SDK. If you cannot access the utility, make sure to change your path to include the Java SDK (`${JAVA_HOME}/bin`) directory.

The following command creates a keystore named "keystore", generates a public/private key pair and creates a self-signed certificate based on the key pair. This certificate can be used as the server certificate or it can be replaced by a CA-signed certificate chain if additional `keytool` commands are executed. Self-signed certificates are only convenient for testing purposes, they are not recommended for use in deployments in which the set of clients is not well-defined and carefully controlled. If clients are configured to blindly trust any server certificate, then they may be vulnerable to man-in-the-middle attacks.

The `-dname` option is used to specify the certificate's subject, which generally includes a CN attribute with a value equal to the fully-qualified name that clients will use to communicate with the Metrics Engine. Some clients may refuse to establish an SSL or StartTLS session with the server if the certificate subject contains a CN value which does not match the address that the client is trying to use, so this should be chosen carefully. If the `-dname` option is omitted, you will be prompted for input. The certificate will be valid for 180 days.

```
$ keytool -genkeypair \  
-dname "CN=server.example.com,ou=Metrics Engine Certificate,\  
O=Example Company,C=US" \  
-alias server-cert \  
-keyalg rsa \  
-keystore keystore \  
-keypass changeit \  
-storepass changeit \  
-storetype JKS \  
-validity 180 \  
-noprompt
```



Note: The `-keypass` and `-storepass` arguments can be omitted to cause the tool to interactively prompt for the password. Also, the key password should match the keystore password.

3. View the keystore. Notice the entry type is `privateKeyEntry` which indicates that the entry has a private key associated with it, which is stored in a protected format to prevent unauthorized access. Also note that the Owner and the Issuer are the same, indicating that this certificate is self-signed.

```
$ keytool -list -v -keystore keystore -storepass changeit
```

```
Keystore type: JKS  
Keystore provider: SUN  
  
Your keystore contains 1 entry  
  
Alias name: server-cert  
Creation date: Sep 30, 2011  
Entry type: PrivateKeyEntry
```

```
Certificate chain length: 1
Certificate[1]:
Owner: CN=server.example.com, OU=Metrics Engine Certificate, O=Example Company, C=US
Issuer: CN=server.example.com, OU=Metrics Engine Certificate, O=Example Company,
C=US
Serial number: 4ac3695f
Valid from: Wed Sep 30 09:21:19 CDT 2011 until: Mon Mar 29 09:21:19 CDT 2012
Certificate fingerprints:
MD5: 3C:7B:99:BA:95:A8:41:3B:08:85:11:91:1B:E1:18:00
SHA1: E9:7E:38:0F:1C:68:29:29:C0:B4:8C:08:2B:7C:DA:14:BF:41:DE:F5
Signature algorithm name: SHA1withRSA
Version: 3
```

4. If you are going to have your certificate signed by a Certificate Authority, skip to step 7. Otherwise export the self-signed certificate. Then examine the certificate.

```
$ keytool -export -alias server-cert -keystore keystore -rfc -file server.crt
Enter keystore password:
Certificate stored in file <server.crt>
```

```
$ cat server.crt
-----BEGIN CERTIFICATE-----
MIICVTCCAb6gAwIBAgIESsNpXzANBgkqhkiG9w0BAQUFADBvMQswCQYDVQQGEwJVUzEYMBYGA1UEChMPRXhhb
XBsZSBDb2lwYW55MS8wLQYDVQQLEyZVbmJvdW5kaWQgRGlyZW50b3J5IFNlcnZlciBD ZXJ0aWZpY2F0ZTEV
BMGA1UEAxMMMTcyLjE2LjE5My4xMB4XDTA5MDkzMDE0MjExOVVOTDEwMDMjE5OVVOTDEwMDMjE5OVVOTDEw
MCVVMxGDAWBgNVBAoTD0V4YW1wbGUgQ29tcGFueTEvMC0GALUE CxMmVW5ib3VuZG1kIERpcmVjdG9yeSBZ
J2Z2XIGQ2Vydg1maWNhdGUxFTATBgNVBAMTDDE3Mi4x Ni4xOTMuMTCBnzANBgkqhkiG9w0BAQEFAAOBjQAwG
YkCgYEAuRBPSeRcqr4XP8PjJWcGDVR3lwE cItmMImbjpf0rTq+KG8Ssp8+se+LjLHLaeNg3itR3xMBwp7mQ4
E42i2PBIIZ0PwOKBRPzXDxpsITsSy3o9anTsopIVglUpST2iHGBQ+j+VY33cdcc5EoJwYykZ4dliu45yc834
VByXjiKUCAwEAATANBgkqhkiG9w0BAQUFAAOBgQCJIZfsfQuUig4F0kPC/0fFbhW96TrLTOi6AMIOtork1SuJ
lkxp/nT+eD8eGoE+zshyJWTFvVnzMDIIFMjWdIIVvnyYmyeRlVlCchyJE6JyFiLpBWs6RuLD8iuHydYEWK8NkEF
YvVb/UIKqJlZ8H8+1lppt0bENRnGD7zMwJv5ZE49w==
-----END CERTIFICATE-----
```

5. Import the self-signed certificate into a truststore, and then type `yes` to trust the certificate.

```
$ keytool -importcert -alias server-cert -file server.crt \
-keystore truststore -storepass changeit

Owner: CN=server.example.com, OU=Metrics Engine Certificate, O=Example Company, C=US
Issuer: CN=server.example.com, OU=Metrics Engine Certificate, O=Example Company,
C=US
Serial number: 4ac3695f
Valid from: Wed Sep 30 09:21:19 CDT 2011 until: Mon Mar 29 09:21:19 CDT 2012
Certificate fingerprints:
MD5: 3C:7B:99:BA:95:A8:41:3B:08:85:11:91:1B:E1:18:00
SHA1: E9:7E:38:0F:1C:68:29:29:C0:B4:8C:08:2B:7C:DA:14:BF:41:DE:F5
Signature algorithm name: SHA1withRSA
Version: 3
Trust this certificate? [no]: yes
Certificate was added to keystore
```

6. View the truststore with the self-signed certificate. If you intend to use this self-signed certificate as your server certificate, you are done. *Again, it is not recommended to use self-signed certificate in production deployments.* Note that the entry type of `trustedCertEntry` indicates that the keystore owner trusts that the public key in the certificate belongs to the entity identified by the owner of the certificate.

```
$ keytool -list -v -keystore truststore -storepass changeit
```

```
Keystore type: JKS
Keystore provider: SUN

Your keystore contains 1 entry

Alias name: server-cert
Creation date: Sep 30, 2011
Entry type: trustedCertEntryOwner: CN=server.example.com, OU=Metrics Engine
Certificate, O=Example Company, C=US
Issuer: CN=server.example.com, OU=Metrics Engine Certificate, O=Example Company,
C=US
```

```
Serial number: 4ac3695f Valid from: Wed Sep 30 09:21:19 CDT 2011 until: Mon Mar 29
09:21:19 CDT 2012
Certificate fingerprints:
MD5: 3C:7B:99:BA:95:A8:41:3B:08:85:11:91:1B:E1:18:00
SHA1: E9:7E:38:0F:1C:68:29:29:C0:B4:8C:08:2B:7C:DA:14:BF:41:DE:F5
Signature algorithm name: SHA1withRSA
Version: 3
```

7. Create the Certificate Signing Request (CSR) by writing to the file `server.csr`. Follow the instructions of the third-party Certificate Authority (CA), and submit the file to a CA. The CA authenticates you and then returns a certificate reply, which you can save as `signed.crt`.

```
$ keytool -certreq -v -alias server-cert -keystore keystore \
-storepass changeit -file server.csr
```

```
Certification request stored in file <server.csr>
Submit this to your CA
```

8. If you are working with a third-party CA or if your company has your own CA server, then both the key and trust stores should include information about the CA's root certificate as well as any intermediate certificates used to sign the Metrics Engine certificate. Obtain the CA root and any intermediate certificates to set up a chain of trust in your keystore. View the trusted CA and intermediate certificates to check that the displayed certificate fingerprints match the expected ones.

```
$ keytool -v -printcert -file root.crt
$ keytool -v -printcert -file intermediate.crt
```

9. Import the CA's root certificate in the keystore and truststore. If there are other intermediate certificates, then import them using the same commands, giving them each different aliases in the key and trust stores.

```
$ keytool -importcert -v -trustcacerts -alias cacert \
-keystore keystore -storepass changeit -file root.crt
$ keytool -importcert -v -trustcacerts -alias cacert -keystore truststore \
-storepass changeit -file root.crt
```

10. Import the Metrics Engine certificate signed by the CA into your keystore, which will replace the existing self-signed certificate created when the private key was first generated.

```
$ keytool -importcert -v -trustcacerts -alias server-cert -keystore keystore -
storepass changeit -file signed.crt
```

```
Owner: CN=server.example.com, OU=Metrics Engine Certificate, O=Example Company, C=US
Issuer: EMAILADDRESS=whatever@example.com, CN=Cert Auth, OU=My Certificate Authority,
O=Example Company, L=Austin, ST=Texas, C=US
Serial number: e19cb2838441dbb6 Valid from: Wed Sep 30 10:10:30 CDT 2011 until: Thu
Sep 30 10:10:30 CDT 2012
Certificate fingerprints:
MD5: E0:C5:F7:CF:0D:13:F5:FC:2D:A6:A4:87:FD:4C:36:1A
SHA1: E4:15:0B:ED:99:1C:13:47:29:66:76:A0:3B:E3:4D:60:33:F1:F8:21
Signature algorithm name: SHA1withRSA
Version: 1
Trust this certificate? [no]: yes
Certificate was added to keystore [Storing changeit]
```

11. Add the certificate to the truststore.

```
$ keytool -importcert -v -trustcacerts -alias server-cert \
-keystore truststore -storepass changeit -file signed.crt
```

Client Certificates

Client certificates can be used when stronger client authentication is desired but are not required for SSL connections to be established. The process for creating client certificates usually involve following an organization's certificate management policies. There are two important considerations to take into account:

- If a client presents its own certificate to the server, then the server must trust that certificate. This generally means that self-signed client certificates are not acceptable for anything but testing purposes or cases in which there are very small number of clients that will be presenting their own certificates. Otherwise, it is not feasible to configure the server to trust every client certificate.
- If the client certificates will be used for LDAP authentication via SASL EXTERNAL, then the certificate must contain enough information to allow the Metrics Engine to associate it with exactly one user entry. The requirements for this are dependent upon the certificate mapper configured for use in the server, but this may impose constraints on the certificate (for example, the format of the certificate's subject).

Creating PKCS#12 Certificates

PKCS#12 is an industry standard format for deploying X.509 certificates (or certificate chains) and a private key as a single file. PKCS#12 is part of the family of standards called the Public-Key Cryptography Standard (PKCS) developed by RSA Laboratories.

To Generate PKCS#12 Certificates using Keytool

- To create a new certificate in PKCS#12 format, follow the same procedures as in [Creating Server Certificates using Keytool](#), except use the `--storetype pkcs12` argument. For example, to create a PKCS#12 self-signed certificate and keystore, use the following command:

```
$ keytool -genkeypair \
  -dname "CN=server.example.com,ou=Metrics Engine Certificate,O=Example Company,C=US" \
  -alias server-cert -keyalg rsa -keystore keystore.pk12 -keypass changeit \
  -storepass changeit -storetype pkcs12 -validity 180 -noprompt
```

To Export a Certificate from an NSS Database in PKCS#12 Format

Some directory servers, including the Sun/Oracle DSEE Directory Server, use the Network Security Services (NSS) library to manage certificates. If you have such a directory server and wish to migrate its certificates for use with the UnboundID Metrics Engine, then PKCS#12 can be used to accomplish this task. Use the `pk12util` NSS command-line utility to export a certificate from an NSS certificate database in PKCS12 format. You can use the PKCS#12 certificate when using QuickSetup or setting up SSL.

- Run the following `pk12util` command.

```
$ pk12util -o server.p12 -n server-cert -k /tmp/pwdfile \  
-w /tmp/pwdfile -d . -P "ds-"
```

```
nss-pk12util: PKCS12 EXPORT SUCCESSFUL
```

Working with PKCS#11 Tokens

The Cryptographic Token Interface Standard, PKCS#11, defines the native programming interfaces to cryptographic tokens, like Smartcards and hardware cryptographic accelerators. A security token provides cryptographic services. PKCS#11 provides an interface to cryptographic devices via "slots". Each slot, which corresponds to a physical reader or other device interface, may contain a token. A token is typically a PKCS#11 hardware token implemented in physical devices, such as hardware accelerators or smart cards. A software token is a PKCS#11 token implemented entirely in software.



Note: Because different types of PKCS#11 tokens have different mechanisms for creating, importing, and managing certificates, it may or may not be possible to achieve this using common utilities like `keytool`. In some cases (particularly for devices with strict Note FIPS 140-2 compliance), it may be necessary to use custom tools specific to that PKCS#11 token for managing its certificates. Consult the documentation for your PKCS#11 token for information about how to configure certificates for use with that token.

Configuring the Key and Trust Manager Providers

Java uses key managers to get access to certificates to use for SSL and StartTLS communication. Administrators use the Metrics Engine's key manager providers to provide access to keystore contents. There are three types of key manager providers:

- **JKS Key Manager Provider.** Provides access to certificates stored in keystores using the Java-default JKS format.
- **PKCS#11 Key Manager Provider.** Provides access to certificates maintained in PKCS#11 tokens.
- **PKCS#12 Key Manager Provider.** Provides access to certificates in PKCS#12 files.

Trust manager providers are used to determine whether to trust any client certificate that may be presented during the process of SSL or StartTLS negotiation. The available trust manager provider types include:

- **Blind Trust Manager Provider.** Automatically trusts any client certificate presented to the server. This should only be used for testing purposes. Never use it for production environments, because it can be used to allow users to generate their own certificates to impersonate other users in the server.

- **JKS Trust Manager Provider.** Attempts to determine whether to trust a client certificate, or the certificate of any of its issuers, is contained in a JKS-formatted file.
- **PKCS#12 Trust Manager Provider.** Attempts to determine whether to trust a client certificate, or the certificate of any of its issuers, is contained in a PKCS#12 file.

Configuring the JKS Key and Trust Manager Provider

The following procedures are identical to those in the previous section except that the `dsconfig` tool in non-interactive mode commands are presented from the command line.

To Configure the JKS Key Manager Provider

1. Change to the server root.

```
$ cd /ds/UnboundID-Metrics-Engine
```

2. Create a text file containing the password for the certificate keystore. It is recommended that file permissions (or filesystem ACLs) be configured so that the file is only readable by the Metrics Engine user.

```
$ echo 'changeit' > config/keystore.pin
$ chmod 0400 keystore.pin
```

3. Use the `dsconfig` tool to enable the key manager provider.

```
$ bin/dsconfig set-key-manager-provider-prop \
  --provider-name JKS --set enabled:true
```

4. Use `dsconfig` to enable the trust manager provider.

```
$ bin/dsconfig set-trust-manager-provider-prop \
  --provider-name JKS --set enabled:true
```

5. Use `dsconfig` to enable the LDAPS connection handler. Port 636 is typically reserved for LDAPS, but if your server is using the port, you should specify another port, like 1636. If the certificate alias differs from the default "server-cert", use the `--set ssl-cert-nickname:<aliasname>` to set it, or you can let the server decide by using the `--reset ssl-cert-nickname` option. For example, if the server certificate has an alias of "server," add the option `--set ssl-cert-nickname:server` to the command.

```
$ bin/dsconfig set-connection-handler-prop \
  --handler-name "LDAPS Connection Handler" \
  --set listen-port:1636 --set enabled:true
```

6. Test the listener port for SSL-based client connection on port 1636 to return the Root DSE. Type `yes` to trust the certificate.

```
$ bin/ldapsearch --port 1636 --useSSL --baseDN "" --searchScope base \
  "(objectclass=*)"
```

```
The server is using the following certificate:
  Subject DN: CN=179.13.201.1, OU=Metrics Engine Certificate, O=Example Company,
  L=Austin, ST=Texas, C=US
```

```
Issuer DN: EMAILADDRESS=whatever@example.com, CN=Cert Auth, OU=My Certificate
Authority, O=Example Company, L=Austin, ST=Texas, C=US
Validity: Fri Sep 25 15:21:10 CDT 2011 through Sat Sep 25 15:21:10 CDT 2012
Do you wish to trust this certificate and continue connecting to the server?
Please enter 'yes' or 'no':yes
```

7. If desired, you may disable the LDAP Connection Handler so that communication can only go through SSL.

```
$ bin/dsconfig set-connection-handler-prop \
--handler-name "LDAP Connection Handler" \
--set enabled:false
```

Configuring the PKCS#12 Key Manager Provider

PKCS#12 (sometimes referred to as the Personal Information Exchange Syntax Standard) is a standard file format used to store private keys with its accompanying public key certificates, protected with a password-based symmetric key.

To Configure the PKCS#12 Key Manager Provider

1. Change to the identity data store root.

```
$ cd /ds/UnboundID-Metrics-Engine
```

2. Create a text file containing the password for the certificate keystore. It is recommended that file permissions (or filesystem ACLs) be configured so that the file is only readable by the Metrics Engine user.

```
$ echo 'changeit' > config/keystore.pin
$ chmod 0400 keystore.pin
```

3. Use the `dsconfig` tool to configure and enable the PKCS#12 key manager provider.

```
$ bin/dsconfig set-key-manager-provider-prop \
--provider-name PKCS12 \
--set enabled:true \
--set key-store-file:/config/keystore.p12 \
--set key-store-type:PKCS12 \
--set key-store-pin-file:/config/keystore.pin
```

4. Use the `dsconfig` tool to configure and enable the PKCS#12 trust manager provider.

```
$ bin/dsconfig set-trust-manager-provider-prop \
--provider-name PKCS12 \
--set enabled:true \
--set trust-store-file:/config/truststore.p12
```

5. Use `dsconfig` to enable the LDAPS connection handler. Port 636 is typically reserved for LDAPS, but if your server is using the port, you should specify another port, like 1636. If the certificate alias differs from the default "server-cert", use the `--set ssl-cert-nickname:<aliasname>` to set it, or you can let the server decide by using the `--reset ssl-cert-nickname` option. For example, if the server certificate has an alias of "server," add the option `--set ssl-cert-nickname:server` to the command.

```
$ bin/dsconfig set-connection-handler-prop \
```



```
--handler-name "LDAPS Connection Handler" \
--set enabled:true \
--set listen-port:2636 \
--set ssl-cert-nickname:1 \
--set key-manager-provider:PKCS12 \
--set trust-manager-provider:PKCS12
```

Configuring the PKCS#11 Key Manager Provider

The Cryptographic Token Interface (Cryptoki), or PKCS#11, format defines a generic interface for cryptographic tokens used in single sign-on or smartcard systems. The Metrics Engine supports PKCS#11 keystores.

To Configure the PKCS#11 Key Manager Provider

1. Change to the server root.

```
$ cd /ds/UnboundID-Metrics-Engine
```

2. Create a text file containing the password for the certificate keystore. It is recommended that file permissions (or filesystem ACLs) be configured so that the file is only readable by the Metrics Engine user.

```
$ echo 'changeit' > config/keystore.pin
$ chmod 0400 keystore.pin
```

3. Use the `dsconfig` tool to configure and enable the PKCS#11 key manager provider.

```
$ bin/dsconfig set-key-manager-provider-prop \
--provider-name PKCS11 \
--set enabled:true \
--set key-store-type:PKCS11 \
--set key-store-pin-file:/config/keystore.pin
```

4. Use the `dsconfig` tool to enable the trust manager provider. Since there is no PKCS#11 trust manager provider, then you must use one of the other truststore provider types (for example, JKS or PKCS#12).

```
$ bin/dsconfig set-trust-manager-provider-prop \
--provider-name JKS \
--set enabled:true \
--set trust-store-file:/config/truststore.jks
```

5. Use `dsconfig` to enable the LDAPS connection handler. Port 636 is typically reserved for LDAPS, but if your server is using the port, you should specify another port, like 1636. If the certificate alias differs from the default "server-cert", use the `--set ssl-cert-nickname:<aliasname>` to set it, or you can let the server decide by using the `--reset ssl-cert-nickname` option. For example, if the server certificate has an alias of "server," add the option `--set ssl-cert-nickname:server` to the command.

```
$ bin/dsconfig set-connection-handler-prop \
--handler-name "LDAPS Connection Handler" \
--set enabled:true \
--set listen-port:1636 \
--set ssl-cert-nickname:1 \
--set key-manager-provider:PKCS11 \
--set trust-manager-provider:JKS
```

Configuring the Blind Trust Manager Provider

The Blind Trust Manager provider accepts any peer certificate presented to it and is provided for testing purposes only. This trust manager should not be used in production environments, because it can allow any client to generate a certificate that could be used to impersonate any user in the server.

To Configure the Blind Trust Manager Provider

1. Change to the Metrics Engine install root.

```
$ cd /ds/UnboundID-Metrics-Engine
```

2. Use the `dsconfig` tool to enable the blind trust manager provider.

```
$ bin/dsconfig set-trust-manager-provider-prop \  
--provider-name "Blind Trust" --set enabled:true
```

3. Use `dsconfig` to enable the LDAPS connection handler. Port 636 is typically reserved for LDAPS, but if your server is using the port, you should specify another port, like 1636. If the certificate alias differs from the default "server-cert", use the `--set ssl-cert-nickname:<aliasname>` to set it, or you can let the server decide by using the `--reset ssl-cert-nickname` option. For example, if the server certificate has an alias of "server," add the option `--set ssl-cert-nickname:server` to the command.

Configuring SSL in the Metrics Engine

The UnboundID Metrics Engine provides a means to enable SSL or StartTLS at installation time, using either an existing certificate or by automatically generating a self-signed certificate. However, if SSL was not configured at install time, then it may be enabled at any time using the following process. These instructions assume that the certificate is available in a JKS-formatted keystore, but a similar process may be used for certificates available through other mechanisms like a PKCS#12 file or a PKCS#11 token.

To Configure SSL in the Metrics Engine

1. Change to the server root directory.

```
$ cd /ds/UnboundID-Metrics-Engine
```

2. Create a text file containing the password for the certificate keystore. It is recommended that file permissions (or filesystem ACLs) be configured so that the file is only readable by the Metrics Engine user.

```
$ echo 'changeit' > config/keystore.pin  
$ chmod 0400 config/keystore.pin
```

3. Run the `dsconfig` command with no arguments in order to launch the `dsconfig` tool in interactive mode. Enter the connection parameters when prompted.
4. On the **Metrics Engine Configuration Console main** menu, enter `o` (lowercase letter "o") to change the complexity of the configuration objects menu. Select the option to show objects at the Standard menu.
5. On the **Metrics Engine Configuration Console main** menu, enter the number corresponding to the Key Manager Provider.
6. On the **Key Manager Provider management** menu, select the option to view and edit an existing key manager.
7. On the **Key Manager Provider** menu, enter the option for JKS. You will see other options, like Null, PKCS11, and PKCS12.
8. Make any necessary changes to the JKS key manager provider for the keystore that you will be using. The `enabled` property must have a value of `TRUE`, the `key-store-file` property must reflect the path to the keystore file containing the server certificate, and the `key-store-pin-file` property should reflect the path to a file containing the password to use to access the keystore contents.
9. On the **Enabled Property** menu, enter the option to change the value to `TRUE`.
10. On the **File Based Key Manager Provider**, type `f` to save and apply the changes.
11. Return to the **dsconfig main** menu, and enter the number corresponding to Trust Manager Provider.
12. On the **Trust Manager Provider management** menu, enter the option to view and edit an existing trust manager provider.
13. On the **Trust Manager Provider** menu, enter the option for JKS. You will see other options for Blind Trust (accepts any certificate) and PKCS12 reads information about trusted certificates from a PKCS#12 file.
14. Ensure that the JKS trust manager provider is enabled and that the `trust-store-file` property has a value that reflects the path to the truststore file to consult when deciding whether to trust any presented certificates.
15. On the **File Based Trust Manager Provider** menu, type `f` to save and apply the changes.
16. Return to the **dsconfig main** menu, enter the number corresponding to Connection Handler.
17. On the **Connection Handler management** menu, enter the option to view and edit and existing connection handler.
18. On the **Connection Handler** menu, enter the option for LDAPS Connection Handler. You will see other options for JMX Connection Handler and LDAP Connection Handler.
19. On the **LDAP Connection Handler** menu, ensure that the connection handler has an appropriate configuration for use. The `enabled` property should have a value of `TRUE`, the

listen-port property should reflect the port on which to listen for SSL-based connections, and the ssl-cert-nickname property should reflect the alias for the target certificate in the selected keystore. Finally, when completing the changes, type `f` to save and apply the changes.

20. Verify that the server is properly configured to accept SSL-based client connections using an LDAP-based tool like `ldapsearch`. For example:

```
$ bin/ldapsearch --port 1636 --useSSL --baseDN "" \
--searchScope base "(objectclass=*)"
```

```
The server is using the following certificate:
Subject DN: CN=179.13.201.1, OU=Metrics Engine
Certificate, O=Example Company, L=Austin, ST=Texas,
C=US Issuer DN: EMAILADDRESS=whatever@example.com,
CN=Cert Auth, OU=My Certificate Authority, O=Example
Company, L=Austin, ST=Texas, C=US
Validity: Fri Sep 25 15:21:10 CDT 2011 through Sat Sep 25 15:21:10 CDT 2012
Do you wish to trust this certificate and continue connecting to the server?
Please enter 'yes' or 'no':yes
```

21. If desired, you may disable the LDAP connection handler so only the LDAPS connection handler will be enabled and the server will only accept SSL-based connections.

Configuring StartTLS

The StartTLS extended operation is used to initiate a TLS-secured communication channel over a clear-text connection, such as an insecure LDAP connection. The main advantage of StartTLS is that it provides a way to use a single connection handler capable of both secure and insecure communication rather than requiring a dedicated connection handler for secure communication.

To Configure StartTLS

1. Use `dsconfig` to configure the Connection Handler to allow StartTLS. The `allow-start-tls` property cannot be set if SSL is enabled. The connection handler must also be configured with a key manager provider and a trust manager provider.

```
$ bin/dsconfig set-connection-handler-prop \
--handler-name "LDAP Connection Handler" \
--set allow-start-tls:true \
--set key-manager-provider:JKS \
--set trust-manager-provider:JKS
```

2. Use `ldapsearch` to test StartTLS.

```
$ bin/ldapsearch -p 1389 --useStartTLS -b "" -s base "(objectclass=*)"
```

```
The server is using the following certificate:
Subject DN: CN=Server Cert, OU=Metrics Engine Certificate,
O=Example Company, L=Austin, ST=Texas, C=US
Issuer DN: EMAILADDRESS=whatever@example.com, CN=Cert Auth,
OU=My Certificate Authority, O=Example Company, L=Austin, ST=Texas, C=US
Validity: Thu Oct 29 10:29:59 CDT 2011 through Fri Oct 29 10:29:59 CDT 2012

Do you wish to trust this certificate and continue connecting to the server?
Please enter 'yes' or 'no':yes
```

```
dn:  
objectClass: ds-root-dse  
objectClass: top  
startupUUID: 6fa8f196-d112-40b4-b8d8-93d6d44d59ea
```

Authentication Mechanisms

The UnboundID Metrics Engine supports the use of both simple and Simple Authentication and Security Layer (SASL) authentication.

Simple Authentication

Simple authentication allows a client to identify itself to the Metrics Engine using the DN and password of the target user. Because the password is provided in the clear, simple authentication is inherently insecure unless the client communication is encrypted using a mechanism like SSL or StartTLS.

If both the DN and password of a simple bind request are empty (i.e., zero-length strings), then the server will process it as an anonymous bind. This will have no effect if the client is not already authenticated, but it can be used to destroy any previous authentication session and revert the connection to an unauthenticated state as if no bind had ever been performed on that connection.

Working with SASL Authentication

SASL (Simple Authentication and Security Layer, defined in RFC 4422) provides an extensible framework that can be used to add support for a range of authentication and authorization mechanisms. The UnboundID Metrics Engine provides support for a number of common SASL mechanisms.

Figure 37: Simple Authentication and Security Layer

Working with the SASL ANONYMOUS Mechanism

The ANONYMOUS SASL mechanism does not actually perform any authentication or authorization, but it can be used to destroy an existing authentication session. It also provides an option to allow the client to include a trace string, which can be used to identify the purpose of the connection. Because there is no authentication, the content of the trace string cannot be trusted.

The SASL ANONYMOUS mechanism is disabled by default but can be enabled if desired using the `dsconfig` tool. The SASL configuration options are available as an **Advanced menu** option using `dsconfig` in interactive mode.

The LDAP client tools provided with the Metrics Engine support the use of SASL ANONYMOUS. The optional "trace" SASL option may be used to specify the trace string to include in the bind request.

To Configure SASL ANONYMOUS

1. Use `dsconfig` to enable the SASL ANONYMOUS mechanism.

```
$ bin/dsconfig set-sasl-mechanism-handler-prop \  
--handler-name ANONYMOUS --set enabled:true
```

2. Use `ldapsearch` to view the root DSE and enter a trace string in the access log.

```
$ bin/ldapsearch --port 1389 --saslOption mech=ANONYMOUS \  
--saslOption "trace=debug trace string" --baseDN "" \  
--searchScope base "(objectclass=*)"
```

```
dn:  
objectClass: ds-root-dse  
objectClass: top  
startupUUID: 59bab79d-4429-49c8-8a88-c74a86792f26
```

3. View the access log using a text editor in `/ds/UnboundID-Metrics-Engine/logs` folder.

```
[26/Oct/2011:16:06:33 -0500] BIND RESULT conn=2 op=0 msgID=1 resultCode=0  
additionalInfo="trace='debug trace string'" etime=345.663  
clientConnectionPolicy="default"
```

Working with the SASL PLAIN Mechanism

SASL PLAIN is a password-based authentication mechanism which uses the following information:

- **Authentication ID.** Used to identify the target user to the server. It should be either "dn:" followed by the DN of the user or "u:" followed by a username. If the "u:"-style syntax is used, then an identify mapper will be used to map the specified username to a user entry. An authentication ID of "dn:" that is not actually followed by a DN may be used to request an anonymous bind.
- **Clear-text Password.** Specifies the password for the user targeted by the authentication ID. If the given authentication ID was "dn:", then this should be an empty string.
- **Optional Authorization ID.** Used to request that operations processed by the client be evaluated as if they had been requested by the user specified by the authorization ID rather than the authentication ID. It can allow one user to issue requests as if he/she had authenticated as another user. The use of an alternate authorization identity will only be allowed for clients with the `proxied-auth` privilege and the proxy access control permission.

Because the bind request includes the clear-text password, SASL PLAIN bind requests are as insecure as simple authentication. To avoid an observer from capturing passwords sent over the network, it is recommended that SASL PLAIN binds be issued over secure connections.

By default, the SASL PLAIN mechanism uses an Exact Match Identity Mapper that expects the provided username to exactly match the value of a specified attribute in exactly one entry

(for example, the provided user name must match the value of the `uid` attribute). However, an alternate identity mapper may be configured for this purpose which can identify the user in other ways (for example, transforming the provided user name with a regular expression before attempt to find a user entry with that transformed value).

LDAP clients provided with the server can use SASL PLAIN with the following SASL options:

- **authID**. Specifies the authentication ID to use for the bind. This must be provided.
- **authzID**. Specifies an optional alternate authorization ID to use for the bind.

To Configure SASL PLAIN

1. Use `dsconfig` to enable the SASL PLAIN mechanism.

```
$ bin/dsconfig set-sasl-mechanism-handler-prop \
  --handler-name PLAIN --set enabled:true
```

2. Use `ldapsearch` to view the root DSE using the authentication ID (`authid`) with the username `jdoe`. The `authid` option is required. Enter a password for the authentication ID.

```
$ bin/ldapsearch --port 1389 --saslOption mech=PLAIN \
  --saslOption "authid=u:jdoe" --baseDN "" \
  --searchScope base "(objectclass=*)"
Password for user 'u:jdoe':
```

Note: You can also specify the fully DN of the user when using the SASL PLAIN option:



```
$ bin/ldapsearch --port 1389 --saslOption mech=PLAIN \
  --saslOption "authid=dn:uid=jdoe,ou=People,dc=example,dc=com" \
  --baseDN "" --searchScope base "(objectclass=*)"
Password for user 'dn:uid=jdoe,ou=People,dc=example,dc=com':
```

```
dn:
objectClass: ds-root-dse
objectClass: top
startupUUID: 59bab79d-4429-49c8-8a88-c74a86792f26
```

Working with the SASL CRAM-MD5 Mechanism

CRAM-MD5 is a password-based SASL mechanism that prevents exposure of the clear-text password by authenticating through the use of an MD5 digest generated from a number of elements, including the clear-text password, the provided authentication ID, and a challenge comprised of randomly-generated data. This ensures that the clear-text password itself is not transmitted, and the inclusion of server-generated random data protects against replay attacks.

During the CRAM-MD5 session, the client sends a bind request of type SASL CRAM-MD5. The Metrics Engine sends a response with a SASL "Bind in Progress" result code plus credential information that includes a randomly generated challenge string to the LDAP client. The client combines that challenge with other information, including the authentication ID and clear-text password and uses that to generate an MD5 digest to be included in the SASL credentials, along

with a clear-text version of the authentication ID. When the Metrics Engine receives the second request, it will receive the clear-text password from the target user's entry and generate the same digest. If the digest that the server generates matches what the client provided, then the client will have successfully demonstrated that it knows the correct password.

Note that although CRAM-MD5 does offer some level of protection for the password, so that it is not transferred in the clear, the MD5 digest that it uses is not as secure as the encryption used by SSL or StartTLS. As such, authentication mechanisms that use a clear-text password are more secure communication channel. However, the security that CRAM-MD5 offers may be sufficient for cases in which the performance overhead that SSL/StartTLS can incur. It is available for use in the UnboundID Metrics Engine because some clients may require it.

Also note that to successfully perform CRAM-MD5 authentication, the Metrics Engine must be able to obtain the clear-text password for the target user. By default, the Metrics Engine encodes passwords using a cryptographically secure one-way digest that does not allow it to determine the clear-text representation of the password. As such, if CRAM-MD5 is used, then the password storage schemes for any users that authenticate in this manner should be updated, so that they will use a password storage scheme that supports reversible encryption. It will be necessary for any existing users to change their passwords so that those passwords will be stored in reversible form. The reversible storage schemes supported by the Metrics Engine include:

- > 3DES
- > AES
- > BASE64
- > BLOWFISH
- > CLEAR
- > RC4

CRAM-MD5 uses an authentication ID to identify the user as whom to authenticate. The format of that authentication ID may be either "dn:" followed by the DN of the target user (or just "dn:" to perform an anonymous bind), or "u:" followed by a username. If the "u:"-style syntax is chosen, then an identity mapper will be used to identify the target user based on that username. The `dsconfig` tool may be used to configure the identity mapper to use CRAM-MD5 authentication.

The LDAP client tools provided with the Metrics Engine support the use of CRAM-MD5 authentication. The `authID` SASL option should be used to specify the authentication ID for the target user.

To Configure SASL CRAM-MD5

1. Use `dsconfig` to enable the SASL CRAM-MD5 mechanism if it is disabled. By default, the CRAM-MD5 mechanism is enabled.

```
$ bin/dsconfig set-sasl-mechanism-handler-prop \  
  --handler-name CRAM-MD5 --set enabled:true
```

2. For this example, create a password policy for CRAM-MD5 using a reversible password storage scheme, like 3DES.

```
$ bin/dsconfig create-password-policy \  
  --policy-name "Test UserPassword Policy" \  
  --storage-scheme 3DES
```



```
--set password-attribute:userpassword \
--set default-password-storage-scheme:3DES
```

3. Use `ldapmodify` to add the `ds-pwp-password-policy-dn` attribute to an entry to indicate the Test UserPassword Policy should be used for that entry. After you have typed the change, press **CTRL-D** to process the modify operation. This step assumes that you have already configured the Test Password Policy.

```
$ bin/ldapmodify
dn: uid=jdoe,ou=People,dc=example,dc=com
changetype: modify
add: ds-pwp-password-policy-dn
ds-pwp-password-policy-dn: cn=Test UserPassword Policy,cn=Password Policies,cn=config

Processing MODIFY request for uid=jdoe,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=jdoe,ou=People,dc=example,dc=com
```

4. Use `ldapmodify` to change the `userPassword` to a reversible password storage scheme. The password storage scheme is specified in the user's password policy.

```
$ bin/ldapmodify
dn: uid=jdoe,ou=People,dc=example,dc=com
changetype: modify
replace: userPassword
userPassword: secret
```

An alternate method to change the `userPassword` attribute password storage scheme is to deprecate the old scheme and then bind as the user using simple authentication or SASL PLAIN. This action will cause any existing password encoding using a deprecated scheme to be re-encoded with the existing scheme.

5. Use `ldapssearch` to view the root DSE using the authentication ID (`authid`) option with the username `jdoe`. The `authid` option is required. Enter a password for the user.

```
$ bin/ldapssearch --port 1389 --sasloption mech=CRAM-MD5 \
--sasloption "authid=u:jdoe" --baseDN "" --searchScope base "(objectclass=*)"
Password for user 'u:jdoe':
```

```
dn:
objectClass: ds-root-dse
objectClass: top
startupUUID: 50567aa3-acd2-4106-a077-37a092275363
```

Working with the SASL DIGEST-MD5 Mechanism

The Metrics Engine supports the SASL DIGEST-MD5 mechanism, which is a stronger mechanism than SASL CRAM-MD5. Like the SASL CRAM-MD5 mechanism, the client authenticates to the Metrics Engine using a stronger digest of the authentication ID plus other information without exposing its clear-text password over the network.

During the DIGEST-MD5 session, the client sends a bind request of type SASL DIGEST-MD5. The Metrics Engine sends a response with a "Bind in Progress" message plus credential information that includes a random challenge string to the LDAP client. The client responds by sending a bind response that includes a digest of the server's random string, a separately generated client string, the authentication ID, the authorization ID if supplied, the user's clear-text password and some other information. The client then sends its second bind request. The Metrics Engine also calculates the digest of the client's credential. The Metrics Engine validates

the digest and retrieves the client's password. Upon completion, the server sends a success message to the client.

As with SASL CRAM-MD5, the client and the server must know the clear-text password for the user. By default, the Metrics Engine encodes passwords using a one-way storage scheme (Salted SHA-1) that stores an encoded representation of the password and does not allow it to determine the clear-text representation of the password. Any users requiring SASL DIGEST-MD5 authentication must use a password policy that supports two-way, reversible encryption, in which the password is encoded, stored, and later decoded when requested. The following password storage schemes are reversible:

- > 3DES
- > AES
- > BASE64
- > BLOWFISH
- > CLEAR
- > RC4

By default, SASL DIGEST-MD5 uses the Exact Match Identity Mapper, which returns a success result if the authorization ID is an exact match for the value of the `uid` attribute. Administrators can configure the SASL DIGEST-MD5 mechanism to use other identity mappers, such as the Regular Expression Identity Mapper or a custom Identity Mapper written using the UnboundID Server SDK.

In many ways, the DIGEST-MD5 SASL mechanism is very similar to the CRAM-MD5 mechanism. It avoids exposing the clear-text password through the use of an MD5 digest generated from the password and other information. It also supports the use of an alternate authorization ID to indicate that operations be processed under the authority of another user. Like CRAM-MD5, DIGEST-MD5 provides better security than mechanisms like SASL-PLAIN that send the clear-text password over an *unencrypted* channel.

DIGEST-MD5 is considered a stronger mechanism than CRAM-MD5, because it includes additional information in the digest that makes it harder to decipher, such as randomly-generated data from the client in addition to the server-provided challenge as well as other elements like a realm and digest URI. DIGEST-MD5 is also considered weaker than sending a clear-text password over an *encrypted* connection, because it requires the server to store passwords in reversible form, which can be a security risk. We recommend that CRAM-MD5 and DIGEST-MD5 be avoided unless required by clients.

The LDAP client tools provided with the Metrics Engine provide the ability to use DIGEST-MD5 authentication using the following properties:

- **authID**. Specifies the authentication ID for the target user, in either the "dn:" or "u:" forms. This property is required.
- **authzID**. Specifies an optional authorization ID that should be used for operations processed on the connection.
- **realm**. The realm in which the authentication should be processed. This may or may not be required, based on the server configuration.

- **digest-uri.** The digest URI that should be used for the bind. It should generally be "ldap://" followed by the fully-qualified address for the Metrics Engine. If this is not provided, then a value will be generated.
- **qop.** The quality of protection to use for the bind request. At present, only `auth` is supported (indicating that the DIGEST-MD5 bind should only be used for authentication and should not provide any subsequent integrity or confidentiality protection for the connection), and if no value is provided then `auth` will be assumed.

To Configure SASL DIGEST-MD5

1. Use `dsconfig` to enable the SASL DIGEST-MD5 mechanism if it is disabled. By default, the DIGEST-MD5 mechanism is enabled.

```
$ bin/dsconfig set-sasl-mechanism-handler-prop \
--handler-name DIGEST-MD5 --set enabled:true
```

2. Set up a reversible password storage scheme as outlined [Working with the SASL CRAM-MD5 Mechanism](#), steps 2–5, which is also required for DIGEST-MD5.
3. Use `ldapsearch` to view the root DSE using the authentication ID with the username `jdoe`. The `authid` option is required. Enter a password for the authentication ID.

```
$ bin/ldapsearch --port 1389 --saslOption mech=DIGEST-MD5 \
--saslOption "authid=u:jdoe" --baseDN "" \
--searchScope base "(objectclass=*)"
Password for user 'u:jdoe':
```

```
dn:
objectClass: ds-root-dse
objectClass: top
startupUUID: 2188e4d4-c2bb-4ab9-8e1c-848e0168c9de
```

4. The user identified by the authentication ID requires the `proxied-auth` privilege to allow it to perform operations as another user.

```
$ bin/ldapmodify
dn: uid=jdoe,ou=People,dc=example,dc=com
changetype: modify
add: ds-privilege-name
ds-privilege-name: proxied-auth
```

5. Use `ldapsearch` with the `authid` (required) and `authzid` option to test SASL DIGEST-MD5.

```
$ bin/ldapsearch --port 1389 --saslOption mech=DIGEST-MD5 \
--saslOption authid=u:jdoe \
--saslOption authzid=dn:uid=admin,dc=example,dc=com \
--base "" --searchScope base "(objectclass=*)"
Password for user 'u:jdoe':
```

```
dn:
objectClass: ds-root-dse
objectClass: top
startupUUID: 2188e4d4-c2bb-4ab9-8e1c-848e0168c9de
```

Working with the SASL EXTERNAL Mechanism

The SASL EXTERNAL mechanism allows a client to authenticate using information about the client, which is available to the server, but is not directly provided over LDAP. In the UnboundID Metrics Engine, SASL EXTERNAL requires the use of a client certificate provided during SSL or StartTLS negotiation. This is a very secure authentication mechanism that does not require the use of passwords, although its use on a broad scale is generally only feasible in environments with a PKI deployment.

Prior to the SASL EXTERNAL session exchange, the client should have successfully established a secure communication channel using SSL or StartTLS, and the client must have presented its own certificate to the server in the process. The SASL EXTERNAL bind request itself does not contain any credentials, and the server will use only the information contained in the provided client certificate to identify the target user.

The Metrics Engine's configuration settings for SASL EXTERNAL includes three important properties necessary for its successful operation:

- **certificate-validation-policy.** Indicates whether to check to see if the certificate presented by the client is present in the target user's entry. Possible values are:
 - **always** - Always require the peer certificate to be present in the user's entry. Authentication will fail if the user's entry does not contain any certificates, or if it contains one or more certificates and the certificate presented by the client is not included in the user's entry.
 - **ifpresent** - (Default) If the user's entry contains one or more certificates, require that one of them match the peer certificate. Authentication will be allowed to succeed if the user's entry does not have any certificates, but it will fail if the user's entry has one or more certificates and the certificate provided by the client is not included in the user's entry.
 - **never** - Do not look for the peer certificate to be present in the user's entry. Authentication may succeed if the user's entry does not contain any client certificates, or if the user's entry contains one or more certificates regardless of whether the provided certificate is included in that set.
- **certificate-attribute.** Specifies the name of the attribute that holds user certificates to be examined if the `ds-cfg-certificate-validation-policy` attribute has a value of `ifpresent` or `always`. This property must specify the name of a valid attribute type defined in the server schema. Default value is `userCertificate`. Note that LDAP generally requires certificate values to use the `"binary"` attribute modifier, so certificates should actually be stored in user entries using the attribute `"userCertificate;binary"` rather than just `"userCertificate"`.
- **certificate-mapper.** Specifies the certificate mapper that will be used to identify the target user based on the certificate presented by the client. For more information on certificate mappers, see [Configuring Certificate Mappers](#). The LDAP client tools provided with the Metrics Engine support the use of SASL EXTERNAL authentication. This mechanism does not require any specific SASL options to be provided (other than `mech=EXTERNAL` to indicate that SASL EXTERNAL should be used). However, additional arguments are required to use SSL or StartTLS, and to provide a keystore so that a client certificate will be available.

To Configure SASL EXTERNAL

1. Change to the server root directory.

```
$ cd /ds/UnboundID-Metrics-Engine
```

2. Determine the `certificate-validation-policy` property. If you do not need to store the DER-encoded representation of the client's certificate in the user's entry, skip to the next step.

If you select `Always`, you must ensure that the user's entry has the attribute present with a value. If you select `ifpresent`, you can optionally have the `userCertificate` attribute present. You can store the client's certificate in the user entry using `ldapmodify`.

```
$ bin/ldapmodify
dn: uid=jdoe,ou=People,dc=example,dc=com
changetype: modify
add: userCertificate;binary
userCertificate;binary:<file:///path/to/client.der
```

3. If you have an attribute other than `userCertificate`, then specify it using the `certificate-attribute` property. You may need to update your schema to support the attribute.
4. Determine the `certificate-mapper` property. For more information on certificate mappers, see [Configuring Certificate Mappers](#).
5. Use `dsconfig` to enable the SASL EXTERNAL mechanism if it is disabled. By default, the SASL mechanism is enabled. For this example, set the `certificate-mapper` property to "Subject Attribute to User Attribute". All other defaults are kept.

```
$ bin/dsconfig set-sasl-mechanism-handler-prop \
--handler-name EXTERNAL --set enabled:true \
--set "certificate-mapper:Subject Attribute to User Attribute"
```

6. Use `ldapsearch` to test SASL EXTERNAL.

```
$ bin/ldapsearch --port 1636 --useSSL \
--keyStorePath /path/to/clientkeystore \
--keyStorePasswordFile /path/to/clientkeystore.pin \
--trustStorePath /path/to/truststore \
--saslOption mech=EXTERNAL --baseDN "" \
--searchScope base "(objectClass=*)"
```

Working with the GSSAPI Mechanism

The SASL GSSAPI mechanism provides the ability to authenticate LDAP clients using Kerberos V, which is a single sign-on mechanism commonly used in enterprise environments. In these environments, user credentials are stored in the Kerberos key distribution center (KDC) rather than the Metrics Engine. When an LDAP client attempts to authenticate to the Metrics Engine using GSSAPI, a three-way exchange occurs that allows the client to verify its identity to the server through the KDC.

The Metrics Engine's support for GSSAPI is based on the Java Authentication and Authorization Service (JAAS). By default, the server will automatically generate a JAAS configuration that

should be appropriate for the most common use cases. For more complex deployments, it is possible for an administrator to supply a custom JAAS configuration that is most appropriate for that environment.

While the GSSAPI specification includes a provision for protecting client-server communication through integrity (in which the communication is not encrypted, but is signed so that it is possible to guarantee that it was not be altered in transit) or confidentiality (in which the communication is encrypted so that it cannot be examined by third-party observers), the Metrics Engine currently supports GSSAPI only for the purpose of authenticating clients but not for securing their communication with the server.

Preparing the Kerberos Environment for GSSAPI Authentication

To implement GSSAPI authentication in the Metrics Engine, it is assumed that you already have a working Kerberos V deployment in which the Metrics Engine and LDAP clients will participate. The process for creating such a deployment is beyond the scope of this documentation, and you should consult the documentation for your operating system to better understand how to construct a Kerberos deployment. However, there are a few things to keep in mind:

- It is recommended that the KDC be configured to use "aes128-cts" as the TKT and TGS encryption type, as this encryption type should be supported by all Java VMs. Some other encryption types may not be available by default in some Java runtime environments. In Kerberos environments using the MIT libraries, this can be achieved by ensuring that the following lines are present in the [libdefaults] section of the `/etc/krb.conf` configuration file on the KDC system:

```
default_tkt_enctypes = aes128-cts
default_tgs_enctypes = aes128-cts
permitted_enctypes = aes128-cts
```

- When a client uses Kerberos to authenticate to a server, the addresses of the target server and the KDC are used in cryptographic operations. It is important to ensure that all systems agree on the addresses of the Metrics Engine and KDC systems. It is therefore strongly recommended that DNS be configured so that the primary addresses for the KDC and Metrics Engine systems are the addresses that clients will use to communicate with them.
- Kerberos authentication is time-sensitive and if system clocks are not synchronized, then authentication may fail. It is therefore strongly recommended that NTP or some other form of time synchronization be used for all KDC, Metrics Engine, and client systems.

To authenticate itself to the Kerberos environment, the KDC should include both host and service principals for all Metrics Enginesystems. The host principal is in the form "host/" followed by the fully-qualified address of the server system, and the service principal should generally be "ldap/" followed by the fully-qualified address (for example, "host/directory.example.com" and "ldap/directory.example.com", respectively). In a MIT Kerberos environment, the `kadmin` utility may be used to create these principals, as follows:

```
# /usr/sbin/kadmin -p kws/admin
Authenticating as principal kws/admin with password.
Password for kws/admin@EXAMPLE.COM:
kadmin: add_principal -randkey host/directory.example.com
WARNING: no policy specified for host/directory.example.com@EXAMPLE.COM;
        defaulting to no policy
Principal "host/directory.example.com@EXAMPLE.COM" created.
```

```
kadmin: ktadd host/directory.example.com
Entry for principal host/directory.example.com with kvno 3, encryption type AES-128
CTS mode with 96-bit SHA-1 HMAC added to keytab WRFILE:/etc/krb5/krb5.keytab.
kadmin: add_principal -randkey ldap/directory.example.com
WARNING: no policy specified for ldap/directory.example.com@EXAMPLE.COM;
defaulting to no policy
Principal "ldap/directory.example.com@EXAMPLE.COM" created.
kadmin: quit
```

On each Metrics Engine system, the service principal for that instance must be exported to a keytab file, which may be accomplished using a command as follows:

```
# /usr/sbin/kadmin -p kws/admin
Authenticating as principal kws/admin with password.
Password for kws/admin@EXAMPLE.COM:
kadmin: ktadd -k /ds/UnboundID-Metrics-Engine/config/server.keytab ldap/
directory.example.com
Entry for principal ldap/directory.example.com with kvno 4, encryption type AES-128
CTS mode with 96-bit SHA-1 HMAC added to keytab WRFILE:/ds/UnboundID-Metrics-Engine/
config/
server.keytab.
kadmin: quit
```

Because this file contains the credentials that the Metrics Engine will use to authenticate to the KDC, it is strongly recommended that appropriate protection be taken to ensure that it is only accessible to the Metrics Engine itself (for example, by configuring file permissions and/or file system access controls).

Configuring the GSSAPI SASL Mechanism Handler

The GSSAPI SASL mechanism handler provides the following configuration options:

- **enabled.** Indicates whether the GSSAPI SASL mechanism handler is enabled for use in the server. By default, it is disabled.
- **kdc-address.** Specifies the address that the Metrics Engine should use to communicate with the KDC. If this is not specified, then the server will attempt to determine it from the underlying system configuration.
- **server-fqdn.** Specifies the fully-qualified domain name that clients will use to communicate with the Metrics Engine. If this is not specified, the server will attempt to determine it from the underlying system configuration.
- **realm.** Specifies the Kerberos realm that clients will use. If this is not specified, the server will attempt to determine it from the underlying system configuration.
- **kerberos-service-principal.** Specifies the service principal that the Metrics Engine will use to authenticate itself to the KDC. If this is not specified, the service principal will be "ldap/" followed by the fully-qualified server address (for example, ldap/directory.example.com).
- **keytab.** Specifies the path to the keytab file that holds the credentials for the Kerberos service principal that the Metrics Engine will use to authenticate itself to the KDC. If this is not specified, the server will use the system-wide keytab.
- **identify-mapper.** Specifies the identify mapper that the Metrics Engine will use to map a client's Kerberos principal to the entry of the corresponding user account in the server. In the default configuration, the server will use a regular expression identity mapper that will look for an entry with a uid value equal to the username portion of the Kerberos principal

For example, for a Kerberos principal of `jdoo@EXAMPLE.COM`, the identity mapper will perform an internal search with a filter of `(uid=jdoo)`.

- **enable-debug**. Indicates whether the Metrics Engine should write debugging information about Kerberos-related processing (including JAAS processing) that the server performs. If enabled, this information will be written to standard error, which will appear in the `logs/server.out` log file.
- **jaas-config file**. Specifies the path to a JAAS configuration file that the server should use. If this is not specified, the server will generate a JAAS configuration file based on the values of the other configuration properties. It is recommended that this only be used in extraordinary circumstances in which the server-generated JAAS configuration is not acceptable.

Testing GSSAPI Authentication

Once the GSSAPI SASL mechanism handler has been enabled and configured in the Metrics Engine, then clients should be able to use GSSAPI to authenticate to the server using Kerberos. The `ldapsearch` tool provided with the Metrics Engine may be used to test this, with a command like:

```
$ bin/ldapsearch --hostname directory.example.com --port 389 \  
--saslOption mech=GSSAPI --saslOption authID=jdoo@EXAMPLE.COM \  
--baseDN "" --searchScope base "(objectClass=*)"
```

If the client already has a valid Kerberos session authenticated with a principal of `jdoo@EXAMPLE.COM`, then this command should make use of that existing session and proceed without requiring any further credentials. If there is no existing Kerberos session, then the `ldapsearch` command will prompt for the Kerberos password for that user (or it may be supplied using either the `--bindPassword` or `--bindPasswordFile` arguments).

The `--saslOption` command-line argument may be used to specify a number of properties related to SASL authentication, with values to that option be given in "name=value" format. When using SASL authentication, the `mech` property must always be used to specify the SASL mechanism to use, and `--saslOption mech=GSSAPI` indicates that the GSSAPI mechanism will be used. When the GSSAPI mechanism has been selected, then the following additional SASL options are available for use:

- **authid**. Specifies the authentication ID, which is the Kerberos principal for the user authenticating to the server. This option must always be provided when using GSSAPI.
- **authzID**. Specifies the authorization ID that should be used. At present, the Metrics Engine does not support the use of an alternate authorization identity, so this should either be omitted or identical to the value of the `authID` property.
- **kdc**. Specifies the address of the KDC that the client should use during the authentication processing. If this is not provided, the client will attempt to determine it from the system's Kerberos configuration.
- **realm**. Specifies the Kerberos realm that should be used. If this is not provided, the client will attempt to determine it from the system's Kerberos configuration.

- **protocol.** Specifies the protocol that the Metrics Engine uses for its service principal (i.e., the portion of the service principal that appears before the slash and fully-qualified server address). If this is not provided, a default protocol of "ldap" will be used.
- **useTicketCache.** Indicates whether the client should attempt to make use of a Kerberos ticket cache to leverage an existing Kerberos session, which may allow the client to authenticate to the server without the need to supply any additional credentials. If this is not provided, or if it is provided with a value of TRUE, then a ticket cache will be used if available. The use of a ticket cache may be disabled by providing this option with a value of FALSE.
- **requireCache.** Indicates whether to require the use of a ticket cache in order to leverage an existing Kerberos session rather than allowing the use of user-supplied credentials for authentication. By default, this will be assumed to have a value of FALSE, but if it is provided with a value of TRUE, then authentication will only be successful if the user already has an existing Kerberos session. This will be ignored if the useTicketCache option has been provided with a value of FALSE.
- **ticketCache.** Specifies the path to the file to use as the Kerberos ticket cache. If this is not provided, the default ticket cache file path will be assumed. This will be ignored if the useTicketCache option has been provided with a value of FALSE.
- **renewTGT.** Indicates whether to attempt to renew the user's ticket-granting ticket when authenticating with an existing Kerberos session. If this is not provided, a default value of FALSE will be used.
- **debug.** Indicates whether to write debug information about the GSSAPI authentication processing to standard error. By default, no debug information will be written, but it may be enabled with a value of TRUE.
- **configFile.** Used to specify the path to a JAAS configuration file that the client should use when performing GSSAPI processing. If this is not specified, then a default JAAS configuration file will be generated based on other properties.

These options are available for use with all tools supplied with the Metrics Engine which support SASL authentication.

Working with the UNBOUNDID-TOTP SASL Mechanism

The Metrics Engine supports a proprietary multifactor authentication mechanism that allows the server to use the Time-based One-Time Password (TOTP) algorithm, specified in RFC 6238. The TOTP algorithm is an extension of the Hash-based Message Authentication Code One-Time Password (HTOP) algorithm, specified in RFC 4226. The TOTP algorithm computes a temporary code using the current time and a secret key that is shared between the client app (e.g., Google Authenticator) and the server. When combined with a static password, a TOTP code can provide a means of multifactor authentication that offers dramatically better security than can be achieved using a static password by itself.

This proprietary security mechanism, UNBOUNDID-TOTP SASL, issues a bind request that includes at least an authentication ID and a TOTP code, but may also include an authorization ID and/or a static password. When the Metrics Engine receives such a bind request, it first uses the authentication ID to identify the user that is authenticating and then retrieves the shared

secret from the user's entry (stored as a base32-encoded value in the `ds-auth-totp-shared-secret` operational attribute) and uses that in conjunction with the current time to generate a TOTP code. If that matches the code that the user entered, then that confirms that the client knows the shared secret. If a static password was also provided, then the server will confirm that it matches what is stored in the `userPassword` attribute (or whatever password attribute is specified in the user's password policy). By default, the server will require the client to provide a static password, since without it, the client will only be performing single-factor authentication.

The Commercial Edition of the LDAP SDK for Java provides the necessary client-side support for the UNBOUNDID-TOTP SASL mechanism and provides a `com.unboundid.ldap.sdk.unboundidds.OneTimePassword` class to generate HOTP and TOTP codes for testing purposes.

Notes about the UnboundID-TOTP SASL Mechanism

The UnboundID-TOTP SASL mechanism supports some new features of interest that add extra security to your system:

- **Limiting the Reuse of the One-Time Password.** Although TOTP passwords are only valid for a limited period of time, it is possible that an individual observing an unencrypted TOTP authentication could replay the bind request in order to reuse the TOTP code as long as the server considers it valid. To avoid this, the `prevent-totp-reuse` property may be used to cause the server to store information in the user's entry about TOTP codes that have been used to successfully authenticate and may still be valid. Subsequent TOTP authentication attempts will then ensure that the provided TOTP code does not match a previously-used value.
- **Implementing the Validate TOTP Extended Operation.** The Identity Data Store supports a Validate TOTP Extended Operation, which validates the TOTP password without performing any authentication on the user. This feature is enabled by default. This is not needed for UNBOUNDID-TOTP SASL support and nor does it alter the authentication state of a connection in any way, but it may be useful for third-party applications to use TOTP as a type of "step-up" authentication mechanism or to add extra assurance about the identity of an already authenticated user.
- **Using Sensitive Attributes with the TOTP Shared Secret.** You can use a sensitive attribute definition to prevent clients from retrieving TOTP shared secrets from the server and to ensure that all shared secret changes occur over secure connections. Note that this sensitive attribute definition must be referenced from the `sensitive-attribute` property of a client connection policy or the global `sensitive-attribute` property to be enabled.

To Configure UNBOUNDID-TOTP SASL

1. Configure the server so that `ds-auth-totp-shared-secret` is a sensitive attribute that can only be set over a secure connection and cannot ever be retrieved from the server. Create the sensitive attribute and reference it from the global configuration using `dsconfig`.

```
$ bin/dsconfig create-sensitive-attribute \  
  --attribute-name ds-auth-totp-shared-secret \  
  --set attribute-type:ds-auth-totp-shared-secret \  
  --set allow-in-returned-entries:suppress \  
  --set allow-in-filter:reject \  
  --set allow-in-compare:reject \  
  --set allow-in-modify:reject
```

```
--set allow-in-add:secure-only \
--set allow-in-modify:secure-only

$ bin/dsconfig set-global-configuration-prop \
--add sensitive-attribute:ds-auth-totp-shared-secret
```

2. Update a user entry so that it contains a `ds-auth-totp-shared-secret` attribute with a value that holds the base32-encoded shared secret that will be used for TOTP authentication. If you put the sensitive attribute in place, then you will need to do this over a secure connection, such as over SSL or StartTLS. There is no maximum limit to the length of the `ds-auth-totp-shared-secret` string, but there is a minimum length of 16 base32-encoded characters. Note that Google Authenticator requires a base32 string whose length is a multiple of 8, and it cannot include the padding character ("=").

```
dn: uid=user.0,ou=People,dc=example,dc=com
changetype: modify
add: ds-auth-totp-shared-secret
ds-auth-totp-shared-secret: ONSWG4TFORRW6ZDF
```

3. To test this feature, install a TOTP client. For this example, you can use the Google Authenticator app on your Android, iOS, and Blackberry mobile device. On the Google Authenticator app, choose the **Add Account** option to manually add an account. Enter a name and the same base32-encoded key that you assigned to the user in the previous step. The default account type is "Time Based"; do not choose "Counter Based". You should see an item with the name you selected and a six-digit code that will change every 30 seconds.



Note: The Google Authenticator app only needs to know the current time and the shared secret in order to compute the TOTP code. It does not require a Google account, nor does it require a data connection or the ability to perform network communication.

4. The Metrics Engine's tools provide support for the UNBOUNDID-TOTP SASL mechanism. You can run an LDAP search using the UNBOUNDID-TOTP SASL mechanism in the same way as any other SASL component.

```
$ bin/ldapsearch --saslOption mech=UNBOUNDID-TOTP \
--saslOption authID=u:user.0 \
--saslOption totpPassword=628094 \
--bindPassword password \
--baseDN "" \
--searchScope base \
"(objectClass=*)"
```

Working with the UNBOUNDID-DELIVERED-OTP SASL

The Metrics Engine now includes support for a new form of two-factor authentication, *UNBOUNDID-DELIVERED-OTP SASL*, which uses one-time passwords (OTPs) that are delivered to the end user through some out-of-band mechanism. Out of the box, the server provides support for e-mail (through the same SMTP external server approach used for email) and SMS (through the Twilio web service). The Server SDK also provides support for creating custom delivery mechanisms.

The process for authenticating using this new mechanism involves two steps:

- The client must first send a "deliver one-time password" extended request to the server. This request includes an authentication ID (either "dn:" followed by the DN or "u:" followed by the username), the user's static password, and an optional set of allowed delivery mechanisms. If successful, this will cause the server to generate a one-time password, store it in the user's entry, and send it to the user through some mechanism.
- Once the user has received the one-time password, the client should perform an UNBOUNDID-DELIVERED-OTP SASL bind (which may be on the same connection or a different connection as was used to process the "deliver one-time password" extended operation). The credentials for this SASL mechanism include an authentication ID to identify the user, an optional authorization ID (if operations performed by the client should be authorized as a different user), and the one-time password that was delivered to them.

The static password is not included in the SASL bind request, but because the user must provide the static password in order to obtain the one-time password, it still qualifies as a form of multifactor authentication. Unlike UNBOUNDID-TOTP SASL, there is no need to have a shared secret between the client and the server, or any special client-side software to generate the one-time password, or a need to worry about whether the client and server clocks are roughly in sync.

To Configure the UNBOUNDID-DELIVERED OTP SASL

1. Add support for one or more OTP delivery mechanisms. For email, you first need to create an SMTP external server and associate it with the global configuration before you can create the delivery mechanism.

```
$ bin/dsconfig create-external-server \  
--server-name "Intranet SMTP Server" \  
--type smtp \  
--set server-host-name:server.example.com  
  
$ bin/dsconfig set-global-configuration-prop \  
--add "smtp-server:Intranet SMTP Server"  
  
$ bin/dsconfig create-otp-delivery-mechanism \  
--mechanism-name E-Mail \  
--type email \  
--set enabled:true \  
--set 'sender-address:otp@example.com' \  
--set "email-address-attribute-type:mail" \  
--set "message-subject:Your one-time password" \  
--set "message-text-before-otp:Your one-time password: "
```

2. If you have a Twilio account, you can use it to configure the server to deliver one-time passwords over SMS.

```
dsconfig create-otp-delivery-mechanism \  
--mechanism-name SMS \  
--type twilio \  
--set enabled:true  
--set twilio-account-sid:xxxxx \  
--set twilio-auth-token:xxxxx \  
--set "sender-phone-number:xxxxx" \  
--set phone-number-attribute-type:mobile \  
--set "message-text-before-otp:Your one-time password: "
```

3. Once you have your OTP delivery mechanisms, you can configure the extended operation handler.

```
$ bin/dsconfig create-extended-operation-handler \
--handler-name "Deliver One-Time Password" \
--type deliver-otp \
--set enabled:true \
--set "identity-mapper:Exact Match" \
--set "password-generator:One-Time Password Generator" \
--set default-otp-delivery-mechanism:SMS \
--set default-otp-delivery-mechanism:E-Mail
```

4. Next, configure the SASL mechanism handler.

```
$ bin/dsconfig create-sasl-mechanism-handler \
--handler-name UNBOUNDID-DELIVERED-OTP \
--type unboundid-delivered-otp \
--set enabled:true \
--set "identity-mapper:Exact Match" \
--set "otp-validity-duration:5 minutes"
```

5. Make sure the server contains a user account with the account needed to deliver the one-time password to the user (i.e., a valid email address or mobile number).
6. Next, use the deliver one-time password extended operation to have the server generate and send a one-time password to the user. The Commercial Edition of UnboundID LDAP SDK contains support for the extended request and response needed to do this. In actual production deployments, you can create a web form to allow the user to enter the information and click a button. The server comes with a new deliver-one-time-password command-line tool that can achieve the same result.

```
$ bin/deliver-one-time-password \
--userName jdoe \
--promptForBindPassword \
--deliveryMechanism SMS
Enter the static password for the user:

Successfully delivered a one-time password via mechanism 'SMS' to '123-456-7890'
```

If processed successfully, you will receive a text as follows:

```
Your one-time password: 123456
```

7. Finally, authenticate to the server using the UNBOUNDID-DELIVERED-OTP SASL mechanism. The Commercial Edition of the LDAP SDK can help you accomplish this so that the user sees an interface. Or, you can use `ldapsearch` or some other tool to accomplish the same result.

```
$ bin/ldapsearch \
-o mech=UNBOUNDID-DELIVERED-OTP \
-o authID=u:jdoe \
-o otp=123456 \
-b '' \
-s base '(objectClass=*)' \
ds-supported-otp-delivery-mechanism
```

The search returns:

```
dn:
ds-supported-otp-delivery-mechanism: E-Mail
ds-supported-otp-delivery-mechanism: SMS
```

Configuring Pass-Through Authentication

Pass-through authentication (PTA) is a mechanism by which one Metrics Engine receives the bind request and can consult another Metrics Engine to authenticate the bind request. Administrators can implement this functionality by configuring a PTA plug-in that enables the Metrics Engine to accept simple password-based bind operations.

To Configure Pass-Through Authentication

1. First, use `dsconfig` to define the external servers for the instances that will be used to perform the authentication. The bind DN is set to `uid=pass-through-user,dc=example,dc=com`, which is used to bind to the target LDAP server for simple authentication. The `verify-credentials-method` property ensures that a single set of connections for processing binds and all other types of operations is in place without changing the identity of the associated connection.

```
$ bin/dsconfig create-external-server \  
--server-name "ds-with-pw-1.example.com:389" \  
--type unboundid-metrics-engine \  
--set server-host-name:ds-with-pw-1.example.com \  
--set server-port:389 \  
--set "bind-dn:uid=pass-through-user,dc=example,dc=com" \  
--set authentication-method:simple \  
--set verify-credentials-method:retain-identity-control
```

2. Repeat step 1 so that you have multiple external servers in case one of them becomes unavailable.

```
$ bin/dsconfig create-external-server \  
--server-name "ds-with-pw-2.example.com:389" \  
--type unboundid-metrics-engine \  
--set server-host-name:ds-with-pw-2.example.com \  
--set server-port:389 \  
--set "bind-dn:uid=pass-through-user,dc=example,dc=com" \  
--set authentication-method:simple \  
--set verify-credentials-method:retain-identity-control
```

3. Create an instance of the pass-through authentication plug-in that will use the external server(s) as a source of authentication. Based on this configuration, the server will first try to process a local bind as the target user (`try-local-bind:true`). The `try-local-bind:true` together with the `override-local-password:true` means that if the local bind fails for any reason, then it will try sending the request to either `ds-with-pw-1.example.com:389` or `ds-with-pw-2.example.com:389` (`server-access-mode:round-robin`). If the bind succeeds against the remote server, then the local entry will be updated to store the password that was used (`update-local-password:true`). The number of connections to initially establish to the LDAP external server is set to 10 (`initial-connections:10`). The maximum number of connections maintained to the LDAP external server is 10 (`max-connections:10`).

```
$ bin/dsconfig create-plugin \  
--plugin-name "Pass-Through Authentication" \  
--type pass-through-authentication \  
--set enabled:true \  
--set server:ds-with-pw-1.example.com:389 \  
--set server:ds-with-pw-2.example.com:389 \  
--set try-local-bind:true
```

```
--set override-local-password:true \
--set update-local-password:true \
--set server-access-mode:round-robin \
--set initial-connections:10 \
--set max-connections:10
```

Note:



The `try-local-bind` property works in conjunction with the `override-local-password` property. If `try-local-bind` is `true` and `override-local-password` is set to its default value of `false`, then the server attempts a local bind first. If it fails *because no password is set*, then it will forward the bind request to a remote server. If the password was set but still fails, the server will not send the request to the remote server.

If `try-local-bind` is `true` and `override-local-password` is `true`, then a local bind will be attempted. The server will forward the request to the remote server if the local bind fails for any reason.

Adding Operational Attributes that Restrict Authentication

The Metrics Engine provides a number of operational attributes that can be added to user entries in order to restrict the way those users can authenticate and the circumstances under which they can be used for proxied authorization. The operational attributes are as follows:

- **ds-auth-allowed-address.** Used to indicate that the user should only be allowed to authenticate from a specified set of client systems. Values should be specified as individual IP addresses, IP address patterns (using wildcards like "1.2.3.*", CIDR notation like "1.2.3.0/24", or subnet mask notation like "1.2.3.0/255.255.255.0"), individual DNS addresses, or DNS address patterns (using wildcards like "*.example.com"). If no allowed address values are present in a user entry, then no client address restrictions will be enforced for that user.
- **ds-auth-allowed-authentication-type.** Used to indicate that the user should only be allowed to authenticate in certain ways. Allowed values include "simple" (to indicate that the user should be allowed to bind using simple authentication) or "sasl {mech}" (to indicate that the user should be allowed to bind using the specified SASL mechanism, like "sasl PLAIN"). If no authentication type values are present in a user entry, then no authentication type restrictions will be enforced for that user.
- **ds-auth-require-secure-authentication.** Used to specify whether the user should be required to authenticate in a secure manner. If this attribute is present with a value of "true", then that user will only be allowed to authenticate over a secure connection or using a mechanism that does not expose user credentials (e.g., the CRAM-MD5, DIGEST-MD5, and GSSAPI SASL mechanisms). If this attribute is present with a value of "false", or it is not present in the user's entry, then the user will not be required to authenticate in a secure manner.
- **ds-auth-require-secure-connection.** Used to specify whether the user should be required to communicate with the server over a secure connection. If this attribute is present in a user

entry with a value of "true", then that user will only be allowed to communicate with the server over a secure connection (using SSL or StartTLS). If this attribute is present with a value of "false", or if it is not present in the user's entry, then the user will not be required to use a secure connection.

- **ds-auth-is-proxyable.** Used to indicate whether the user can be used as the target of proxied authorization (using the proxied authorization v1 or v2 control, the intermediate client control, or a SASL mechanism that allows specifying an alternate authorization identity). If this attribute is present in a user entry with a value of "required", then that user will not be allowed to authenticate directly to the server but instead will only be allowed to be referenced by proxied authorization. If this attribute is present with a value of "prohibited", then that user will not be allowed to be the target of proxied authorization but may only authenticate directly to the server. If this attribute is present with a value of "allowed", or if it is not present in the user's entry, then the user may authenticate directly against the server or be the target of proxied authorization.
- **ds-auth-is-proxyable-by.** Used to restrict the set of accounts that may target the user for proxied authorization. If this attribute is present in a user's entry, then its values must be the DNs of the users that can target the user for proxied authorization (as long as those users have sufficient rights to use proxied authorization). If it is absent from the user's entry, then any account with appropriate rights may target the user via proxied authorization.

Configuring Certificate Mappers

SASL EXTERNAL requires that a certificate mapper be configured in the server. The certificate mapper is used to identify the entry for the user to whom the certificate belongs. The Metrics Engine supports a number of certificate mapping options including:

- **Subject Equals DN.** The Subject Equals DN mapper expects the subject of the certificate to exactly match the DN of the associated user entry. This option is not often practical as certificate subjects (e.g., `cn=jdoe,ou=Client Cert,o=Example Company,c=Austin,st=Texas,c=US`) are not typically in the same form as an entry (e.g., `cn=jdoe,ou=People,o=Example Company,Or uid=jdoe,ou=People,dc=example,dc=com`).
- **Fingerprint.** The Fingerprint mapper expects the user's entry to contain an attribute (`ds-certificate-fingerprint` by default, although this is configurable), whose values are the SHA-1 or MD5 fingerprints of the certificate(s) that they can use to authenticate. This attribute must be indexed for equality.
- **Subject Attribute to User Attribute.** The Subject Attribute to User Attribute mapper can be used to build a search filter to find the appropriate user entry based on information contained in the certificate subject. For example the default configuration expects the `cn` value from the certificate subject to match the `cn` value of the user's entry, and the `e` value from the certificate subject to match the `mail` value of the user's entry.
- **Subject DN to User Attribute.** The Subject DN to User Attribute mapper expects the user's entry to contain an attribute (`ds-certificate-subject-dn` by default, although this is configurable), whose values are the subjects of the certificate(s) that they can use to authenticate. This multi-valued attribute can contain the subjects of multiple certificates. The attribute must be indexed for equality.

Configuring the Subject Equals DN Certificate Mapper

The Subject Equals DN Certificate Mapper is the default mapping option for the SASL EXTERNAL mechanism. The mapper requires that the subject of the client certificate exactly match the distinguished name (DN) of the corresponding user entry. The mapper, however, is only practical if the certificate subject has the same format as your Metrics Engine's entries.

To Configure the Subject Equals DN Certificate Mapper

- Change the certificate mapper for the SASL EXTERNAL mechanism.

```
$ bin/dsconfig --no-prompt set-sasl-mechanism-handler-prop \
  --handler-name EXTERNAL \
  --set "certificate-mapper:Subject Equals DN"
```

Configuring the Fingerprint Certificate Mapper

The Fingerprint Mapper causes the server to compute an MD5 or SHA-1 fingerprint of the certificate presented by the client and performs a search to find that fingerprint value in a user's entry (`ds-certificate-fingerprint` by default). The `ds-certificate-fingerprint` attribute can be added to the user's entry together with the `ds-certificate-user` auxiliary object class. For multiple certificates, the attribute can have separate values for each of the acceptable certificates. If you decide to use this attribute, you must index the attribute as it is not indexed by default.

The following example will use this certificate:

```
Alias name: client-cert
Creation date: Oct 29, 2011
Entry type: PrivateKeyEntry

Certificate chain length: 1 Certificate[1]:
Owner: CN=jdoe, OU=Client Cert, O=Example Company, L=Austin, ST=Texas, C=US
Issuer: EMAILADDRESS=whatever@example.com, CN=Cert Auth, OU=My Certificate Authority,
O=Example Company, L=Austin, ST=Texas, C=US
Serial number: e19cb2838441dbcd
Valid from: Thu Oct 29 13:07:10 CDT 2011 until: Fri Oct 29 13:07:10 CDT 2012
Certificate fingerprints:
  MD5: 40:73:7C:EF:1B:4A:3F:F4:9B:09:C3:50:2B:26:4A:EB
  SHA1: 2A:89:71:06:1A:F5:DA:FF:51:7B:3D:2D:07:2E:33:BE:C6:5D:97:13
  Signature algorithm name: SHA1withRSA
  Version: 1
```

To Configure the Fingerprint Certificate Mapper

1. Create an LDIF file to hold a modification that adds the `ds-certificate-user` object class and `ds-certificate-fingerprint` attribute to the target user's entry.

```
dn: uid=jdoe,ou=People,dc=example,dc=com
changetype: modify
add: objectClass
objectClass: ds-certificate-user
-
add: ds-certificate-fingerprint
ds-certificate-fingerprint: 40:73:7C:EF:1B:4A:3F:F4:9B:09:C3:50:2B:26:4A:EB
```

2. Then, apply the change to the entry using `ldapmodify`:

```
$ bin/ldapmodify --filename add-cert-attr.ldif

dn: uid=jdoe,ou=People,dc=example,dc=com
ds-certificate-fingerprint:40:73:7C:EF:1B:4A:3F:F4:9B:09:C3:50:2B:26:4A:EB
```

3. Check that the attribute was added to the entry using `ldapsearch`.

```
$ bin/ldapsearch --baseDN dc=example,dc=com "(uid=jdoe)" \
ds-certificate-fingerprint
dn:uid=jdoe,ou=People,dc=example,dc=com
ds-certificate-fingerprint:40:73:7C:EF:1B:4A:3F:F4:9B:09:C3:50:2B:26:4A:EB
```

4. Create an index for the `ds-certificate-fingerprint` attribute. If the server is configured with multiple data backends, then the attribute should be indexed in each of those backends.

```
$ bin/dsconfig create-local-db-index --backend-name userRoot \
--index-name ds-certificate-fingerprint --set index-type:equality
```

5. Use the `rebuild-index` tool to cause an index to be generated for this attribute.

```
$ bin/rebuild-index --task --baseDN dc=example,dc=com \
--index ds-certificate-fingerprint

[14:56:28] The console logging output is also available in
'/ds/UnboundID-Metrics-Engine/logs/tools/rebuild-index.log'
[14:56:29] Due to changes in the configuration, index
dc_example_dc_com_ds-certificate-fingerprint.equality is currently
operating in a degraded state and must be rebuilt before it can used
[14:56:29] Rebuild of index(es) ds-certificate-fingerprint started with 161 total
records to process
[14:56:29] Rebuild complete. Processed 161 records in 0 seconds
(average rate 1125.9/sec)
```

6. Change the certificate mapper for the SASL EXTERNAL mechanism.

```
$ bin/dsconfig --no-prompt set-sasl-mechanism-handler-prop \
--handler-name EXTERNAL \
--set "certificate-mapper:Fingerprint Mapper"
```

Configuring the Subject Attribute to User Attribute Certificate Mapper

The Subject Attribute to User Attribute Certificate Mapper maps common attributes from the subject of the client certificate to the user's entry. The generated search filter must match exactly one entry within the scope of the base DN(s) for the mapper. If no match is returned or if multiple matches are found, the mapping fails.

Given the subject of the client certificate:

```
Owner: CN=John Doe, OU=Client Cert, O=Example Company, L=Austin, ST=Texas, C=US
```

We want to match to the following user entry:

```
dn: uid=jdoe,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
uid: jdoe
givenName: John
```

```
sn: Doe
cn: John Doe
mail: jdoe@example.com
```

To Configure the Subject Attribute to User Attribute Certificate Mapper

- Change the certificate mapper for the SASL EXTERNAL mechanism.

```
$ bin/dsconfig --no-prompt set-sasl-mechanism-handler-prop \
--handler-name EXTERNAL \
--set "certificate-mapper:Subject Attribute to User Attribute"
```

Configuring the Subject DN to User Attribute Certificate Mapper

The Subject DN to User Attribute Certificate mapper expects the user's entry to contain an attribute (`ds-certificate-subject-dn` by default) whose values match the subjects of the certificates that the user can use to authenticate. The `ds-certificate-subject-dn` attribute can be added to the user's entry together with the `ds-certificate-user` auxiliary object class. The attribute is multi-valued and can contain the Subject DN's of multiple certificates. The certificate mapper must match exactly one entry, or the mapping will fail.

If you decide to use this attribute, you must add an equality index for this attribute in all data backends.

To Configure the Subject DN to User Attribute Certificate Mapper

1. Create an LDIF file to hold a modification that adds the `ds-certificate-user` object class and `ds-certificate-subject-dn` attribute to the target user's entry.

```
dn: uid=jdoe,ou=People,dc=example,dc=com
changetype: modify
add: objectClass
objectClass: ds-certificate-user
-
add: ds-certificate-subject-dn
ds-certificate-subject-dn:CN=John Doe,OU=Client Certificate,O=Example
Company,L=Austin,ST=Texas,C=US
```

2. Then, apply the change to the entry using `ldapmodify`:

```
$ bin/ldapmodify --filename add-cert-attr.ldif
```

3. Check that the attribute was added to the entry using `ldapsearch`.

```
$ bin/ldapsearch --baseDN dc=example,dc=com "(uid=jdoe)" \
ds-certificate-subject-dn

dn: uid=jdoe,ou=People,dc=example,dc=com
ds-certificate-fingerprint:CN=jdoe, OU=Client Cert, O=Example Company,
L=Austin, ST=Texas, C=US
```

4. Create an index to the `ds-certificate-subject-dn` attribute.

```
$ bin/dsconfig create-local-db-index --backend-name userRoot \
--index-name ds-certificate-subject-dn --set index-type:equality
```

5. Use the `rebuild-index` tool to ensure that the index is properly generated in all appropriate backends.

```
$ bin/rebuild-index --task --baseDN dc=example,dc=com \  
--index ds-certificate-subject-dn
```

```
[15:39:19] The console logging output is also available in  
'/ds/UnboundID-Metrics-Engine/logs/ tools/rebuild-index.log'  
[15:39:20] Due to changes in the configuration, index  
dc_example_dc_com_ds-certificate-subject-dn.equality is currently operating  
in a degraded state and must be rebuilt before it can used  
[15:39:20] Rebuild of index(es) ds-certificate-subject-dn started with 161 total  
records to process  
[15:39:20] Rebuild complete. Processed 161 records in 0 seconds  
(average rate 2367.6/sec)
```

6. Change the certificate mapper for the SASL EXTERNAL mechanism.

```
$ bin/dsconfig --no-prompt set-sasl-mechanism-handler-prop \  
--handler-name EXTERNAL \  
--set "certificate-mapper:Subject DN to User Attribute"
```

Chapter

8

Troubleshooting the Metrics Engine

This chapter provides the common problems and potential solutions that might occur when running UnboundID Metrics Engine.

This chapter presents the following information:

Topics:

- [*Debugging the Metrics Engine*](#)
- [*Working with the Troubleshooting Tools*](#)
- [*Metrics Engine Troubleshooting Tools*](#)
- [*Troubleshooting Resources for Java Applications*](#)
- [*Troubleshooting Resources in the Operating System*](#)
- [*Troubleshooting Performance Problems*](#)
- [*Troubleshooting the Metrics Engine API*](#)
- [*Common Problems and Potential Solutions*](#)

Debugging the Metrics Engine

You can enable the JVM debugging options to track garbage collection data for your system. The options can impact JVM performance, but they provide valuable data to tune your server when troubleshooting garbage collection issues. While the `jstat` utility with the `-gc` option can be used to obtain some information about garbage collection activity, there are additional arguments that can be added to the JVM to use when running the server to provide additional detail.

```
-XX:+PrintGCDetails  
-XX:+PrintTenuringDistribution  
-XX:+PrintGCApplicationConcurrentTime  
-XX:+PrintGCApplicationStoppedTime  
-XX:+PrintGCDateStamps
```

To run the Metrics Engine with these options, edit the `config/java.properties` file and add them to the end of the line that begins with `"start-metrics-engine.java-args"`. After the file has been saved, invoke the following command to make those new arguments take effect the next time the server is started:

```
$ bin/dsjavaproperties
```

Working with the Troubleshooting Tools

The UnboundID Metrics Engine provides a highly-reliable service that satisfies your company's objectives. However, if problems do arise (whether from issues in the Metrics Engine itself or a supporting component, like the JVM, operating system, or hardware), then it is essential to be able to diagnose the problem quickly to determine the underlying cause and the best course of action to take towards resolving it.

Working with the Collect Support Data Tool

The Metrics Engine provides a significant amount of information about its current state including any problems that it has encountered during processing. If a problem occurs, the first step is to run the `collect-support-data` tool in the `bin` directory. The tool aggregates all relevant support files into a zip file that administrators can send to your authorized support provider for analysis. The tool also runs data collector utilities, such as `jps`, `jstack`, and `jstat` plus other diagnostic tools for Solaris and Linux machines, and bundles the results in the zip file.

The tool may only archive portions of certain log files to conserve space, so that the resulting support archive does not exceed the typical size limits associated with e-mail attachments.

The data collected by the `collect-support-data` tool varies between systems. For example, on Solaris Zone, configuration information is gathered using commands like `zonename` and `zoneadm`. However, the tool always tries to get the same information across all systems for the target Metrics Engine. The data collected includes the configuration directory, summaries and snippets from the `logs` directory, an LDIF of the monitor and RootDSE entries, and a list of all files in the server root.

To Run the Collect Support Data Tool

1. Go to the server root directory.
2. Use the `collect-support-data` tool. Make sure to include the host, port number, bind DN, and bind password.

```
$ bin/collect-support-data --hostname 127.0.0.1 --port 389 \  
--bindDN "cn=Directory Manager" --bindPassword secret \  
--serverRoot /opt/UnboundID-Metrics-Engine --pid 1234
```

3. Email the zip file to your Authorized Support Provider.

Metrics Engine Troubleshooting Tools

The UnboundID Metrics Engine provides a set of tools that can also be used to obtain information for diagnosing and solving problems.

Server Version Information

If it becomes necessary to contact your authorized support provider, then it will be important to provide precise information about the version of the Metrics Engine software that is in use. If the server is running, then this information can be obtained from the "cn=Version,cn=monitor" entry. It can also be obtained using the command:

```
$ bin/status --fullVersion
```

This command outputs a number of important pieces of information, including:

- Major, minor, point and patch version numbers for the server.
- Source revision number from which the server was built.
- Build information including build ID with time stamp, OS, user, Java and JVM version for the build.
- Auxiliary software versions: Jetty, JZlib, SNMP4j (SNMP4J, Agent, Agentx), Groovy, UnboundID LDAP SDK for Java, and UnboundID Server SDK.

Embedded Profiler

If the Metrics Engine appears to be running slowly, then it is helpful to know what operations are being processed in the server. The JVM Stack Trace monitor entry can be used to obtain a point-in-time snapshot of what the server is doing, but in many cases, it might be useful to have information collected over a period of time.

The embedded profiler is configured so that it is always available but is not active by default so that it has no impact on the performance of the running server. Even when it is running, it has

a relatively small impact on performance, but it is recommended that it remain inactive when it is not needed. It can be controlled using the `dsconfig` tool or the web administration console by managing the "Profiler" configuration object in the "Plugin" object type, available at the standard object level. The `profile-action` property for this configuration object can have one of the following values:

- **start** – Indicates that the embedded profiler should start capturing data in the background.
- **stop** – Indicates that the embedded profiler should stop capturing data and write the information that it has collected to a `logs/profile{timestamp}` file.
- **cancel** – Indicates that the embedded profiler should stop capturing data and discard any information that it has collected.

Any profiling data that has been captured can be examined using the `profiler-viewer` tool. This tool can operate in either a text-based mode, in which case it dumps a formatted text representation of the profile data to standard output, or it can be used in a graphical mode that allows the information to be more easily understood.

To Invoke the Profile Viewer in Text-based Mode

- Run the `profile-viewer` command and specify the captured log file using the `--fileName` option.

```
$ bin/profile-viewer --fileName logs/profile.20110101000000Z
```

To Invoke the Profile Viewer in GUI Mode

- Run the `profile-viewer` command and specify the captured log file using the `--fileName` option. To invoke GUI mode, add the option `--useGUI`.

```
$ bin/profile-viewer --fileName logs/profile.20110101000000Z --useGUI
```

Troubleshooting Resources for Java Applications

Because the UnboundID Metrics Engine is written entirely in Java, it is possible to use standard Java debugging and instrumentation tools when troubleshooting problems with the Metrics Engine. In many cases, obtaining the full benefit of these tools requires access to the Metrics Engine source code. These Java tools should be used under the advisement of your authorized support provider.

Java Troubleshooting Documentation (Oracle/Sun JDK)

There are a number of documents providing general information about troubleshooting Java-based applications. Some of these documents include:

- <http://www.oracle.com/technetwork/java/javase/index-138283.html> – Troubleshooting Java SE

- <http://www.oracle.com/technetwork/java/javase/index-137495.html> – Troubleshooting Guide for Java SE 6 with HotSpot VM
- <http://www.sun.com/bigadmin/hubs/java/troubleshoot/> – BigAdmin Page on Java SE Troubleshooting
- <http://www.oracle.com/technetwork/java/javase/tools6-unix-139447.html> – Tools for troubleshooting Java on Solaris and Linux

Java Troubleshooting Tools (Oracle/Sun JDK)

The Java Development Kit provides a number of very useful tools to obtain information about Java applications and diagnosing problems. These tools are not included with the Java Runtime Environment (JRE), so the full Java Development Environment (JDK) should always be installed and used to run the UnboundID Metrics Engine.

jps

The `jps` tool is a Java-specific version of the UNIX `ps` tool. It can be used to obtain a list of all Java processes currently running and their respective process identifiers. When invoked by a non-root user, it will list only Java processes running as that user. When invoked by a root user, then it lists all Java processes on the system.

This tool can be used to see if the Metrics Engine is running and if a process ID has been assigned to it. This process ID can be used in conjunction with other tools to perform further analysis.

This tool can be run without any arguments, but some of the more useful arguments that include:

- **-v** – Includes the arguments passed to the JVM for the processes that are listed.
- **-m** – Includes the arguments passed to the main method for the processes that are listed.
- **-l** (lowercase L). Include the fully qualified name for the main class rather than only the base class name.

Additional documentation for the `jps` tool is available at:

- <http://java.sun.com/javase/6/docs/techs/tools/share/jps.html>

jstack

The `jstack` tool is used to obtain a stack trace of a running Java process, or optionally from a core file generated if the JVM happens to crash. A stack trace can be extremely valuable when trying to debug a problem, because it provides information about all threads running and exactly what each is doing at the point in time that the stack trace was obtained.

Stack traces are helpful when diagnosing problems in which the server appears to be hung or behaving slowly. Java stack traces are generally more helpful than native stack traces, because Java threads can have user-friendly names (as do the threads used by the UnboundID Metrics

Engine), and the frame of the stack trace may include the line number of the source file to which it corresponds. This is useful when diagnosing problems and often allows them to be identified and resolved quickly.

To obtain a stack trace from a running JVM, use the command:

```
jstack {processID}
```

where {processID} is the process ID of the target JVM as returned by the `jps` command. To obtain a stack trace from a core file from a Java process, use the command:

```
jstack {pathToJava} {pathToCore}
```

where {pathToJava} is the path to the java command from which the core file was created, and {pathToCore} is the path to the core file to examine. In either case, the stack trace is written to standard output and includes the names and call stacks for each of the threads that were active in the JVM.

In many cases, no additional options are necessary. The `-l` option can be added to obtain a long listing, which includes additional information about locks owned by the threads. The `-m` option can be used to include native frames in the stack trace.

Additional documentation for the `jstack` tool is available at <http://java.sun.com/javase/6/docs/techs/tools/share/jstack.html>.

jmap

The `jmap` tool is used to obtain information about the memory consumed by the JVM. It is very similar to the native `pmap` tool provided by many operating systems. As with the `jstack` tool, `jmap` can be invoked against a running Java process by providing the process ID, or against a core file, like:

```
jmap {processID}
jmap {pathToJava} {pathToCore}
```

Some of the additional arguments include:

- **-dump:live,format=b,file=filename** – Dump the live heap data to a file that can be examined by the `jhat` tool
- **-heap** – Provides a summary of the memory used in the Java heap, along with information about the garbage collection algorithm in use.
- **-histo:live** – Provides a count of the number of objects of each type contained in the heap. If the `:live` portion is included, then only live objects are included; otherwise, the count include objects that are no longer in use and are garbage collected.

Additional information about the `jmap` tool can be found at <http://java.sun.com/javase/6/docs/techs/tools/share/jmap.html>.

jhat

The `jhat` (Java Heap Analysis Tool) utility provides the ability to analyze the contents of the Java heap. It can be used to analyze a heap dump file, which is generated if the Metrics Engine encounters an out of memory error (as a result of the `"-XX:+HeapDumpOnOutOfMemoryError"` JVM option) or from the use of the `jmap` command with the `"-dump"` option.

The `jhat` tool acts as a web server that can be accessed by a browser in order to query the contents of the heap. Several predefined queries are available to help determine the types of objects consuming significant amounts of heap space, and it also provides a custom query language (OQL, the Object Query Language) for performing more advanced types of analysis.

The `jhat` tool can be launched with the path to the heap dump file, like:

```
jhat /path/to/heap.dump
```

This command causes the `jhat` web server to begin listening on port 7000. It can be accessed in a browser at `http://localhost:7000` (or `http://address:7000` from a remote system). An alternate port number can be specified using the `"-port"` option, like:

```
jhat -port 1234 /path/to/heap.dump
```

To issue custom OQL searches, access the web interface using the URL `http://localhost:7000/oql/` (the trailing slash must be provided). Additional information about the OQL syntax may be obtained in the web interface at `http://localhost:7000/oqlhelp/`. Additional information for the `jhat` tool may be found at `http://java.sun.com/javase/6/docs/techs/tools/share/jhat.html`.

jstat

The `jstat` tool is used to obtain a variety of statistical information from the JVM, much like the `vmstat` utility that can be used to obtain CPU utilization information from the operating system. The general manner to invoke it is as follows:

```
jstat {type} {processID} {interval}
```

The `{interval}` option specifies the length of time in milliseconds between lines of output. The `{processID}` option specifies the process ID of the JVM used to run the Metrics Engine, which can be obtained by running `jps` as mentioned previously. The `{type}` option specifies the type of output that should be provided. Some of the most useful types include:

- **-class** – Provides information about class loading and unloading.
- **-compile** – Provides information about the activity of the JIT complex.
- **-printcompilation** – Provides information about JIT method compilation.
- **-gc** – Provides information about the activity of the garbage collector.
- **-gccapacity** – Provides information about memory region capacities.

Java Diagnostic Information

In addition to the tools listed in the previous section, the JVM can provide additional diagnostic information in response to certain events.

JVM Crash Diagnostic Information

If the JVM itself should happen to crash for some reason, then it generates a fatal error log with information about the state of the JVM at the time of the crash. By default, this file is named `hs_err_pid{processID}.log` and is written into the base directory of the Metrics Engine installation. This file includes information on the underlying cause of the JVM crash, information about the threads running and Java heap at the time of the crash, the options provided to the JVM, environment variables that were set, and information about the underlying system. More information about the content that may be written to this log file may be found at <http://java.sun.com/javase/6/webs/trouble/TSG-VM/html/felog.html>.

Java Troubleshooting Tools (IBM JDK)

The UnboundID Metrics Engine can be run on machines using the IBM JDK. IBM provides Java monitoring and diagnostic tools that can assess JVM performance and troubleshoot any Java application failures. The following tools are available for the IBM JDK. For more detailed information, see the IBM Developers web-site for a description of each tool:

- **Health Center Version 1.3.** Monitors Java applications running on the JDK. The tool provides profiling information for performance, memory usage, system environment, object allocations and other areas.
- **Memory Analyzer Version 1.1.** Analyzes Java heap memory using a system or heap dump snapshot of a Java process.
- **Garbage Collection and Memory Visualizer Version 2.6.** Fine-tunes Java performance by optimizing garbage collection performance, provides Java heap recommendations based on peak and average memory usage, and detects memory leaks and heap exhaustion.
- **Dump Analyzer Version 2.2.** Helps troubleshoot the cause of any application failure using an operating system dump. The tool detects any potential problems based on state, thread, stack information and error messages that were generated when the application failed.
- **Diagnostics Collector Version 1.0.** Collects diagnostic and context information during Java runtime processes that failed. The tool verifies your Java diagnostic configuration to ensure that disabled diagnostic analyzers are enabled to troubleshoot a problem.
- **IBM Diagnostic Tool Framework for Java Version 1.5.** Runs on dump data extracted by the `jextract` tool. The tool checks memory locations, Java threads, Java objects and other important diagnostic areas when the system dump was produced.

Troubleshooting Resources in the Operating System

The underlying operating system also provides a significant amount of information that can help diagnose issues that impact the performance and the stability of the Metrics Engine. In some cases, problems with the underlying system can be directly responsible for the issues seen with the Metrics Engine, and in others system, tools can help narrow down the cause of the problem.

Identifying Problems with the Underlying System

If the underlying system itself is experiencing problems, it can adversely impact the function of applications running on it. Places to look for problems in the underlying system include:

- The system log file (`/var/adm/messages` on Solaris and `/var/log/messages` on Linux). Information about faulted or degraded devices or other unusual system conditions are written there.
- On Solaris systems, if the fault management system has detected a problem with a system component, information about that problem is obtain by running the `fmddump` command.
- If the ZFS filesystem is in use, then the `zpool status` command provides information about read errors, write errors, or data checksum errors.

Examining CPU Utilization

Observing CPU utilization for the Metrics Engine process and the system as a whole provides clues as to the nature of the problem.

System-Wide CPU Utilization

To investigate CPU consumption of the system as a whole, use the `vmstat` command with a time interval in seconds, like:

```
vmstat 5
```

The specific output of this command varies between different operating systems, but it includes the percentage of the time the CPU was spent executing user-space code (user time), the percentage of time spent executing kernel-space code (system time), and the percentage of time not executing any code (idle time).

If the CPUs are spending most of their time executing user-space code, the available processors are being well-utilized. If performance is poor or the server is unresponsive, it can indicate that the Metrics Engine is not optimally tuned. If there is a high system time, it can indicate that the system is performing excessive disk and/or network I/O, or in some cases, there can be some other system-wide problem like an interrupt storm. If the system is mostly idle but the Metrics Engine is performing poorly or is unresponsive, there can be a resource constraint elsewhere (for example, waiting on disk or memory access, or excessive lock contention), or the JVM can

be performing other tasks like stop-the-world garbage collection that cannot be run heavily in parallel.

Per-CPU Utilization

To investigate CPU consumption on a per-CPU basis, use the `mpstat` command with a time interval in seconds, like:

```
mpstat 5
```

On Linux systems, it might be necessary to add `"-P ALL"` to the command, like:

```
mpstat -P ALL 5
```

Among other things, this shows the percentage of time each CPU has spent in user time, system time, and idle time. If the overall CPU utilization is relatively low but `mpstat` reports that one CPU has a much higher utilization than the others, there might be a significant bottleneck within the server or the JVM might be performing certain types of garbage collection which cannot be run in parallel. On the other hand, if CPU utilization is relatively even across all CPUs, there is likely no such bottleneck and the issue might be elsewhere.

Per-Process Utilization

To investigate CPU consumption on a per-process basis, use the `prstat` tool on Solaris or the `top` utility on Linux. If a process other than the Java process used to run the Metrics Engine is consuming a significant amount of available CPU, it might be interfering with the ability of the Metrics Engine to run effectively.

If the `mpstat` command showed that one CPU was much more heavily utilized than the others, it might be useful to identify the thread with the highest CPU utilization as it is likely the one that is a bottleneck preventing other threads from processing. On Solaris, this can be achieved by using the `prstat` command with the `"-L"` option, like:

```
prstat -L -p {processID}
```

This command will cause each thread to be displayed on a separate line, with the LWPID (lightweight process identifier) displayed as the last item on each line, separated from the process name by a slash. The thread that is currently consuming the largest amount of CPU will be displayed at the top of the list, and the `pstack` command can be used to identify which thread is responsible.

Examining Disk Utilization

If the underlying system has a very high disk utilization, it can adversely impact Metrics Engine performance. It could delay the ability to read or write database files or write log files. It could also raise concerns for server stability if excessive disk I/O inhibits the ability of the cleaner threads to keep the database size under control.

The `iostat` tool may be used to obtain information about the disk activity on the system. On Solaris systems, this should be invoked using the `"-x"` and `"-n"` arguments, like:

```
iostat -x -n 5
```

On Linux systems, `iostat` should be invoked with the `-x` argument, like:

```
iostat -x 5
```

A number of different types of information will be displayed, but to obtain an initial feel for how busy the underlying disks are, look at the `%b` column on Solaris and the `%util` column on Linux. Both of these fields show the percentage of the time that the underlying disks are actively servicing I/O requests. A system with a high disk utilization likely exhibits poor Metrics Engine performance.

If the high disk utilization is on one or more disks that are used to provide swap space for the system, the system might not have enough free memory to process requests. As a result, it might have started swapping blocks of memory that have not been used recently to disk. This can cause very poor server performance. It is important to ensure that the server is configured appropriately to avoid this condition. If this problem occurs on a regular basis, then the server is likely configured to use too much memory. If swapping is not normally a problem but it does arise, then check to see if there are any other processes running, which are consuming a significant amount of memory, and check for other potential causes of significant memory consumption (for example, large files in a `tmpfs` filesystem).

On Solaris systems using ZFS, you can use the `zpool iostat {interval}` command to obtain information about I/O activity on a per-pool basis. While this command provides a useful display of the number of read and write operations and the amount of data being read from and written to the disks, it does not actually show how busy the underlying disks. As a result, the `zpool iostat` command is generally not as useful as the traditional `iostat` command for identifying potential I/O bottlenecks.

Examining Process Details

There are a number of tools provided by the operating system that can help examine a process in detail.

ps

The standard `ps` tool can be used to provide a range of information about a particular process. For example, the command can be used to display the state of the process, the name of the user running the process, its process ID and parent process ID, the priority and nice value, resident and virtual memory sizes, the start time, the execution time, and the process name with arguments:

```
ps -fly -p {processID}
```

Note that for a process with a large number of arguments, the standard `ps` command displays only a limited set of the arguments based on available space in the terminal window. In that case, the BSD version of the `ps` command (available on Solaris as `/usr/ucb/ps`) can be used to obtain the full command with all arguments, like:

```
/usr/ucb/ps auxwww {processID}
```

pstack

The `pstack` command can be used to obtain a native stack trace of all threads in a process. While a native stack trace might not be as user-friendly as a Java stack trace obtained using `jstack`, it includes threads that are not available in a Java stack trace. For example, the command displays those threads used to perform garbage collection and other housekeeping tasks. The general usage for the `pstack` command is:

```
pstack {processID}
```

dbx / gdb

A process debugger provides the ability to examine a process in detail. Like `pstack`, a debugger can obtain a stack trace for all threads in the process, but it also provides the ability to examine a process (or core file) in much greater detail, including observing the contents of memory at a specified address and the values of CPU registers in different frames of execution. The GNU debugger `gdb` is widely-used on Linux systems and is available on Solaris, but the Sun Studio debugger `dbx` is generally preferred over `gdb` on Solaris.

Note that using a debugger against a live process interrupts that process and suspends its execution until it detaches from the process. In addition, when running against a live process, a debugger has the ability to actually alter the contents of the memory associated with that process, which can have adverse effects. As a result, it is recommended that the use of a process debugger be restricted to core files and only used to examine live processes under the direction of your authorized support provider.

pfiles / lsof

To examine the set of files that a process is using (including special types of files, like sockets) on Solaris, you can use the `pfiles` command, like:

```
pfiles {processID}
```

On Linux systems, the `lsof` tool can be used, like:

```
lsof -p {processID}
```

Tracing Process Execution

If a process is unresponsive but is consuming a nontrivial amount of CPU time, or if a process is consuming significantly more CPU time than is expected, it might be useful to examine the activity of that process in more detail than can be obtained using a point-in-time snapshot like you can get with `pstack` or a debugger. For example, if a process is performing a significant amount of disk reads and/or writes, it can be useful to see which files are being accessed. Similarly, if a process is consistently exiting abnormally, then beginning tracing for that process just before it exits can help provide additional information that cannot be captured in a core file (and if the process is exiting rather than being terminated for an illegal operation, then no core file may be available).

On Solaris systems, the `dtrace` tool provides an unmatched mechanism for tracing the execution of a process in extremely powerful and flexible ways, but it is also relatively complex and describing its use is beyond the scope of this document. In many cases, however, observing the system calls made by a process can reveal a great deal about what it is doing. This can be accomplished using the `truss` utility on Solaris or the `strace` tool on Linux.

The `truss` utility is very powerful and has a lot of options, but two of the most useful forms in which it may be invoked are:

- **`truss -f -p {processID}`** – Provides a basic overview of all system calls being made by the specified process (and any subprocesses that it creates) and their associated return values.
- **`truss -fear all -p {processID}`** – Provides an extremely verbose trace of all system call activity, including details about data being read from or written to files and sockets.

In both cases, the output may be written to a file instead of the terminal window by adding the `-o {path}` option. Further, rather than observing an already-running process, it is possible to have `truss` launch the process and trace execution over its entire life span by replacing `-p {processID}` with name and arguments for the command to invoke.

On Linux systems, the basic equivalent of the first `truss` variant above is:

```
strace -f -p {processID}
```

Consult the `strace` manual page for additional information about using it to trace process execution on Linux.

Examining Network Communication

Because the UnboundID Metrics Engine is a network-based application, it can be valuable to observe the network communication that it has with clients. The Metrics Engine itself can provide details about its interaction with clients by enabling debugging for the protocol or data debug categories, but there may be a number of cases in which it is useful to view information at a much lower level. A network sniffer, like the `snoop` tool on Solaris or the `tcpdump` tool on Linux, can be used to accomplish this.

There are many options that can be used with these tools, and their corresponding manual pages will provide a more thorough explanation of their use. However, to perform basic tracing to show the full details of the packets received for communication on port 389 with remote host 1.2.3.4, the following commands can be used on Solaris and Linux, respectively:

```
snoop -d {interface} -r -x 0 host 1.2.3.4 port 389
tcpdump -i {interface} -n -XX -s 0 host 1.2.3.4 and port 389
```

On Solaris systems, the `snoop` command provides enhanced support for parsing LDAP communication (but only when the Metrics Engine is listening on the default port of 389). By adding the `-v` argument to the `snoop` command line, a verbose breakdown of each packet will be displayed, including protocol-level information. It does not appear that the `tcpdump` tool provides support for LDAP parsing. However, in either case it is possible to write capture data to a file rather than displaying information on the terminal (using `-o {path}` with `snoop`, or `-w {path}` with `tcpdump`), so that information can be later analyzed with a graphical tool like Wireshark, which provides the ability to interpret LDAP communication on any port.

Note that enabling network tracing generally requires privileges that are not available to normal users and therefore may require root access. On Solaris systems, granting the `net_rawaccess` privilege to a user should be sufficient to allow that user to run the `snoop` utility.

Troubleshooting Performance Problems

This section addresses some possible performance issues that the Metrics Engine may experience. The Metrics Engine monitors itself at the same time that it monitors other servers, so the historical view of the status and performance of the Metrics Engine is captured in the DBMS and is available for historical analysis.

Example of Interpreting Performance Data to Troubleshoot Problems

This section describes troubleshooting system performance problems. It uses a contrived example and answers the question of why an application, which was performing great 30 minutes ago, now exhibits terrible performance.

The help desk receives a phone call at 11:50 AM from a user indicating that application XYZ is performing poorly. The help desk personnel check and all applicable servers appear to be up and running, CPU utilization is within tolerance, and there are no observable network issues. After 30 minutes pass, the help desk staff make no progress with the issue and it gets escalated -- to you.

The application in question is hosted on a pair of identity proxies with both servers sharing the same pair of identity data stores in a round-robin configuration.

First, you get a plot of the average Identity Proxy response time that covers the time frame of the initial complaint. This chart is captured using the following `query-metric` command:

```
$ bin/query-metric query --metric response-time --instanceType proxy \  
--startTime -1h
```

The command displays the following chart.

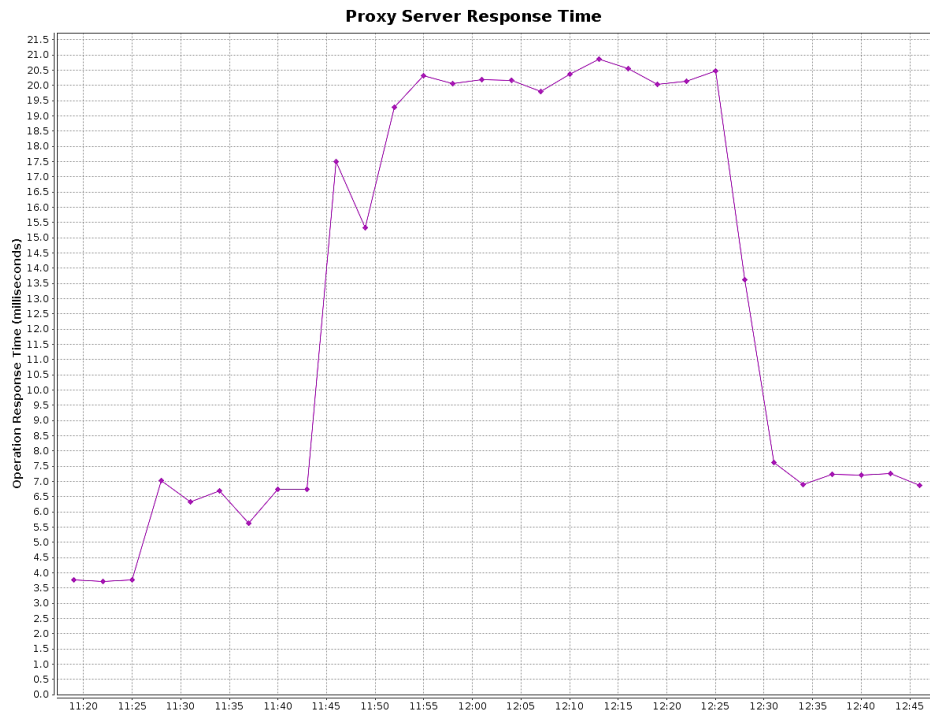


Figure 38: Proxy Server Response Time

This chart shows the problem that the user observed. Application response time tripled right around the time they called in. The average shifted up, meaning that either a few request to a really long time, or maybe everything slowed down. To get more information, you use the `query-metric` command to get a plot of the application response time histogram over the same time. The result is the following graph.

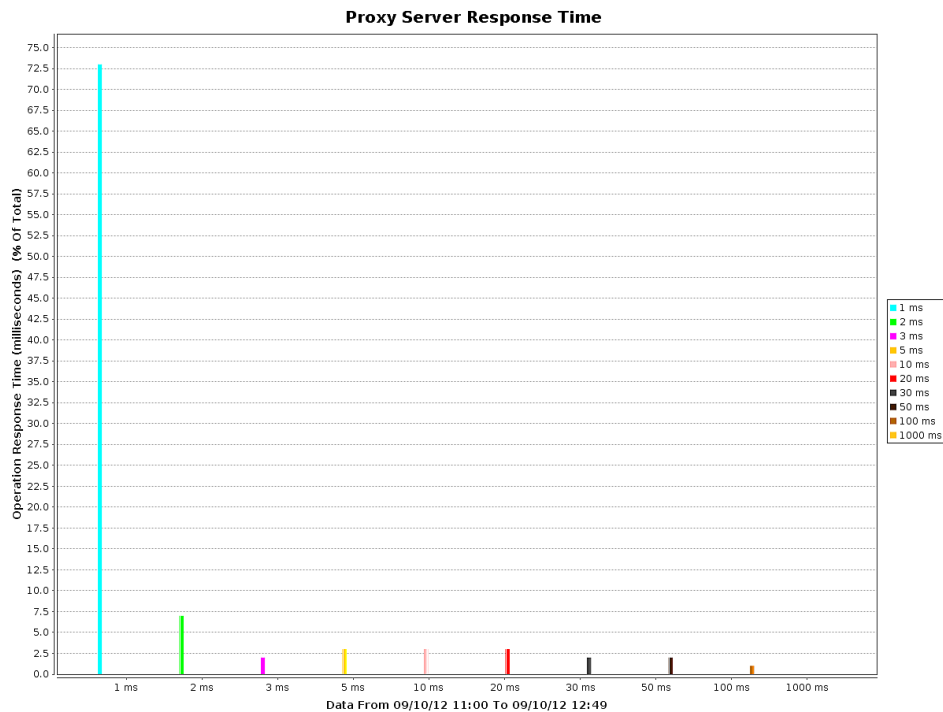


Figure 39: Application Response Time Histogram

The graph shows that no requests during this period took a really long time. So it appears that all operations were slow, so we look at the external server health.

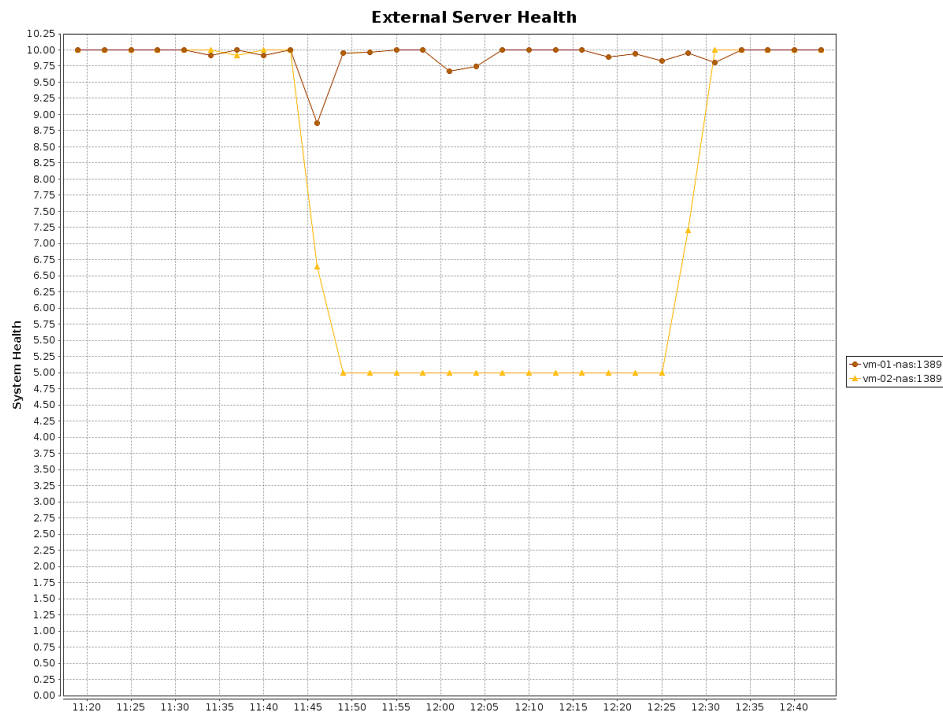


Figure 40: External Server Health

Here, we see an increase in response time that matches the decrease in external server health on vm-02-nas:1389. So, the problem appears to be on that specific Identity Data Store. Next, we look at what each Identity Data Store was doing.

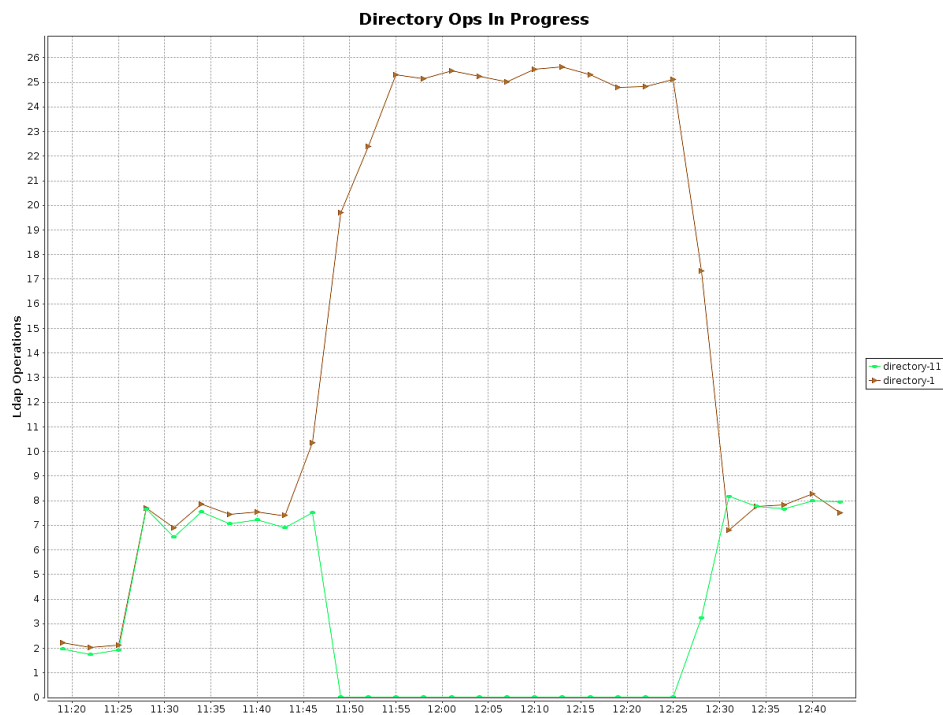


Figure 41: Directory Operations in Progress

During the "bad" period from the first plot, we see that directory-11 (vm-02-nas:1389) stopped doing anything. Something happened on directory-11 and then cleared up about 30 minutes later. Finally, we consult the most recent status on directory-11 using the `status` command. We see the following:

```
--- Administrative Alerts ---
Severity : Time : Message
-----:-----:-----
-----:-----:-----
Error : 10/Sep/2012 11:47:39 -0500 : A severe backlog has been detected in the
Directory Server work queue. The operation currently at the head of the queue has
been waiting for 25785 milliseconds
Error : 10/Sep/2012 11:47:25 -0500 : A severe backlog has been detected in the
Directory Server work queue. The operation currently at the head of the queue has
been waiting for 11790 milliseconds
Warning : 10/Sep/2012 11:47:12 -0500 : The Directory Server has detected that the
amount of usable disk space is below the configured low disk space warning threshold
for the following path(s):
: : '/home/slj/deploy/ds2' (totalBytes:
18624344064, usableBytes: 1851559936, usablePercent: 10),
'/home/slj/deploy/ds2/changelogDb' (totalBytes: 18624344064,
: : usableBytes: 1851559936, usablePercent:
10), '/home/slj/deploy/ds2/config' (totalBytes: 18624344064, usableBytes:
1851559936, usablePercent: 10),
: : '/home/slj/deploy/ds2/db/changelog'
(totalBytes: 18624344064, usableBytes: 1851559936, usablePercent: 10),
'/home/slj/deploy/ds2/db/userRoot' (totalBytes:
: : 18624344064, usableBytes: 1851559936,
usablePercent: 10), '/home/slj/deploy/ds2/logs' (totalBytes: 18624344064,
usableBytes: 1851559936, usablePercent: 10)
```

Looking at the charts and server status above, you conclude that available disk space on directory-11 went below the warning threshold for a period, resulting in the traffic shifting from two identity data stores to only one for about 30 minutes. At the end of that time, both identity data stores resumed normal operations and the response time returned to normal. What caused the disk space to suddenly decrease is not known.

All of the charts above were captured using the `query-metric` tool of the Metrics Engine. You can write a script that will capture historical information and use it to quickly analyze performance problems that occurred hours, days, or even weeks ago with a high degree of confidence.

Long Time Before Samples Appear in Queries

The delay between when a metric sample is capture and when it is available in the Metrics Engine is a combination of queuing and polling delays. The default configuration allows the monitored server queue samples in memory for up to 30 seconds before writing them to disk. Samples are not available for the Metrics Engine to capture until after they are written to disk on the monitored servers, so there is a delay of up to 30 seconds in queuing o the monitored server.

The Metrics Engine polls each monitored server every 30 seconds by default, looking for new data. In a worst case, a sample may have been captured on the monitored server 60 seconds before it has been captured and queued for import on the Metrics Engine. When all servers are running normally, 60 seconds is the upper limit of a normal delay between when a sample is captured on the monitored server and when it is available to a query on the Metrics Engine.

Sometimes there is a backlog of blocks of sample data to be imported into the Metrics Engine. In this case, a sample block may be delayed by minutes or even hours before becoming available to a query, in part because the import of sample blocks is a sequential operation. Fortunately,

you can easily observe this condition and predict when the backlog will be cleared and normal latency can once again be expected.

Use the following URL in a browser to chart the number of sample blocks queued by the Metrics Engine as a function of time over the past hour. You can estimate, using the downward slope of the spike, how long it will take to clear the backlog.

```
http://<metrics-engine-host:port>/api/v1/metrics/monitor-import-queue-depth/chart?maxIntervals=60&startTime=-1h
```

Below is a sample from a Metrics Engine that was shut down for 10 minutes. The spike that occurs on startup results from the fact that all monitored servers continued to queue sample blocks, and when the Metrics Engine started back up it fetched them and queued them for import. You can see from the chart that about 1500 sample blocks were queued and it took the Metrics Engine about three minutes to catch back up.

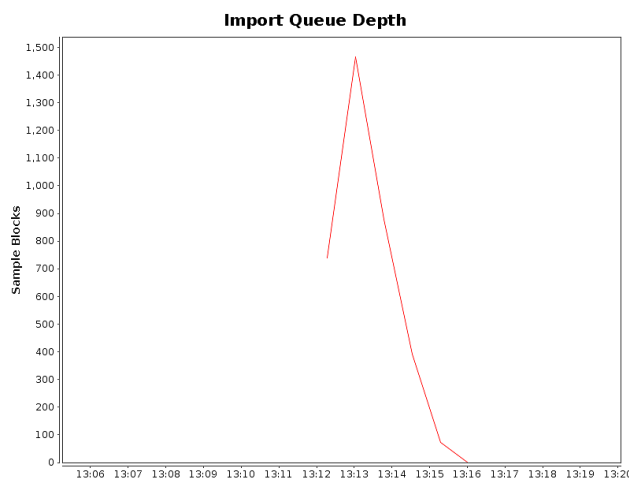


Figure 42: Import Queue Depth

If you choose to monitor over LDAP, the following LDAP entry contains the equivalent information.

```
dn: cn=Aggregation,cn=monitor
Attribute: import-queue - number of sample blocks waiting for import
                        (should be close to zero)
Attribute: import-load-delay-millis - milliseconds between when the
                        sample block arrived and when it was imported
                        (should be less than 5 seconds)
Attribute: import-load-millis - milliseconds to load the block to DBMS
                        (should be less than 50 milliseconds)
Attribute: import-parse-millis - milliseconds to parse the block to a
                        normalized form ready for import
                        (should be less than 75 milliseconds)
```

The Metrics Engine captures and stores all of the data above, so you can easily go back and look at the data's history to judge how well things are working.

Slow Queries for a Particular Metric

The Metrics Engine DBMS is designed for minimal space usage and the data in the samples tables is eventually optimized for query performance. However, there are cases where some queries may be slow. The expected query performance for a metric query should be less than 500 milliseconds per query. If the Metrics Engine host system has adequate CPU and

disk performance, as well as enough RAM for both the Metrics Engine server process and PostgreSQL DBMS processes, then 500 milliseconds or less per query is expected for most queries. There are a few exceptions. Understanding the performance considerations can help you improve query response time.

Some metric queries must read millions of records from the DBMS. If the query has not been executed in the recent past, then chances are very good that all of the data will need to come from disk. If the tables holding the data have been layout optimized, this process can take several seconds. If the tables have not been layout optimized, this process can take more than a minute. The Metrics Engine caches recent query results, so making the same query a second time increases the likelihood that it can be much of the data from the sample cache, bypassing the DBMS and reducing the overall query time.

If you have problems with a particular query and want to understand it better, enable the `slow-query-threshold` property using `dsconfig`. Queries for the specified metric that take longer than the threshold will print query statistics to the server's error log. The statistics include the percentage of the query that was already in cache (as a function of time), the number of records read from the DBMS, and how long the DBMS query took.

The following command causes any query for the `throughput` metric that take more than 500 milliseconds to have its query statistics printed to the server error log.

```
dsconfig set-monitoring-configuration-prop \
  --set slow-query-threshold-ms:500:throughput
```

For metrics that you know you want to query, but you cannot predict the frequency of the queries, you can configure metric queries to run in the background. Running them in the background keeps the metrics in the cache and avoids the slow first query. The `slow-query-threshold` setting above prints the command you should use to setup a prefetch query when a query exceeds the specified `slow-query-threshold`. See the Prefetched Metric Query configuration object with `dsconfig` for the details on how to configure this feature.

All Metric Queries are Slow

The `evicted-count` attribute of the sample cache sets the number of entries that have been evicted from the cache due to a lack of space. If this attribute is much great than zero, the cache is undersized for the query load placed on the server. You can increase the size of the sample cache with the following command, which sets the maximum size to 200000.

```
dsconfig set-monitoring-configuration-prop \
  --set sample-cache-max-cached-series:200000
```

Some queries are so infrequent that the cached data expires due to age. The default age is ten minutes, but this can be increased up to one hour. If you observe the `expired-count` monitor attribute increasing between queries, you may consider increasing the idle timeout as follows:

```
dsconfig set-monitoring-configuration-prop \
  --set sample-cache-idle-series-timeout:20m
```

Strange Query Results for Time Ranges Ending Now

The query API attempts by default to aggregate samples across servers and dimension values. Sometimes, the samples for different servers, or even different dimension values, are imported into the Metrics Engine at different times. The only guarantee about the importing of metric samples is that they will be imported in time-order for each server. You can not set the ordering across servers and samples for a specific time may arrive in stages. So, a metric query that aggregates across servers or dimensions may get partial data when the query time range ends close to now. This problem is compounded when the monitored servers have significant clock skew relative to each other, because samples are timestamped with the monitored server clock, not the Metrics Engine clock. Since the query looks at a single time range, the more clock skew the monitored servers have, the higher the probability of the results close to now looking strange.

To illustrate this problem, consider the following example. We want to look at the throughput metric for four proxy server. and we want to know how many LDAP operations have occurred every minute of the last hour. The delay problem is most like to appear in the last minute, because the DBMS has throughput data for some of the servers but not all. So, for 59 of the 60 minutes, the throughput data shows all four proxy servers. However, for the last minute, it only has data for two of the four servers. The last sample has only half the value of all the others. While it appears that throughput has dropped dramatically, in fact the last minute sample only contains part of the data, the rest has not yet arrived. This problem can occur for metrics that are average-based (like response-time) as well, though it usually is not as dramatic.

If you see this behavior and want to understand it better, the API makes it very easy to investigate. With the PI, you can pivot (split) the data by server and dimension and look at the last few minutes. Since the API lets you format the results as an HTML table, you can see that the data has not arrived and get a better idea of how to formulate your query to avoid this data influx area.

The following sequence of API URLs return the last three minutes of data in 10-second increments:

```
http://<metrics-engine-host:port>/api/v1/metrics/throughput/datatable?
maxIntervals=30&startTime=-3m;&tx=html&tz=US/Central

http://<metrics-engine-host:port>/api/v1/metrics/throughput/datatable?
maxIntervals=30&startTime=-3m;&tx=html&tz=US/Central&pivot=instance

http://<metrics-engine-host:port>/api/v1/metrics/throughput/datatable?
maxIntervals=30&startTime=-3m;&tx=html&tz=US/Central&pivot=instance&pivot=op-type
```

The first URL aggregate all servers and LDAP operations into a single number split across time. The second URL splits out the data by server and time. The third URL splits out the data by server, LDAP operation, and time.

As you add dimension pivots (splits), you can see more clearly how the results are aggregations of partial data, a fact that is particularly pronounced in the most recent 60 seconds. The Metrics Engine is especially good at processing large flows of data, but less well suited to low latency reporting.

Note that this behavior is not limited to the most recent 60 seconds. If a server stops reporting metric samples for any reason, this behavior will occur. A server can remain active with LDAP activity but be inaccessible to the Metrics Engine (for example, if the WAN link is disrupted) for a period of time, and the same pattern will be visible in the data. However, this occurs almost all the time within the most recent 30 to 60 seconds.

Optimizing the Layout of the Sample Data Table

The Metrics Engine loads data into the sample data tables in close to chronological order, so that the records in the table are essentially time contiguous. Sample data tables are partitioned by time, so that all samples for a given time range are in a single partition. While the insert order does not guarantee the record layout on disk, the records will not be optimized for the supported queries. A sample block may contain samples for 50 different metrics, such that the metric of interest for a query only occurs every 50 records. As a result, the DBMS storage may contain only one record in each DBMS disk page, which is pathological for query performance. The Metrics Engine compensates for this by optimizing the partition when it believes no new records will be added (at the end of the time range the partition supports). This optimization takes up to a minute while it rewrites the entire partition in an order that matches the index order used for metric queries. Query performance for an unoptimized partition is about 80% slower than performance for an optimized partition. This simple background task is critical for good query performance. If a query arrives during partition optimization and needs data from the partition being optimized, the query will be blocked until optimization completes.

Troubleshooting the Metrics Engine API

When making requests of the Metrics Engine API, you may get an HTTP response indicating an internal server error (HTTP code 500). These errors may indicate a problem processing the request that resulted in an exception. If you encounter this error, enable the debug logger for the API resources, as the UnboundID support staff will need the debug log to help diagnose the problem. Enable the debug logger as follows:

```
dsconfig create-debug-target --publisher-name "File-Based Debug Logger" \
  --target-name com.unboundid.directory.mon.api.v1.resources --set debug-level:info \
  --set include-throwable-cause:true
```

Common Problems and Potential Solutions

This section describes a number of different types of problems that can occur and common potential causes for them.

The Server Will Not Run Setup

If the `setup` tool does not run properly, some of the most common reasons include the following:

A Suitable Java Environment Is Not Available

The UnboundID Metrics Engine requires that Java be installed on the system and made available to the server, and it must be installed prior to running `setup`. If the `setup` tool does not detect that a suitable Java environment is available, it will refuse to run.

To ensure that this does not happen, the `setup` tool should be invoked with an explicitly-defined value for the `JAVA_HOME` environment variable that specifies the path to the Java installation that should be used. For example:

```
env JAVA_HOME=/ds/java ./setup
```

If this still does not work for some reason, then it can be that the value specified in the provided `JAVA_HOME` environment variable can be overridden by another environment variable. If that occurs, try the following command, which should override any other environment variables that can be set:

```
env UNBOUNDID_JAVA_HOME="/ds/java" UNBOUNDID_JAVA_BIN="" ./setup
```

Unexpected Arguments Provided to the JVM

If the `setup` script attempts to launch the `java` command with an invalid set of Java arguments, it might prevent the JVM from starting. By default, no special options are provided to the JVM when running `setup`, but this might not be the case if either the `JAVA_ARGS` or `UNBOUNDID_JAVA_ARGS` environment variable is set. If the `setup` tool displays an error message that indicates that the Java environment could not be started with the provided set of arguments, then invoke the following command before trying to re-run `setup`:

```
unset JAVA_ARGS UNBOUNDID_JAVA_ARGS
```

The Server Has Already Been Configured or Used

The `setup` tool is only intended to provide the initial configuration for the Metrics Engine. It refuses to run if it detects that the `setup` tool has already been run, or if an attempt has been made to start the Metrics Engine prior to running the `setup` tool. This protects an existing Metrics Engine installation from being inadvertently updated in a manner that could harm an existing configuration or data set.

If the Metrics Engine has been previously used and if you want to perform a fresh installation, it is recommended that you first remove the existing installation, create a new one and run `setup` in that new installation. However, if you are confident that there is nothing of value in the existing installation (for example, if a previous attempt to run `setup` failed to complete successfully for some reason but it will refuse to run again), the following steps can be used to allow the `setup` program to run:

- Remove the `config/config.ldif` file and replace it with the `config/update/config.ldif.{revision}` file containing the initial configuration.
- If there are any files or subdirectories below the `db` directory, then remove them.
- If a `config/java.properties` file exists, then remove it.

- If a `lib/setup-java-home` script (or `lib\set-java-home.bat` file on Microsoft Windows) exists, then remove it.

The Server Will Not Start

If the Metrics Engine does not start, then there are a number of potential causes.

The Server or Other Administrative Tool Is Already Running

Only a single instance of the Metrics Engine can run at any time from the same installation root. If an instance is already running, then subsequent attempts to start the server will fail. Similarly, some other administrative operations can also prevent the server from being started. In such cases, the attempt to start the server should fail with a message like:

```
The Metrics Engine could not acquire an exclusive lock on file
/ds/UnboundID-Metrics-Engine/locks/server.lock: The exclusive lock requested for file
/ds/UnboundID-Metrics-Engine/locks/ server.lock was not granted, which indicates
that another process already holds a shared or exclusive lock on that
file. This generally means that another instance of this server is already
running
```

If the Metrics Engine is not running (and is not in the process of starting up or shutting down) and there are no other tools running that could prevent the server from being started, and the server still believes that it is running, then it is possible that a previously-held lock was not properly released. In that case, you can try removing all of the files in the `locks` directory before attempting to start the server.

If you wish to have multiple instances running at the same time on the same system, then you should create a completely separate installation in another location on the filesystem.

There Is Not Enough Memory Available

When the Metrics Engine is started, the JVM attempts to allocate all memory that it has been configured to use. If there is not enough free memory available on the system, then the Metrics Engine generates an error message that indicates that the server could not be started with the specified set of arguments. Note that it is possible that an invalid option was provided to the JVM (as described below), but if that same set of JVM arguments has already been used successfully to run the server, then it is more likely that the system does not have enough memory available.

There are a number of potential causes for this:

- If the amount of memory in the underlying system has changed (for example, system memory has been removed, or if the Metrics Engine is running in a zone or other type of virtualized container and a change has been made to the amount of memory that container will be allowed to use), then the Metrics Engine might need to be re-configured to use a smaller amount of memory than had been previously configured.
- Another process running on the system is consuming a significant amount of memory so that there is not enough free memory available to start the server. If this is the case, then

either terminate the other process to make more memory available for the Metrics Engine, or reconfigure the Metrics Engine to reduce the amount of memory that it attempts to use.

- The Metrics Engine was just shut down and an attempt was made to immediately restart it. In some cases, if the server is configured to use a significant amount of memory, then it can take a few seconds for all of the memory that had been in use by the server, when it was previously running, to be released back to the operating system. In that case, run the `vmstat` command and wait until the amount of free memory stops growing before attempting to restart the server.
- For Solaris-based systems only, if the system has one or more ZFS filesystems (even if the Metrics Engine itself is not installed on a ZFS filesystem), but it has not been configured to limit the amount of memory that ZFS can use for caching, then it is possible that ZFS caching is holding onto a significant amount of memory and cannot release it quickly enough when it is needed by the Metrics Engine. In that case, the system should be re-configured to limit the amount of memory that ZFS is allowed to use as described in the Using the Collect Support Data Tool.
- If the system is configured with one or more memory-backed filesystems, for example, `tmpfs` used for `/tmp` for Solaris), then look to see if there are any large files that can be consuming a significant amount of memory in any of those locations. If so, then remove them or relocate them to a disk-based filesystem.
- For Linux systems only, if there is a mismatch between the huge pages setting for the JVM and the huge pages reserved in the operating system. For more information, see Configure Huge Page Support (Linux).

If nothing else works and there is still not enough free memory to allow the JVM to start, then as a last resort, try rebooting the system.

An Invalid Java Environment or JVM Option Was Used

If an attempt to start the Metrics Engine fails with an error message indicating that no valid Java environment could be found, or indicates that the Java environment could not be started with the configured set of options, then you should first ensure that enough memory is available on the system as described above. If there is a sufficient amount of memory available, then other causes for this error can include the following:

- The Java installation that was previously used to run the server no longer exists (for example, an updated Java environment was installed and the old installation was removed). In that case, update the `config/java.properties` file to reference to path to the new Java installation and run the `bin/dsjavaproperties` command to apply that change.
- The Java installation used to run the server has been updated and the server is trying to use the correct Java installation but one or more of the options that had worked with the previous Java version no longer work with the new version. In that case, it is recommended that the server be re-configured to use the previous Java version, so that it can be run while investigating which options should be used with the new installation.
- If an `UNBOUNDID_JAVA_HOME` or `UNBOUNDID_JAVA_BIN` environment variable is set, then its value may override the path to the Java installation used to run the server as defined in the `config/java.properties` file. Similarly, if an `UNBOUNDID_JAVA_ARGS`

environment variable is set, then its value might override the arguments provided to the JVM. If this is the case, then explicitly unset the `UNBOUNDID_JAVA_HOME`, `UNBOUNDID_JAVA_BIN`, and `UNBOUNDID_JAVA_ARGS` environment variables before trying to start the server.

Note that any time the `config/java.properties` file is updated, the `bin/dsjavaproperties` tool must be run to apply the new configuration. If a problem with the previous Java configuration prevents the `bin/dsjavaproperties` tool from running properly, then it can be necessary to remove the `lib/set-java-home` script (or `lib\set-java-home.bat` file on Microsoft Windows) and invoke the `bin/dsjavaproperties` tool with an explicitly-defined path to the Java environment, like:

```
env UNBOUNDID_JAVA_HOME=/ds/java bin/dsjavaproperties
```

An Invalid Command-Line Option Was Provided

There are a small number of arguments that are provided when running the `bin/start-ds` command, but in most cases, none are required. If one or more command-line arguments were provided for the `bin/start-ds` command and any of them is not recognized, then the server provides an error message indicating that an argument was not recognized and displays version information. In that case, correct or remove the invalid argument and try to start the server again.

The Server Has an Invalid Configuration

If a change is made to the Metrics Engine configuration using an officially-supported tool like `dsconfig` or the Management Console, the server should validate that configuration change before applying it. However, it is possible that a configuration change can appear to be valid at the time that it is applied, but does not work as expected when the server is restarted. Alternately, a change in the underlying system can cause a previously-valid configuration to become invalid.

In most cases involving an invalid configuration, the Metrics Engine displays (and writes to the error log) a message that explains the problem, and this can be sufficient to identify the problem and understand what action needs to be taken to correct it. If for some reason the startup failure does not provide enough information to identify the problem with the configuration, then look in the `logs/config-audit.log` file to see what recent configuration changes have been made with the server online, or in the `config/archived-configs` directory to see if there might have been a recent configuration change resulting from a direct change to the configuration file itself that was not made through a supported configuration interface.

If the server does not start as a result of a recent invalid configuration change, then it can be possible to start the server using the configuration that was in place the last time that the server started successfully (for example, the "last known good" configuration). This can be achieved using the `--useLastKnownGoodConfig` option:

```
$ bin/start-ds --useLastKnownGoodConfig
```

Note that if it has been a long time since the last time the server was started and a number of configuration changes have been made since that time, then the last known good configuration

can be significantly out of date. In such cases, it can be preferable to manually repair the configuration.

If there is no last known good configuration, if the server no longer starts with the last known good configuration, or if the last known good configuration is significantly out of date, then manually update the configuration by editing the `config/config.ldif` file. In that case, you should make sure that the server is offline and that you have made a copy of the existing configuration before beginning. You might wish to discuss the change with your authorized support representative before applying it to ensure that you understand the correct change that needs to be made.



Note: In addition to manually-editing the config file, you can look at previous achived configurations to see if the most recent one works. You can also use the `ldif-diff` tool to compare the configurations in the archive to the current configuration to see what is different.

You Do Not Have Sufficient Permissions

The Metrics Engine should only be started by the user or role used to initially install the server. In most cases, if an attempt is made to start the server as a user or role other than the one used to create the initial configuration, then the server will fail to start, because the user will not have sufficient permissions to access files owned by the other user, such as database and log files. However, if the server was initially installed as a non-root user and then the server is started by the root account, then it can no longer be possible to start the server as a non-root user because new files that are created would be owned by root and could not be written by other users.

If the server was inadvertently started by root when it is intended to be run by a non-root user, or if you wish to change the user account that should be used to run the server, then it should be sufficient to simply change ownership on all files in the Metrics Engine installation, so that they are owned by the user or role under which the server should run. For example, if the Metrics Engine should be run as the "ds" user in the "other" group, then the following command can be used to accomplish this (invoked by the root user):

```
chown -R ds:other /ds/UnboundID-Metrics-Engine
```

The Server Has Crashed or Shut Itself Down

You can first check the current server state by using the `bin/server-state` command. If the Metrics Engine was previously running but is no longer active, then the potential reasons include the following:

- The Metrics Engine was shut down by an administrator. Unless the server was forcefully terminated (for example, using “kill -9”), then messages are written to the `error` and `server.out` logs explaining the reason for the shutdown.
- The Metrics Engine was shut down when the underlying system crashed or was rebooted. If this is the case, then running the `uptime` command on the underlying system shows that it was recently booted.

- The Metrics Engine process was terminated by the underlying operating system for some reason (for example, the out of memory killer on Linux). If this happens, then a message will be written to the system error log.
- The Metrics Engine decided to shut itself down in response to a serious problem that had arisen. At present, this should only occur if the server has detected that the amount of usable disk space has become critically low, or if significant errors have been encountered during processing that left the server without any remaining worker threads to process operations. If this happens, then messages are written to the `error` and `server.out` logs (if disk space is available) to provide the reason for the shutdown.
- The JVM in which the Metrics Engine was running crashed. If this happens, then the JVM should dump a fatal error log (a `hs_err_pid{processID}.log` file) and potentially a core file.

In the event that the operating system itself crashed or terminated the process, then you should work with your operating system vendor to diagnose the underlying problem. If the JVM crashed or the server shut itself down for a reason that is not clear, then contact your authorized support provider for further assistance.

The Server Will Not Accept Client Connections

You can first check the current server state by using the `bin/server-state` command. If the Metrics Engine does not appear to be accepting connections from clients, then potential reasons include the following:

- The Metrics Engine is not running.
- The underlying system on which the Metrics Engine is installed is not running.
- The Metrics Engine is running but is not reachable as a result of a network or firewall configuration problem. If that is the case, then connection attempts should time out rather than be rejected.
- If the Metrics Engine is configured to allow secure communication via SSL or StartTLS, then a problem with the key manager and/or trust manager configuration can cause connections to be rejected. If that is the case, then messages should be written to the server access log for each failed connection attempt.
- If the Metrics Engine has been configured with a maximum allowed number of connections, then it can be that the maximum number of allowed client connections are already established. If that is the case, then messages should be written to the server access log for each rejected connection attempt.
- If the Metrics Engine is configured to restrict access based on the address of the client, then messages should be written to the server access log for each rejected connection attempt.
- If a connection handler encounters a significant error, then it can stop listening for new requests. If this occurs, then a message should be written to the server error log with information about the problem. Another solution is to restart the server. A third option is to restart the connection handler using the LDIF connection handler to make it available again. To do this, create an LDIF file that disables and then re-enables the connection handler,

create the `config/auto-process-ldif` directory if it does not already exist, and then copy the LDIF file into it.

The Server is Unresponsive

You can first check the current server state by using the `bin/server-state` command. If the Metrics Engine process is running and appears to be accepting connections but does not respond to requests received on those connections, then potential reasons for this behavior include:

- If all worker threads are busy processing other client requests, then new requests that arrive will be forced to wait in the work queue until a worker thread becomes available. If this is the case, then a stack trace obtained using the `jstack` command shows that all of the worker threads are busy and none of them are waiting for new requests to process.



Note: If all of the worker threads are tied up processing the same operation for a long time, the server will also issue an alert that it might be deadlocked, which may not actually be the case. All threads might be tied up processing unindexed searches.

- If a request handler is stuck performing some expensive processing for a client connection, then other requests sent to the server on connections associated with that request handler is forced to wait until the request handler is able to read data on those connections. If this is the case, then only some of the connections can experience this behavior (unless there is only a single request handler, in which it will impact all connections), and stack traces obtained using the `jstack` command shows that a request handler thread is continuously blocked rather than waiting for new requests to arrive. Note that this scenario is a theoretical problem and one that has not appeared in production.
- If the JVM in which the Metrics Engine is running is not properly configured, then it can be forced to spend a significant length of time performing garbage collection, and in severe cases, could cause significant interruptions in the execution of Java code. In such cases, a stack trace obtained from a `pstack` of the native process should show that most threads are idle but at least one thread performing garbage collection is active. It is also likely that one or a small number of CPUs is 100% busy while all other CPUs are mostly idle. The server will also issue an alert after detecting a long JVM pause (due to garbage collection). The alert will include details of the pause.
- If the JVM in which the Metrics Engine is running has hung for some reason, then the `pstack` utility should show that one or more threads are blocked and unable to make progress. In such cases, the system CPUs should be mostly idle.
- If a network or firewall configuration problem arises, then attempts to communicate with the server cannot be received by the server. In that case, a network sniffer like `snoop` or `tcpdump` should show that packets sent to the system on which the Metrics Engine is running are not receiving TCP acknowledgement.
- If the system on which the Metrics Engine is running has become hung or lost power with a graceful shutdown, then the behavior is often similar to that of a network or firewall configuration problem.

If it appears that the problem is with the Metrics Engine software or the JVM in which it is running, then you need to work with your authorized support provider to fully diagnose the problem and determine the best course of action to correct it.

Problems with the Management Console

If a problem arises when trying to use the Management Console, then potential reasons for the problem may include the following:

- The web application container used to host the console is not running. If an error occurs while trying to start it, then consult the logs for the web application container.
- If a problem occurs while trying to authenticate to the web application container, then make sure that the target Metrics Engine is online. If it is online, then the access log may provide information about the reasons for the authentication failure.
- If a problem occurs while attempting to interact with the Identity Proxy instance using the Management Console, then the access and error logs for that Metrics Engine instance might provide additional information about the underlying problem.

Providing Information for Support Cases

If a problem arises that you are unable to fully diagnose and correct on your own, then contact your authorized support provider for assistance. To ensure that the problem can be addressed as quickly as possible, be sure to provide all of the information that the support personnel may need to fully understand the underlying cause by running the `collect-support-data` tool, and then sending the generated zip file to your authorized support provider. It is good practice to run this tool and send the ZIP file to your authorized support provider before any corrective action has taken place.

