Cisco IoT Field Network Director Installation Guide, Release 4.2.x

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Installing Cisco IoT FND

This chapter provides an overview of the steps required to install Cisco IoT Field Network Director (Cisco IoT FND) in your network.

Note: For an overview of the features and functionality of the application and details on how to configure features and manage the Cisco IoT Field Network Director after its installation, refer to the Cisco IoT Field Network Director User Guide, Release 4.2.x.

How to install IoT FND and related software:

- Before You Install IoT FND
- Installing and Setting Up the IoT FND Database
- Installing and Setting Up IoT FND
- Installing and Configuring the IoT FND TPS Proxy
- Backing Up and Restoring the IoT FND Database
- Deploying IoT FND/Oracle/TPS Virtual Machines on ESX 5.x

Before You Install IoT FND

Use the procedures in the following sections to prepare for your IoT FND installation:

- IoT FND Map View Requirements
- System Requirements
- Obtaining IoT FND and CNR Licenses
- Installing the Linux Packages Required for Installing Oracle
- Obtaining IoT FND RPM Packages
- Configuring NTP Service
- IoT FND Installation Overview

IoT FND Map View Requirements

On any device tab, click the Map button in the main pane to display a GIS map of device locations. In its Map View pane, IoT FND uses a GIS map to display device locations. However, before you can use this feature, you must configure your firewall to enable access for all IoT FND operator systems to Cisco-provided GIS map tile servers. Only IoT FND operator browsers are allowed access to the GIS map tile servers.

Note: The operator browsers will not have access to other Google sites. No Internet access is required for the IoT FND application server.

You must also assign a fully qualified domain name (FQDN) for each IoT FND server installation and provide Cisco at ask-fnd-pm-external@cisco.com with the following:

- The number of IoT FND installation environments (test and production)
- The FQDN of the IoT FND server
- For cluster deployments, the FQDN of any load balancer in the deployment

Note: The FQDN is only used to provision and authorize access to the licensed Cisco IoT FND installation and make API calls to Enterprise Google Map to download the map tiles. No utility operational data or asset information is ever used (that is, sent over Internet) to retrieve Google map tiles. Map tiles are retrieved only using geographic location information.

FQDN INFORMATION EXAMPLE

For example, your non-cluster installation has a domain named UtilityA.com, and cgnms1 as the hostname with an FQDN of cgms1.UtilityA.com. You would email **ask-fnd-pm-external@cisco.com** and include the FQDN, cgms1.UtilityA.com.

In a cluster deployment with one or more IoT FND servers and a load balancer with the FQDN of loadbalancer-vip, which directs traffic to the cgnms-main or cnms-dr cluster (DR installations), you would email **ask-fnd-pm-external@cisco.com** and include the FQDN, loadbalancer-vip.UtilityA.com.

System Requirements

Refer to the IoT FND Release Notes for the latest details on hardware and software requirements, as well as requirements for large scale deployments.

Obtaining IoT FND and CNR Licenses

- Contact your Cisco partner to obtain the necessary licenses to use IoT FND and CNR.
- Obtain a license to use SafeNet as your HSM for mesh endpoint security.

Installing the Linux Packages Required for Installing Oracle

Install these packages in this order before you install the Oracle database:

1. libaio-devel-0.3.106-5.i386.rpm
2. libaio-devel-0.3.106-5.x86_64.rpm
3. sysstat-7.0.2-11.el5.x86_64.rpm
4. unixODBC-libs-2.2.11-10.el5.i386.rpm
5. unixODBC-libs-2.2.11-10.el5.x86_64.rpm
6. unixODBC-2.2.11-10.el5.i386.rpm
7. unixODBC-2.2.11-10.el5.x86_64.rpm
8. unixODBC-devel-2.2.11-10.el5.i386.rpm
9. unixODBC-devel-2.2.11-10.el5.x86_64.rpm

Obtaining IoT FND RPM Packages

Before you install and set up your IoT FND system, ensure that you have the following packages:

RPM Package	Description
cgms-*version_number*.x86_64.rpm	Contains the IoT FND installer. This is the main RPM that contains the IoT FND application server itself. Install this package on the IoT FND application servers.
cgms-oracle-*version_number*.x86_64.rpm	Contains the scripts and tools to create the IoT FND Oracle database. This package contains the Oracle database template and management scripts. Install this package on the IoT FND database server system.
cgms-tools-*version_number*.x86_64.rpm	Contains a few optional command-line tools. If needed, install this package on the system running the IoT FND application server.
cgms-ssm-*version_number*.x86_64.rpm	Contains the Software Security Module (SSM). Install this package on the system running the IoT FND application server.
cgms-tpsproxy-*version_number*.x86_64.rpm	Contains the TPS proxy application. Install this package on the IoT FND TPS proxy system.

Configuring NTP Service

Configure all RHEL servers (including all servers that run IoT FND) in your IoT FND deployment to have their NTP service enabled and configured to use the same time servers as the rest of the system.

Caution: Before certificates are generated, synchronize the clocks of all system components.

To configure NTP on your RHEL servers:

1. Configure the /etc/ntp.conf file.

   For example:

   ```
   cat /etc/ntp.conf
   ...
   # Use the same NTP servers on all our Connected Grid systems.
   server 0.ntp.example.com
   server 1.ntp.example.com
   server 2.ntp.example.com
   ...
   ```

2. Restart the NTP daemon and ensure that it is set to run at boot time.

   ```
   service ntpd restart
   chkconfig ntpd on
   ```

3. Check the configuration changes by checking the status of the NTP daemon.

This example shows that the system at 192.0.2.1 is configured to be a local NTP server. This server synchronizes its time using the NTP server at 10.0.0.0.

```
# ntpq -p
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
*192.0.2.1       198.51.100.1     3 u  309 1024  377    0.694    0.899   0.435
 LOCAL(0)        .LOCL.          10 l   36   64  377    0.000    0.000   0.001
```

For information about configuring NTP on RHEL servers, refer to RHEL documentation.

IoT FND Installation Overview

Complete the following procedures to install IoT FND:

1. Installing and Setting Up the IoT FND Database.
2. Installing and Setting Up IoT FND.
3. Installing and Configuring the IoT FND TPS Proxy.

Installing and Setting Up the IoT FND Database

Complete the following procedures to finish your IoT FND installation:

- Installation and Setup Overview
- Downloading and Unpacking Oracle Database
- Running the Oracle Database Installer
- Setting Up the IoT FND Database
- Additional IoT FND Database Topics

Installation and Setup Overview

The following topics provide an overview of IoT FND deployment:

- Single-Server Deployment
- High Availability Deployment

Single-Server Deployment

To install and set up IoT FND database for a single-server database deployment:

1. Log in to the database server.
2. Downloading and Unpacking Oracle Database.
3. Running the Oracle Database Installer.
4. Setting Up the IoT FND Database.

High Availability Deployment

To install and set up IoT FND database for HA:

1. Log in to the primary IoT FND database server.
2. Downloading and Unpacking Oracle Database.
3. Running the Oracle Database Installer.
4. Log in to the standby database server.
5. Downloading and Unpacking Oracle Database.

6. Running the Oracle Database Installer.
7. Setting Up IoT FND Database for HA.

Downloading and Unpacking Oracle Database

To download the Oracle database:

1. Log in to your server as root.
2. Download Oracle 11g Enterprise Edition (11.2.0.3 64-bit) or Oracle12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production (with Patch 20830993).
3. To avoid display-related errors when installing the Oracle Database software, as root run this command:

```
# xhost + local:oracle
```

4. Create the **oracle** user and **dba** group:

```
# groupadd dba
# adduser -d /home/oracle -g dba -s /bin/bash oracle
```

5. Unpack the Oracle Database zip archives.

```
p10404530_112030_Linux-x86-64_1of7.zip
p10404530_112030_Linux-x86-64_2of7.zip
p10404530_112030_Linux-x86-64_3of7.zip
p10404530_112030_Linux-x86-64_4of7.zip
p10404530_112030_Linux-x86-64_5of7.zip
p10404530_112030_Linux-x86-64_6of7.zip
p10404530_112030_Linux-x86-64_7of7.zip
```

Running the Oracle Database Installer

Note: Before running the Oracle installer, disable the firewall.

To install the Oracle database:

1. Switch to user **oracle** and run the Oracle database installer:

```
# su - oracle
# setenv DISPLAY <desktop>
# path_to_DB_installation_folder/database/runInstaller
```

2. Click **Yes**, and then click **Next**.
3. Click **Install database software only**, and then click **Next**.
4. Click **Single instance database installation**, and then click **Next**.
5. Select **English** as the language in which the database runs, and then click **Next**.
6. Click **Enterprise Edition (4.29GB (Oracle 11g)** or **6.4GB (Oracle12c)**, and then click **Next**.
7. Select the following two default installation values, Oracle Base and Software Location (**11.2.0** or **12.1.0**), and then click **Next**.
   - Oracle Base—**/home/oracle/app/oracle**

- Software Location–**/home/oracle/app/oracle/product/11.2.0/dbhome_1**
- Software Location–**/home/oracle/app/oracle/product/12.1.0/dbhome_1**

Later you will create the environment variables ORACLE_BASE and ORACLE_HOME based on the values of the Oracle Base and Software Location properties.

8. On the **Create Inventory** page, keep the default values, and then click **Next**.

- Inventory Directory–**/home/oracle/app/oraInventory**
- oraInventory_Group Name–**dba**

9. On the **Privileged Operating System Groups** page, keep the default values, and then click **Next**.

- Database Administrator (OSDBA) group–**dba**
- Database Operator (OSOPER) group–**dba**

Database Backup and Recovery (OSBACKUPDBA) group–**dba** (12c only)

- Data Guard administrative (OSDGDBA) group–**dba** (12c only)
- Encryption Key Management administrative (OSKMDBA) group–**dba** (12c only)

10. (optional) On the **Perform Prerequisite Checks** page, install any required software or run supplied scripts.

The installer might require the installation of additional software based on your system kernel settings, and may also instruct you to run scripts to configure your system and complete the database installation.

Note: If no missing packages are noted or you see the message “This is a prerequisite condition to test whether the package “ksh” is available on the system, check the **Ignore All** box.

11. After installing any missing packages, click **Fix & Check Again**.

Keep doing this until all requirements are met.

Caution: Do not ignore errors on this page. If there are errors during database installation, IoT FND may not function properly.

12. Click **Next**.

13. On the **Summary** page, verify the database settings, and then click **Finish** (11g) or **Install** (12c) to start the installation process.

14. At the prompts, run the supplied configuration scripts.

Because the installer runs as the user *oracle*, it cannot perform certain installation operations that require root privileges. For these operations, you will be prompted to run scripts to complete the installation process. When prompted, open a terminal window and run the scripts as root.

15. If the installation succeeds, click **Close** on the **Finish** page.

Note: If performing a new installation of Oracle 12c or upgrading from Oracle 11g, you **must** install the Oracle 12c Patch 20830993. Go to (Mandatory) Installing 12c Patch.

(Mandatory) Installing 12c Patch

For all new Oracle 12c database installations and all Oracle 11g upgrades, you must install the 12c patch.

To install the patch:

1. Stop IoT FND application if running.
2. Stop Oracle service if running.
3. Run the following commands to verify inventory of installed Oracle software components and patches. No patches are applied at this stage. The following displays at the end: *There are no interim patches installed in this Oracle Home*.

```
/home/oracle/app/oracle/product/12.1.0/dbhome_1/OPatch/opatch lsinventory -details

Oracle Interim Patch Installer version 12.1.0.1.3
Copyright (c) 2016, Oracle Corporation.  All rights reserved.

Oracle Home       : /home/oracle/app/oracle/product/12.1.0/dbhome_1
Central Inventory : /home/oracle/app/oraInventory   from           :
/home/oracle/app/oracle/product/12.1.0/dbhome_1/oraInst.loc
OPatch version    : 12.1.0.1.3
OUI version       : 12.1.0.2.0
Log file location
:/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/opatch2016-02-25_10-37-50AM_1.log

Lsinventory Output file location :
/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/lsinv/lsinventory2016-02-25_10-37-50
AM.txt
--------------------------------------------------------------------------------

Installed Top-level Products (1):
Oracle Database 12c                                                  12.1.0.2.0
There are 1 products installed in this Oracle Home.
Installed Products (135):
Assistant Common Files                                               12.1.0.2.0
Buildtools Common Files                                              12.1.0.2.0
Cluster Verification Utility Common Files                            12.1.0.2.0
Database Configuration and Upgrade Assistants                        12.1.0.2.0
Database Migration Assistant for Unicode                             12.1.0.2.0
Database SQL Scripts                                                 12.1.0.2.0
Database Workspace Manager                                           12.1.0.2.0
DB TOOLS Listener                                                    12.1.0.2.0
Deinstallation Tool                                                  12.1.0.2.0
Enterprise Edition Options                                           12.1.0.2.0
Expat libraries                                                       2.0.1.0.2
Generic Connectivity Common Files                                    12.1.0.2.0
Hadoopcore Component                                                 12.1.0.2.0
HAS Common Files                                                     12.1.0.2.0
HAS Files for DB                                                     12.1.0.2.0
Installation Common Files                                            12.1.0.2.0
Installation Plugin Files                                            12.1.0.2.0
Installer SDK Component                                              12.1.0.2.0J
Accelerator (COMPANION)                                              12.1.0.2.0
Java Development Kit                                                 1.6.0.75.0
LDAP Required Support Files                                          12.1.0.2.0
OLAP SQL Scripts                                                     12.1.0.2.0
Oracle Advanced Security                                             12.1.0.2.0
Oracle Application Express                                           12.1.0.2.0
Oracle Bali Share                                                    11.1.1.6.0
Oracle Call Interface (OCI)                                          12.1.0.2.0
Oracle Clusterware RDBMS Files                                       12.1.0.2.0
Oracle Configuration Manager                                         10.3.8.1.1
Oracle Configuration Manager Client                                  10.3.2.1.0
Oracle Configuration Manager Deconfiguration                         10.3.1.0.0
Oracle Containers for Java                                           12.1.0.2.0
Oracle Context Companion                                             12.1.0.2.0
Oracle Core Required Support Files                                   12.1.0.2.0
Oracle Core Required Support Files for Core DB                       12.1.0.2.0
Oracle Core XML Development Kit                                      12.1.0.2.0
Oracle Data Mining RDBMS Files                                       12.1.0.2.0
Oracle Database 12c                                                  12.1.0.2.0
Oracle Database 12c                                                  12.1.0.2.0
Oracle Database 12c Multimedia Files                                 12.1.0.2.0
Oracle Database Deconfiguration                                      12.1.0.2.0
Oracle Database Gateway for ODBC                                     12.1.0.2.0
Oracle Database Plugin for Oracle Virtual Assembly Builder           12.1.0.2.0
Oracle Database User Interface                                       11.0.0.0.0
Oracle Database Utilities                                            12.1.0.2.0
Oracle Database Vault option                                         12.1.0.2.0
Oracle DBCA Deconfiguration                                          12.1.0.2.0
Oracle Extended Windowing Toolkit                                    11.1.1.6.0
Oracle Globalization Support                                         12.1.0.2.0
Oracle Globalization Support                                         12.1.0.2.0
Oracle Globalization Support For Core                                12.1.0.2.0
Oracle Help for Java                                                 11.1.1.7.0
Oracle Help Share Library                                            11.1.1.7.0
Oracle Ice Browser                                                   11.1.1.7.0
Oracle Internet Directory Client                                     12.1.0.2.0
Oracle Java Client                                                   12.1.0.2.0
Oracle Java Layout Engine                                            11.0.0.0.0
Oracle JDBC Server Support Package                                   12.1.0.2.0
Oracle JDBC/OCI Instant Client                                       12.1.0.2.0
Oracle JDBC/THIN Interfaces                                          12.1.0.2.0
Oracle JFC Extended Windowing Toolkit                                11.1.1.6.0
Oracle JVM                                                           12.1.0.2.0
Oracle JVM For Core                                                  12.1.0.2.0
Oracle Label Security                                                12.1.0.2.0
Oracle LDAP administration                                           12.1.0.2.0
Oracle Locale Builder                                                12.1.0.2.0
Oracle Message Gateway Common Files                                  12.1.0.2.0
Oracle Multimedia                                                    12.1.0.2.0
Oracle Multimedia Client Option                                      12.1.0.2.0
Oracle Multimedia Java Advanced Imaging                              12.1.0.2.0
Oracle Multimedia Locator                                            12.1.0.2.0
Oracle Multimedia Locator Java Required Support Files                12.1.0.2.0
Oracle Multimedia Locator RDBMS Files                                12.1.0.2.0
Oracle Net                                                           12.1.0.2.0
Oracle Net Java Required Support Files                               12.1.0.2.0
Oracle Net Listener                                                  12.1.0.2.0
Oracle Net Required Support Files                                    12.1.0.2.0
Oracle Net Services                                                  12.1.0.2.0
Oracle Netca Client                                                  12.1.0.2.0
Oracle Notification Service                                          12.1.0.2.0
Oracle Notification Service (eONS)                                   12.1.0.2.0
Oracle Notification Service for Instant Client                       12.1.0.2.0
Oracle ODBC Driver                                                   12.1.0.2.0
Oracle ODBC Driverfor Instant Client                                 12.1.0.2.0
Oracle OLAP                                                          12.1.0.2.0
Oracle OLAP API                                                      12.1.0.2.0
Oracle OLAP RDBMS Files                                              12.1.0.2.0
Oracle One-Off Patch Installer                                       12.1.0.1.2
Oracle Partitioning                                                  12.1.0.2.0
Oracle Programmer                                                    12.1.0.2.0
Oracle Quality of Service Management (Client)                        12.1.0.2.0
Oracle R Enterprise Server Files                                     12.1.0.2.0
Oracle RAC Deconfiguration                                           12.1.0.2.0
Oracle RAC Required Support Files-HAS                                12.1.0.2.0
Oracle Real Application Testing                                      12.1.0.2.0
Oracle Recovery Manager                                              12.1.0.2.0
Oracle Security Developer Tools                                      12.1.0.2.0
Oracle Spatial and Graph                                             12.1.0.2.0
Oracle SQL Developer                                                 12.1.0.2.0
Oracle Starter Database                                              12.1.0.2.0
Oracle Text                                                          12.1.0.2.0
Oracle Text ATG Language Support Files                               12.1.0.2.0
Oracle Text for Core                                                 12.1.0.2.0
Oracle Text Required Support Files                                   12.1.0.2.0
Oracle Universal Connection Pool                                     12.1.0.2.0
Oracle Universal Installer                                           12.1.0.2.0
Oracle USM Deconfiguration                                           12.1.0.2.0
Oracle Wallet Manager                                                12.1.0.2.0
Oracle XML Development Kit                                           12.1.0.2.0
Oracle XML Query                                                     12.1.0.2.0
oracle.swd.oui.core.min                                              12.1.0.2.0
Parser Generator Required Support Files                              12.1.0.2.0
Perl Interpreter                                                     5.14.1.0.0
Perl Modules                                                         5.14.1.0.0
PL/SQL                                                               12.1.0.2.0
PL/SQL Embedded Gateway                                              12.1.0.2.0
Platform Required Support Files                                      12.1.0.2.0
Precompiler Common Files                                             12.1.0.2.0
Precompiler Common Files for Core                                    12.1.0.2.0
Precompiler Required Support Files                                   12.1.0.2.0
Precompilers                                                         12.1.0.2.0
RDBMS Required Support Files                                         12.1.0.2.0
RDBMS Required Support Files for Instant Client                      12.1.0.2.0
RDBMS Required Support Files Runtime                                 12.1.0.2.0
Required Support Files                                               12.1.0.2.0
Sample Schema Data                                                   12.1.0.2.0
Secure Socket Layer                                                  12.1.0.2.0
SQL*Plus                                                             12.1.0.2.0
SQL*Plus Files for Instant Client                                    12.1.0.2.0
SQL*Plus Required Support Files                                      12.1.0.2.0
SQLJ Runtime                                                         12.1.0.2.0
SSL Required Support Files for InstantClient                         12.1.0.2.0
Tracle File Analyzer                                                 12.1.0.2.0
XDK Required Support Files                                           12.1.0.2.0
XML Parser for Java                                                  12.1.0.2.0
XML Parser for Oracle JVM                                            12.1.0.2.0
There are 135 products installed in this Oracle Home.

There are no Interim patches installed in this Oracle Home.
_______________________________________________________________________________
```

4. Apply the patch.

   a. On the database machine. Copy the patch file: `“p20830993_121020_Linux-x86-64.zip”`

   b. Run a prerequisite check. It should pass.

```
$ cd /home/oracle/patches/20830993/
$ /home/oracle/app/oracle/product/12.1.0/dbhome_1/OPatch/opatch prereq
CheckConflictAgainstOHWithDetail -ph ./
Oracle Interim Patch Installer version 12.1.0.1.3
Copyright (c) 2016, Oracle Corporation.  All rights reserved.

PREREQ session

Oracle Home       : /home/oracle/app/oracle/product/12.1.0/dbhome_1
Central Inventory : /home/oracle/app/oraInventory
   from           : /home/oracle/app/oracle/product/12.1.0/dbhome_1/oraInst.loc
OPatch version    : 12.1.0.1.3
OUI version       : 12.1.0.2.0
```

```
Log file location :/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtool
logs/opatch/opatch2016-02-25_10-48-48AM_1.log

Invoking prereq "checkconflictagainstohwithdetail"

Prereq "checkConflictAgainstOHWithDetail" passed.

OPatch succeeded.
```

c. Apply the patch.

```
$ /home/oracle/app/oracle/product/12.1.0/dbhome_1/OPatch/opatch apply
Oracle Interim Patch Installer version 12.1.0.1.3
Copyright (c) 2016, Oracle Corporation.  All rights reserved.

Oracle Home       : /home/oracle/app/oracle/product/12.1.0/dbhome_1
Central Inventory : /home/oracle/app/oraInventory   from           :
/home/oracle/app/oracle/product/12.1.0/dbhome_1/oraInst.loc
OPatch version    : 12.1.0.1.3
OUI version       : 12.1.0.2.0
Log file location:
/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/20830993_Feb_25_2016_10_53_25/ap
ply2016-02-25_10-53-25AM_1.log

Applying interim patch '20830993' to OH '/home/oracle/app/oracle/product/12.1.0/dbhome_1'
Verifying environment and performing prerequisite checks...
All checks passed.

Please shutdown Oracle instances running out of this ORACLE_HOME on the local system.
(Oracle Home = '/home/oracle/app/oracle/product/12.1.0/dbhome_1')

Is the local system ready for patching? [y|n]
y
User Responded with: Y
Backing up files...

Patching component oracle.rdbms, 12.1.0.2.0...

Verifying the update...
Patch 20830993 successfully applied
Log file location:/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/
20830993_Feb_25_2016_10_53_25/apply2016-02-25_10-53-25AM_1.log

OPatch succeeded.
```

d. Run Opatch utility to verify that the patch is now recognized. Notice the mention of " Interim Patch" at the end of following output.

```
$ /home/oracle/app/oracle/product/12.1.0/dbhome_1/OPatch/opatch lsinventory -details
Oracle Interim Patch Installer version 12.1.0.1.3
Copyright (c) 2016, Oracle Corporation.  All rights reserved.

Oracle Home       : /home/oracle/app/oracle/product/12.1.0/dbhome_1
Central Inventory : /home/oracle/app/oraInventory
   from           : /home/oracle/app/oracle/product/12.1.0/dbhome_1/oraInst.loc
OPatch version    : 12.1.0.1.3
OUI version       : 12.1.0.2.0
Log file location :
/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/opatch2016-02-25_11-05-19AM_1.lo
g
Lsinventory Output file location :
/home/oracle/app/oracle/product/12.1.0/dbhome_1/cfgtoollogs/opatch/lsinv/lsinventory2016-02-25_11-0
5-19AM.txt
```

```
--------------------------------------------------------------------------------
Installed Top-level Products (1):
Oracle Database 12c                                                  12.1.0.2.0
There are 1 products installed in this Oracle Home.

Installed Products (135):

Assistant Common Files                                               12.1.0.2.0
Buildtools Common Files                                              12.1.0.2.0
Cluster Verification Utility Common Files                            12.1.0.2.0
Database Configuration and Upgrade Assistants                        12.1.0.2.0
Database Migration Assistant for Unicode                             12.1.0.2.0
Database SQL Scripts                                                 12.1.0.2.0
Database Workspace Manager                                           12.1.0.2.0
DB TOOLS Listener                                                    12.1.0.2.0
Deinstallation Tool                                                  12.1.0.2.0
Enterprise Edition Options                                           12.1.0.2.0
Expat libraries                                                       2.0.1.0.2
Generic Connectivity Common Files                                    12.1.0.2.0
Hadoopcore Component                                                 12.1.0.2.0
HAS Common Files                                                     12.1.0.2.0
HAS Files for DB                                                     12.1.0.2.0
Installation Common Files                                            12.1.0.2.0
Installation Plugin Files                                            12.1.0.2.0
Installer SDK Component                                              12.1.0.2.0
JAccelerator (COMPANION)                                             12.1.0.2.0
Java Development Kit                                                 1.6.0.75.0
LDAP Required Support Files                                          12.1.0.2.0
LAP SQL Scripts                                                      12.1.0.2.0
Oracle Advanced Security                                             12.1.0.2.0
Oracle Application Express                                           12.1.0.2.0
Oracle Bali Share                                                    11.1.1.6.0
Oracle Call Interface (OCI)                                          12.1.0.2.0
Oracle Clusterware RDBMS Files                                       12.1.0.2.0
Oracle Configuration Manager                                         10.3.8.1.1
Oracle Configuration Manager Client                                  10.3.2.1.0
Oracle Configuration Manager Deconfiguration                         10.3.1.0.0
Oracle Containers for Java                                           12.1.0.2.0
Oracle Context Companion                                             12.1.0.2.0
Oracle Core Required Support Files                                   12.1.0.2.0
Oracle Core Required Support Files for Core DB                       12.1.0.2.0
Oracle Core XML Development Kit                                      12.1.0.2.0
Oracle Data Mining RDBMS Files                                       12.1.0.2.0
Oracle Database 12c                                                  12.1.0.2.0
Oracle Database 12c                                                  12.1.0.2.0
Oracle Database 12c Multimedia Files                                 12.1.0.2.0
Oracle Database Deconfiguration                                      12.1.0.2.0
Oracle Database Gateway for ODBC                                     12.1.0.2.0
Oracle Database Plugin for Oracle Virtual Assembly Builder           12.1.0.2.0
Oracle Database User Interface                                       11.0.0.0.0
Oracle Database Utilities                                            12.1.0.2.0
Oracle Database Vault option                                         12.1.0.2.0
Oracle DBCA Deconfiguration                                          12.1.0.2.0
Oracle Extended Windowing Toolkit                                    11.1.1.6.0
Oracle Globalization Support                                         12.1.0.2.0
Oracle Globalization Support                                         12.1.0.2.0
Oracle Globalization Support For Core                                12.1.0.2.0
Oracle Help for Java                                                 11.1.1.7.0
Oracle Help Share Library                                            11.1.1.7.0
Oracle Ice Browser                                                   11.1.1.7.0
Oracle Internet Directory Client                                     12.1.0.2.0
Oracle Java Client                                                   12.1.0.2.0
Oracle Java Layout Engine                                            11.0.0.0.0
Oracle JDBC Server Support Package                                   12.1.0.2.0
Oracle JDBC/OCI Instant Client                                       12.1.0.2.0
Oracle JDBC/THIN Interfaces                                          12.1.0.2.0
Oracle JFC Extended Windowing Toolkit                                11.1.1.6.0
Oracle JVM                                                           12.1.0.2.0
Oracle JVM For Core                                                  12.1.0.2.0
Oracle Label Security                                                12.1.0.2.0
Oracle LDAP administration                                           12.1.0.2.0
Oracle Locale Builder                                                12.1.0.2.0
Oracle Message Gateway Common Files                                  12.1.0.2.0
Oracle Multimedia                                                    12.1.0.2.0
Oracle Multimedia Client Option                                      12.1.0.2.0
Oracle Multimedia Java Advanced Imaging                              12.1.0.2.0
Oracle Multimedia Locator                                            12.1.0.2.0
Oracle Multimedia Locator Java Required Support Files                12.1.0.2.0
Oracle Multimedia Locator RDBMS Files                                12.1.0.2.0
Oracle Net                                                           12.1.0.2.0
Oracle Net Java Required Support Files                               12.1.0.2.0
Oracle Net Listener                                                  12.1.0.2.0
Oracle Net Required Support Files                                    12.1.0.2.0
Oracle Net Services                                                  12.1.0.2.0
Oracle Netca Client                                                  12.1.0.2.0
Oracle Notification Service                                          12.1.0.2.0
Oracle Notification Service (eONS)                                   12.1.0.2.0
Oracle Notification Service for Instant Client                       12.1.0.2.0
Oracle ODBC Driver                                                   12.1.0.2.0
Oracle ODBC Driverfor Instant Client                                 12.1.0.2.0
Oracle OLAP                                                          12.1.0.2.0
Oracle OLAP API                                                      12.1.0.2.0
Oracle OLAP RDBMS Files                                              12.1.0.2.0
Oracle One-Off Patch Installer                                       12.1.0.1.2
Oracle Partitioning                                                  12.1.0.2.0
Oracle Programmer                                                    12.1.0.2.0
Oracle Quality of Service Management (Client)                        12.1.0.2.0
Oracle R Enterprise Server Files                                     12.1.0.2.0
Oracle RAC Deconfiguration                                           12.1.0.2.0
Oracle RAC Required Support Files-HAS                                12.1.0.2.0
Oracle Real Application Testing                                      12.1.0.2.0
Oracle Recovery Manager                                              12.1.0.2.0
Oracle Security Developer Tools                                      12.1.0.2.0
Oracle Spatial and Graph                                             12.1.0.2.0
Oracle SQL Developer                                                 12.1.0.2.0
Oracle Starter Database                                              12.1.0.2.0
Oracle Text                                                          12.1.0.2.0
Oracle Text ATG Language Support Files                               12.1.0.2.0
Oracle Text for Core                                                 12.1.0.2.0
Oracle Text Required Support Files                                   12.1.0.2.0
Oracle Universal Connection Pool                                     12.1.0.2.0
Oracle Universal Installer                                           12.1.0.2.0
Oracle USM Deconfiguration                                           12.1.0.2.0
Oracle Wallet Manager                                                12.1.0.2.0
Oracle XML Development Kit                                           12.1.0.2.0
Oracle XML Query                                                     12.1.0.2.0
oracle.swd.oui.core.min                                              12.1.0.2.0
Parser Generator Required Support Files                              12.1.0.2.0
Perl Interpreter                                                     5.14.1.0.0
Perl Modules                                                         5.14.1.0.0
PL/SQL                                                               12.1.0.2.0
PL/SQL Embedded Gateway                                              12.1.0.2.0
Platform Required Support Files                                      12.1.0.2.0
Precompiler Common Files                                             12.1.0.2.0
Precompiler Common Files for Core                                    12.1.0.2.0
Precompiler Required Support Files                                   12.1.0.2.0
Precompilers                                                         12.1.0.2.0
RDBMS Required Support Files                                         12.1.0.2.0
RDBMS Required Support Files for Instant Client                      12.1.0.2.0
RDBMS Required Support Files Runtime                                 12.1.0.2.0
Required Support Files                                               12.1.0.2.0
Sample Schema Data                                                   12.1.0.2.0
Secure Socket Layer                                                  12.1.0.2.0
SQL*Plus                                                             12.1.0.2.0
SQL*Plus Files for Instant Client                                    12.1.0.2.0
SQL*Plus Required Support Files                                      12.1.0.2.0
SQLJ Runtime                                                         12.1.0.2.0
SSL Required Support Files for InstantClient                         12.1.0.2.0
Tracle File Analyzer                                                 12.1.0.2.0
XDK Required Support Files                                           12.1.0.2.0
XML Parser for Java                                                  12.1.0.2.0
XML Parser for Oracle JVM                                            12.1.0.2.0
There are 135 products installed in this Oracle Home.

Interim patches (1) :

Patch  20830993     : applied on Thu Feb 25 10:53:50 PST 2016
Unique Patch ID:  18912657
Created on 13 May 2015, 00:37:38 hrs PST8PDT
   Bugs fixed:     20830993
Files Touched:
 /qksvc.o --> ORACLE_HOME/lib/libserver12.a
 ins_rdbms.mk --> ORACLE_HOME/rdbms/lib/ioracle
Patch Location in Inventory:
 /home/oracle/app/oracle/product/12.1.0/dbhome_1/inventory/oneoffs/20830993
Patch Location in Storage area:
 /home/oracle/app/oracle/product/12.1.0/dbhome_1/.patch_storage/20830993_May_13_2015_00_37_38
--------------------------------------------------------------------------------
```

Process complete.

Continue to Setting Up the IoT FND Database

Setting Up the IoT FND Database

Complete the following procedures to set up the IoT FND database:

- IoT FND Database Setup Overview
- Defining Oracle Database Environment Variables
- Installing IoT FND Oracle Database Scripts
- Creating the IoT FND Oracle Database
- Starting the IoT FND Oracle Database

IoT FND Database Setup Overview

To set up the IoT FND database:

1. Defining Oracle Database Environment Variables.
2. Installing IoT FND Oracle Database Scripts.
3. Creating the IoT FND Oracle Database.
4. Starting the IoT FND Oracle Database.

Defining Oracle Database Environment Variables

Before installing the IoT FND Oracle database, switch to the **oracle** user account and define the following Oracle database environment variables.

Table 1 Oracle Database Environment Variables

Variable	Description
ORACLE_BASE	Defines the path to the Oracle root directory on your system. For example: `$ export ORACLE_BASE=/home/oracle/app/oracle` If this variable is not set, the IoT FND setup script displays an error.
ORACLE_HOME	Defines the path to the Oracle home of the IoT FND database. For example: `$ export ORACLE_HOME=/home/oracle/app/oracle/product/11.2.0/dbhome_1` **Note:** Do not have any trailing backslashes in the ORACLE_HOME environment variable.
PATH	Defines the path to the Oracle binaries. For example: `$ export PATH=$PATH:$ORACLE_HOME/bin`
LD_LIBRARY_PATH	Defines the path to the libraries. For example: `$ export LD_LIBRARY_PATH=$ORACLE_HOME/lib:$LD_LIBRARY_PATH`

ORACLE_SID	Defines the Oracle System ID (SID).
	If you are only using one database server or installing an HA deployment, set this variable on the *primary* database server to **cgms**:
	`$ export ORACLE_SID=cgms`
	If deploying a standby database server, set this variable on the *standby* database server to **cgms_s**:
	`$ export ORACLE_SID=cgms_s`
	If this variable is not set, the IoT FND setup script displays an error.

You can set these variables manually, as shown in the following example:

On a Single or Primary Database Server	On a Standby Database Server

`$` **`su - oracle`**
`$ export ORACLE_BASE=/home/oracle/app/oracle`
`$ export ORACLE_HOME=/home/oracle/app/oracle/product/11.2.0/dbhome_1`
`$ export PATH=$PATH:$ORACLE_HOME/bin`
`$ export LD_LIBRARY_PATH=$ORACLE_HOME/lib:$LD_LIBRARY_PATH`
`$ export ORACLE_SID=cgms`
	`$` **`su - oracle`**
	`$ export ORACLE_BASE=/home/oracle/app/oracle`
	`$ export ORACLE_HOME=/home/oracle/app/oracle/product/11.2.0/dbhome_1`
	`$ export PATH=$PATH:$ORACLE_HOME/bin`
	`$ export LD_LIBRARY_PATH=$ORACLE_HOME/lib:$LD_LIBRARY_PATH`
	`$ export ORACLE_SID=cgms_s`

You can also use a .bashrc file to define these variables.

Installing IoT FND Oracle Database Scripts

IoT FND is packaged with scripts and Oracle database templates.

To install the Oracle scripts on your Oracle server:

1. Log in as the root user.
2. Securely copy the IoT FND Oracle script RPM to your Oracle server:

```
$ scp cgms-oracle-version_number.x86_64.rpm root@oracle-machine:~
$ rpm -ivh cgms-oracle-version_number.x86_64.rpm
```

3. Create the cgms directory and download the scripts and templates to it:

```
$ cd $ORACLE_BASE/app/oracle
$ mkdir cgms
$ cd cgms
$ cp -R /opt/cgms-oracle/scripts .
$ cp -R /opt/cgms-oracle/templates .
$ cp -R /opt/cgms-oracle/tools .
$ cd ..
$ chown -R oracle:dba cgms
```

Creating the IoT FND Oracle Database

To create the IoT FND Oracle database in a single-database-server deployment, run the setupCgmsDb.sh script as the user *oracle*. This script starts the Oracle Database and creates the IoT FND database.

This script creates the user **cgms_dev** used by IoT FND to access the database. The default password for this user account is **cgms123**.

The default password for the sys DBA account is **cgmsDba123**.

Note: We strongly recommend that you change all default passwords. Do not use special characters such as, @, #, !, or + when using the encryption_util.sh script. The script cannot encrypt special characters.

Note: This script might run for several minutes. To check the setup progress, run the command:

```
$ tail -f /tmp/cgmsdb_setup.log
```

```
$ su - oracle
$ export DISPLAY=localhost:0
$ cd $ORACLE_BASE/cgms/scripts
$ ./setupCgmsDb.sh
09-13-2012 10:38:07 PDT: INFO: ======== CGMS Database Setup Started ==========
09-13-2012 10:38:07 PDT: INFO: Log file: /tmp/cgmsdb_setup.log

Are you sure you want to setup CG-NMS database (y/n)? y

09-13-2012 10:38:08 PDT: INFO: User response: y
09-13-2012 10:38:08 PDT: INFO: CGMS database does not exist.
Enter new password for SYS DBA:
Re-enter new password for SYS DBA:
09-13-2012 10:38:14 PDT: INFO: User entered SYS DBA password.

Enter new password for CG-NMS database:
Re-enter new password CG-NMS database:
09-13-2012 10:38:18 PDT: INFO: User entered CG-NMS DB password.
09-13-2012 10:38:18 PDT: INFO: Stopping listener ...
09-13-2012 10:38:18 PDT: INFO: Listener already stopped.
09-13-2012 10:38:18 PDT: INFO: Deleting database files ...
09-13-2012 10:38:18 PDT: INFO: Creating listener ...
09-13-2012 10:38:19 PDT: INFO: Listener creation completed successfully.
09-13-2012 10:38:19 PDT: INFO: Configuring listener ...
09-13-2012 10:38:19 PDT: INFO: Listener successfully configured.
```

```
09-13-2012 10:38:19 PDT: INFO: Creating database. This may take a while. Please be patient ...
09-13-2012 10:42:55 PDT: INFO: Database creation completed successfully.
09-13-2012 10:42:55 PDT: INFO: Updating /etc/oratab ...
09-13-2012 10:42:55 PDT: INFO: /etc/oratab updated.
09-13-2012 10:42:55 PDT: INFO: Configuring database ...
09-13-2012 10:42:56 PDT: INFO: Starting listener ...
09-13-2012 10:42:56 PDT: INFO: Listener start completed successfully.
09-13-2012 10:42:56 PDT: INFO: Starting database configuration ...
09-13-2012 10:43:17 PDT: INFO: Database configuration completed successfully.
09-13-2012 10:43:17 PDT: INFO: Starting Oracle ...
09-13-2012 10:43:17 PDT: INFO: Starting Oracle in mount state ...
ORACLE instance started.

Total System Global Area 1.6836E+10 bytes
Fixed Size    2220032 bytes
Variable Size 8589934592 bytes
Database Buffers 8187281408 bytes
Redo Buffers   56487936 bytes
Database mounted.
09-13-2012 10:43:26 PDT: INFO: Opening database for read/write ...

Database altered.

09-13-2012 10:43:29 PDT: INFO: ========== CGMS Database Setup Completed Successfully ==========
```

Starting the IoT FND Oracle Database

To start the IoT FND Oracle database:

1. Run the script:

```
$ su - oracle
$ cd $ORACLE_BASE/cgms/scripts
$ ./startOracle.sh
```

2. Configure a cron job that starts IoT FND database at bootup by running this script:

```
./installOracleJob.sh
```

Additional IoT FND Database Topics

The following procedures discuss database management:

- Stopping the IoT FND Oracle Database
- Removing the IoT FND Database
- Changing the SYS DBA and IoT FND Database Passwords
- Changing the SYS DBA and IoT FND Database Passwords
- IoT FND Database Helper Scripts

Stopping the IoT FND Oracle Database

Typically, you do not have to stop the Oracle database during the installation procedure. However, if it becomes necessary to stop the Oracle database, use the stop script in the scripts directory:

```
su - oracle
cd $ORACLE_BASE/cgms/scripts
./stopOracle.sh
```

```
...
SQL> Database closed.
Database dismounted.
ORACLE instance shut down.
...
```

Removing the IoT FND Database

Caution: The following script is destructive. Do not use this script during normal operation.

To remove the IoT FND database, run this script:

```
cd $ORACLE_BASE/cgms/scripts
./deleteCgmsDb.sh
```

Changing the SYS DBA and IoT FND Database Passwords

To change default IoT FND database password for the cgms_dba user:

1. On the IoT FND server, run the setupCgms.sh script and change the password for the cgms_dba user.

   Caution: The password for the IoT FND database and the cgnms_dba user password must match or IoT FND cannot access the database.

```
# cd /opt/cgms/bin
# ./setupCgms.sh
...
Do you want to change the database password (y/n)? y
09-13-2012 17:15:07 PDT: INFO: User response: y
Enter database password:
Re-enter database password:
09-13-2012 17:15:31 PDT: INFO: Configuring database password. This may take a while. Please wait
...
09-13-2012 17:15:34 PDT: INFO: Database password configured.
...
```

For information about running the setupCgms.sh script, see Setting Up IoT FND.

2. On the Oracle server, run the change_password.sh script and change the password for the cgms_dba user:

```
$ ./change_password.sh
09-13-2012 10:48:32 PDT: INFO: ======== Database Password Util Started ==========
09-13-2012 10:48:32 PDT: INFO: Log file: /tmp/cgms_oracle.log

Are you sure you want to change CG-NMS database password (y/n)? y
09-13-2012 10:48:33 PDT: INFO: User response: y

Enter current password for SYS DBA:
Re-enter current password for SYS DBA:
09-13-2012 10:48:41 PDT: INFO: User entered current SYS DBA password.
Enter new password for SYS DBA:
Re-enter new password for SYS DBA:
09-13-2012 10:48:54 PDT: INFO: User entered SYS DBA password.

Enter new password for CG-NMS database:
Re-enter new password CG-NMS database:
09-13-2012 10:49:03 PDT: INFO: User entered CG-NMS DB password.
User altered.
...
```

   Note: As root, you can also use this script to change the password for the sys user (SYS DBA).

3. On the IoT FND server, run the cgms_status.sh script to verify the connection between IoT FND and the IoT FND database:

```
# service cgms status
09-06-2012 18:51:20 PDT: INFO: CG-NMS database server: localhost
09-06-2012 18:51:21 PDT: INFO: CG-NMS database connection verified.
```

IoT FND Database Helper Scripts

Table 2 describes helper IoT FND database scripts available in the $ORACLE_BASE/cgms/scripts/ directory:

Table 2 IoT FND Database Helper Scripts

Script	Description
change_password.sh	Use this script to change the passwords for the database administration and IoT FND database user accounts. The IoT FND database user account is used by IoT FND to access the database.
backup_archive_log.sh	Use this script to back up the archive logs.
backupCgmsDb.sh	Use this script to back up the IoT FND database. This script supports full and incremental backups.
restoreCgmsDb.sh	Use this script to restore the IoT FND database from a backup.
setupCgmsDb.sh	Use this script to set up IoT FND database.
startOracle.sh	Use this script to start the IoT FND database.
stopOracle.sh	Use this script to stop the IoT FND database.
setupStandbyDb.sh	(IoT FND database HA installations only) Use this script to set up the standby database server.
setupHaForPrimary.sh	(IoT FND database HA installations only) Use this script to set up the primary database server.
getHaStatus.sh	Run this script to verify that the database is set up for HA.

Installing and Setting Up the SSM

The Software Security Module (SSM) is a low-cost alternative to a Hardware Security Module (HSM). IoT FND uses the CSMP protocol to communicate with meters, DA Gateway (IR500 devices), and range extenders. SSM uses CiscoJ to provide cryptographic services such as signing and verifying CSMP messages, and CSMP Keystore management. SSM ensures Federal Information Processing Standards (FIPS) compliance, while providing services. You install SSM on the IoT FND application server or other remote server. SSM remote-machine installations use HTTPS to securely communicate with IoT FND.

This section describes SSM installation and set up, including:

- Installing or Upgrading the SSM Server
- Uninstalling the SSM Server
- Integrating SSM and IoT FND

With the SSM server installed, configured, and started and with IoT FND configured for SSM, you can view the CSMP certificate on **Admin > Certificates > Certificate for CSMP**.

Note: See Setting Up an HSM Client for information on the Hardware Security Module (HSM).

BEFORE YOU BEGIN

Ensure that the installation meets the hardware and software requirements listed in the IoT FND Release Notes.

Installing or Upgrading the SSM Server

To install the SSM server:

1. Run the cgms-ssm-<version>-<release>.<architecture>.rpm rpm script:

   ```
   [root@VMNMS demossm]# rpm -Uvh cgms-ssm-<version>.x86_64.rpm
   Preparing...                ########################################### [100%]
      1:cgms-ssm               ########################################### [100%]
   ```

2. Get the IoT FND configuration details for the SSM. SSM ships with following default credentials:

   - ssm_csmp_keystore password: **ciscossm**
   - csmp alias name: **ssm_csmp**
   - key password: **ciscossm**
   - ssm_web_keystore password: **ssmweb**

   ```
   [root@VMNMS demossm]# cd /opt/cgms-ssm/bin/
   [root@VMNMS bin]# ./ssm_setup.sh

   Software Security Module Server
   1. Generate a new keyalias with self signed certificate for CSMP
   2. Generate a new keypair & certificate signing request for CSMP
   3. Import a trusted certificate
   4. Change CSMP keystore password
   5. Print CG-NMS configuration for SSM
   6. Change SSM server port
   7. Change SSM-Web keystore password
   Select available options.Press any other key to exit
   Enter your choice :
   ```

3. Enter 5 at the prompt, and complete the following when prompted:

   ```
   Enter current ssm_csmp_keystore password :ciscossm
   Enter alias name : ssm_csmp
   Enter key password :ciscossm

   security-module=ssm
   ssm-host=<Replace with IPv4 address of SSM server>
   ssm-port=8445
   ssm-keystore-alias=ssm_csmp
   ssm-keystore-password=NQ1/zokip4gtUeUyQnUuNw==
   ssm-key-password=NQ1/zokip4gtUeUyQnUuNw==
   ```

4. To connect to this SSM server, copy paste the output from 3. into the cgms.properties file.

   Note: You must include the IPv4 address of the interface for IoT FND to use to connect to the SSM server.

5. (Optional) Run the ssm_setup.sh script to:

   - Generate a new key alias with self-signed certificate for CSMP
   - Change SSM keystore password
   - Change SSM server port
   - Change SSM-Web keystore password

Note: If you perform any of the above operations, you must run the SSM setup script, select “Print CG-NMS configuration for SSM,” and copy and paste all details into the cgms.properties file.

6. Start the SSM server:

```
[root@VMNMS ~]# service ssm start
Starting Software Security Module Server:                    [  OK  ]
```

Monitoring SSM Log Files

You can monitor SSM logs in /opt/cgms-ssm/log/ssm.log

The default metrics report interval is 900 secs (15 min.), which is the minimum valid value. Only servicing metrics are logged. If there are no metrics to report, no messages are in the log.

You can change the metrics report interval by setting the **ssm-metrics-report-interval** field (in secs) in the /opt/cgms-ssm/conf/ssm.properties file.

Note: Your SSM server must be up and running before starting the IoT FND server.

Uninstalling the SSM Server

This section presents steps to completely uninstall the SSM server, including the steps for a fresh installation.

Note: Do not use this procedure for upgrades. Use the procedure in Installing or Upgrading the SSM Server.

To uninstall the SSM server:

1. Stop the SSM server:

```
service ssm stop
```

2. Copy and move the /opt/cgms-ssm/conf directory and contents to a directory outside of /opt/cgms-ssm.
3. Uninstall the cgms-ssm rpm:

```
rpm -e cgms-ssm
```

Fresh installations only

4. Install a new SSM server.
5. Copy and overwrite the /opt/cgms-ssm/conf directory with the contents moved in 2..

Integrating SSM and IoT FND

Note: You must install and start the SSM server before switching to SSM.

To switch from using the Hardware Security Module (HSM) for CSMP-based messaging and use the SSM:

1. Stop IoT FND.

```
service cgms stop
```

2. Run the ssm_setup.sh script on the SSM server.
3. Select option 3 to print IoT FND SSM configuration.
4. Copy and paste the details into the cgms.properties to connect to that SSM server.

EXAMPLE

```
security-module=ssm
ssm-host=127.107.155.85
ssm-port=8445
ssm-keystore-alias=ssm_csmp
ssm-keystore-password=NQ1/zokip4gtUeUyQnUuNw==
ssm-key-password=NQ1/zokip4gtUeUyQnUuNw==
```

5. To set up the HSM, specify the following properties in the cgms.properties file (see also, Setting Up an HSM Client):

```
security-module=ssm/hsm (required; hsm : Hardware Security Module default.)
hsm-keystore-name=testGroup1 (optional; hsm partition name; testGroup1 default)
hsm-keystore-password=TestPart1 (optional; encrypted hsm partition password; TestPart1 default)
```

6. Ensure that the SSM up and running and you can connect to it.

7. Start IoT FND.

Installing and Setting Up IoT FND

Complete the following procedures to finish your IoT FND installation:

- Installation and Setup Overview
- Installing IoT FND
- Setting Up IoT FND
- Starting IoT FND
- Checking IoT FND Status
- Running the IoT FND Database Migration Script
- Accessing the IoT FND Web GUI

BEFORE YOU BEGIN

To install IoT FND, first obtain the IoT FND installation RPM:

```
cgms-version_number.x86_64.rpm
```

Note: Ensure that /etc/hosts and /etc/resolv.conf files are correctly configured on the IoT FND server.

Installation and Setup Overview

These topics provide an overview of the two types of IoT FND installations:

- Single-Server Deployment
- Cluster Deployment (HA)

Single-Server Deployment

To install and set up IoT FND for a single-server deployment:

1. Log in to the RHEL server that will host IoT FND.
2. Installing IoT FND.

3. Setting Up IoT FND.
4. Running the IoT FND Database Migration Script.
5. Checking IoT FND Status.
6. Accessing the IoT FND Web GUI

Cluster Deployment (HA)

To install and set up IoT FND for HA deployments, repeat the steps in Single-Server Deployment, but only run the IoT FND database migration script once.

Installing IoT FND

To install the IoT FND application:

1. Run the IoT FND installation RPM:

   ```
   $ rpm -ivh cgms-version.x86_64.rpm
   ```

2. Verify installation and check the RPM version:

   ```
   $ rpm -qa | grep -i cgms
   cgms-1.0
   ```

Setting Up IoT FND

To set up IoT FND, run the setupCgms.sh script.

Note: If deploying a IoT FND server cluster, the setupCgms.sh script must be run on every node in the cluster.

Caution: The IoT FND certificate encrypts data in the database. The setupCgms.sh script runs database migration, which requires access to the IoT FND certificate in the keystore. You must set up certificates before running setupCgms.sh. The script results in an error if it migrates the database and cannot access the certificate (see Generating and Installing Certificates).

Caution: Ensure that the database password entered while running the setupCgms.sh script is valid. If you enter an invalid password multiple times, Oracle might lock your user account. You can unlock your account on the database server. For more information about unlocking your password, see “Unlocking the IoT FND Database Password” in the Troubleshooting chapter of the IoT Field Network Director User Guide, Release 4.1.x.

This example uses the setupCgms.sh script to set up a single-server IoT FND system that uses one database.

```
# cd /opt/cgms/bin
# ./setupCgms.sh
09-13-2012 17:10:00 PDT: INFO: ========== CG-NMS Setup Started - 2012-09-13-17-10-00 ==========
09-13-2012 17:10:00 PDT: INFO: Log file: /opt/cgms/bin/../server/cgms/log/cgms_setup.log

Are you sure you want to setup CG-NMS (y/n)? y

09-13-2012 17:10:02 PDT: INFO: User response: y

Do you want to change the database settings (y/n)? y

09-13-2012 17:10:05 PDT: INFO: User response: y

Enter database server IP address [example.com]: 128.107.154.246
09-13-2012 17:11:02 PDT: INFO: Database server IP: 128.107.154.246
```

```
Enter database server port [1522]:
09-13-2012 17:11:07 PDT: INFO: Database server port: 1522

Enter database SID [cgms]:
09-13-2012 17:11:12 PDT: INFO: Database SID: cgms

Do you wish to configure another database server for this CG-NMS ? (y/n)? n

09-13-2012 17:11:18 PDT: INFO: User response: n
09-13-2012 17:11:18 PDT: INFO: Configuring database settings. This may take a while. Please wait ...
09-13-2012 17:11:19 PDT: INFO: Database settings configured.

Do you want to change the database password (y/n)? y
09-13-2012 17:15:07 PDT: INFO: User response: y

Enter database password:
Re-enter database password:

09-13-2012 17:15:31 PDT: INFO: Configuring database password. This may take a while. Please wait ...
09-13-2012 17:15:34 PDT: INFO: Database password configured.

Do you want to change the keystore password (y/n)? n

09-13-2012 17:16:18 PDT: INFO: User response: n

Do you want to change the web application 'root' user password (y/n)? n
09-13-2012 17:16:34 PDT: INFO: User response: n

Do you want to change the FTP settings (y/n)? n
09-13-2012 17:16:45 PDT: INFO: User response: n
09-13-2012 17:16:45 PDT: INFO: ========== CG-NMS Setup Completed Successfully ==========
```

The setupCgms.sh script lets you configure these settings:

- Configuring Database Settings
- Configuring Database HA
- Configuring the IoT FND Database Password
- Configuring the Keystore Password
- Configuring the Web root User Password
- Configuring FTPS Settings

Configuring Database Settings

To configure the database settings, the setupCgms.sh script prompts you for this information:

- IP address of the primary IoT FND database server
- Port number of the IoT FND database server

  Press Enter to accept the default port number (1522).
- Database System ID (SID), which is cgms for the primary database server

  Press Enter to accept the default SID (cgms). This SID identifies the server as the primary database server.

```
Do you want to change the database settings (y/n)? y
09-13-2012 17:10:05 PDT: INFO: User response: y
```

```
Enter database server IP address [example.com]: 128.107.154.246
09-13-2012 17:11:02 PDT: INFO: Database server IP: 128.107.154.246

Enter database server port [1522]:
09-13-2012 17:11:07 PDT: INFO: Database server port: 1522

Enter database SID [cgms]:
09-13-2012 17:11:12 PDT: INFO: Database SID: cgms
```

Configuring Database HA

To configure the standby database settings, the setupCgms.sh script prompts you for the following information:

- IP address of the standby IoT FND database server
- Port number of the standby IoT FND database server

  Enter **1522**.

- Database System ID (SID), which is cgms for the primary database server

  Enter **cgms_s**. This SID identifies the server as the standby database server.

```
Do you wish to configure another database server for this CG-NMS ? (y/n)? y

09-13-2012 17:11:18 PDT: INFO: User response: y
Enter database server IP address []: 128.107.154.20
09-13-2012 17:11:02 PDT: INFO: Database server IP: 128.107.154.20
Enter database server port []: 1522
09-13-2012 17:11:07 PDT: INFO: Database server port: 1522
Enter database SID []: cgms_s
09-13-2012 17:11:12 PDT: INFO: Database SID: cgms_s
09-13-2012 17:11:18 PDT: INFO: Configuring database settings. This may take a while. Please wait ...
09-13-2012 17:11:19 PDT: INFO: Database settings configured.
```

For information about setting up database HA, see Setting Up IoT FND Database for HA.

Configuring the IoT FND Database Password

When prompted to change the IoT FND database password, enter the password of the cgms_dba user account on the database server. If using the default password, do not change the database password now.

```
Do you want to change the database password (y/n)? y

09-13-2012 17:15:07 PDT: INFO: User response: y

Enter database password:
Re-enter database password:

09-13-2012 17:15:31 PDT: INFO: Configuring database password. This may take a while. Please wait ...
09-13-2012 17:15:34 PDT: INFO: Database password configured.
```

Configuring the Keystore Password

To configure the keystore password:

```
Do you want to change the keystore password (y/n)? y
09-13-2012 10:21:52 PDT: INFO: User response: y

Enter keystore password: keystore_password
Re-enter keystore password: keystore_password
```

```
09-13-2012 10:21:59 PDT: INFO: Configuring keystore password. This may take a while. Please wait ...
09-13-2012 10:22:00 PDT: INFO: Keystore password configured.
```

Configuring the Web root User Password

To change the password of the root user account that lets you access the IoT FND browser-based interface, enter **y** and provide the password:

```
Do you want to change the web application 'root' user password (y/n)? n
09-13-2012 17:16:34 PDT: INFO: User response: n
```

Configuring FTPS Settings

If deploying a cluster, provide the FTPS settings required for downloading logs. FTPS securely transfers files between cluster nodes. If the FTPS settings are not configured, you can only download logs from the IoT FND node where you are currently logged in.

```
Do you want to change the FTP settings (y/n)? y
09-13-2012 17:16:45 PDT: INFO: User response: y

Enter FTP user password:
Re-enter FTP user password:

09-13-2012 17:16:49 PDT: INFO: Configuring FTP settings. This may take a while. Please wait ...
09-13-2012 17:16:57 PDT: INFO: FTP settings configuration completed successfully
```

Checking IoT FND Status

Before you can start IoT FND, check its connection to the IoT FND database by running this command:

```
# service cgms status
09-06-2012 18:51:20 PDT: INFO: CG-NMS database server: localhost
09-06-2012 18:51:21 PDT: INFO: CG-NMS database connection verified.
```

This command provides the IP address or hostname and status of the IoT FND database, and also verifies the connection to the IoT FND database. If the connection is not verified, you cannot start IoT FND.

Running the IoT FND Database Migration Script

IoT FND uses a special database migration system that lets you quickly migrate your IoT FND database without having to perform a database dump and restore. Each database migration creates or modifies some of the tables in the IoT FND database so that IoT FND can keep a record of migrations already performed.

Before launching IoT FND the first time, run the database migration script to set up the IoT FND tables in the database:

```
# cd /opt/cgms/bin
# ./db-migrate
```

Note: This script runs for a few minutes before launching IoT FND for the first time. Running this script after upgrading to a new version of IoT FND takes longer depending on the amount of data in the IoT FND database.

Note: If deploying a IoT FND server cluster, run the db-migrate script on only one cluster node.

The **db-migrate** command prompts you for the database password. The default password is **cgms123**.

Caution: Ensure that the password entered while running the db-migrate script is the correct password. If you enter an incorrect password multiple times, Oracle might lock your user account. If so, you have to unlock your account on the database server. Follow the steps below to unlock your password:

- If you enter an incorrect IoT FND Database password multiple times, Oracle locks your user account. Unlock your password using the Oracle software, as shown in this example:

```
# su - oracle
# sqlplus sys/<database_password>@cgms as sysdba
alter user cgms_dev account unlock;
exit;.
```

Accessing the IoT FND Web GUI

IoT FND has a self-signed certificate for its Web GUI. You must add a security exception in your browser to access the IoT FND GUI. Once you start IoT FND, you can access its web GUI at:

https://*nms_machine_IP_address*/

The initial default username is root; the password is **root123**.

IoT FND uses the default password of **root123** unless the password was changed when the setup script ran.

For more information on the setup script, see Setting Up IoT FND.

Note: If the IoT FND includes the Hardware Security Module (HSM), the Firefox browser will not connect to IoT FND. To work around this issue, open Firefox Preferences, navigate to **Advanced**, and click the **Encryption** tab. Under Protocols, clear the **Use TLS 1.0** check box. Reconnect to IoT FND and ensure that the page loaded properly.

HTTPS Connections

IoT FND only accepts TLSv1.2 based HTTPS connections. To access the IoT FND GUI, you must enable the TLSv1.2 protocol to establish an HTTPS connection with the IoT FND.

Note: IoT FND Release 2.1.1-54 and later do not support TLSv1.0 or TLSv1.1 based connections.

First-Time Log In Actions

Changing the Password

When you log in to IoT FND for the first time, a popup window prompts you to change the password.

Note: IoT FND supports a maximum 32-character password length.

1. Enter your New password.
2. Re-enter the new password in the Confirm Password field.
3. Click **Change Password**.

Configuring the Time Zone

To configure the time zone, follow these steps:

1. From the *username* drop-down menu (top right), choose **Time Zone**.
2. Select a time zone.
3. Click **Update Time Zone**.
4. Click **OK**.

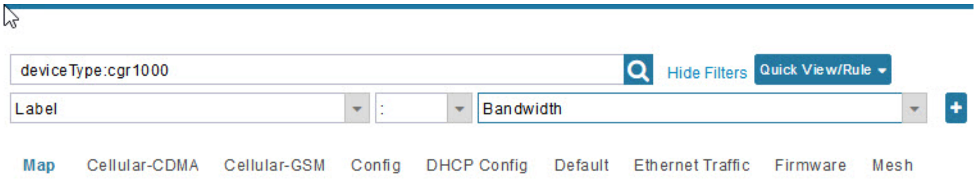
Changing the Sorting Order of Columns

For pages that display lists under a column heading (such as a list of routers) you can change the sort order (ascending or descending) by toggling the triangle icon in the column heading,

Filtering Lists

IoT FND lets you define filters on the DEVICES and OPERATIONS pages.

- To define a filter, click **Show Filters** to the right of the search field to open a filter definition panel (shown below). After you define the search parameters in the field, click the magnifying glass icon to start search. Results display beneath the filter field.



deviceType:cgr1000

Label : Bandwidth

- Click **Hide Filters** to close the search field.

In the following example, typing the search string **deviceType:cgmesh status:up** in the Search Devices field lists the mesh endpoint devices with an Up status.

Setting User Preferences for User Interface

You can define what items display in the user interface by selecting the Preferences option under the <*user name*> drop-down menu (top right).

In the User Preferences panel that displays, you can select those items (listed below) that you want to display by checking the box next to that option. Click **Apply** to save.

User Preference options include:

- Show chart on events page
- Show summary counts on events/issues page
- Enable map:
- Default to map view
- Show device type and function on device pages: Routers, Endpoints, Head End Routers, Servers

Logging Out

Click **Log Out** in the <*user name*> drop-down menu (top right).

IoT FND CLIs

This section addresses key command-line interface (CLI) commands used to manage IoT FND:

- Starting IoT FND
- Checking IoT FND Status
- Stopping IoT FND
- Restarting IoT FND
- IoT FND Log File Location
- IoT FND Helper Scripts
- Upgrading IoT FND
- Uninstalling IoT FND

Starting IoT FND

To start IoT FND, run this command:

```
service cgms start
```

To configure IoT FND so that it runs automatically at boot time, run this command:

```
chkconfig cgms on
```

Checking IoT FND Status

To check IoT FND status, run this command:

```
service cgms status
```

Stopping IoT FND

To stop IoT FND, run this command:

```
service cgms stop
```

Note: The application typically takes approximately 10 seconds to stop. Run **ps | grep java** to verify that no Java processes are running.

Restarting IoT FND

To restart IoT FND, run this command:

```
service cgms restart
```

IoT FND Log File Location

The IoT FND log file (server.log) is located in the /opt/cgms/server/cgms/log directory.

IoT FND Helper Scripts

Table 3 describes the helper IoT FND scripts in the /opt/cgms/bin/ directory.

Table 3 IoT FND Helper Scripts

Script	Description
deinstall_cgms_watchdog.sh	Uninstalls the watchdog script.
install_cgms_watchdog.sh	Installs the watchdog script.
mcast_test.sh	Tests the communication between cluster members.
password_admin.sh	Changes or resets the user password used to access IoT FND.
print_cluster_view.sh	Prints cluster members.

Upgrading IoT FND

Note: It is not necessary to stop the database during normal upgrades. All upgrades are in-place.

Note: For virtual IoT FND installations using custom security certificates, see Managing Custom Certificates before performing this upgrade.

Caution: Run the following steps sequentially.

To upgrade the IoT FND application:

1. Obtain the new IoT FND RPM.
2. Stop IoT FND:

   ```
   service cgms stop
   ```

   Note: The application typically takes approximately 10 seconds to stop. Run **ps | grep java** to verify that no Java processes are running.
3. Make sure the cgms service has stopped:

   ```
   service cgms status
   ```
4. Upgrade the IoT FND RPM:

   ```
   rpm -Uvh new_cgms_rpm_filename
   ```

   Note: These files overwrite the files in /opt/cgms.
5. Run the database migrations to upgrade the database from the /opt/cgms directory:

   ```
   cd /opt/cgms/bin
   ./db-migrate
   ```

   Note: You must run the db-migrate script after each upgrade.
6. When prompted, enter the database password. The default password is **cgms123**.
7. Start IoT FND:

   ```
   # service cgms start
   ```

   You can also use the RHEL (Red Hat Enterprise Linux) GUI to start the IoT FND service (**ADMIN > System Management > Server Settings > Services**). For information, see the RHEL documentation.

Uninstalling IoT FND

Note: This deletes all IoT FND local installation configuration settings and installation files (for example, the keystore with your certificates).

Tip: If you plan to reinstall IoT FND, copy your current keystore and certificate files to use to overwrite the keystore and certificate files included with the install package.

To remove the IoT FND application, run these commands:

```
# rpm -e cgms
# rm -rf /opt/cgms
```

Cleaning up the IoT FND Database

To clean up the IoT FND database:

1. (HA database configurations) Stop the Observer server.
2. (HA database configurations) Run the $ORACLE_BASE/cgms/scripts/ha/deleteStandbyDb.sh script to delete the standby database.
3. (HA database configurations) Run the $ORACLE_BASE/cgms/scripts/ha/deletePrimaryDbHa.sh script to delete the HA configuration from primary database.
4. Run the $ORACLE_BASE/cgms/scripts/deleteCgmsDb.sh script to delete primary database.

Installing and Configuring the IoT FND TPS Proxy

The first use of the optional TPS proxy is typically when a CGR sends an inbound request to initialize the portion of Zero Touch Deployment (ZTD) handled by IoT FND. IoT FND operates behind a firewall and does not have a publicly reachable IP address. When field area routers (CGRs) contact IoT FND for the first time, IoT FND requires that they use the TPS proxy. This server lets these routers contact the IoT FND application server to request tunnel provisioning (see Managing Tunnel Provisioning).

The TPS proxy does not have its own GUI. You must edit the properties in the **cgnms.properties** and **tpsproxy.properties-template** files for HTTPS outbound tunnel provisioning requests so that IoT FND recognizes them as requests from the TPS proxy.

After provisioning the tunnel(s), the field area routers can contact IoT FND directly without using the TPS proxy. IoT FND is notified of the exact certificate subject from the proxy certificate, and then authenticates that the HTTPS inbound requests are coming from the TPS proxy.

Setting Up the TPS Proxy

Install the cgms-tpsproxy RPM package Java application on a separate (TPS proxy) server to act as a stateless extension of IoT FND outside the firewall. The TPS proxy can be a Red Hat Enterprise Linux (RHEL) server (see TPS proxy system requirements in the IoT FND Release Notes). The cgnms-tpsproxy application runs as a daemon on the server and requires the following configuration parameters:

- URL of the IoT FND server (to forward inbound requests).
- IP address of the IoT FND server, as part of a whitelist (approved list) for forwarding outbound requests.

Before you install the TPS proxy, obtain the TPS proxy installation package:

```
cgms-tpsproxy-version_number.x86_64.rpm
```

To configure the proxy-server settings:

1. Configure a RHEL server to use as the TPS proxy.
2. Connect this RHEL server so that it can be reached while outside the firewall.
3. Configure the TPS proxy using the template file:

   ```
   ssh root@tps_proxy_server
   cd /opt/cgms-tpsproxy/conf
   cp tpsproxy.properties-template tpsproxy.properties
   ```

   Note: Edit the cgnms.properties and tpsproxy.properties files after running the encryption_util.sh script during IoT FND TPS Proxy Enrollment.

4. Edit the tpsproxy.properties file to add the following lines defining the inbound and outbound addresses for the IoT FND application server:

   ```
   [root@cgr-centos57 conf]# cat tpsproxy.properties-template
   inbound-proxy-destination=https://nms_domain_name:9120
   outbound-proxy-allowed-addresses=nms_ip_address
   cgms-keystore-password-hidden=<obfuscated password>
   ```

   Note: You must edit the properties in the cgnms.properties and tpsproxy.properties-template files for HTTPS outbound tunnel provisioning requests so that IoT FND recognizes them as requests from the TPS proxy.

Configuring the TPS Proxy Firewall

To configure the TPS proxy firewall:

- Set up a firewall rule to allow HTTPS connections from the TPS proxy to the IoT FND server on port 9120 (for HTTPS inbound requests).
- Set up a firewall rule to allow HTTPS connections from the IoT FND server to the TPS proxy on port 9122 (for HTTPS outbound requests).

IoT FND TPS Proxy Enrollment

The enrollment process for the TPS proxy is the same as the IoT FND enrollment process. The certification authority (CA) that signs the certificate of the IoT FND application server must also sign the certificate of the TPS proxy. The certificate of the TPS proxy is stored in a Java keystore and is similar to the IoT FND certificate.

For the enrollment process, consider these scenarios:

- Fresh installation
  - If the keystore password is the same as the default password, change the default password.

  Note: We **strongly recommend** that you change all default passwords. Do not use special characters such as, @, #, !, or + as the encryption_util.sh script cannot encrypt special characters.

  - If the keystore password is different from default password, run the encryption_util.sh script and copy the encrypted password to the properties file.

  Note: Edit the cgnms.properties and tpsproxy.properties files after running the encryption_util.sh script.

- Upgrade

  Regardless of whether you are using the default password or a custom one, the upgrade process encrypts the password in the /opt/cgms-tpsproxy/conf/tpsproxy.properties file.

For information on IoT FND enrollment, refer to *Generating and Exporting Certificates* in the Generating and Installing Certificates chapter of this guide.

To enroll the terminal TPS proxy:

1. Create a **cgms_keystore** file.
2. Add your certifications to this file.
3. Copy the file to the **/opt/cgms-tpsproxy/conf** directory.

Configuring IoT FND to Use the TPS Proxy

You must edit the properties in the cgnms.properties and tpsproxy.properties-template files for HTTPS outbound tunnel provisioning requests so that IoT FND recognizes them as requests from the TPS proxy. The TPS proxy logs all inbound and outbound requests.

Note: If the properties in the cgnms.properties and tpsproxy.properties-template files are not set, IoT FND does not recognize the TPS proxy, drops the forwarded request, and considers it from an unknown device.

Note: The following examples employ variable not mandatory values, and are provided as examples only.

To configure IoT FND to use the TPS proxy:

1. Open an SSH connection to the IoT FND server:

   ```
   ssh root@nms_machine
   cd /opt/cgms/server/cgms/conf/
   ```

   Note: Edit the cgnms.properties and tpsproxy.properties files after running the encryption_util.sh script during IoT FND TPS Proxy Enrollment.

2. Edit the **cgms.properties** file to add lines identifying the TPS proxy IP address, domain name, and user subjects in the cgdm-tpsproxy-subject property:

   Note: The cgdm-tpsproxy-subject property must match the installed TPS proxy certificate.

   ```
   cgdm-tpsproxy-addr=proxy_server_IP_address
   cgdm-tpsproxy-subject=CN="common_name", OU="organizational_unit", O="organization", L="location",
   ST="state", C="country"
   ```

   Note: Use quotes around comma-separated strings.

Starting the IoT FND TPS Proxy

Start the TPS proxy after it is installed, configured, and enrolled.

To start the TPS proxy, run the start script:

```
service tpsproxy start
```

The TPS proxy log file is located at:

```
/opt/cgms-tpsproxy/log/tpsproxy.log
```

Note: For information, see TPS Proxy Validation.

TPS Proxy Validation

The TPS proxy logs all HTTPS inbound and outbound requests in the TPS proxy log file located at /opt/cgms-tpsproxy/log/tpsproxy.log

The following entry in the TPS proxy tpsproxy.log file defines inbound requests for a CGR:

```
73: cgr-centos57: May 21 2014 01:05:20.513 -0700: %CGMS-6-UNSPECIFIED:
%[ch=TpsProxyServlet-49dc423f][eid=CGR1240/K9+JAF1732ARCJ][ip=192.168.201.5][sev=INFO][tid=qtp46675819-
29]: Inbound proxy request from [192.168.201.5] with client certificate subject
[CN=CGRJAF1732ARCJ.example.com, SERIALNUMBER=PID:CGR1240/K9 SN:JAF1732ARCJ]
```

This message entry in the TPS proxy tpsproxy.log file indicates that the TPS successfully forwarded the message to IoT FND:

```
74: cgr-centos57: May 21 2014 01:05:20.564 -0700: %CGMS-6-UNSPECIFIED:
%[ch=TpsProxyServlet-49dc423f][sev=INFO][tid=com.cisco.cgms.tpsproxy.TpsProxyServlet-49dc423f-22]:
Completed inbound proxy request from [192.168.201.5] with client certificate subject
[CN=CGRJAF1732ARCJ.example.com, SERIALNUMBER=PID:CGR1240/K9 SN:JAF1732ARCJ]
```

The following entry in the IoT FND server log file identifies the TPS proxy:

```
Request came from proxy
Using forwarded client subject (CN=cg-cgr-1, SERIALNUMBER=PID:CGR1240/K9 SN:JSJ15220047) for
authentication
```

The following entry in the TPS proxy tpsproxy.log file defines outbound requests:

```
%CGMS-6-UNSPECIFIED: %[ch=TpsProxyOutboundHandler][ip=192.168.205.5][sev=INFO][tid=qtp257798932-15]:
Outbound proxy request from [192.168.205.5] to [192.168.201.5:8443]
```

The following entry in the IoT FND server log file identifies the HTTPS connection:

```
Using proxy at 192.168.201.6:9122 to send to https://192.168.201.4:8443/cgdm/mgmt commands:
```

Backing Up and Restoring the IoT FND Database

The following topics demonstrate how IoT FND supports both full and incremental database backups:

- Before You Begin
- Creating a Full Backup of the IoT FND Database
- Scheduling a Full IoT FND Backup
- Restoring a IoT FND Backup

Before You Begin

Before backing up your IoT FND database:

1. Download and install the latest cgms-oracle-*version_number*.x86_64.rpm package.
2. Copy the scripts, templates, and tools folders from the /opt/cgms-oracle folder to the $ORACLE_BASE/cgms folder.
3. Set the ownership of the files and folders you copied to oracle:dba.

Creating a Full Backup of the IoT FND Database

Full backups back up all the blocks from the data file. Full backups are time consuming and consume more disk space and system resources than partial backups.

IoT FND lets you perform full hot backups of IoT FND database. In a hot backup, IoT FND and the IoT FND database are running during the backup.

Note: The destination backup directory must be writable by the oracle user and have enough space for the IoT FND data.

To create a backup file of the IoT FND software:

1. On the IoT FND database server, open a CLI window.
2. Switch to the user oracle:

   ```
   su - oracle
   ```

3. Change directory to the location of the IoT FND backup script (backupCgmsDb.sh):

   ```
   cd /home/oracle/app/oracle/cgms/scripts
   ```

4. Run the backup script and specify the destination folder. For example, to store the backup data in the /home/oracle/bkp folder, enter this command:

   ```
   ./backupCgmsDb.sh full /home/oracle/bkp
   08-03-2012 15:54:10 PST: INFO: ========== CGMS Database Backup Started ==========
   08-03-2012 15:54:10 PST: INFO: Log file: /tmp/cgms_backup_restore.log
   Are you sure you want to backup CG-NMS database (y/n)? y
   ```

5. Enter y to begin the backup process.

Scheduling a Full IoT FND Backup

To schedule a full IoT FND backup to run daily at 1:00 AM (default setting):

Note: The destination backup directory must be writable by the oracle user and have enough space for the IoT FND data.

1. On the IoT FND database server, open a CLI window.
2. Switch to the user *oracle*:

   ```
   su - oracle
   ```

3. Change directory to the location of the IoT FND backup script (backupCgmsDb.sh):

   ```
   cd /home/oracle/app/oracle/cgms/scripts
   ```

4. Run the backup script and specify the destination folder.

To change the backup scheduling interval, edit the installCgmsBackupJob.sh script before running it.
For example, to store the backup data in /home/oracle/bkp, enter this command:

```
./installCgmsBackupJob.sh /home/oracle/bkp
```

To delete the backup job, enter these commands:

```
cd /home/oracle/app/oracle/cgms/scripts
./deinstallCgmsBackupJob.sh
```

Backing Up the IoT FND Database Incrementally

Incremental backups only back up data file blocks that changed since the previous specified backup. IoT FND supports two incremental backup levels, and an hourly log backup:

- incr0–Base backup for subsequent incremental backups. This is similar to a full backup. For large deployments (millions of mesh endpoints and several thousand routers such as CGR1000 and IR800), run incr0 backups twice a week.

- incr1-Differential backup of all blocks changed since the last incremental backup. For large deployments (millions of mesh endpoints and several thousand routers), run incr1 backups once a day.

Note: An incr0 backup must run before an incr1 backup to establish a base for the incr1 differential backup.

- Hourly archivelog backup-The Oracle Database uses archived logs to record all changes made to the database. These files grow over time and can consume a large amount of disk space. Schedule the backup_archive_log.sh script to run every hour. This script backs up the database archive (.arc) log files, stores them on a different server, and deletes the source archivelog files to free space on the database server.

  Tip: Before performing any significant operation that causes many changes in the IoT FND database (for example, importing a million mesh endpoints or uploading firmware images to mesh endpoints), perform am incr0 backup. After the operation completes, perform another incr0 backup, and then resume the scheduled incremental backups.

Performing an Incremental Backup

Note: The destination backup directory must be writable by the oracle user and have enough space for the IoT FND data.

To perform an incremental backup:

1. On the IoT FND database server, open a CLI window.
2. Switch to the user *oracle* and change directory to the location of the IoT FND backup script:

```
su - oracle
cd /home/oracle/app/oracle/cgms/scripts
```

3. Run the backup script and specify the incremental backup level and the destination folder where the backup data is stored (for example, /home/oracle/bkp). For example, to perform an incr0 backup to/home/oracle/bkp, enter the command:

```
./backupCgmsDb.sh incr0 /home/oracle/bkp
```

   To perform an incr1 backup, enter the command:

```
./backupCgmsDb.sh incr1 /home/oracle/bkp
```

Restoring a IoT FND Backup

Perform database backups and restores using the scripts provided in the cgms-oracle.rpm package. If using the supplied scripts, backups and restores only work if performed on the same Oracle database version.

Note: Backups from Oracle version 11.2.0.1 can only be restored on v11.2.0.1 if using the supplied scripts. Backups do not work across different versions of Oracle, for example, a backup taken on 11.2.0.1 cannot be restored on 11.2.0.3 using the supplied scripts. If a database upgrade from 11.2.0.1 to 11.2.0.3 is required, follow the Oracle upgrade procedure. Refer to the Oracle upgrade document and Web site.

IoT FND supports restoring IoT FND backups on the same host or different host. If you choose to restore IoT FND backups on a different host, ensure that the host runs the same or a higher version of the Oracle database software and that IoT FND database on the destination host was created using the setupCgmsDb.sh script.

Note: IoT FND does not support cross-platform backups.

To restore a IoT FND backup:

1. Stop IoT FND.

```
service cgms stop
```

2. Switch to the user oracle, change directories to the script location, and stop Oracle:

```
su -oracle
cd /home/oracle/app/oracle/cgms/scripts
./stopOracle.sh
```

3. To restore the IoT FND database, run the command:

   ```
   ./restoreCgmsDb.sh full-backup-file
   ```

   Tip: Performing a restore from a full backup can be time consuming. For large deployments, we recommend restoring the database from incremental backups.

   To restore IoT FND database from an incremental backup, run these commands and specify the path to last incremental backup file:

   ```
   su -oracle
   cd /home/oracle/app/oracle/cgms/scripts
   ./restoreCgmsDb.sh last-incr1-backup-file
   ```

   The restore script might display these errors:

   ```
   06-08-2012 13:12:56 PDT: INFO: Import completed successfully
   06-08-2012 13:12:56 PDT: INFO: Shared memory file system. Required (1K-blocks): 6084456,
   Available (1K-blocks): 4083180
   06-08-2012 13:12:56 PDT: ERROR: Insufficient shared memory file system. Increase your
   shared memory file system before restoring this database.
   06-08-2012 13:12:56 PDT: ERROR: ========== CGMS Database Restore Failed ==========
   06-08-2012 13:12:56 PDT: ERROR: Check log file for more information.
   ```

   To avoid these errors, increase the size of the shared memory file system:

   ```
   ###### as "root" user
   ###### Following command allocates 6G to shm. Adjust size as needed.
   # umount tmpfs
   # mount -t tmpfs tmpfs -o size=6G /dev/shm

   ###### Edit /etc/fstab and replace defaults as shown below
   tmpfs                  /dev/shm               tmpfs   size=6G        0 0
   ```

4. Start Oracle:

   ```
   ./startOracle.sh
   ```

5. Change directories to /opt/cgms and run the db-migrate script:

   ```
   $ cd /opt/cgms
   $ bin/db-migrate
   ```

   When you restore a IoT FND database, the restore script restores the database to the IoT FND version the database was using. An error returns if you restore an old database to a newer version of IoT FND. Run the migrate script to ensure that the database runs with the current version of IoT FND.

6. Start IoT FND:

   ```
   service cgms start
   ```

For disaster recovery, perform a clean restore. The script starts by deleting the current IoT FND database:

```
$ su -oracle
$ cd /home/oracle/app/oracle/cgms/scripts
$ ./deleteCgmsDb.sh
INFO: ======== CGMS Database Deletion Started - 2011-10-16-07-24-09 ==========
INFO: Log file: /tmp/cgmsdb_setup.log
INFO: Deleting database. This may take a while. Please be patient ...
INFO: Delete database completed successfully
```

```
INFO: ========== CGMS Database Deletion Completed Successfully - 2011-10-16-07-25-01 ==========
```

If a clean restore is not required, use the Oracle tool to restore the database.

Deploying IoT FND/Oracle/TPS Virtual Machines on ESX 5.x

You use the VMware vSphere client to import OVA files into ESXi 5.x.

BEFORE YOU BEGIN

- Install the VMware vSphere Client for the ESXi 5.x server.
- Locate the VMware ESXi 5. x credentials to create virtual machines in ESXi 5.x.
- Ensure that you meet the VMware server machine requirements.

  Listed below are the VM CPU and memory requirements for a small scale deployment:

  NMS OVA

  - 16 GB memory
  - 1 core and 4 virtual sockets
  - 150 GB of virtual storage

  Oracle OVA

  - 24 GB of memory
  - 2 virtual sockets with 2 cores per socket
  - 300 GB of virtual storage

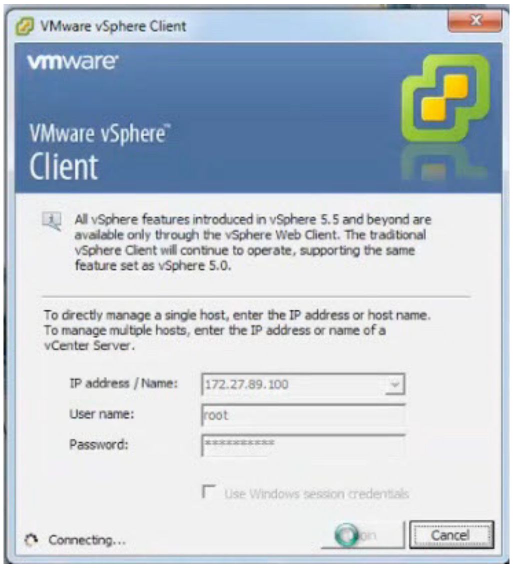
  TPS OVA

  - 4 GB of memory
  - 1 virtual socket with 1 core
  - 50 GB of virtual storage

DETAILED STEPS

To import the IoT FND, Oracle, and TPS virtual appliances into ESXi 5.x or ESXi6.x using VMware vSphere Client version 5.0.0 or 6.0.0, respectively:

1. Select the **Network Adapter > NAT** setting for the server.
2. At the VMware vSphere Client window enter the IP address, username and password of the server where VMware resides. Click **Login**.



All vSphere features introduced in vSphere 5.5 and beyond are available only through the vSphere Web Client. The traditional vSphere Client will continue to operate, supporting the same feature set as vSphere 5.0.

To directly manage a single host, enter the IP address or host name. To manage multiple hosts, enter the IP address or name of a vCenter Server.

IP address / Name: 172.27.89.100

User name: root

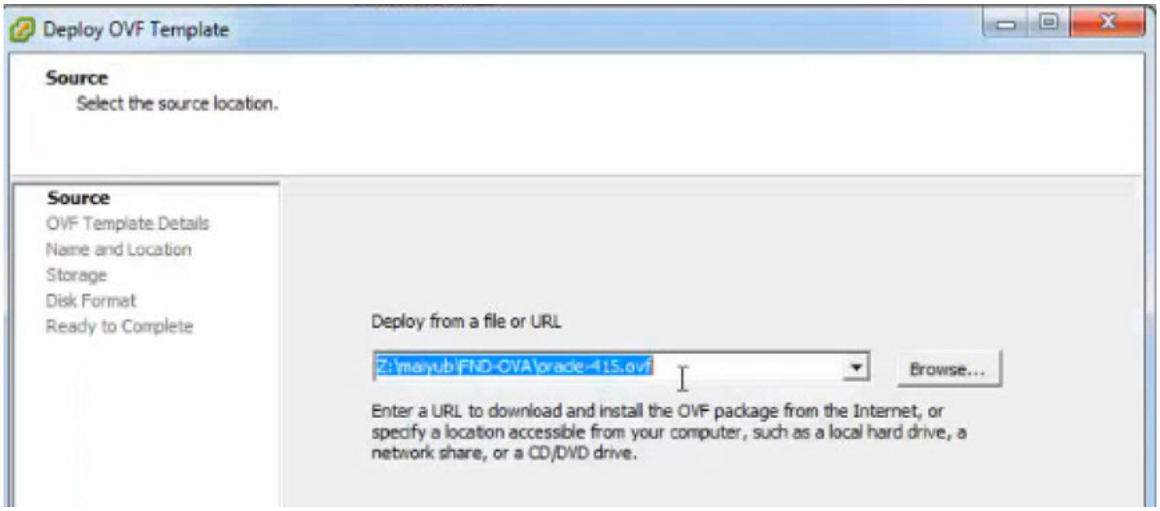
Password: ***********

□ Use Windows session credentials

Connecting...

3. Select **File > Deploy OVF Template...**

4. Browse to the FND-OVA\oracle-415.ovf file.



Deploy from a file or URL

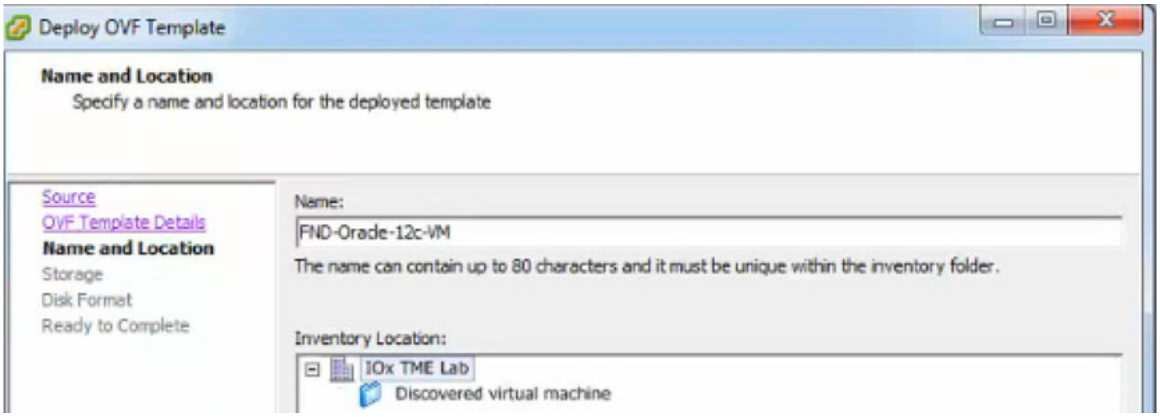
Z:\maiyub\FND-OVA\oracle-415.ovf

Enter a URL to download and install the OVF package from the Internet, or specify a location accessible from your computer, such as a local hard drive, a network share, or a CD/DVD drive.

5. Ensure that the correct OVA file displays in the Source location window, and then click **Next**. (**Note:** The Next button, not shown, is found in the bottom, right-hand portion of the window.)

6. In the OVF Template Details window, enter the Name and Inventory Location of the deployed template (for example, FND-Oracle-12c-VM) Click **Next**.

7. In the next window that appears, verify the OVA file name matches what you entered in the previous window. If no issues, click **Next**. If the OVA file name does **not** match, click **Back** and reenter the information.



Name and Location

Specify a name and location for the deployed template

Name:

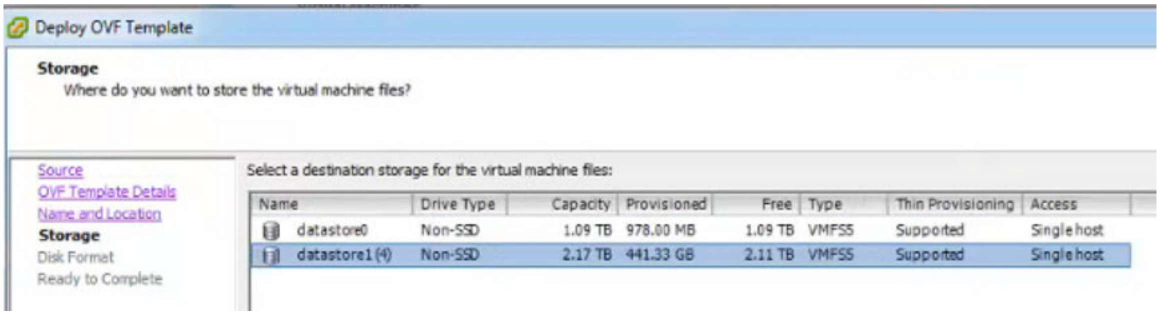
FND-Oracle-12c-VM

The name can contain up to 80 characters and it must be unique within the inventory folder.

Inventory Location:

- IOx TME Lab
  - Discovered virtual machine

8. Select a Storage destination for the VM deployed template.



Storage

Where do you want to store the virtual machine files?

Select a destination storage for the virtual machine files:

Name	Drive Type	Capacity	Provisioned	Free	Type	Thin Provisioning	Access
datastore0	Non-SSD	1.09 TB	978.00 MB	1.09 TB	VMFS5	Supported	Single host
datastore1 (4)	Non-SSD	2.17 TB	441.33 GB	2.11 TB	VMFS5	Supported	Single host

9. In the Disk Format window (not shown), select the **Thin Provision** option, and then click **Next**.

   Note: Thin Provision allows the VM disk to grow as needed.

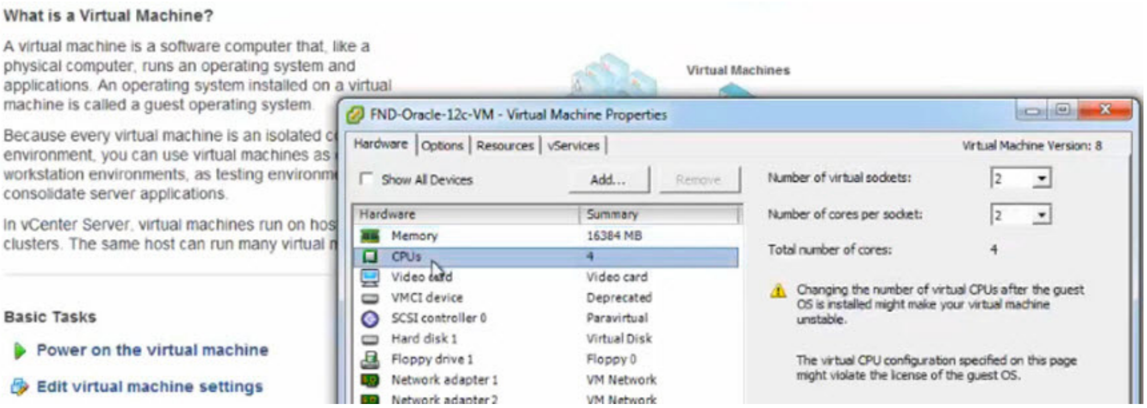
10. In the Ready to Complete window, confirm your deployment settings, and then click **Finish**. Deployment of the FND-Oracle-12C-VM templates begins.

11. After completion of the FND-Oracle-12c-VM install, a window displays.

    – In the left panel, select the FND-Oracle-12c-VM server.

    – In the right panel, Under Basic Task, select Edit virtual machine settings to confirm CPU and MEM settings.

    – Click **OK** to close the window.



What is a Virtual Machine?

A virtual machine is a software computer that, like a physical computer, runs an operating system and applications. An operating system installed on a virtual machine is called a guest operating system.

Because every virtual machine is an isolated c environment, you can use virtual machines as workstation environments, as testing environm consolidate server applications.

In vCenter Server, virtual machines run on hos clusters. The same host can run many virtual n

Basic Tasks

Power on the virtual machine

Edit virtual machine settings

FND-Oracle-12c-VM - Virtual Machine Properties

Hardware | Options | Resources | vServices

Virtual Machine Version: 8

☐ Show All Devices

Add... Remove

Hardware	Summary
Memory	16384 MB
CPUs	4
Video card	Video card
VMCI device	Deprecated
SCSI controller 0	Paravirtual
Hard disk 1	Virtual Disk
Floppy drive 1	Floppy 0
Network adapter 1	VM Network
Network adapter 2	VM Network

Number of virtual sockets: 2

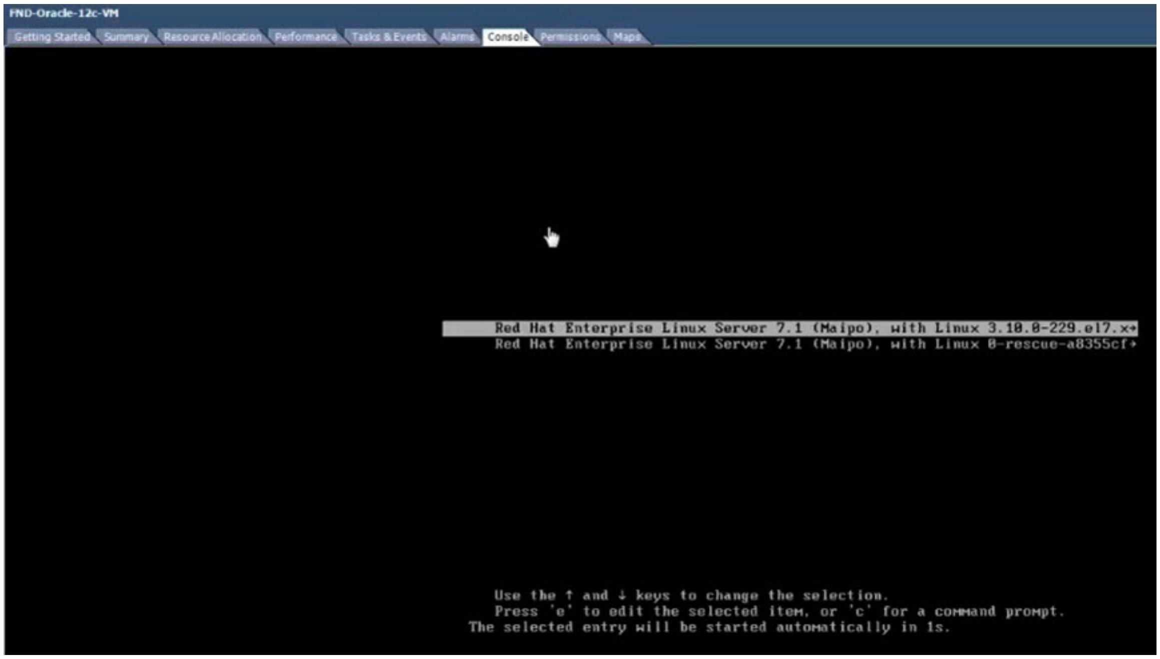
Number of cores per socket: 2

Total number of cores: 4

Changing the number of virtual CPUs after the guest OS is installed might make your virtual machine unstable.

The virtual CPU configuration specified on this page might violate the license of the guest OS.

12. Click **Power on the virtual machines** and select **Console** tab in the window that opens. The console opens showing possible RHEL server versions to select.

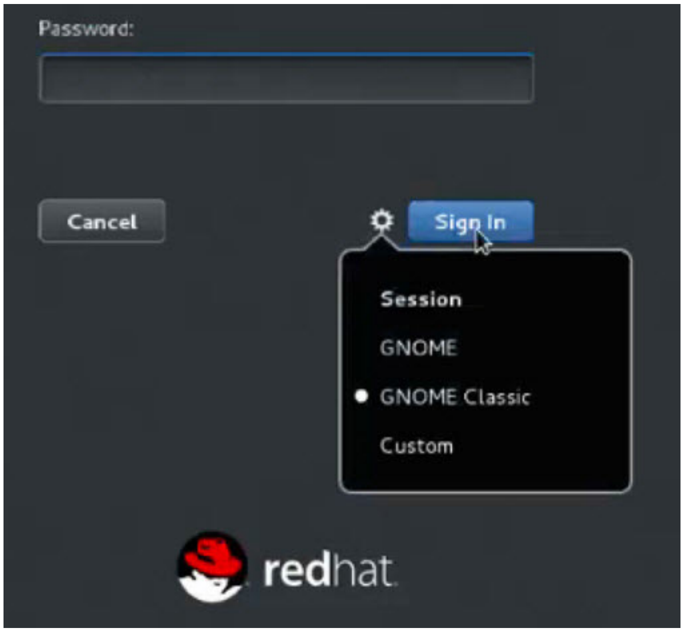


FND-Oracle-12c-VM

```
      Red Hat Enterprise Linux Server 7.1 (Maipo), with Linux 3.10.0-229.el7.x→
      Red Hat Enterprise Linux Server 7.1 (Maipo), with Linux 0-rescue-a8355cf→









      Use the ↑ and ↓ keys to change the selection.
      Press 'e' to edit the selected item, or 'c' for a command prompt.
   The selected entry will be started automatically in 1s.
```

13. After you select a RHEL option, you will be prompted for your username and password.

14. Click **Sign In** and select the **GNOME Classic** option.



15. Click Sign In.

16. At the Welcome screen, select the default language (such as English-United States) for the interface, Click **Next.**

17. Continue through the install script until you reach the final screen that indicates that “Your computer is ready to use.” Click Start using **Red Hat Enterprise Linus Server** button.

18. Close **Getting Started** window, right-click to open.

19. At the Application Places window, right-click in the window to display a menu panel. Select **Open in Terminal**.

Generating and Installing Certificates

This section describes how to generate and install certificates, and includes the following topics:

- Information About Certificates
- Generating and Exporting Certificates
- Installing the Certificates
- Configuring IoT FND to Access the Keystore
- Configuring the TPS Proxy to Access the Keystore
- Setting Up an HSM Client
- Configuring the HSM Group Name and Password

Information About Certificates

The following topics provide information on certificates:

- Role of Certificates
- Keystore

Role of Certificates

All communications between the CGR1000, IR800s, C800s, ESR C5921s, and the Cisco Connected IoT Field Network Director (IoT FND) must be authenticated in both directions through mutual authentication. Before mutual authentication can occur, the Cisco IoT FND and the device must each have a certificate signed by the same Certificate Authority (CA). You can employ either a root CA or subordinate CA (subCA).

For details on generating certificates for CGRs, refer to the Certificate Enrollment Guide for the Cisco 1000 Series Connected Grid Routers.

Generating certificates for IoT FND also involves generating and loading certificates on the IoT FND TPS Proxy (tpsproxy). After generating the certificates, import them into the storage location on the TPS proxy and IoT FND known as the Keystore.

Keystore

The Keystore provides details for a specific system (such as IoT FND or the TPS proxy) and includes the following items:

- The certificate for that system (such as the IoT FND certificate or TPS proxy certificate)
- The private key for the system
- The certificate chain (path to the CA or subCA)

The IoT FND key and certificates are stored in the cgms_keystore file on the IoT FND server in the /opt/cgms/server/cgms/conf directory.

Generating and Exporting Certificates

Note: The IoT FND certificate encrypts data in the database. **Do not lose this certificate!** Loss of this certificate results in some database data that will not be able to be decrypted.

Complete the following procedures to generate and export certificates:

- Configuring a Certificate Template for IoT FND and the IoT FND TPS Proxy
- Enabling a Certificate Template
- Generating Certificates for IoT FND and the IoT FND TPS Proxy
- Command Authorization Support
- Configuring a Custom CA for HSM
- Configuring a Custom CA for SSM
- Exporting the CA Certificate

Configuring a Certificate Template for IoT FND and the IoT FND TPS Proxy

On the CA (or subCA) you must create certificate templates to generate certificates for the IoT FND and TPS proxy.

To create a certificate template:

1. Open the Certificate Authority application on a Windows Server 2008 R2 system operating with the Enterprise edition.

The Certificate Authority application is standard on the above noted Windows Server version.

2. Expand the menu to view the Certificate Templates folder.
3. Right-click **Certificate Templates** and choose **Manage** from the context menu.
4. In the right-pane, right-click **Computer**, choose **Duplicate Template** from the context menu, and enter **NMS**.
5. In the Duplicate Template pane, select **Windows Server 2008 Enterprise**.
6. Click **OK**.
7. Click the **NMS Properties > General** tab, and do the following:
   a. Enter **NMS** in the **Template display name** and **Template name** fields.
   b. Enter an appropriate **Validity** period, which defines the lifetime of the certificate.
   c. Check the **Publish certificate in Active Directory** check box.
   d. Click **OK**.
8. Click the **NMS Properties > Extensions** tab, and do the following:
   a. Select **Application Policies** in the Extensions pane.
   b. In the Application Policies pane, verify that Client Authentication and Server Authentication appear in the bottom pane.
   c. Select **Key Usage** in the Extensions top pane and click **Edit**.
   d. In the **Edit Key Usage Extension** pane, clear the **Make this extension critical** check box.

   e. Click **OK**.

9. Click the **NMS Properties > Request Handling** tab, and do the following:

   a. Choose **Signature and encryption** from the Purpose drop-down menu.

   b. Check the **Allow private key to be exported** check box.

   c. Click **OK**.

10. Click the **NMS Properties > Security** tab, and do the following:

   a. Select **Administrator** within the Group or user names pane.

   b. For each group or user names item listed (such as authenticated users, administrator, domain administrators, enterprise administrators) check the **Allow** check box for all permissions (full control, read, write, enroll, autoenroll).

   c. Click **OK**.

11. Click the **NMS Properties > Cryptography** tab, and retain the following default settings:

- Algorithm name: RSA
- Minimum key site: 2048
- Cryptographic provider: Requests can use any provider available on the subject computer
- Request hash: SHA256

12. Click **OK**.

13. Click the **NMS Properties > Subject Name** tab, and retain the following default settings:

- Radio button for **Supply in the request radio button** selected
- Check box checked for **Use subject information from existing certificates for autoenrollment renewal requests**

14. Click **OK**.

Note: Retain the default settings for the remaining tabs: Superseded Templates, Server, and Issuance Requirements.

Enabling a Certificate Template

Before you can create a certificate, you must enable the certificate template.

To enable the certificate template:

1. Configure a certificate template (see Configuring a Certificate Template for IoT FND and the IoT FND TPS Proxy).
2. Open the Certificate Authority application on the Windows Server.
3. Expand the menu to view the Certificate Templates folder.
4. Right-click **Certificate Templates** and choose **New > Certificate Template to Issue** from the context menu.
5. In the Enable Certificate Templates window, highlight the new **NMS** template.
6. Click **OK**.

Generating Certificates for IoT FND and the IoT FND TPS Proxy

Follow the same steps for generating a certificate for IoT FND and for the TPS proxy by using the configuration template that you previously created.

Go through the steps in this section twice: once to generate the IoT FND certificate, and once to generate the TPS proxy certificate.

Tip: In 9.b the value you enter depends on whether you are creating a certificate for the IoT FND or the TPS proxy.

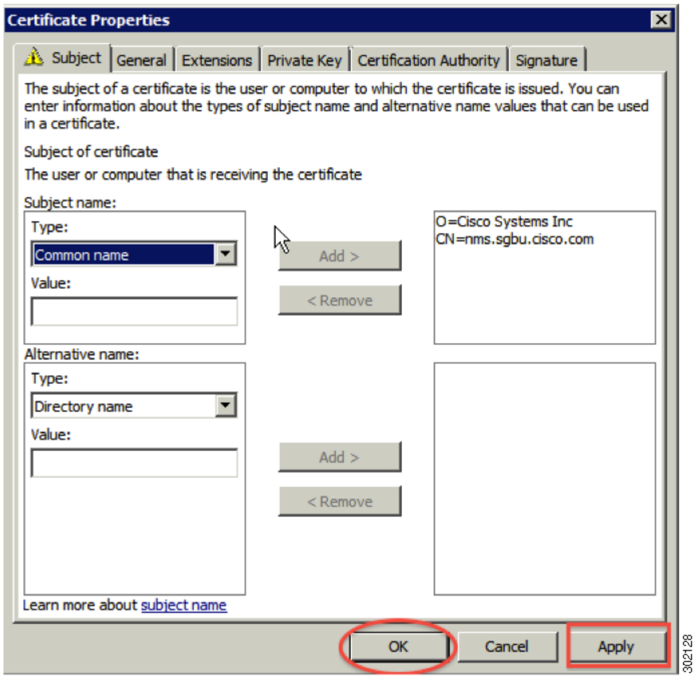
After creating these two certificates, securely transfer the IoT FND certificate to the IoT FND application server, and securely copy the TPS proxy certificate to the TPS proxy server.

To generate a certificate:

1. Configure a certificate template (see Configuring a Certificate Template for IoT FND and the IoT FND TPS Proxy).
2. Enable the certificate template (see Enabling a Certificate Template).
3. From a server running Windows Server 2008, choose **Start > Run** and enter **mmc** to open the MMC console.
4. In the Console 1 window, expand the **Certificates > Personal** folders.
5. Right-click **Certificates** and choose **All Tasks > Request New Certificate** from the context menu.
6. In the Before You Begin window, click **Next**.
7. In the Select Certificate Enrollment Policy window, choose **Active Directory Enrollment Policy**.
   Click **Next**.
8. In the Request Certificates window, do the following:
   a. Check the **NMS** check box.
   b. Click the **More information**... link.
9. In the Certificate Properties window, click the **Subject** tab, and do the following:
   a. From the Type drop-down menu, choose **Common name (CN)**.
   b. In the **Value** field, add the fully-qualified domain name (FQDN):
      - For IoT FND certificates, enter the FQDN of the IoT FND server for your deployment, for example: CN=nms.sgbu.cisco.com.
      - For TPS proxy certificates, enter the FQDN for the TPS proxy for your deployment, for example: CN= tps.sgbu.cisco.com.

   c. Click **Add** and the Common Name appears in the right-pane.
   d. From the Type drop-down menu, choose **Organization (O)**.
   e. In the **Value** field, add the company name or organization for the IoT FND or TPS proxy.
   f. Click **Add** and the organization appears in the right-pane.

Figure 1 Defining a Common Name and Organization for IoT FND



The subject of a certificate is the user or computer to which the certificate is issued. You can enter information about the types of subject name and alternative name values that can be used in a certificate.

Subject of certificate

The user or computer that is receiving the certificate

Subject name:

Type: Common name

Value:

O=Cisco Systems Inc
CN=nms.sgbu.cisco.com

Alternative name:

Type: Directory name

Value:

Learn more about subject name

10. Click **Apply**. Click **OK**.

11. In the Certificate Enrollment window, check the **NMS** check box and click **Enroll**.

12. After enrollment completes, click **Finish**.

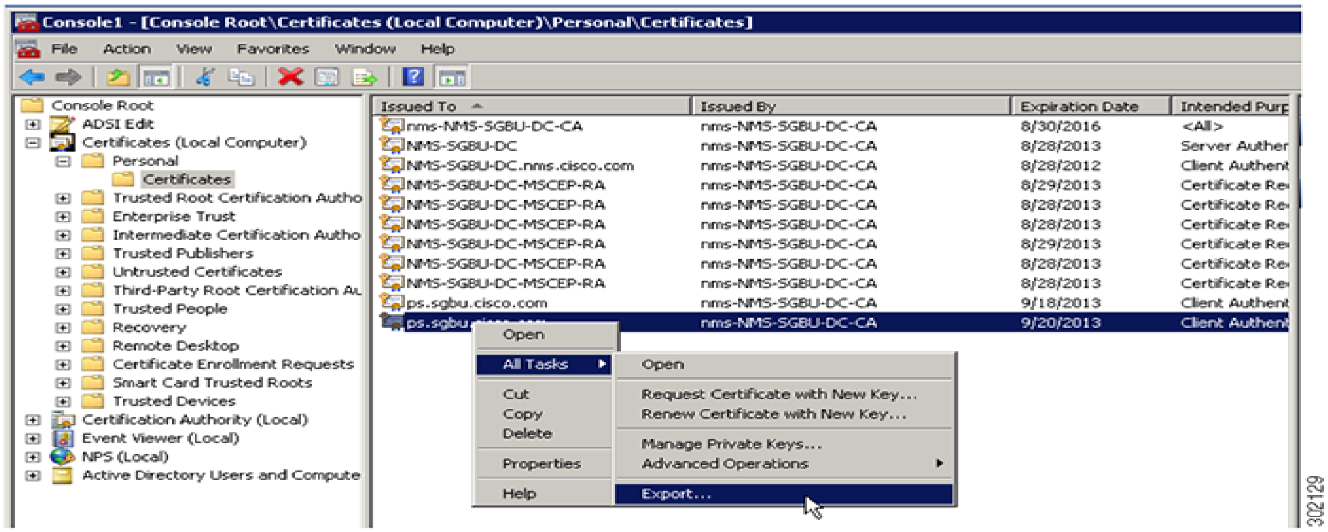
13. In the MMC console (Console 1), expand the **Certificates** folder.

14. Choose **Personal > Certificates**.

15. In the Issued To pane, right-click the new certificate and choose **All Tasks > Export** from the context menu.

    The Export Wizard window appears.

Figure 2 Issued To Pane Showing Supported Certificates


Console1 - [Console Root\Certificates (Local Computer)\Personal\Certificates]
File
Action
View
Favorites
Window
Help
Console Root
ADSI Edit
Certificates (Local Computer)
Personal
Certificates
Trusted Root Certification Autho
Enterprise Trust
Intermediate Certification Autho
Trusted Publishers
Untrusted Certificates
Third-Party Root Certification Au
Trusted People
Recovery
Remote Desktop
Certificate Enrollment Requests
Smart Card Trusted Roots
Trusted Devices
Certification Authority (Local)
Event Viewer (Local)
NPS (Local)
Active Directory Users and Compute
Open
All Tasks
Cut
Copy
Delete
Properties
Help
Open
Request Certificate with New Key...
Renew Certificate with New Key...
Manage Private Keys...
Advanced Operations
Export...
302129

Issued To	Issued By	Expiration Date	Intended Purp
nms-NMS-SGBU-DC-CA	nms-NMS-SGBU-DC-CA	8/30/2016	<All>
NMS-SGBU-DC	nms-NMS-SGBU-DC-CA	8/28/2013	Server Auther
NMS-SGBU-DC.nms.cisco.com	nms-NMS-SGBU-DC-CA	8/28/2012	Client Authent
NMS-SGBU-DC-MSCEP-RA	nms-NMS-SGBU-DC-CA	8/29/2013	Certificate Re
NMS-SGBU-DC-MSCEP-RA	nms-NMS-SGBU-DC-CA	8/28/2013	Certificate Re
NMS-SGBU-DC-MSCEP-RA	nms-NMS-SGBU-DC-CA	8/28/2013	Certificate Re
NMS-SGBU-DC-MSCEP-RA	nms-NMS-SGBU-DC-CA	8/29/2013	Certificate Re
NMS-SGBU-DC-MSCEP-RA	nms-NMS-SGBU-DC-CA	8/28/2013	Certificate Re
NMS-SGBU-DC-MSCEP-RA	nms-NMS-SGBU-DC-CA	8/28/2013	Certificate Re
ps.sgbu.cisco.com	nms-NMS-SGBU-DC-CA	9/18/2013	Client Authent
ps.sgbu.	nms-NMS-SGBU-DC-CA	9/20/2013	Client Authent

16. Initiate the Export Wizard.

17. At the Export Private Key window, select the **Yes, export the private key** radio button. Click **Next**.

18. At the Export File Format window, do the following:

    a. Click the **Personal Information Exchange** radio button.

    b. Check the **Include all certificates in the certification path if possible** check box.

    This option includes the full certificate chain within the certificate.

    c. Click **Next**.

19. In the password window, enter **keystore** and re-enter to confirm.

    The password is the default password that the IoT FND and the TPS proxy use to read this file.

20. Click **Next**.

21. In the File to Export window, enter the file name (such as *nms_cert* or *tps_cert*) and click **Next**.

22. In the Completing the Certificate Export Wizard, click **Finish**.

    Files with a *.pfx extension are automatically saved to the Desktop. PFX refers to the Personal Information Exchange format, which is also known as PKCS_#12 format. PFX is an industry-standard format that allows certificates and their private keys to be transferred (exported) from one computer to another.

23. Securely transfer the two certificate files (such as *nms_cert.pfx* and *tps_cert.pfx*) from the Windows Desktop to the IoT FND (*nms_cert.pfx*) and TPS proxy *(tps_cert.pfx*), respectively.

    Note: For heightened security, after a successful transfer delete the *.pfx files from the Windows Desktop and empty the Recycle bin.

Command Authorization Support

The Cisco Connected Grid Routers (CGRs) are managed by IoT FND over a WAN backhaul connection such as 3G, 4G, or WiMAX. For CG-OS CGRs, you define an OID value to enable administrative privileges for IoT FND.

The OID for this policy is 1.3.6.1.4.1.9.21.3.3.1. This element appears in the certificate if IoT FND is authorized to issue management commands to the CGR with administrative privileges. When IoT FND communicates with the CGR over a secured session, such as TLS, the CGR can execute these commands as if they were issued by the network administrator.

This section discusses the following topics:

- Enabling Command Authorization Using NMS/TPS Certificates
- Adding an OID Value to the CA Certificate
- Renewing Certificates

Enabling Command Authorization Using NMS/TPS Certificates

Follow this procedure to authorize the command authorization (CA) feature of the router, and complete registration with IoT FND.

1. Generate new NMS/TPS certificates (see Generating Certificates for IoT FND and the IoT FND TPS Proxy) or renew the existing NMS/TPS certificate (see Renewing Certificates).
2. Add an OID value to the CA certificate (see Adding an OID Value to the CA Certificate).
3. Generate a new .pfx file for the NMS/TPS certificate (see Generating Certificates for IoT FND and the IoT FND TPS Proxy).
4. Stop IoT FND (see Stopping IoT FND).
5. Rename the existing cgms_keystore file (for example, cgms_keystore_no_oid).
6. Export the .pfx file to IoT FND and create a new cgms_keystore file (see Using Keytool to Create the cgms_keystore File).
7. Install the new certificates (see Installing the Certificates).
8. Add the new cgms_keystore file to IoT FND (see Copying the cgms_keystore File to IoT FND).
9. Start IoT FND (see Starting IoT FND).
10. Register the routers with IoT FND.

Adding an OID Value to the CA Certificate

You must add an OID value to the CA certificate to allow IoT FND to use the admin role for command authorization on the router.

To add an OID value to the CA certificate:

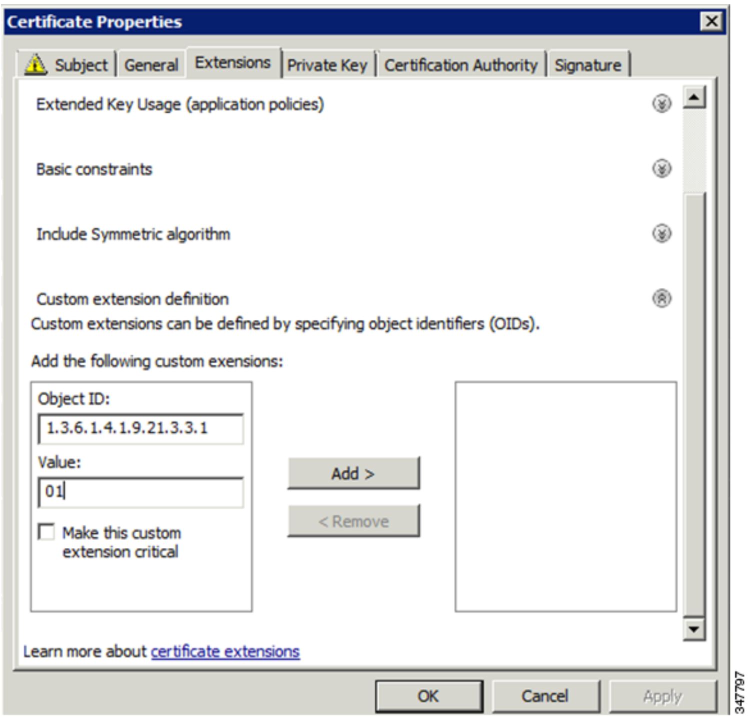
1. On the CA server, open a cmd console and type:

   ```
   certutil -setreg policy\EnableRequestExtensionList +1.3.6.1.4.1.9.21.3.3.1
   ```

2. Restart the CA.
3. In the Select Certificate Enrollment Policy window, choose **Active Directory Enrollment Policy** and click **Next**.
4. In the Request Certificates window, do the following:
   a. Check the **NMS** check box.
   b. Click the **More information**... link.

5. In the Certificate Properties window, click the **Subject** tab and complete the fields.

6. In the Certificate Properties window, click the **Extensions** tab and click the **Custom extension definition** button to expand the section.



Custom extensions can be defined by specifying object identifiers (OIDs).

Add the following custom exensions:

Object ID: 1.3.6.1.4.1.9.21.3.3.1

Value: 01

□ Make this custom extension critical

Learn more about certificate extensions

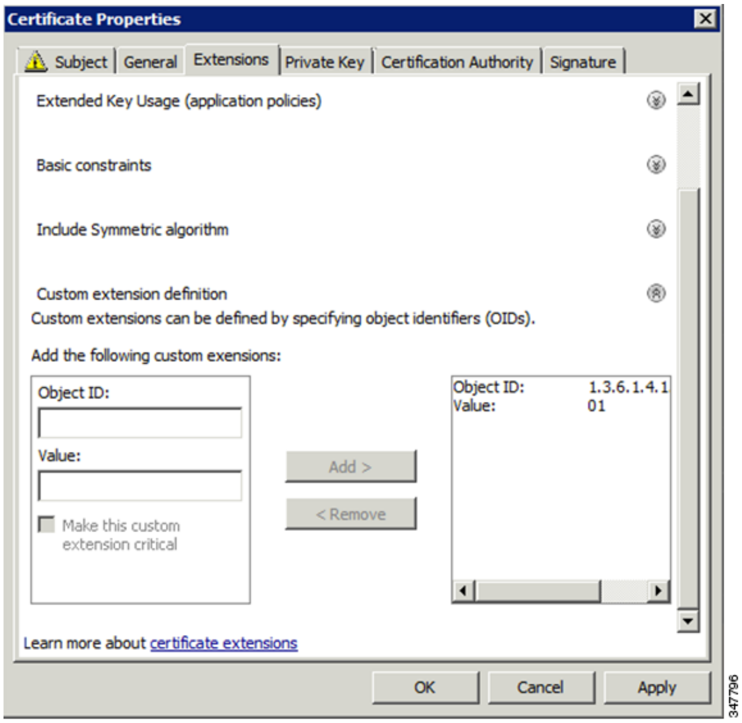
7. Type the following in the **Object ID** field:

```
1.3.6.1.4.1.9.21.3.3.1
```

8. In the **Value** field, type:

```
01
```

9. Click **Add**.



Custom extensions can be defined by specifying object identifiers (OIDs).

Add the following custom exensions:

Object ID: 1.3.6.1.4.1
Value: 01

Learn more about certificate extensions

The OID and Value are added to the field at the right as custom extensions.

10. Ensure that these values are correct, and then click **Apply**.

Renewing Certificates

To renew certificates and add the OID value:

1. From the RSA CA server with the original NMS/TPS certificate, type the following open command at the command prompt:

```
certutil -setreg policy\EnableRequestExtensionList +1.3.6.1.4.1.9.21.3.3.1
```

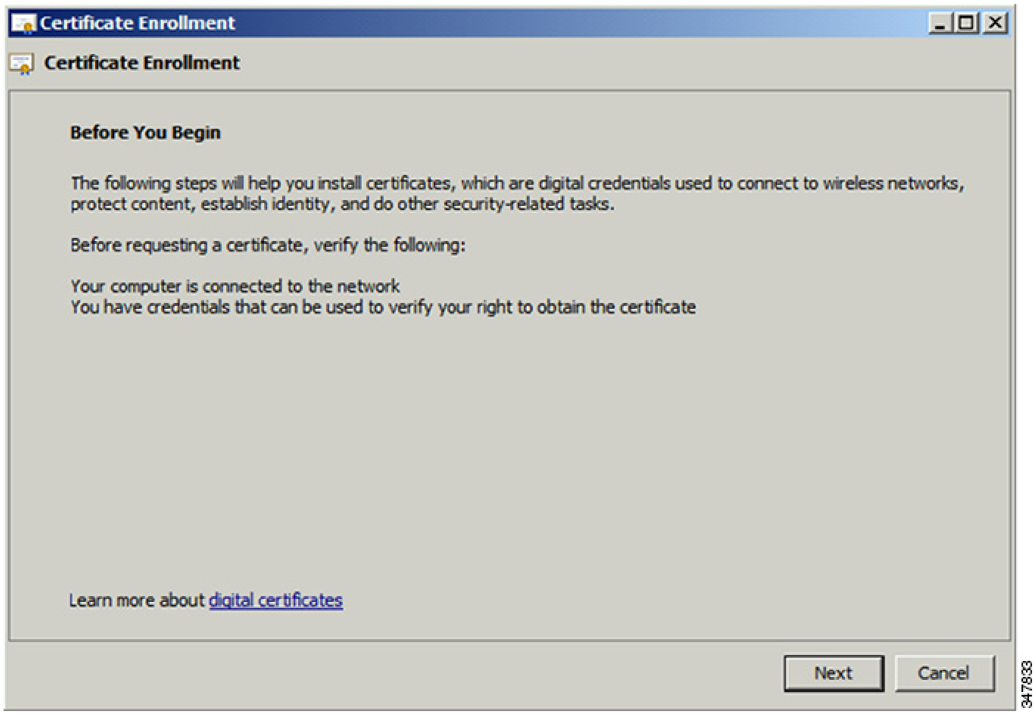
2. Restart the CA server.

3. Open the certificate console in the MMC.

4. Locate the issued NMS/TPS certificate in the Personal folder on the CA server.

5. Right-click on the server icon, and select **All Tasks > Advanced Operations > Renew This Certificate with the Same Key** option from the context menu.

6. In the Certificate Enrollment window, click **Next**.



Before You Begin

The following steps will help you install certificates, which are digital credentials used to connect to wireless networks, protect content, establish identity, and do other security-related tasks.

Before requesting a certificate, verify the following:

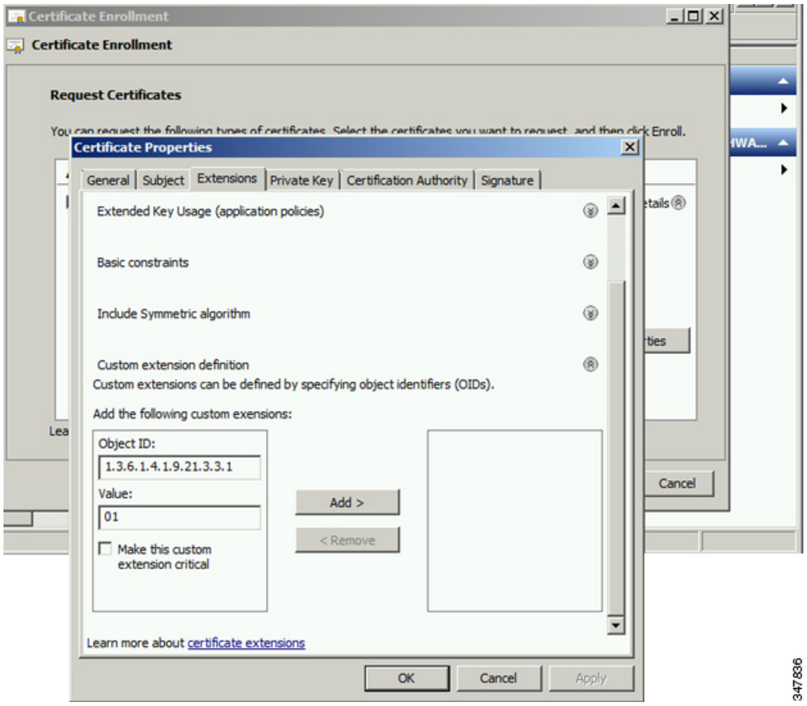
Your computer is connected to the network
You have credentials that can be used to verify your right to obtain the certificate

Learn more about digital certificates

7. Click **Details**.

8. Click **Properties**.

9. Enter the OID and its value, and click **OK**.



Request Certificates

You can request the following types of certificates. Select the certificates you want to request, and then click Enroll.

Extended Key Usage (application policies)

Basic constraints

Include Symmetric algorithm

Custom extension definition

Custom extensions can be defined by specifying object identifiers (OIDs).

Add the following custom exensions:

Object ID: 1.3.6.1.4.1.9.21.3.3.1

Value: 01

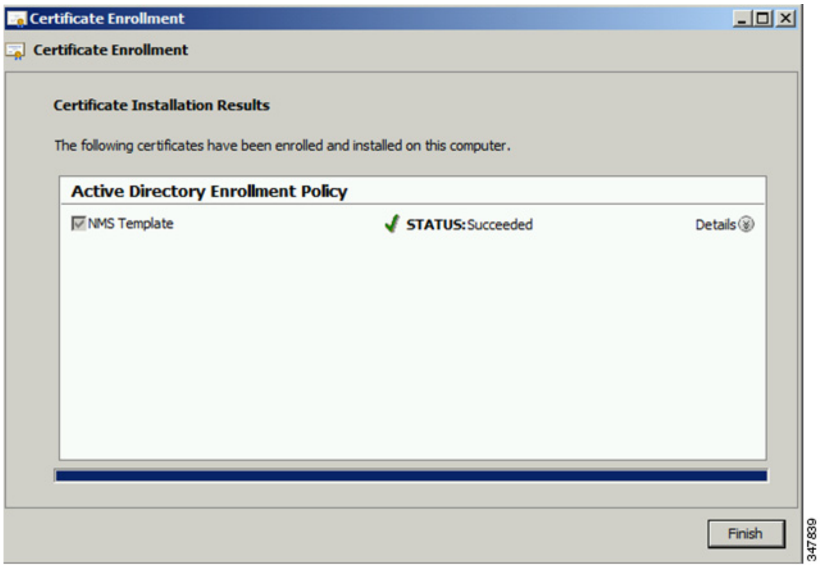
□ Make this custom extension critical

Learn more about certificate extensions

10. Click **Add >**, and then click **OK**.

11. At Request Certificates panel, click **Enroll**.

12. Click **Finish**.



Certificate Enrollment

Certificate Enrollment

Certificate Installation Results

The following certificates have been enrolled and installed on this computer.

Active Directory Enrollment Policy

☑ NMS Template ✓ STATUS: Succeeded Details

13. Verify that the certificate contains the OID value.

Configuring a Custom CA for HSM

This section describes configuring a custom CA for the hardware security module (HSM) for signing CSMP messages sent from IoT FND to mesh devices.

BEFORE YOU BEGIN

- Ensure that you install the SafeNet client software version listed in the system requirements in the IoT FND Release Notes on the IOT-FND server.
- You must have your own CA (for example, Microsoft or OpenSSL).

To configure a custom CA for generating HSM certificates:

1. Create a new partition on the HSM and assign it to your IoT FND client (see Setting Up an HSM Client).
2. Generate a keypair on the HSM and export a CSR for that keypair (see Keystore).

   All commands run from the Luna client on the IoT FND server. You do not have to log in to the HSM machine.

```
[root@<user>-scaledb bin]# cd /usr/safenet/lunaclient/bin/

# Generate a Key Pair (a set of private and public keys. You MUST provide explicit labels to the
private and public keys)
[root@<user>-scaledb bin]# ./cmu generatekeypair -sign=T -verify=T -labelpublic="nms_public_key"
-labelprivate="nms_private_key"
Please enter password for token in slot 1 : ********
Enter key type - [1] RSA  [2] DSA [3] ECDSA : 3    <--- Choose option 3
Enter curve type [1] NISTP 192
                 [2] NISTP 224
                 [3] NISTP 256
                 [4] NISTP 384
                 [5] NISTP 521

Enter curve type [1] NISTP 192
                 [2] NISTP 224
                 [3] NISTP 256   <--- Choose option 3
                 [4] NISTP 384
                 [5] NISTP 521
 (1 to 5) 3
[root@<user>-scaledb bin]#

# Test if the keypair exists on the HSM partition

[root@<user>-scaledb bin]# ./cmu list
Please enter password for token in slot 1 : ********
handle=2000001    label=nms_public_key
handle=2000002    label=nms_private_key

# Now, export a certificate signing request for this keypair. Note that the specific fields for DN
and handle may be different for your HSM. Fill appropriately.

[root@<user>-scaledb bin]#./cmu requestcertificate
Please enter password for token in slot 1 : ********
Select the private key for the request :

Handler    Label
2000002    nms_private_key
Enter handler (or 0 for exit) : 2000002
Enter Subject 2-letter Country Code (C) : US
Enter Subject State or Province Name (S) : CA
Enter Subject Locality Name (L) : San Jose
Enter Subject Organization Name (O) : Cisco Systems Inc.
Enter Subject Organization Unit Name (OU) : IOTSSG
Enter Subject Common Name (CN) : IOT-FND-HSM
Enter EMAIL Address (E) :
Enter output filename : hsm.csr
[root@<user>-scaledb bin]#

# Verify the file exists and has properly formatted content

[root@<user>-scaledb bin]# ls hsm.csr
hsm.csr

[root@<user>-scaledb bin]# cat hsm.csr
-----BEGIN NEW CERTIFICATE REQUEST-----
MIIBKzCB0QIBADBvMQswCQYDVQQGEwJVUzELMAkGA1UECBMCQ0ExETAPBgNVBAcT
CFNhbiBKb3NlMRowGAYDVQQKExFDaXNjbyBTeXN0ZW1zIEluYzEPMA0GA1UECxMG
SW9UU1NHMRMwEQYDVQQDEwpDRy1OTVMtSFNNMFkwEwYHKoZIzj0CAQYIKoZIzj0D
AQcDQgAESfdlrrcVtzN3Yexj9trlI5qd0w5Sdu8Vj2s17JAF/vPFUOYIw/uXwD6+
bb8vq3WHlA6tmgRbj+FU6G3Bmt/vCqAAMAsGByqGSM49BAEFAANIADBFAiEAroJO
qz3dHA2GLrGzBmUO1vYys642Nkb4B4qyEoUZIGsCIFs0iTUyGQreM1BaSDEPHArZ
RvFlrKo/Zi3c8O4gzFZW
-----END NEW CERTIFICATE REQUEST-----
```

3. Save the generated CSR to your CA and sign the certificate.

   Note: Ensure that the certificate is signed for 30 years. Mesh nodes reject any certificate signed for less than 30 years. You can use the root CA that is used for 802.1x authentication for node admission.

4. Copy the signed certificate to the IoT FND server and import it to the HSM.

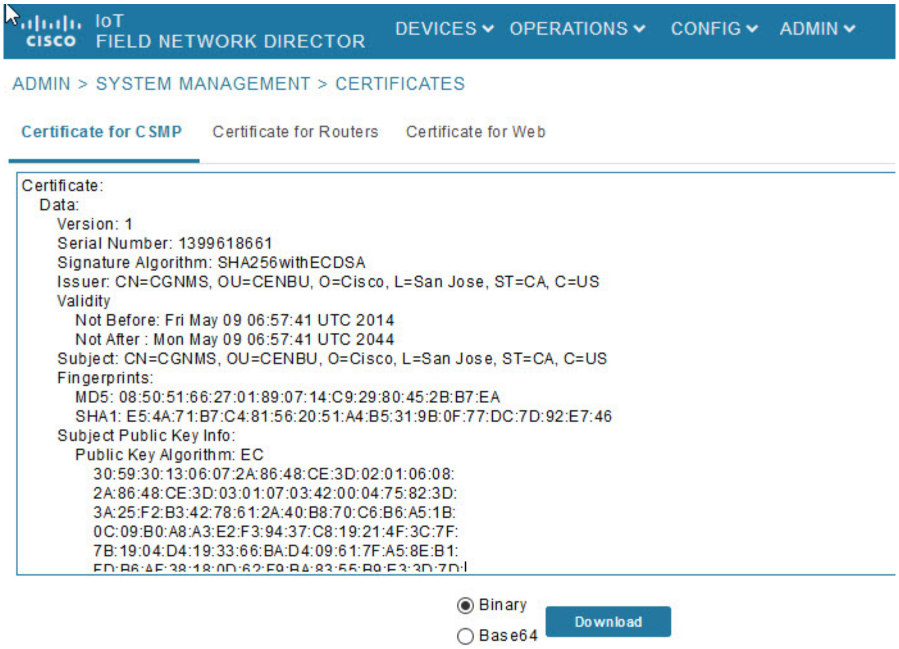
   ```
   [root@<user>-scaledb bin]# ./cmu import
   Please enter password for token in slot 1 : ********
   Enter input filename : <your file name with signed certificate>

   # Verify that the certificate was imported

   [root@<user>-scaledb bin]# ./cmu list
   ```

```
Please enter password for token in slot 1 : ********
handle=2000001    label=nms_public_key
handle=2000002    label=nms_private_key
handle=2000003    label=IOT-FND-HSM    <--- This is my certificate with label = CN
```

5. Configure IoT FND to use this new certificate.

```
[root@kartven2-nms ~]# service cgms stop
[root@kartven2-nms ~]# cd /opt/cgms/server/cgms/conf/

# Add following properties to the cgms.properties file

hsm-private-key-label=nms_private_key     <--- private key label you gave to your public key
hsm-public-key-label=nms_public_key       <--- public key label you gave to your public key
hsm-cert-label=IOT-FND-HSM                <--- label for your signed certificate
hsm-keystore-name=customca-group          <--- your HA partition group
hsm-keystore-password=2bVvZsq+vsq94YxuAKdaag==   <--- encrypted password for the partition

[root@kartven2-nms conf]# service cgms start
[root@kartven2-nms conf]#
```

6. Verify that the certificate appears on the **Certificates for CSMP** tab (**ADMIN > System Management > Certificates**).



```
Certificate:
   Data:
      Version: 1
      Serial Number: 1399618661
      Signature Algorithm: SHA256withECDSA
      Issuer: CN=CGNMS, OU=CENBU, O=Cisco, L=San Jose, ST=CA, C=US
      Validity
         Not Before: Fri May 09 06:57:41 UTC 2014
         Not After : Mon May 09 06:57:41 UTC 2044
      Subject: CN=CGNMS, OU=CENBU, O=Cisco, L=San Jose, ST=CA, C=US
      Fingerprints:
         MD5: 08:50:51:66:27:01:89:07:14:C9:29:80:45:2B:B7:EA
         SHA1: E5:4A:71:B7:C4:81:56:20:51:A4:B5:31:9B:0F:77:DC:7D:92:E7:46
      Subject Public Key Info:
         Public Key Algorithm: EC
            30:59:30:13:06:07:2A:86:48:CE:3D:02:01:06:08:
            2A:86:48:CE:3D:03:01:07:03:42:00:04:75:82:3D:
            3A:25:F2:B3:42:78:61:2A:40:B8:70:C6:B6:A5:1B:
            0C:09:B0:A8:A3:E2:F3:94:37:C8:19:21:4F:3C:7F:
            7B:19:04:D4:19:33:66:BA:D4:09:61:7F:A5:8E:B1:
            FD:B6:AF:38:18:0D:62:F9:BA:83:55:B9:F3:3D:7D:
```

7. Configure your mesh nodes to use this certificate for signatures.

Configuring a Custom CA for SSM

This section describes configuring a custom CA for the software security module (SSM) for signing CSMP messages sent from IoT FND to mesh devices.

BEFORE YOU BEGIN

- Ensure that you install the SafeNet client software version listed in the system requirements in the IoT FND Release Notes on the IOT-FND server.
- Only SSM versions 2.2.0-37 and above are supported.

- You must have your own CA (for example, Microsoft or OpenSSL).

To configure a custom CA for generating SSM certificates:

1. Stop the ssm service.

   ```
   [root@nms-rhel-6-6 ~]# stop ssm
   ```

2. Use the ssm_setup.sh script to configure a new keypair with a specific alias and generate a CSR:

   ```
   [root@nms-rhel-6-6 ~]# cd /opt/cgms-ssm/bin/
   [root@nms-rhel-6-6 bin]# ./ssm_setup.sh


   Software Security Module Server

   1.Generate a new keyalias with self signed certificate for CSMP

   2.Generate a new keypair & certificate signing request for CSMP   <--- Choose option 2

   3.Import a trusted certificate

   4.Change CSMP keystore password

   5.Print CG-NMS configuration for SSM

   6.Change SSM server port

   7.Change SSM-Web keystore password


   Select available options.Press any other key to exit


   Enter your choice : 2
   Warning: This action will modify ssm_csmp_keystore file. Backup the file before performing this
   action.
   Do you want to proceed (y/n): y

   Enter current ssm_csmp_keystore password :
   Enter a new key alias name (8-16): ssmcustomca
   Enter key password (8-12):

   Enter certificate issuer details

   Enter common name CN [Unknown]: IOT-FND-SSM

   Enter organizational unit name OU [Unknown]: IOTSSG

   Enter organization name O [Unknown]: Cisco Systems Inc.

   Enter city or locality name L [Unknown]: San Jose

   Enter state or province name ST [Unknown]: CA

   Enter country code for this unit C [Unknown]: US


   Is [CN=IOT-FND-SSM, OU=IOTSSG, O=Cisco Systems Inc., L=San Jose, ST=CA, C=US] correct (y/n)? :y
   Certificate Signing Request file name: /opt/ssmcustomca.csr
   Succefully generated keypair with alias ssmcustomca. You can use the CSR from /opt/ssmcustomca.csr
   for signature by certificate authority
   [root@nms-rhel-6-6 bin]#
   ```

3. Save the generated CSR to your CA and sign the certificate.

   Note: Ensure that the certificate is signed for 30 years. Mesh nodes reject any certificate signed for less than 30 years. You can use the root CA that is used for 802.1x authentication for node admission.

4. Copy the signed certificate to the IoT FND server and import it to the SSM.

5. Use the ssm_setup.sh script to import the two certificates to the SSM keystore:

```
[root@nms-rhel-6-6 bin]# ./ssm_setup.sh


Software Security Module Server

1.Generate a new keyalias with self signed certificate for CSMP

2.Generate a new keypair & certificate signing request for CSMP

3.Import a trusted certificate   <--- Choose option 3

4.Change CSMP keystore password

5.Print CG-NMS configuration for SSM

6.Change SSM server port

7.Change SSM-Web keystore password


Select available options.Press any other key to exit


Enter your choice : 3

Enter current ssm_csmp_keystore password :
Enter the alias for import: root
Certificate file name: /opt/ca.crt
Certificate reply was installed in keystore
Succefully imported certificate into alias root
```

6. Use the ssm_setup.sh script to import the signed certificate for the alias:

```
[root@nms-rhel-6-6 bin]# ./ssm_setup.sh


Software Security Module Server

1.Generate a new keyalias with self signed certificate for CSMP

2.Generate a new keypair & certificate signing request for CSMP

3.Import a trusted certificate   <--- Choose option 3

4.Change CSMP keystore password

5.Print CG-NMS configuration for SSM

6.Change SSM server port

7.Change SSM-Web keystore password


Select available options.Press any other key to exit
```

```
Enter your choice : 3

Enter current ssm_csmp_keystore password :
Enter the alias for import: ssmcustomca
Certificate file name: /opt/ssmcustomca.crt
Certificate reply was installed in keystore
Succefully imported certificate into alias ssmcustomca
```

7. Update cgms.properties file with following parameters to configure IoT FND to use this certificate on the SSM for signatures:

```
security-module=ssm
ssm-host=172.27.163.153
ssm-port=8445
ssm-keystore-alias=ssmcustomca
ssm-keystore-password=GgeQJAOk3fSIH97qJARGRA==
ssm-key-password=GgeQJAOk3fSIH97qJARGRA==
```

8. Verify that the certificate appears on the **Certificates for CSMP** tab (**ADMIN >System Management > Certificates**).

9. Configure your mesh nodes to use this certificate for signatures.

Exporting the CA Certificate

To export the certificate from the Certificate Authority or subordinate CA to the IoT FND:

1. Open the Certificate Authority application on a Windows Server 2008 R2 system operating with the Enterprise Edition.

2. Expand the menu to view the **Certificates (Local Computer) > Personal > Certificates** folder.

3. Locate the certificate whose fingerprint matches that in use by the Cisco CGR 1000 and Cisco ASR.

4. Right-click the certificate and choose **All Tasks > Export** from the context menu.

5. In the Certificate Export Wizard window, click **Next**.

6. In the Export Private Key window, select the **No, do not export the private key** radio button. Click **Next**.

7. In the Export File Format window, select the **Base-64 encoded X.509 (.CER)** radio button. Click **Next**.

8. In the File to Export window, assign a name for the file that you want to export. Click **Next**.

9. In the File to Export window, enter the file name (such as *ca_cert* or *subca_cert*) and click **Next**.

10. In the Completing the Certificate Export Wizard, click **Finish**.

Files with a *.cer extension are automatically saved to the Desktop.

11. Securely transfer the certificate file (such as *ca_cert.cer*) from the Windows Desktop to IoT FND.

Note: For heightened security, after a successful transfer delete the *.cer file from the Windows Desktop and empty the Recycle bin.

Installing the Certificates

You must create a cgms_keystore file on both the servers running IoT FND and IoT FND TPS Proxy.

- **IoT FND**–When creating the cgms_keystore file, you import the IoT FND certificate, its private key, and the certificate chain. After creating the cgms_keystore file, you copy it into a specific directory on the server.
- **IoT FND TPS Proxy**–When you create the cgms_keystore file, you import the IoT FND TPS Proxy certificate, its private key, and the certificate chain. After you create the cgms_keystore file, you copy it into a specific directory on the TPS proxy.

To create the cgms_keystore file for the TPS proxy and IoT FND, use Keytool and complete the following procedures:

BEFORE YOU BEGIN

Determine the password to use for the keystore. The examples in this chapter refer to this password as *keystore_password*.

- Using Keytool to Create the cgms_keystore File
- Copying the cgms_keystore File to IoT FND
- Importing the CA Certificate
- Installing Custom Browser Certificates

Using Keytool to Create the cgms_keystore File

To create the cgms_keystore file for both IoT FND and the TPS proxy:

1. As root, view the contents of the .pfx file by entering the following command on the server (IoT FND and TPS proxy):

[root@*tps_server* **~]# keytool -list -v -keystore nms_cert.pfx -srcstoretype pkcs12**

Note: Viewing the .pfx provides the Alias Name required during the import.

2. Enter the keystore password when prompted.

This is the same password entered when creating the .pfx file.

The information that displays (see the following Example) includes the alias_name needed for 3.

3. Enter the following command to import the certificates into the cgms_keystore file:

```
keytool -importkeystore -v -srckeystore filename.pfx -srcstoretype pkcs12
-destkeystore cgms_keystore -deststoretype jks -srcalias alias_name -destalias cgms
-destkeypass
keystore_password
```

4. At the prompt, enter the destination keystore password.
5. Re-enter the keystore password when prompted.
6. Enter the password used when creating the .pfx file (either *nms_cert.pfx* or *tps_cert.pfx*) when prompted for the source keystore password.

Note: In this example, **keystore** was the password when we created the *.pfx* file.

Example

To view the *nms_cert.pfx* file and access the Alias name, enter the following commands as root:

Note: This example shows the steps for the *nms_cert.pfx*. To view the details on the *tps_cert.pfx* and import the certificates to the TPS proxy, use the same commands but replace the references to *nms_cert.pfx* with *tps_cert.pfx*, and use the Alias name from the *tps_cert.pfx* file.

```
# keytool -list -v -keystore nms_cert.pfx -srcstoretype pkcs12
Enter keystore password: keystore
Keystore type: PKCS12
Keystone provider: SunJSSE
Your keystore contains 1 entry
Alias name: le-cgnms-75edd1e3-7e65-41b4-97f1-a913ebf21c8b
Creation date: March 29.2012
Entry type: PrivateKey Entry
Certificate chain length: 3
Certificate[1]:
Owner: CN=nms.sgbu.cisco.com
Issuer: CN=cisco-RSA-SUBCA-CA, DC=cisco, DC=com
...
```

To import the certificates to the **cgms_keystore** file on IoT FND, enter the following commands as root:

```
# keytool -importkeystore -v -srckeystore nms_cert.pfx -srcstoretype pkcs12
-destkeystore cgms_keystore -deststoretype jks -srcalias
le-cgnms-75edd1e3-7e65-41b4-97f1-a913ebf21c8b -destalias cgms
-destkeypass
keystore_password

Enter destination keystore password: keystore_password
Re-enter new password: keystore_password
Enter source keystore password: keystore
...Storing cgms_keystore
```

Note: The **storing *cgms*_keystore** text indicates successful completion.

Copying the cgms_keystore File to IoT FND

To copy the **cgms_keystore** file into the following IoT FND and TPS proxy directories:

1. For IoT FND, copy the cgms_keystore file to this directory: **/opt/cgms/server/cgms/conf/**
2. For the TPS proxy, copy the cgms_keystore file to this directory: **/opt/cgms-tpsproxy/conf/**

Note: For these certificates to be active and enforceable, they must be in the correct directory.

Importing the CA Certificate

In addition to importing the NMS certificate, you must import the CA or (subCA) certificate to the cgms_keystore.

To import the CA certificate into the cgms_keystore:

1. On the IoT FND application server, log in as root.
2. Change directory to /opt/cgms/server/cgms/conf, where you have placed the cgms_keystore file:

```
# cd /opt/cgms/server/cgms/conf
```

3. Import the CA certificate:

```
# keytool -import -trustcacerts -alias root -keystore cgms_keystore -file ca_cert.cer
```

A script displays on the screen.

4. Enter the keystore password when prompted.
5. Re-enter the password.
6. Enter **yes** when prompted to trust the certificate.

The certificate is added to the Keystore.

Example

To import the CA certificate, enter the following commands as root:

```
# keytool -import -trustcacerts -alias root -keystore cgms_keystore -file ca_cert.cer
Enter keystore password: keystore_password
Owner:  CN=SGBUNMSCA-WIN-4BGS4M94L66-CA,DC=SGBUNMSCA,DC=lab,DC=co
Issuer: CN=SGBUNMSCA-WIN-4BGS4M94L66-CA,DC=SGBUNMSCA,DC=lab,DC=co
Serial number:50adbd57e6b136984f9c1512a0eb7174
Valid from: Wed Jan 11 10:58:09 PDT 2012 until: Wed Jan 11:08:59 PDT 2016
Certificate _fingerprints:
    MD5: AE:5D:F4:0A:2B:E5:C8:D8:4A:F4:18:56:FD:A7:8D:7D
    SHA1: 83:22:12:8C:6A:23:D3:08:2B:00:55:EF:BD:FF:BA:47:97:99:7E:41
    Signature algorithm name: SHA1withRSA
    Version:3

Extensions:
#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
CA:true
PathLen:2147483647
]
#2:ObjectId: 2.5.29.15 Criticality=false
KeyUsage[
DigitalSignature
Key_CertSign
Crl_Sign
]
#3:ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000:C6 AB 38 CC EE 79 B0 51 3B 4D 13 c8 9A 56 F6 73 ..8..y.Q;M...V.s
0010:B9 19 FF 7B                      ....
]
]
#4: ObjectId:1.3.6.1.4.1.311.21.1 Criticality=false
Trust this certificate [no] yes
Certificate was added to the keystore.
```

Importing the CA Certificate into the IoT FND TPS Proxy Keystore

Follow the same steps as in Importing the CA Certificate to import the CA certificate into cgms_keystore on the IoT FND TPS proxy.

Installing Custom Browser Certificates

Default IoT FND installations use a self-signed certificate for HTTP(S) communication using either a client Web browser or the NB API client. If required, you can use certificates signed by your CA servers. This section presents installation procedures for these custom certificates.

This section covers the following topics:

- Installing Custom Certificates in the Browser Client
- Importing Custom Certificates with the North Bound API Client (Windows)
- Importing Custom Certificates with Windows IE
- Managing Custom Certificates

- Managing North Bound API Events

BEFORE YOU BEGIN

- Clear the client browser cache.
- Remove existing certificates for the NMS server (by IP and DNS) on the client browser.

  In Firefox for example, select **Preferences > Advanced > Encryption > View Certifications**. Remove the certificates in the list for the respective server.
- Choose a common name to use in the signed certificate.

  This name requires a DNS entry that resolves to the NMS server IP address.
- Generate the new certificates and export them to a .PFX file.

  This file must contain the private keys, public certificate, and CA server certificates.

  See Using Keytool to Create the cgms_keystore File for the procedure to generate the private and public keys for the cgms_keystore file and export them to a .PFX file.

Installing Custom Certificates in the Browser Client

1. On the NMS server, copy the existing jbossas.keystore and jbossas.keystore.password files from the /opt/cgms/server/cgms/conf/ directory to a safe location.
2. Delete the existing jbossas.keystore and jbossas.keystore.password files from the /opt/cgms/server/cgms/conf / directory.
3. Determine the alias in the .PFX file that you plan to import into the jbossas.keystore file:

   ```
   #keytool -list -v -keystore newcert.pfx -storetype pkcs12
   ```

   Enter the keystore password: ***keystore_password_when_pfx_file_was_created***

   ```
   Keystore type: PKCS12
   Keystore provider: SunJSSE

   Your keystore contains 1 entry

   Alias name: le-nms-a88ef13a-a519-457f-a2e1-0540f5453ee0
   Creation date: Feb 23, 2016
   Entry type: PrivateKeyEntry
   Certificate chain length: 2
   Certificate[1]:
   …
   ```
4. Import the new custom certificate, in .pfx file format into a new jbossas.keystore file; and, at the same time change the alias name to **jboss**. Follow the prompts:

   ```
   # keytool -importkeystore -v -srckeystore newcert.pfx -srcstoretype pkcs12
   -destkeystore /opt/cgms/server/cgms/conf/jbossas.keystore -deststoretype jks
   -srcalias le-nms-a88ef13a-a519-457f-a2e1-0540f5453ee0 -destalias
   jboss -destkeypass your_keystore_password
   Enter destination keystore password: your_keystore_password
   Enter source keystore password: keystore_password_when_pfx_file_was_created
   [Storing /opt/cgms/server/cgms/conf/jbossas.keystore]
   ```
5. (Optional) Define a salt.

   Note: If salt is unchanged, then you can skip this step.

The salt defines the strength of the encrypted password and must be at least 8 characters long.
For example: A1a1B2b2C3c3D4dE5e5F6f6G7g7H8h8I9i9J10j10K11k11L12l12M13m13N14n14O15

a. Copy the file /opt/cgms/server/cgms/deploy/security-service.xml to a safe location.

b. Update the salt in the /opt/cgms/server/cgms/deploy/security-service.xml file.

NOTE: Select *either* Step 6 *or* Step 7 below, based on the NMS release you are running.

6. **CG-NMS Releases *earlier* than 2.1.0** store the keystore password in the following file: /opt/cgms/server/cgms/conf/jbossas.keystore.password

   This step encrypts the password that will be stored in the jbossas.keystore.password file.

   The password is used to open the jbossas.keystore that has the new custom certificate imported in Step 4.

   a. Run /opt/cgms/bin/encrypt-password.sh script with the following parameters:

   – Specify the new salt defined in step 5. or use the existing one in the /opt/cgms/server/cgms/deploy/security-service.xml file.

   – Set count to 1024.

   – Set the password file to jbossas.keystore.password.

   – Set your_keystore_password.

```
#./encrypt-password.sh
A1a1B2b2C3c3D4dE5e5F6f6G7g7H8h8I9i9J10j10K11k11L12l12M13m13N14n14O15 1024 jbossas.keystore.password
your_keystore_password
```

   b. Move or copy the jbossas.keystore.password to the /opt/cgms/server/cgms/conf directory.

   c. Go to Step 8.

7. **CG-NMS releases *later* than 2.1.0 or IoT FND 3.0 release or later,** store the keystore password in the /opt/cgms/server/cgms/conf/VAULT.dat file

   Perform the following steps to update the password to match the one entered in Step 4 (***your_keystore_password***):

   a. Backup the VAULT.dat and vault.keystore files in /opt/cgms/server/cgms/conf to a safe location.

   b. Update the VAULT.dat file with the new password:

```
#/opt/cgms/bin/vault.sh -k /opt/cgms/server/cgms/conf/vault.keystore -p cgms123
-e /opt/cgms/server/cgms/conf -i 50 -s 12345678 -v vault -b your_keystore_password
-a password -x your_keystore_password
```

   where vault.keystore contains the reference to VAULT.dat and VAULT.dat stores and hides the jboss keystore password. This command creates a new VAULT.dat file that contains the new jboss.keytsore password. The default password to open vault.keystore is cgms123.

8. Restart IoT FND:

```
# service cgms restart
```

9. Use your browser to connect to the NMS server.

10. Accept and add the new certificates.

11. Use your browser to log in to IoT FND.

Importing Custom Certificates with the North Bound API Client (Windows)

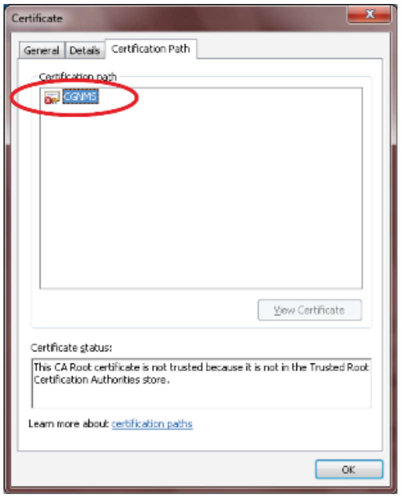
For an NB API client running on a Windows Server, import the CA public certificate to the Certificate Store on your local computer. Matching CA public certificates ensures that the client machine communicates with IoT FND using the NB API client.

Importing Custom Certificates with Windows IE

1. In IE, enter the https URL address of the NMS server.

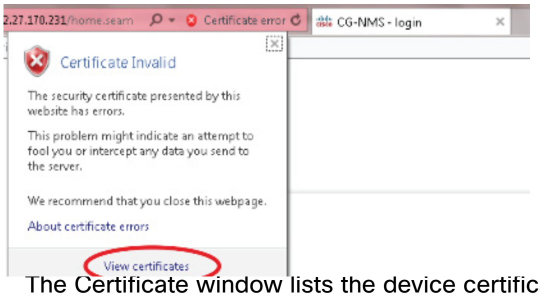
   The URL name must match the Common Name on the NMS Server certificate.

2. In the Security Alert window, click OK.
3. In the security certificate warning window, click the **Continue to this Website (Not Recommended)** link.
4. In the Security Alert window, click **OK**.
5. Click the **Certificate error** section of the address bar.



This CA Root certificate is not trusted because it is not in the Trusted Root Certification Authorities store.

6. In the Certificate Invalid window, click **View certificates**.



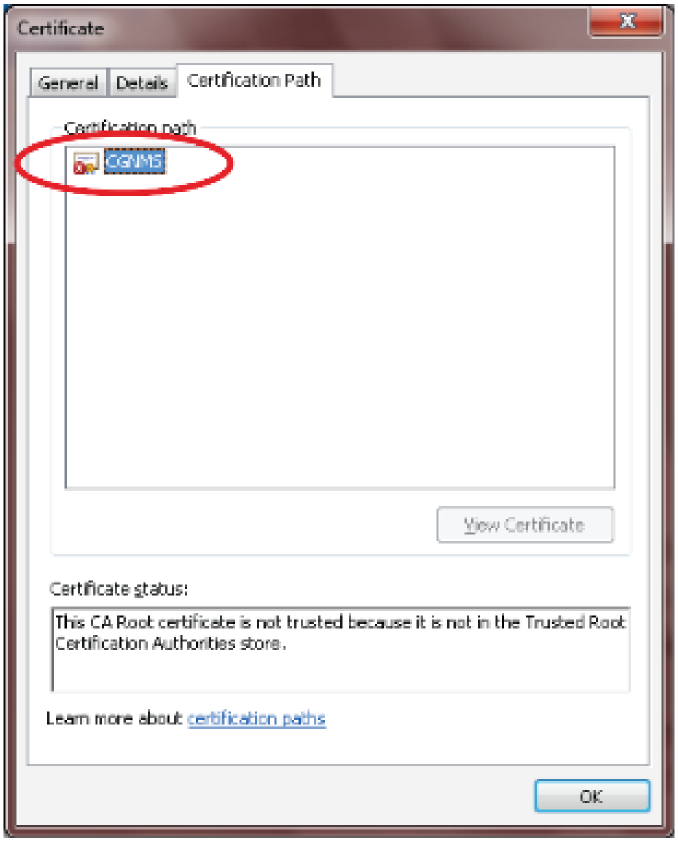
The security certificate presented by this website has errors.

This problem might indicate an attempt to fool you or intercept any data you send to the server.

We recommend that you close this webpage.

   The Certificate window lists the device certificate issued to the NMS server and signed by the issuing CA (or sub CA) server.

7. Select the **Certification Path** tab, and look for the invalid certificate (that is, the one with a red cross).

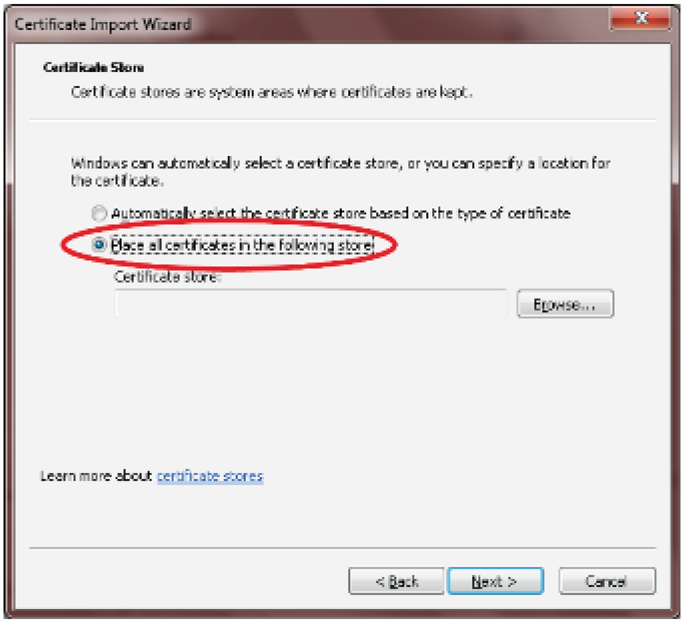


Certificate status:

This CA Root certificate is not trusted because it is not in the Trusted Root Certification Authorities store.

Learn more about certification paths

8. Select the invalid certificate, and select the **General** tab.
9. Click **Install Certificate**.
10. In the Certificate Install Wizard window, click **Next**.
11. Select the **Place all certificates in the Following Store** option, and then click **Browse**.



Certificate Import Wizard

Certificate Store

Certificate stores are system areas where certificates are kept.

Windows can automatically select a certificate store, or you can specify a location for the certificate.

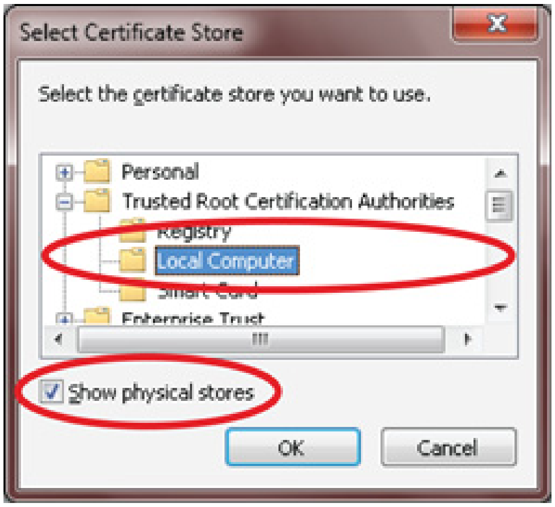
○ Automatically select the certificate store based on the type of certificate

● Place all certificates in the following store

Certificate store:

Learn more about certificate stores

12. In the Certificate Store window, check the **Show physical stores** check box, open the Trusted Root Certification Authorities folder, select **Local Computer**, and then click **OK**.



Select Certificate Store

Select the certificate store you want to use.

☑ Show physical stores

13. Click **Next**.

14. Click **Finish**.

15. Click **OK**.

16. In the Certificate window, click **Install Certificate**.

17. Select the **Place all certificates in the Following Store** option, and then click **Browse**.

18. In the Certificate Store window, check the **Show physical stores** check box, open the Trusted Root Certification Authorities folder, select **Local Computer**, and then click **OK**.

19. Click **Next**.

20. Click **Finish**.

21. Click **OK**.
22. In the Certificate window, click **OK**.
23. Repeat the previous steps if the Certificate error section of the address bar still appears.
    - Ensure that the device certificate issued to the NMS server and signed by the issuing CA (or sub CA) displays server in the Certificate window.
    - Select the Certification Path tab and verify that all certificates in the path are valid (that is, there are no red crosses on the certificates).
24. Close and restart the browser.
25. Enter the IoT FND server secure URL in the address bar.

    The IoT FND login page displays without the security screen.

Managing Custom Certificates

1. Back up the following files that are overwritten when you upgrade or perform a fresh installation of IoT FND:
    - In the /opt/cgms/server/cgms/conf/ directory:
        - jbossas.keystore.password
        - jbossas.keystore
    - In the /opt/cgms/server/cgms/deploy/ directory:
        - security-service.xml file

        This is the file where you added the salt value in Installing Custom Certificates in the Browser Client).
    - In the /opt/cgms/server/cgms/conf directory:
        - VAULT.dat
        - vault.keystore
2. Perform the IoT FND upgrade or new installation (see Upgrading IoT FND).
3. Copy the above files to their respective folders, and restart IoT FND.

Managing North Bound API Events

The North Bound (NB) API client can send events using HTTPS. NB API clients must subscribe to IoT FND by providing a valid HTTPS URL over which IoT FND will send events. IoT FND accepts SSL certificates and handshakes published by the NB API client.

Configuring IoT FND to Access the Keystore

After you create cgms_keystore and import the NMS and CA certificates to it, configure IoT FND to access the cgms_keystore file.

To set the keystore password:

1. Stop IoT FND.

2. Run the setupCgms.sh script:

```
pwd
/opt/cgms/bin
./setupCgms.sh
06-12-2012 10:21:39 PDT: INFO: ========== CG-NMS Setup Started - 2012-06-12-10-21-39 =====
06-12-2012 10:21:39 PDT: INFO: Log file: /opt/cgms/bin/../server/cgms/log/cgms_setup.log
Are you sure you want to setup CG-NMS (y/n)? y
06-12-2012 10:21:39 PDT: INFO: User response: y
...
Do you want to change the keystore password (y/n)? y
06-12-2012 10:21:52 PDT: INFO: User response: y
Enter keystore password: keystore_password
Re-enter keystore password: keystore_password
06-12-2012 10:21:59 PDT: INFO: Configuring keystore password. This may take a while.
Please wait ...
06-12-2012 10:22:00 PDT: INFO: Keystore password configured.
...
```

This script saves the password set in the cgms.properties file.

3. Start IoT FND.

Tip: To protect the cgms_keystore and cgms.properties files, set their permissions to root read only.

Caution: Protect your system! Ensure that only root has access to the IoT FND server. Your firewall should only allow SSH access from internal hosts.

Configuring the TPS Proxy to Access the Keystore

To configure the TPS proxy to access the keystore:

1. Change to the tpsproxy bin directory:

```
cd /opt/cgms-tpsproxy/bin
```

2. Convert your chosen password into encrypted form:

```
./encryptionUtil.sh {your chosen password for cgms_keystore}
7jlXPniVpMvat+TrDWqh1w==
```

3. Copy the encrypted password into the tpsproxy.properties file:

   a. Open the file for editing.

   ```
   cd /opt/cgms-tpsproxy/conf
   emacs tpsproxy.properties
   ```

   b. Add this line to the file:

   ```
   cgms-keystore-password-hidden=keystore_password
   ```

   In this example, the encrypted *keystore_password* is “7jlXPniVpMvat+TrDWqh1w==”.

4. Restart TPS proxy:

```
service tpsproxy restart
```

Setting Up an HSM Client

Complete the following procedures to set up the HSM client:

- Installing an HSM Client on the IoT FND Server
- Configuring an HSM HA Client

Note: If your installation uses SSM for CSMP-based messaging, see Installing and Setting Up the SSM.

Installing an HSM Client on the IoT FND Server

The Hardware Security Module (HSM) works as a security server listening at port 1792. For IoT FND to communicate with HSM:

1. Install an HSM client on the IoT FND server.
2. Configure the HSM client to have the certificate for HSM.
3. Upload the certificate to HSM.

This section describes how to install and configure an HSM client, assuming that HSM is at 172.16.0.1 and the client at 172.31.255.254.

To install and set up an HSM client:

1. Get the HSM client package, unpack it, and run the installation script:

   ```
   sh install.sh
   ```

2. Change to the /usr/lunasa/bin directory:

   ```
   cd /usr/safenet/lunaclient/bin/
   ```

3. Create the client certificate:

   ```
   ./vtl createCert -n ip_address_of_hsm_client
   ```

4. Download the HSM certificate from the HSM server:

   ```
   scp admin@ip_address_of_hsm_server:server.pem .
   ```

5. Upload the client certificate to the HSM server:

   ```
   scp ../cert/client/ip_address_of_hsm_client.pem admin@ip_address_of_hsm_server: .
   ```

6. Load the HSM certificate:

   ```
   vtl addServer -n ip_address_of_hsm_server -c server.pem .
   ```

7. Ensure that the HSM server is added:

   ```
   vtl listServer
   ```

8. From the HSM client, use SSH to log in to the HSM server:

   ```
   ssh admin@ip_address_of_hsm_server
   Last login: Mon Aug 15 15:36:43 2012 from 10.27.164.171
   Luna SA 5.0.1-2 Command Line Shell - Copyright (c) 2001-2010 SafeNet, Inc. All rights reserved.
   [TestLunaSA1] lunash:>
   ```

9. Use SSH to perform these steps on the HSM server:

   a. Add the client to the HSM server:

   ```
   [TestLunaSA1] lunash:>client register -c hsm_client_name -i ip_address_of_hsm_client
   ```

```
'client register' successful.     Command Result : 0 (Success)
```

b. List the clients defined on the server and ensure that the client was added:

```
[TestLunaSA1] lunash:>client list
registered client 1: cg-nms
registered client 2: hsm_client_name
Command Result : 0 (Success)
```

c. Assign the client to a partition:

```
[TestLunaSA1] lunash:>client assignPartition -c hsm_client_name -p partition_name
'client assignPartition' successful.
Command Result : 0 (Success)
```

d. Log out of HSM.

10. On the server running the HSM client, verify the HSM client installation:

```
vtl verify
The following Luna SA Slots/Partitions were found:
Slot    Serial #    Label
====    ========    =====
1    151285008     TestPart1
```

11. After the HSM client installation completes, run the test suite ckdemo.

```
ckdemo
Ckdemo is the property of SafeNet Inc and is provided to our customers for
diagnostic and development purposes only.  It is not intended for use in
production installations.  Any re-distribution of this program in whole or
in part is a violation of the license agreement.

CrystokiConnect()            (modified on Oct 18 2012 at 20:57:53)

*** CHRYSTOKI DEMO - SIMULATION LAB ***


Status: Doing great, no errors (CKR_OK)

TOKEN FUNCTIONS
    ( 1) Open Session  ( 2) Close Session  ( 3) Login
    ( 4) Logout        ( 5) Change PIN     ( 6) Init Token
    ( 7) Init Pin      ( 8) Mechanism List ( 9) Mechanism Info
    (10) Get Info      (11) Slot Info      (12) Token Info
    (13) Session Info  (14) Get Slot List  (15) Wait for Slot Event
                       (18) Factory Reset  (19) CloneMofN
OBJECT MANAGEMENT FUNCTIONS
    (20) Create object (21) Copy object    (22) Destroy object
    (23) Object size   (24) Get attribute  (25) Set attribute
                       (26) Find object    (27) Display Object
SECURITY FUNCTIONS
    (40)  Encrypt file (41) Decrypt file   (42)  Sign
    (43)  Verify       (44) Hash file      (45)  Simple Generate Key
                                           (46)  Digest Key
HIGH AVAILABILITY RECOVERY FUNCTIONS
    (50) HA Init       (51) HA Login
KEY FUNCTIONS
    (60) Wrap key      (61) Unwrap key     (62) Generate random number
    (63) Derive Key    (64) PBE Key Gen    (65) Create known keys
    (66) Seed RNG      (67) EC User Defined Curves
CA FUNCTIONS
    (70) Set Domain    (71) Clone Key      (72) Set MofN
    (73) Generate MofN (74) Activate MofN  (75) Generate Token Keys
    (76) Get Token Cert(77) Sign Token Cert(78) Generate CertCo Cert
    (79) Modify MofN   (86) Dup. MofN Keys (87) Deactivate MofN
    (88) Get Token Certificates     (112) Set Legacy Cloning Domain
OTHERS
    (90) Self Test
    (94) Open Access    (95) Close Access
    (97) Set App ID     (98) Options      (100) LKM Commands
OFFBOARD KEY STORAGE:
   (101) Extract Masked Object            (102) Insert Masked Object
   (103) Multisign With Value             (104) Clone Object
   (105) SIMExtract                       (106) SIMInsert
   (107) SimMultiSign                     (118) Extract Object
                                          (119) Insert Object
SCRIPT EXECUTION:
   (108) Execute Script                   (109) Execute Asynchronous Script
                                          (110) Execute Single Part Script
CLUSTER EXECUTION:
   (111) Get Cluster State
SRK FUNCTIONS:
   (200) SRK Get State  (201) SRK Restore  (202) SRK Resplit
   (203) SRK Zeroize    (204) SRK Enable/Disable

   (  0) Quit demo

Enter your choice : 1

Slots available:
    slot#1 - LunaNet Slot
    slot#2 - Luna UHD Slot
    slot#3 - Luna UHD Slot
    slot#4 - Luna UHD Slot
Select a slot: 1

SO[0] or normal user[1]?

You must enter a number between 0 and 1: 1

Status: Doing great, no errors (CKR_OK)

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    ( 1) Open Session  ( 2) Close Session  ( 3) Login
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    ( 7) Init Pin      ( 8) Mechanism List ( 9) Mechanism Info
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   (203) SRK Zeroize    (204) SRK Enable/Disable

   (  0) Quit demo

Enter your choice : 3
Security Officer[0]
Crypto-Officer  [1]
Crypto-User     [2]: 1
Enter PIN          : 9JT5-WMYG-E5FE-TExs

Status: Doing great, no errors (CKR_OK)

TOKEN FUNCTIONS
    ( 1) Open Session  ( 2) Close Session  ( 3) Login
    ( 4) Logout        ( 5) Change PIN     ( 6) Init Token
    ( 7) Init Pin      ( 8) Mechanism List ( 9) Mechanism Info
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SRK FUNCTIONS:
   (200) SRK Get State  (201) SRK Restore  (202) SRK Resplit
   (203) SRK Zeroize    (204) SRK Enable/Disable

   (  0) Quit demo

Enter your choice : 27

Enter handle of object to display (-1 to list available objects) :

You must enter a number between -1 and 10000000: -1

No objects found

Enter handle of object to display (-1 to list available objects) :

You must enter a number between -1 and 10000000:

You must enter a number between -1 and 10000000:

You must enter a number between -1 and 10000000: 0
ERROR: Can not find object with handle 0

Status: C_GetObjectSize returned error. (CKR_OBJECT_HANDLE_INVALID)

TOKEN FUNCTIONS
    ( 1) Open Session  ( 2) Close Session  ( 3) Login
    ( 4) Logout        ( 5) Change PIN     ( 6) Init Token
    ( 7) Init Pin      ( 8) Mechanism List ( 9) Mechanism Info
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SRK FUNCTIONS:
   (200) SRK Get State  (201) SRK Restore  (202) SRK Resplit
   (203) SRK Zeroize    (204) SRK Enable/Disable

   (  0) Quit demo

Enter your choice : 0

Exiting GESC SIMULATION LAB
```

Configuring an HSM HA Client

Note: You must perform the steps in this section even if you only have one HSM server. You must also create a group that contains the HSM server.

To configure an HSM HA client:

1. Configure the HSM client so that it connects with both HSM servers, as described in Installing an HSM Client on the IoT FND Server.

2. Change to the /usr/safenet/lunaclient/bin/ directory:

   ```
   /usr/safenet/lunaclient/bin/
   ```

3. Create a group that contains only the partition of the first HSM server by running this command and providing the serial number (*serial_num*) of the HSM server obtained by running the **./vtl verify** command (10.), the name of the group (*group_name*), and the password (*prtn_password*) for accessing the partition:

   ```
   ./vtl haAdmin newGroup -serialNum serial_num -label group_name -password prtn_password
   ```

   For example:

   ```
   ./vtl haAdmin newGroup -serialNum 151285008 -label testGroup1 -password TestPart1

   Warning:  There are 2 objects currently on the new member.
             Do you wish to propagate these objects within the HA
             group, or remove them?

             Type 'copy' to keep and propagate the existing
             objects, 'remove' to remove them before continuing,
             or 'quit' to stop adding this new group member.
             > copy

   New group with label "testGroup1" created at group number 1151285008.
   Group configuration is:

                   HA Group Label:  testGroup1
                  HA Group Number:  1151285008
                  Synchronization:  enabled
                    Group Members:  151285008
                       Needs sync:  no
   ```

4. Add the partition of the second HSM to the group.

For example:

```
./vtl haAdmin addMember -group testGroup1 -serialNum 151268008 -password TestPart1
Member 151268008 successfully added to group testGroup1. New group
configuration is:

                HA Group Label:  testGroup1
               HA Group Number:  1151285008
               Synchronization:  enabled
                 Group Members:  151285008, 151268008
                    Needs sync:  yes

Please use the command 'vtl haAdmin -synchronize' when
you are ready to replicate data between all members of the
HA group. (If you have additional members to add, you may
wish to wait until you have added them before synchronizing
to save time by avoiding multiple synchronizations.)
```

5. Verify that both partitions can be listed:

```
./vtl haAdmin -listGroups

If you would like to see synchronization data for group testGroup1,
please enter the password for the group members. (Press enter to
skip the synchronization check):
> *********

                HA Group Label:  testGroup1
               HA Group Number:  1151285008
               Synchronization:  enabled
                 Group Members:  151285008, 151268008
                    Needs sync:  yes

          HA auto recovery:  disabled
                HA logging:  disabled
```

6. Enable HA auto recovery:

```
[root@localhost bin]# ./vtl haAdmin -autoRecovery

vtl haAdmin -autoRecovery [ -retry <count> | -interval <seconds> ] -retry <retry count>
-interval <seconds>
```

- Set the **retry** value between -1 and 500 where, -1 is an infinite number of retries and 0 disables auto recovery.
- Specify the auto recovery poll **interval** in seconds.

7. Enable HA.

```
./vtl haAdmin -HAOnly -enable
```

Configuring the HSM Group Name and Password

The HSM Group name and password is provided by Cisco at manufacture.

To allow the HSM Group name and password to be configured by the user:

1. Edit the **cgms.properties** file to add the following properties:

- hsm-keystore-name *<name>*
- hsm-keystore-password *<encrypted password>*

Tip: You can use the same HSM server for multiple IoT FND installations by creating multiple partitions on the HSM server, configuring the HSM client, and specifying the partition name and partition password in the cgms.properties file.

2. Save the cgms.properties file.
3. To apply these changes, start the cgms service:

```
service cgms start
```

Managing Tunnel Provisioning

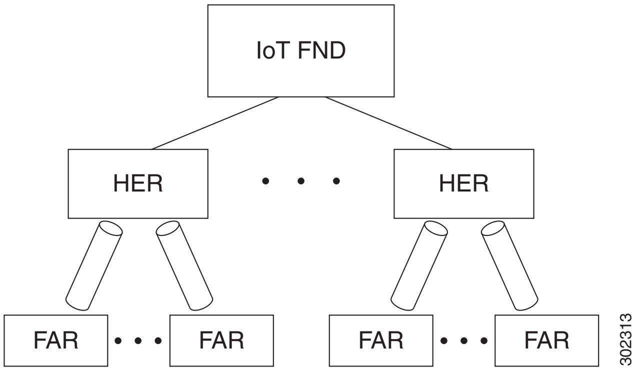
This section describes how to configure IoT FND for tunnel provisioning and how to manage and monitor tunnels connecting FARs (CGRs and C800s) and HERs. This section includes the following topics:

- Overview
- Configuring Tunnel Provisioning
- Monitoring Tunnel Status
- Reprovisioning CGRs

Overview

IoT FND sends the commands generated from processing the tunnel provisioning templates to FARs and HERs to provision secure tunnels between them. The default IoT FND templates contain CLI commands to set up and configure GRE and IPsec tunnels. One HER can serve up to 500 FARs, which may include multiple tunnels with the same HER EID and name.

Figure 1 Tunnels Connect FARs and their Corresponding HERs



To provision tunnels between HERs and FARs, IoT FND executes CLI tunnel configuration commands on these devices. By default, IoT FND provides basic tunnel configuration templates containing the CLI tunnel configuration commands. You can also use your own templates. Although the tunnel provisioning process is automatic, you must first complete the configuration steps outlined in Tunnel Provisioning Configuration Process. After that, whenever a FAR comes online, IoT FND automatically provisions it with a tunnel. Before you configure IoT FND for tunnel provisioning, ensure that the IoT FND TPS Proxy is installed and running.

ZTD without IPSec

Beginning with IoT FND Release 3.1.x, you have the option to initiate ZTD with no IPSec configured by ensuring that the Tunnel Provisioning Template is empty of any CLI. This initial approach of bringing up your network without a factory configuration does not preclude subsequent use of IPSec in your network.

Tunnel Provisioning Configuration Process

You must generate the keystore files on the IoT FND and TPS Proxy before configuring tunnel provisioning. Then, you configure IoT FND and the TPS Proxy to talk to one another (Setting Up the TPS Proxy and Configuring IoT FND to Use the TPS Proxy).

To configure IoT FND for tunnel provisioning:

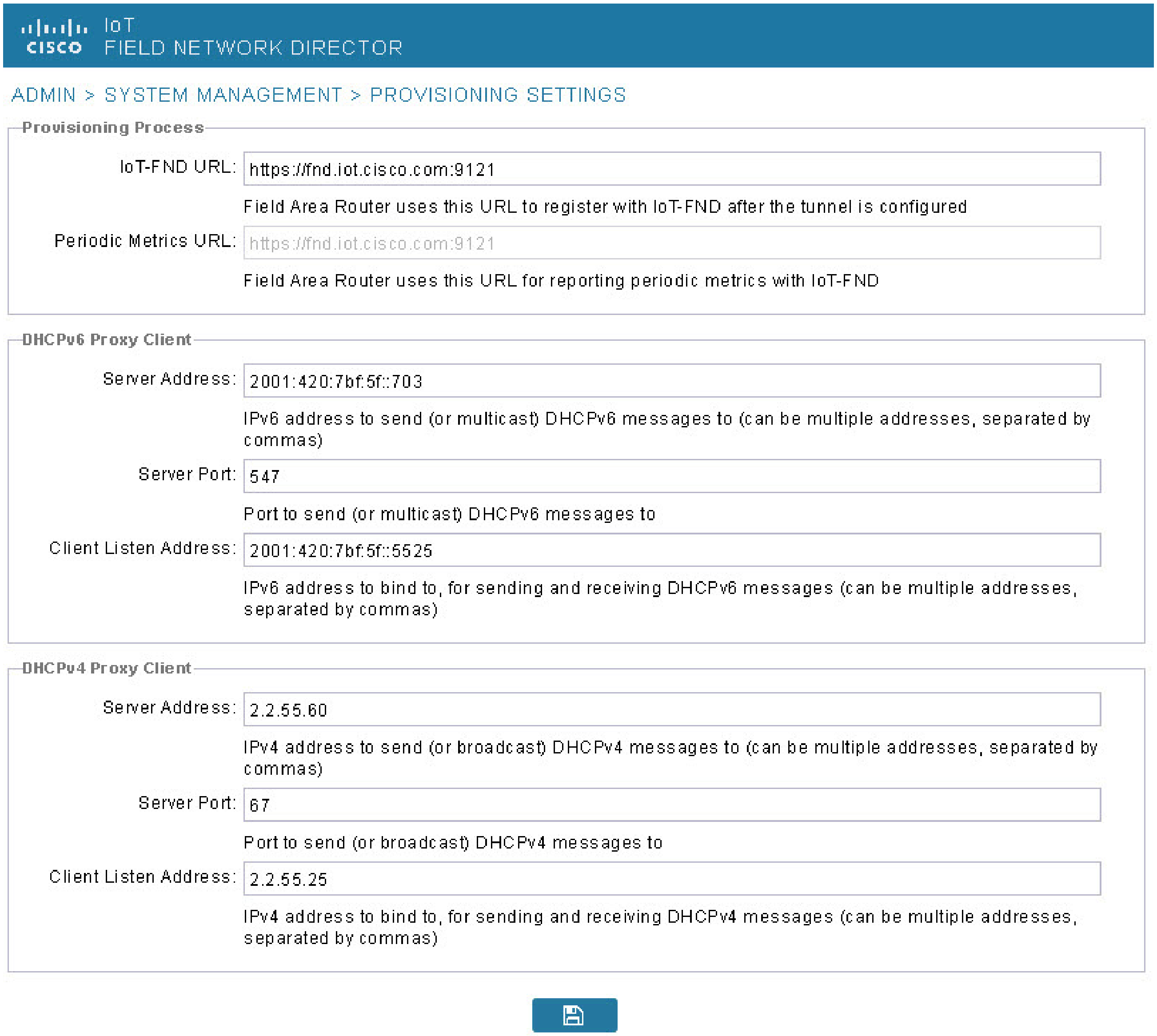
		Notes
1.	Configure the DHCP servers. Configure DHCP servers to provide unique IP addresses to IoT FND. The default IoT FND tunnel provisioning templates configure a loopback interface and the IP addresses required to create the tunnels. Cisco IOS CGRs use FlexVPN. Ensure that the template only contains addresses for the loopback interface.	Configuring the DHCP Server for Tunnel Provisioning.
2.	Configure the tunnel settings. Configure the NMS URL and the DHCP proxy client settings on the Provisioning Settings page in IoT FND (**Admin > System Management > Provisioning Settings**).	See “Managing System Settings” chapter in Cisco IoT Field Network Director User Guide, Release 4.1.x.
3.	(CG-OS CGRs) Configure IoT FND to accept FAR registration requests on first contact (*call home*) to request tunnel provisioning. Cisco IOS CGRs use the CGNA service.	
4.	Configure HER management. Configure HERs to allow management by IoT FND using NETCONF over SSH.	Configuring HERs Before Adding them to IoT FND. See “Managing Devices” chapter in Cisco IoT Field Network Director User Guide, Release 4.1.x.
5.	Add HERs to IoT FND.	Adding HERs to IoT FND. See “Managing Devices” chapter in Cisco IoT Field Network Director User Guide, Release 4.1.x.
6.	Review the IoT FND tunnel provisioning templates to ensure that they create the correct type of tunnel.	
7.	(Optional) If you plan to use your own templates for tunnel provisioning, create one or more tunnel provisioning groups and modify the default tunnel provisioning templates.	Configuring Tunnel Provisioning Templates
8.	(CG-OS CGRs) Configure FARs to call home. Configure FARs to contact IoT FND over HTTPS through the IoT FND TPS proxy.	This step is typically performed at the factory where the FARs are configured to contact the TPS Proxy.
9.	Add FARs to IoT FND. Import the FARs into IoT FND using the Notice-of-Shipment XML file.	
10.	Map FARs to their corresponding HER.	Tunnel Provisioning Configuration Process

After completing the previous steps, deploy the FARs and power them on. Tunnel provisioning happens automatically.

This is the sequence of events after a FAR is turned on:

1. Upon joining the uplink network after being turned on, the FAR sends a request for certificate enrollment.
2. The FAR then requests tunnel provisioning to IoT FND through the IoT FND TPS Proxy.
3. IoT FND looks up the FAR record in the IoT FND database and determines which tunnel provisioning templates to use. IoT FND also looks up which HERs to which to establish a tunnel.
4. For Cisco IOS CGRs, the default templates configure the CGR to use FlexVPN. The FlexVPN client is configured on the CGR that will contact the HER and ask for a FlexVPN tunnel to be dynamically constructed. This is how the HER dynamically adds a new tunnel endpoint interface for the CGR.
5. Before processing FAR templates, IoT FND processes the HER Tunnel Deletion template and sends the resulting commands to the HERs. This is done for each HER to remove existing tunnel configuration that may be associated with the FAR.
6. IoT FND uses the FreeMarker template engine to process the FAR Tunnel Addition template. The engine converts the templates to text, which IoT FND assumes to be CLI configuration commands (CG-OS or Cisco IOS, per the CGR). IoT FND uses these commands to configure and bring up one end of the tunnel on the FAR.
7. IoT FND uses the FreeMarker template engine to process the HER Tunnel Addition template. The engine converts the templates to text, which IoT FND assumes to be commands for configuring the tunnel on the HERs.
8. This step is OS-specific:

   - For Cisco IOS CGRs, if no errors occurred applying the commands generated by the templates to the FAR and HERs, IoT FND configures a new active CGNA profile “cg-nms-register,” and deactivates the cg-nms-tunnel profile. That cg-nms-register profile uses the IoT FND URL.
   - For CG-OS CGRs, IoT FND re-configures the call home URL to the IoT FND URL specified in the Provisioning Settings page (**ADMIN > System Management > Provisioning Settings**).



ADMIN > SYSTEM MANAGEMENT > PROVISIONING SETTINGS

Provisioning Process

IoT-FND URL: https://fnd.iot.cisco.com:9121

Field Area Router uses this URL to register with IoT-FND after the tunnel is configured

Periodic Metrics URL: https://fnd.iot.cisco.com:9121

Field Area Router uses this URL for reporting periodic metrics with IoT-FND

DHCPv6 Proxy Client

Server Address: 2001:420:7bf:5f::703

IPv6 address to send (or multicast) DHCPv6 messages to (can be multiple addresses, separated by commas)

Server Port: 547

Port to send (or multicast) DHCPv6 messages to

Client Listen Address: 2001:420:7bf:5f::5525

IPv6 address to bind to, for sending and receiving DHCPv6 messages (can be multiple addresses, separated by commas)

DHCPv4 Proxy Client

Server Address: 2.2.55.60

IPv4 address to send (or broadcast) DHCPv4 messages to (can be multiple addresses, separated by commas)

Server Port: 67

Port to send (or broadcast) DHCPv4 messages to

Client Listen Address: 2.2.55.25

IPv4 address to bind to, for sending and receiving DHCPv4 messages (can be multiple addresses, separated by commas)

The specified URL uses the IoT FND registration port (default 9121) instead of the tunnel provisioning port. The Fully Qualified Domain Name (FQDN) in that URL is different and resolves to an IP address that is only reachable through the tunnels.

Configuring Tunnel Provisioning

This section describes how to configure IoT FND for tunnel provisioning.

- Configuring the DHCP Server for Tunnel Provisioning
- Configuring DHCP for Tunnel Provisioning Using CNR

Configuring the DHCP Server for Tunnel Provisioning

For tunnel provisioning to succeed, configure the DHCP server used by IoT FND to supply addresses to create tunnels between the FARs and HERs. For example, configure the DHCP server to provide IP addresses for tunnel provisioning on a permanent-lease basis.

IoT FND makes the DHCP requests based on the settings defined in the tunnel provisioning templates. During tunnel provisioning, the IoT FND templates can make two kinds of DHCP requests:

- Request an IP address, and then make it available to the template.
- Request a subnet with two IP addresses, and then make both addresses available to the template.

IoT FND can make these requests for IPv4 addresses and IPv6 addresses.

The ability to request DHCP addresses from the template gives you maximum flexibility when defining tunnel configurations because you allocate the exact address needed for each FAR and corresponding interface on the HER. The default tunnel provisioning templates provided address the most common use case: one IPsec tunnel between the FAR and its corresponding HER. Each end of this IPsec tunnel gets a dynamically allocated IPv4 address:

- If your DHCP server supports subnet allocation, use it to obtain two addresses that belong to the same subnet.
- If your DHCP server only supports address allocation, configure it so that the two DHCP address requests return addresses that can be used as ends of an IPsec tunnel.
- If your routing plan calls for allocating unique IPv4 addresses for each FAR and assigning it to a loopback interface above the IPsec tunnel, allocate this address using the IoT FND template.

If you choose to build IPv6 GRE tunnels, allocate the IPv6 addresses for each end of the tunnel using DHCP prefix delegation or individual address requests.

This section describes example DHCP settings for tunnel provisioning. How you configure these settings depends on your installation. This section provides general guidelines for configuring the DHCP server for tunnel provisioning using the Cisco Network Registrar (CNR).

Configuring DHCP for Tunnel Provisioning Using CNR

The CNR CLI script in the following example configures the CNR DHCP server to service requests made by the default tunnel provisioning templates in IoT FND. When using this script, ensure that the subnets are appropriate for your DHCP server environment.

Example CNR DHCP Server Tunnel Provisioning Script

```
# These commented out commands support re-applying the configuration by first
# removing any previously applied configuration, in reverse order. This should
# not be done in a production environment, but may be useful when initially
# developing and testing a configuration.

# scope v4address-perm delete
# dhcp-address-block v4subnet-perm delete
# prefix v6subnet-perm delete
# prefix v6address-perm delete
# policy permanent delete

# Configure the server to automatically map any IPv4 or IPv6 user class
# option values to selection tags. By default CG-NMS includes a value of
# "CG-NMS" for the user class in its requests. The tag is used to insure
# prefixes and scopes configured to satisfy requests from CG-NMS are only
# used for that purpose.

dhcp set map-user-class-id=append-to-tags

# Since CG-NMS uses the leased addresses and subnets in router
# configuration the addresses and subnets must be permanently allocated
# for that purpose. Create a policy that instructs the DHCP server to
# offer a permanent lease.
```

```
policy permanent create
policy permanent set permanent-leases=enabled

# Configure DHCPv6.

# The default CG-NMS tunnel template will request IPv6 addresses for
# use with CGR loopback interfaces.

prefix v6address-perm create 2001:DB8:0:0:1::/80 dhcp-type=dhcp
prefix v6address-perm set description="Pool for leasing addresses for loopback interfaces."
prefix v6address-perm set policy=permanent
prefix v6address-perm set selection-tags=CG-NMS

# The default CG-NMS tunnel template will request IPv6 prefixes for
# use with GRE tunnels. Force use of a /127 prefix.

prefix v6subnet-perm create 2001:DB8:0:0:2::/80 dhcp-type=prefix-delegation
prefix v6subnet-perm set description="Pool for leasing prefixes for GRE tunnels."
prefix v6subnet-perm set policy=permanent
prefix v6subnet-perm set selection-tags=CG-NMS
prefix-policy v6subnet-perm set default-prefix-length=127
prefix-policy v6subnet-perm set shortest-prefix-length=127

# Configure DHCPv4.

# The default CG-NMS tunnel template will request IPv4 subnets for
# use with IPsec tunnels. Note that currently address pools for
# IPv4 subnet allocation can only be configured using the CLI as the
# CNR Web UI does not currently support them.

# If CNR allowed you to set a description on DHCP address blocks it would be:
# "Pool for leasing subnets for IPsec tunnels."

dhcp-address-block v4subnet-perm create 192.0.2.0/24
dhcp-address-block v4subnet-perm set default-subnet-size=31
dhcp-address-block v4subnet-perm set policy=permanent
dhcp-address-block v4subnet-perm set selection-tags=CG-NMS

# The default CG-NMS tunnel template will request IPv4 addresses for
# use with loopback interfaces.

scope v4address-perm create 198.51.100.0 255.255.255.0
scope v4address-perm set description="Pool for leasing addresses for loopback interfaces."
scope v4address-perm set policy=permanent
scope v4address-perm addRange 198.51.100.2 198.51.100.254
scope v4address-perm set selection-tag-list=CG-NMS

# Configure detailed logging of incoming and outgoing packets. This is useful when
# debugging issues involving DHCP, however this level of logging will lower the
# performance of the DHCP server. If this is a production server under heavy load
# it may be necessary to forgo detailed packet logging.

dhcp set
log-settings=missing-options,incoming-packet-detail,outgoing-packet-detail,unknown-criteria,client-deta
il,client-criteria-processing,dropped-waiting-packets,v6-lease-detail

# Save the changes and reload the server to have them take effect.
save
dhcp reload

# List the current configuration.

policy list
prefix list
dhcp-address-block list
```

```
scope list
dhcp show
```

Configuring Tunnel Group Settings

You use groups in IoT FND to bulk configure tunnel provisioning. By default, all FARs are added to the appropriate default group (default-cgr, default-c800). Default groups contain the templates used for tunnel provisioning.

Topics in this section include the following:

- Creating Tunnel Groups
- Deleting Tunnel Groups
- Viewing Tunnel Groups
- Moving FARs to Another Group
- Renaming a Tunnel Group

Creating Tunnel Groups

If you plan to use one set of templates for all FARs, whether using the default templates, modified default templates or custom templates, do not create additional groups. To define multiple sets of templates, create groups and customize the templates for these groups.

Note: CGRs and C800s can be in the same tunnel provisioning group if your custom templates are applicable to both router types.

To create a tunnel group:

1. Choose **CONFIG > Tunnel Provisioning**.
2. Click **+** icon in left pane to add a group.
3. Enter a name of the new group, and then click **OK**.

   The group appears in the Tunnel Groups pane.

After creating a tunnel group, the next step is to move FARs from other groups to it, as described in Moving FARs to Another Group.

Deleting Tunnel Groups

Only empty groups can be deleted. Before you can delete a tunnel group, you must move the devices it contains to another group.

To delete an empty tunnel group:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS left pane, select the tunnel group to delete.
3. Click (▬) to delete the group.
4. Click **Yes** to confirm deletion.

Viewing Tunnel Groups

The Tunnel Provisioning page lists information about existing tunnel groups.

Follow these steps to view the tunnel groups defined in IoT FND:

1. Choose **CONFIG > Tunnel Provisioning**.
2. Click **Group Members** tab.
3. In the TUNNEL GROUPS pane (left), select a group.

IoT FND displays the following Tunnel Group information for each router in the group. Not all routers support all fields. (See Table 1).

Table 1 Tunnel Group Fields

Field	Description
Name	Router EID (device identifier).
Status	Status of the router: ■ Unheard—The router has not contacted IoT FND yet. ■ Unsupported—The router is not supported by IoT FND. ■ Up—The router is in operation. ■ Down—The router is turned off.
Last Heard	Last time the router contacted or sent metrics to IoT FND. If the router never contacted IoT FND, **never** appears in this field. Otherwise, IoT FND displays the date and time of the last contact, for example, **4/10 19:06**.
Tunnel Source Interface 1 Tunnel Source Interface 2	Router interface used by the tunnel.
OSPF Area 1 OSPF Area 2	Open shortest path first (OSPF) areas 1 and 2.
OSPFv3 Area 1 OSPFv3 Area 1	OSPFv3 area 1. OSPFv3 area 2.
IPsec Dest Addr 1 IPsec Dest Addr 2	IPv4 destination address of the tunnel.
GRE Tunnel Dest Addr 1 GRE Tunnel Dest Addr 2	IPv6 destination address of the tunnel.
Certificate Issuer Common Name	Name of the CA that issued the certificate.

Renaming a Tunnel Group

You can rename a tunnel group at any time. Cisco recommends using short, meaningful names. Names cannot be more than 250 characters long.

To rename a tunnel group:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, mouse over the tunnel group to rename and click the **Edit** pencil icon (✎).
3. Enter the new Group Name and then click **OK**.

Note: When you enter an invalid character entry (such as, @, #, !, or +) in the entry field, the field is highlighted in red and disables the **OK** button.

Moving FARs to Another Group

You can move FARs to another group in two ways:

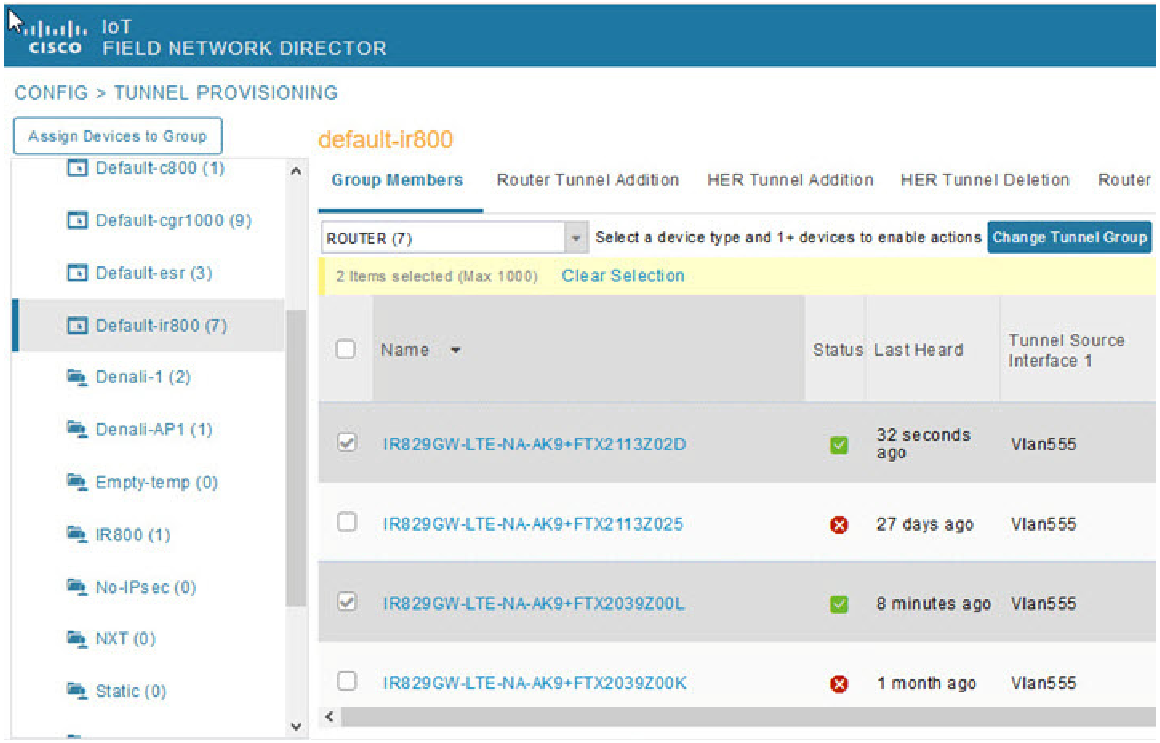
- Moving FARs to Another Group Manually
- Moving FARs to Another Group in Bulk

Moving FARs to Another Group Manually

To move FARs to another group manually:

1. Choose **CONFIG > Tunnel Provisioning**.
2. Click the **Group Members** tab.
3. In the TUNNEL GROUPS pane, select the tunnel group with the routers to move.
4. Choose the device type from the **Select a device type** drop-down menu.
5. Check the check boxes of the FARs to move.

   To select all FARs in a group, click the check box at the top of the column. When you select devices, a yellow bar displays that maintains a count of selected devices and has the Clear Selection and Select All commands. The maximum number of devices you can select is 1000.
6. Click the **Change Tunnel Group** button.



Select a device type and 1+ devices to enable actions

2 Items selected (Max 1000) Clear Selection

☐	Name	Status	Last Heard	Tunnel Source Interface 1
☑	IR829GW-LTE-NA-AK9+FTX2113Z02D	✓	32 seconds ago	Vlan555
☐	IR829GW-LTE-NA-AK9+FTX2113Z025	☒	27 days ago	Vlan555
☑	IR829GW-LTE-NA-AK9+FTX2039Z00L	✓	8 minutes ago	Vlan555
☐	IR829GW-LTE-NA-AK9+FTX2039Z00K	☒	1 month ago	Vlan555

7. From the drop-down menu, choose the tunnel group to which you want to move the FARs.

8. Click **Change Tunnel Group**.

9. Click **OK** to close the dialog box.

Moving FARs to Another Group in Bulk

You can move FARs in bulk to another group by importing a CSV or XML file containing the names of the FARs to move. Ensure that the file contains entries in the format shown the following example:

```
eid
CGR1120/k9+JSM1
CGR1120/k9+JSM2
CGR1120/k9+JSM3
CGR1120/k9+JSM4
C819HGW-S-A-K9+FTX174685V0
```

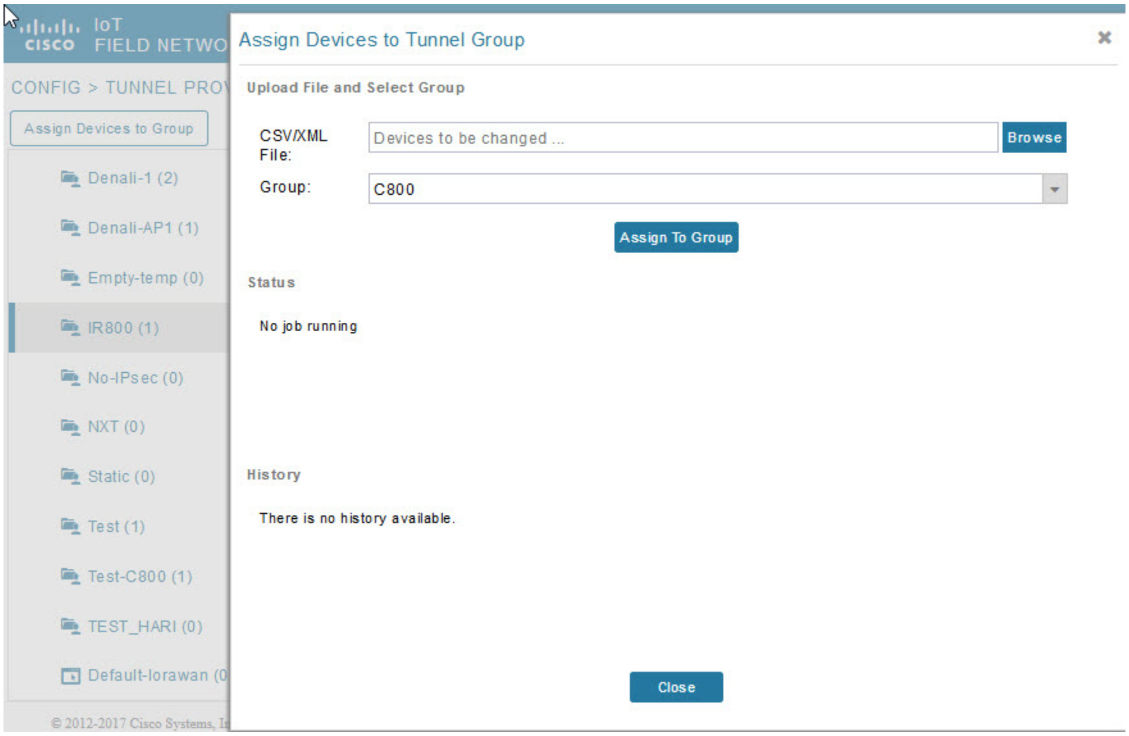
The first line is the header, which tells IoT FND to expect FAR EIDs in the remaining lines (one FAR EID per line).

To move FARs to another group in bulk:

1. Create a CSV or XML file with the EIDs of the devices to move to a different group.

2. Choose **CONFIG > Tunnel Provisioning**.

3. Click **Assign Devices to Tunnel Group** to open an entry panel.



Assign Devices to Tunnel Group

Upload File and Select Group

CSV/XML File: Devices to be changed ...

Group: C800

Status

No job running

History

There is no history available.

4. Click **Browse** and locate the file that contains the FARs that you want to move.

5. From the **Group** drop-down menu, choose the destination tunnel group.

6. Click **Assign To Group**.

7. Click **Close**.

Configuring Tunnel Provisioning Templates

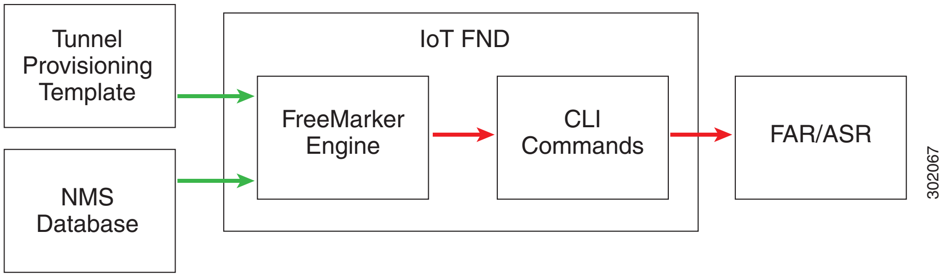
IoT FND has three default tunnel provisioning templates:

- Field Area Router Tunnel Addition—IoT FND uses this template to generate the CLI configuration commands for creating one end of an IPsec tunnel on the FAR.
- Head-End Router Tunnel Addition—IoT FND uses this template to generate the CLI configuration commands for creating the other end of the IPsec tunnel on the HER.
- Head-End Router Tunnel Deletion—IoT FND uses this template to generate the CLI configuration commands for deleting any existing tunnel to the FAR at the other end of the tunnel.

Tunnel Provisioning Template Syntax

The IoT FND tunnel provisioning templates are expressed with the FreeMarker syntax. FreeMarker is an open-source Java-based engine for processing templates and is built into IoT FND. As shown in Figure 2, FreeMarker takes as input the tunnel provisioning template and data supplied by IoT FND, and generates CLI commands that IoT FND runs on the FARs and HERs in the “configure terminal” context.

Figure 2 CLI Command Generation from Templates in IoT FND



In IoT FND, the tunnel provisioning templates consist of router CLI commands and FreeMarker variables and directives. The use of FreeMarker syntax allows IoT FND to define one template to provision multiple routers.

This section describes the basic FreeMarker syntax in the tunnel provisioning templates. For information about FreeMarker visit http://freemarker.sourceforge.net/.

- Template Syntax
- Data Model

Template Syntax

Table 2 describes the syntax in the default tunnel provisioning templates.

Table 2 Tunnel Provisioning Template Syntax

Component	Description
Text	Unmarked text is carried through as CG-OS CLI configuration commands for FARs and Cisco IOS CLI commands for HERs.
Interpolations	${variable} FreeMarker replaces this construct with the value of a string variable that IoT FND supplies. In this example, IoT FND provides the EID of the FAR: `description IPsec tunnel to ${`**`far.eid`**`}`
Default Values	${variable!" Default" } FreeMarker replaces this construct with the value of a string variable. If the variable is not set, FreeMarker replaces this construct with **Default**.

Conditionals	<#if condition> output1 <#else> output2 </#if>
	FreeMarker uses this construct to determine the text to use in the output. For example:
	`<#if far.ipsecTunnelDestAddr1??>`
	`      <#assign destinationAddress=far.ipsecTunnelDestAddr1>`
	`    <#else>`
	`      <#assign destinationAddress=`
	`   her.interfaces("GigabitEthernet0/0/0")[0].v4.addresses[0].address>`
	`</#if>`

Iteration over lists	<#list list as variable> ${variable} </#list> FreeMarker uses this construct to iterate over a list.
Comments	<#-- this is a comment --> FreeMarker allows comments, but does not retain them in the output.

Table 2 Tunnel Provisioning Template Syntax (continued)

Component	Description

Assign statements	<#assign name=value>
	This construct declares a local variable within the template and assigns a value to it. After that, use this construct to reference the variable:
	${name}
	For example:
	`<#assign interfaceNumber=0>`
	`...`
	`interface Tunnel${interfaceNumber}`

Macros	These constructs are similar to function calls.
	<#macro name(param1,param2, ... ,paramN)>
	... ${param1} ...
	</#macro>
	Here is an example of a macro definition:
	`<#macro configureTunnel(interfaceNamePrefix,ospfCost)>`
	`  <#assign wanInterface=far.interfaces(interfaceNamePrefix)>`
	`  <#if (wanInterface[0].v4.addresses[0].address)??>`
	`    <#assign interfaceName=wanInterface[0].name>`
	`    interface Tunnel${her.unusedInterfaceNumber()}`
	`      description IPsec tunnel to ${far.eid}`
	`      ...`
	`      ip ospf cost ${ospfCost}`
	`      ...`
	`</#macro>`

Macro calls	To call macros in a tunnel provisioning template: <@name param1, param2 ... paramN> FreeMarker replaces the macro call with the output of the macro after resolving all variables. For example: `<@configureTunnel far.tunnelSrcInterface1!"Wimax", 100/>`

Data Model

This section describes the data model in the tunnel provisioning templates. The **far** and **her** prefixes provide access to the properties of the FARs and HERs, respectively. These properties are stored in the IoT FND database. Table 3 describes referencing the information provided by the data model in tunnel provisioning templates.

Table 3 Data Model

Property	Description
far.eid	Returns the EID of the FAR. For example: `${far.eid}`
far.hostname	Returns the hostname of the FAR.
far.tunnelSrcInterface1	Returns the name of the FAR interface on which to establish the tunnel.

Table 3 Data Model (continued)

Property	Description
far.ipsecTunnelDestAddr1	Returns the name of the tunnel destination IP address on the HER.

far.ipv4Address(*clientId*, *linkAddress*, *userClass*)	Returns an IPv4 address. The IPv4 address method takes these parameters as input:
	■ clientId – DCHP Client Identifier for the DHCP request
	■ linkAddress – Link address for the DHCP request
	■ userClass – Value for the DHCP User Class option (defaults to “CG-NMS”)
	To establish a loopback interface and assign it an address:
	`interface Loopback0`
	`ip address ${far.ipv4Address(dhcpClientId(far.enDuid, 0),`
	`far.dhcpV4LoopbackLink).address}/32`
	`ipv6 address ${far.ipv6Address(far.enDuid, 0,`
	`far.dhcpV6LoopbackLink).address}/128`
	`exit`

far.ipv4Subnet()	Returns a DHCP IPv4 subnet lease. This call takes a clientId and linkAddress as arguments.
	Construct the clientId from the FAR EID and interface ID number using the dhcpClientId() method provided in the template API. This method takes as input a DHCPv6 Identity Association Identifier (IAID) and a DHCP Unique Identifier (DUID) and generates the DHCPv4 client identifier, as specified in RFC 4361. This method provides consistency for how network elements are identified by the DHCP server.
	For example:
	`<#assign lease=far.ipv4Subnet(dhcpClientId(far.enDuid,iaId),`
	`far.dhcpV4TunnelLink)>`

far.[any device property]	Returns the value of the specified property. For example, far.tunnelSrcInterface1 returns the value of the FAR tunnelSrcInterface1 property.

far.interfaces(interfaceNamePrefix)	Returns a list of device interfaces that match the requested prefix (not case sensitive).
	Use square brackets to index list members, for example, [0], [1], [2], and so on. Use the <#list> construct to iterate list members.
	For example:
	`<#assign wanInterface = far.interfaces(interfaceNamePrefix)>`
	`  <#if (wanInterface[0].v4.addresses[0].address)??>`
	`...`

Addresses

Table 4 describes referencing addresses in the tunnel provisioning templates.

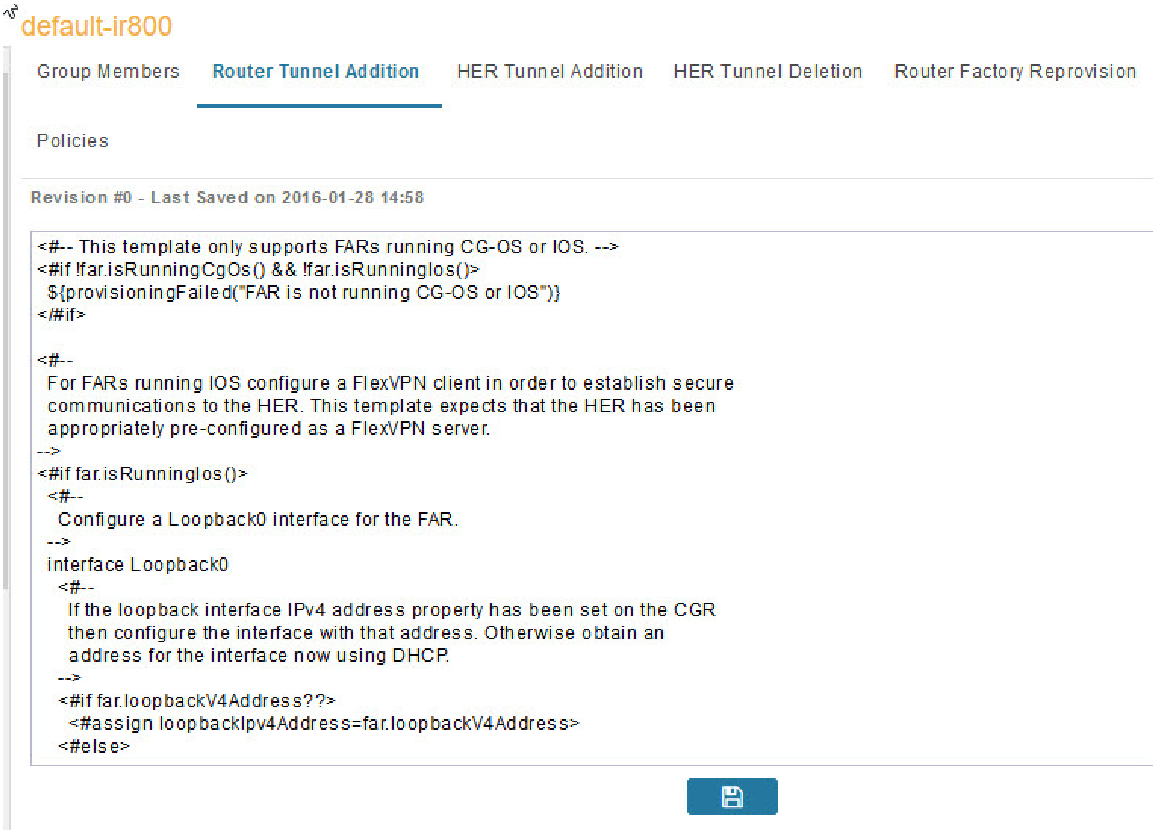
Table 4 Address References

Property	Description
address.address	Returns the address of the interface.
address.prefixLength	Returns the prefix length of the address.
address.prefix	Returns the address prefix.
address.subnetMask	Returns the subnet mask for the address.
address.wildcardMask	Returns the wildcard mask for the subnet.

Configuring the Field Area Router Tunnel Addition Template

To edit the FAR Tunnel Addition template to provide one end of an IPsec tunnel on FARs in the group:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, select the tunnel group with the template to edit.
3. Click the **Router Tunnel Addition** tab.



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```
<#-- This template only supports FARs running CG-OS or IOS. -->
<#if !far.isRunningCgOs() && !far.isRunningIos()>
 ${provisioningFailed("FAR is not running CG-OS or IOS")}
</#if>

<#--
 For FARs running IOS configure a FlexVPN client in order to establish secure
 communications to the HER. This template expects that the HER has been
 appropriately pre-configured as a FlexVPN server.
-->
<#if far.isRunningIos()>
 <#--
  Configure a Loopback0 interface for the FAR.
 -->
 interface Loopback0
  <#--
   If the loopback interface IPv4 address property has been set on the CGR
   then configure the interface with that address. Otherwise obtain an
   address for the interface now using DHCP.
  -->
  <#if far.loopbackV4Address??>
   <#assign loopbackIpv4Address=far.loopbackV4Address>
  <#else>
```

4. Modify the default template.

   Tip: Use a text editor to modify templates and copy the text into the template field in IoT FND.

5. Click the **Disk** icon to save changes.
6. Click **OK** to confirm the changes.

See also, Tunnel Provisioning Template Syntax.

Configuring the Head-End Router Tunnel Addition Template

Note: To ensure that both endpoints are in a matching subnet, this template must use the same IAID as the FAR template.

To edit the HER Tunnel Addition template to create the other end of the IPsec tunnel on HERs in the group:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, select a tunnel group.
3. Click the **HER Tunnel Addition** tab.
4. Modify the default HER addition template.
5. Click the **Disk** icon to save changes.
6. Click **OK** to confirm the changes.

Configuring the HER Tunnel Deletion Template

To edit the HER tunnel deletion template to delete existing tunnels to FARs at the other end of the tunnel:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, select the tunnel group whose template to edit.
3. Click the **HER Tunnel Deletion** tab.
4. Modify the default HER deletion template.
5. Click the **Disk** icon to save changes.
6. Click **OK** to confirm the changes.

Monitoring Tunnel Status

To view tunnel status, choose **OPERATIONS > Tunnel Status**. The Tunnel Status page lists devices and their provisioned tunnels and displays relevant information about tunnels and their status. Tunnels are provisioned between HERs and FARs.

When you select **Show Filter** at the top of the page (when selected, replaced by Hide Filter), a number of search fields appear. You can filter by all the Field Names listed in Table 5. The value entered in one search field will determine the available selections in the other fields. Select **Hide Filter** to remove the search fields.

Table 5 describes the tunnel status fields. To change the sort order of tunnels in the list by name, click the HER Name column heading. A small arrow next to the heading indicates the sort order.

Note: It takes time for the status of the newly created tunnel to be reflected in IoT FND.

Table 5 Tunnel Status Fields

Field	Description
HER Name	The EID of the HER at one end of the tunnel. To view the HER details, click its EID. **Note:** Because one HER can serve up to 500 FARs, there may be multiple tunnels in the list with the same HER EID. The Network Interfaces area of the Device Info page displays a list of tunnels configured on the HER. The Config Properties and Running Config tabs also contain information about tunnels configured on this HER.
HER Interface	The name of the HER tunnel interface. These names are automatically generated when tunnels are created (Tunnel1, Tunnel2, Tunnel3, and so on) or Virtual-Interface1, Virtual-Interface 2 and so on).
Admin Status	The administrative status of the tunnel (up or down). This indicates if the administrator enabled or disabled the tunnel.
Oper. Status	The operational status of the tunnel (up or down). If the tunnel is down, traffic does not flow through the tunnel, which indicates a problem to troubleshoot. Ping the HER and FAR to determine if they are online, or log on to the routers over SSH to determine the cause of the problem.
Protocol	The protocol used by the tunnel (IPSEC, PIM, or GRE).
HER Tunnel IP Address	The IP address of the tunnel at the HER side. Depending on the protocol used, the IP address appears in dotted decimal (IPv4) or hexadecimal (IPv6) slash notation.
HER IP Address	The destination IP address of the tunnel on the HER side.
FAR IP Address	The destination IP address of the tunnel on the FAR side.
FAR Interface	The name of the interface on the FAR used by the tunnel.
FAR Tunnel IP Address	The IP address of the tunnel on the FAR side. **Note:** The IP addresses on both sides of the tunnel are on the same subnet.
FAR Name	The EID of the FAR. To view the FAR details, click its EID. The Network Interfaces area of the Device Info page displays a list of tunnels configured on the FAR. The Config Properties and Running Config tabs also contain information about tunnels configured on this FAR.

Reprovisioning CGRs

In IoT FND, CGR reprovisioning is a process for modifying the configuration files on CGRs.

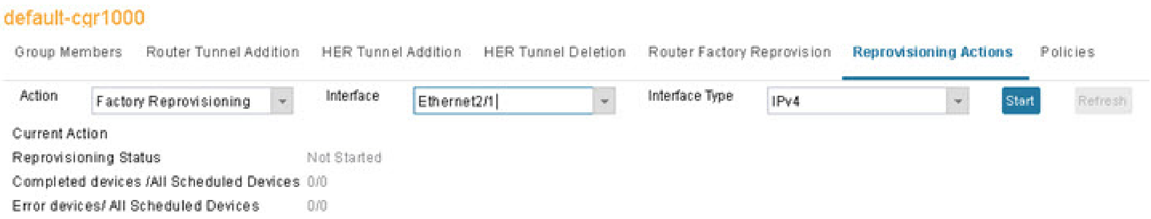
- CGR Reprovisioning Basics
- Tunnel Reprovisioning
- Factory Reprovisioning

Note: C800s do not support reprovisioning.

CGR Reprovisioning Basics

- CGR Reprovisioning Actions
- CGR Reprovisioning Sequence

CGR Reprovisioning Actions



Action: Factory Reprovisioning

Interface: Ethernet2/1

Interface Type: IPv4

Current Action

Reprovisioning Status: Not Started

Completed devices /All Scheduled Devices: 0/0

Error devices/ All Scheduled Devices: 0/0

In IoT FND, you can perform the following two CGR reprovisioning actions at the Reprovisioning Actions pane of the Tunnel Provisioning page (**CONFIG > Tunnel Provisioning > Reprovisioning Actions**). You can also activate mesh firmware.

Tip: You can also type in the interface instead of selecting the preloaded interface values.

Reprovisioning Actions	Description
Factory Reprovisioning	Drop-down menu allows you to change the express-setup-config file loaded on the CGR during factory configuration. This file contains a minimal set of information and is loaded on the CGR at the factory. This file provides the CGR with information to contact IoT FND (call home) through the TPS Proxy after the CGR is deployed and powered on.
Tunnel Reprovisioning	Drop-down menu allows you to change the golden-config file on a CGR. This file has the tunnel configuration defined on the CGR.
Mesh Firmware Activation	Drop-down menu allows you to select the Interface (such as cellular, Ethernet, etc.) and Interface Type (IPv6 or IPv4).

Table 6 describes the fields on the Reprovisioning Actions pane.

Table 6 Reprovisioning Actions Pane Fields

Field	Description
Current Action	The current reprovisioning action being performed and the associated interface.
Reprovisioning Status	The status of the reprovisioning action.
Completed devices /All Scheduled Devices	The number of CGRs that were processed relative to the number of all CGRs scheduled to be processed.
Error devices/ All Scheduled Devices	The number of CGRs that reported an error relative to the number of all CGRs scheduled to be processed.
Name	The EID of the CGR.
Reprovisioning Status	The status of the reprovisioning action for this CGR.
Last Updated	The last time the status of the reprovisioning action for this CGR was updated.

Table 6 Reprovisioning Actions Pane Fields (continued)

Field	Description
Template Version	The version of the Field Area Router Factory Reprovision template being applied.
Error Message	The error message reported by the CGR, if any.
Error Details	The error details.

CGR Reprovisioning Sequence

When you start tunnel or factory reprovisioning on a tunnel provisioning group, the reprovisioning algorithm sequentially goes through 12 CGRs at a time and reprovisions them.

After IoT FND reprovisions a router successfully or if an error is reported, IoT FND starts the reprovisioning process for the next router in the group. IoT FND repeats the process until all CGRs are reprovisioned.

There is a timeout of 4 hours when reprovisioning each CGR in the group. If the CGR does not report successful reprovisioning or an error within the timeout period, then IoT FND changes the Reprovisioning Status of the CGR to Error and displays a timeout error and any further information displays in the Error Details field.

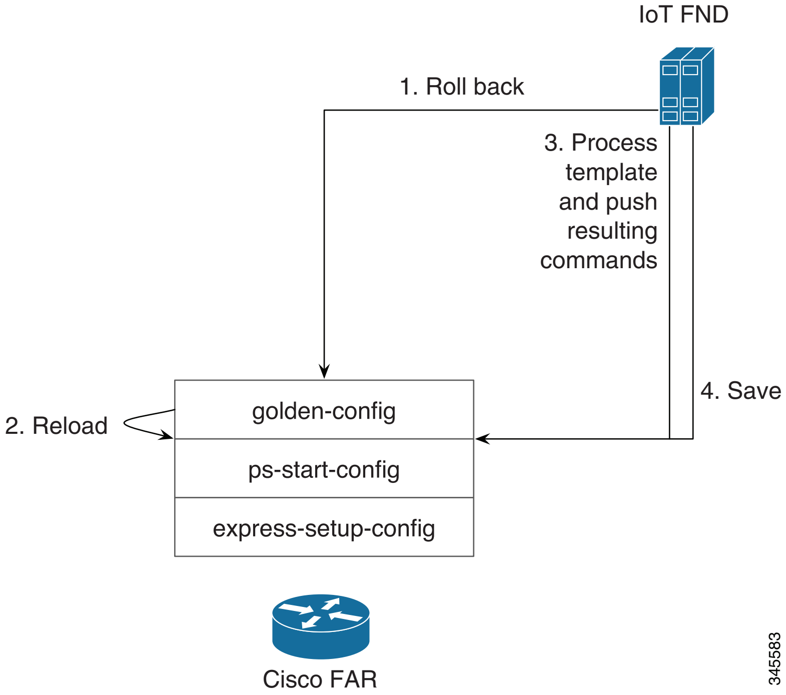
Tunnel Reprovisioning

If you make changes to the Field Area Router Tunnel Addition template and want all CGRs already connected to IoT FND reprovisioned with new tunnels based on the modified template, use the tunnel reprovisioning feature of IoT FND.

Tunnel reprovisioning places the CGR in a state where no tunnels are configured, and then initiates a new tunnel provisioning request. To reprovision tunnels, IoT FND sequentially goes through the FARs (12 at a time) in a tunnel provisioning group. For every CGR, IoT FND rolls back the configuration of the CGR to that defined in the ps-start-config template file.

After a rollback to ps-start-config, the CGR contacts IoT FND to request tunnel provisioning. IoT FND processes the Field Area Router Tunnel Addition template and sends the resultant configuration commands for creating new tunnels to the CGR. As shown in Figure 3, the tunnel provisioning process includes updating the golden-config file to include the new configuration information.

Figure 3 Tunnel Reprovisioning Process (CG-OS Routers)



Note: For CG-OS CGRs, FND initiates a config rollback and if the rollback fails, the router will go through a reload. Also, when IoT FND rolls back a CGR, IoT FND removes the corresponding tunnel information from the HERs to which the CGR was connected.

For Cisco IOS routers, the checkpoint files are before-tunnel-config, before-registration-config, and Express-setup-config. You perform a configuration replace for Cisco IOS based CGRs.

Note: The Field Area Router Factory Reprovision template is not used when performing tunnel reprovisioning.

To configure and trigger tunnel reprovisioning:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, select the tunnel group whose template to provision.
3. Click the **Reprovisioning Actions** tab.
4. From the Action drop-down menu, choose **Tunnel Reprovisioning**.
5. Click **Start**.

   IoT FND changes the Reprovisioning Status field to Initialized, and then to Running.

   Note: If you click **Stop** while tunnel reprovisioning is running, IoT FND stops the reprovisioning process only for the FARs in the queue that were not selected. However, for those CGRs in the queue that were selected for reprovisioning, the process completes (success or error) and cannot be stopped.

   The reprovisioning process completes after IoT FND finishes attempting to reprovision each CGR in the tunnel provisioning group. If a CGR cannot be reprovisioned, IoT FND displays the error message reported by the CGR.

Factory Reprovisioning

Use the Factory Reprovisioning feature in IoT FND to change the factory configuration of CGRs (express-setup-config).

Factory Reprovisioning involves these steps:

1. Sending the roll back command to the CGR.
2. Reloading the CGR.
3. Processing the Field Area Router Factory Reprovision template, and pushing the resultant commands to the CGR.
4. Saving the configuration in the express-setup-config file.

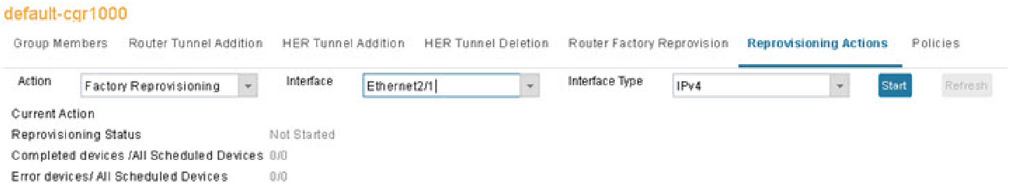
After these steps complete successfully, IoT FND processes the Field Area Router Tunnel Addition, Head-End Router Tunnel Addition, and Head-End Router Tunnel Deletion templates and pushes the resultant commands to the CGR (see Tunnel Provisioning Configuration Process).

To configure and trigger factory reprovisioning:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, select the tunnel group whose template you want to edit.
3. Click the **Router Factory Reprovision** tab and enter the template that contains the configuration commands to apply.

   Note: The Router Factory Reprovision template is processed twice during factory reprovisioning; once when pushing the configuration and again before saving the configuration in express-setup-config. Because of this, when making your own template, use the specific if/else condition model defined in the default template.

4. Click **Disk** icon to Save.
5. If needed, make the necessary modifications to the Field Area Router Tunnel Addition, Head-End Router Tunnel Addition, and Head-End Router Tunnel Deletion templates.
6. Click **Reprovisioning Actions** tab.
7. Select **Factory Reprovisioning**.



Action: Factory Reprovisioning
Interface: Ethernet2/1
Interface Type: IPv4

Current Action
Reprovisioning Status Not Started
Completed devices /All Scheduled Devices 0/0
Error devices/ All Scheduled Devices 0/0

8. From the Interface drop-down menu, choose the CGR interface for IoT FND to use to contact the FARs for reprovisioning.
9. From the Interface Type drop-down menu, choose **IPv4** or **IPv6**.
10. Click the **Start** button.

    IoT FND changes the Reprovisioning Status field to Initialized, and then to Running.

    Note: If you click **Stop** while factory reprovisioning is running, IoT FND stops the reprovisioning process only for the FARs in the queue that were not selected. However, for those CGRs in the queue that were selected for reprovisioning, the process completes and cannot be stopped.

The reprovisioning process completes after IoT FND has finished attempting to reprovision each CGR in the tunnel provisioning group. If a CGR cannot be reprovisioned, IoT FND displays the error message reported by the CGR.

Sample Field Area Router Factory Reprovision Template

This sample template changes the WiFi SSID and passphrase in the factory configuration.

```
<#--IMPORTANT: This template is processed twice during factory reprovisioning. The if/else condition
described below is needed to determine which part of the template is applied.
In this example, if no schedule name wimaxMigrationRebootTimer is found in runningConfig, then the if
part of the if/else section is applied. During the second pass, this template runs the commands in the
else section and the no scheduler command is applied. If modifying this template, do not remove the
if/else condition or else the template fails. -->

<#if !far.runningConfig.text?contains("scheduler schedule name wimaxMigrationRebootTimer")>

<#--Comment: This is a sample of generating wifi ssid and passphrase randomly-->

wifi ssid ${far.randomSSID("PREFIX_")}
authentication key-management wpa2
wpa2-psk ascii ${far.randomPassword(10)}
exit

feature scheduler
scheduler job name wimaxMigration
reload
exit

scheduler schedule name wimaxMigrationRebootTimer
time start +02:00
job name wimaxMigration
exit

<#else>

no scheduler job name wimaxMigration
no scheduler schedule name wimaxMigrationRebootTimer

</#if>
```

Managing High Availability Installations

This section describes how to set up IoT FND for high availability, and includes the following sections:

- Overview of IoT FND High Availability
- HA Guidelines and Limitations
- Configuring IoT FND Installations for HA

Overview of IoT FND High Availability

This section provides an overview of IoT FND high availability installations, including the following sections:

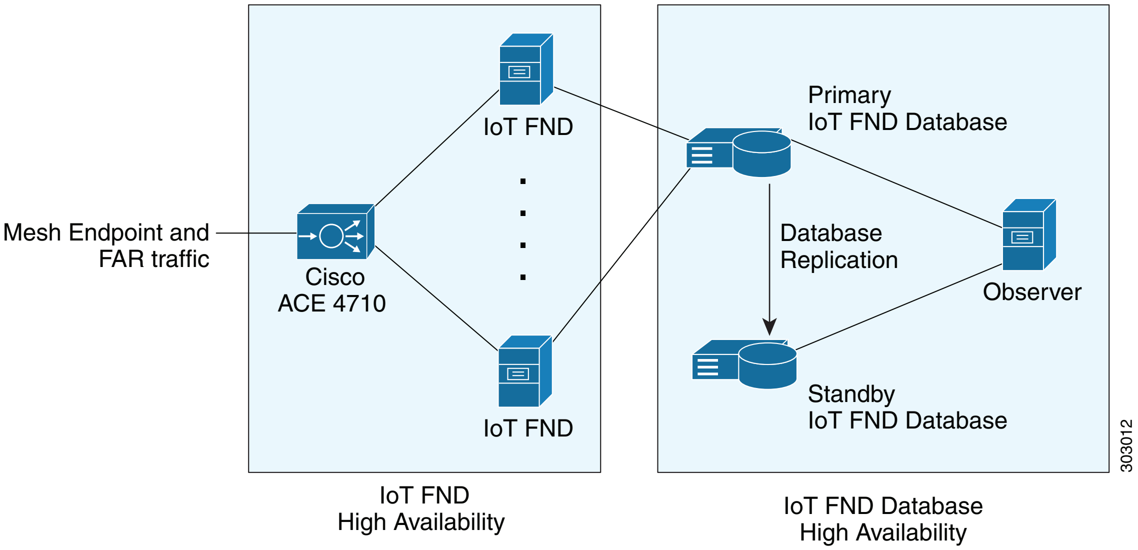
- Load Balancer
- Server Heartbeats
- Database High Availability
- Tunnel Redundancy

IoT FND is a critical application for monitoring and managing a connected grid. IoT FND High Availability (IoT FND HA) solutions address the overall availability of IoT FND during software, network, or hardware failures.

IoT FND provides two main levels of HA, as shown in Figure 1:

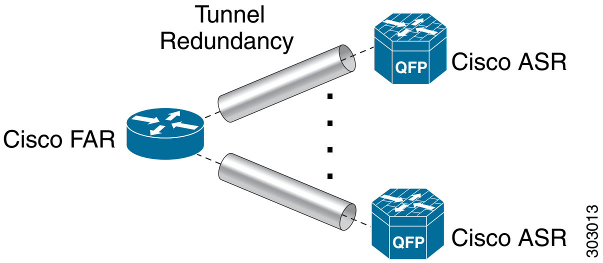
- IoT FND Server HA—This is achieved by connecting multiple IoT FND servers to a Cisco ACE 4710 load balancer. Traffic originating at MEs, FARs, and ASRs goes to the load balancer, which uses a round-robin protocol to distribute the load among the IoT FND cluster servers.
- IoT FND Database HA—This is achieved by configuring two IoT FND Database servers: a primary server and a standby (or secondary) server. When the primary database receives new data it sends a copy to the standby database. A separate system runs the Observer (the Observer can also run on the standby server), which is a program that monitors the IoT FND Database servers. If the primary database fails, the Observer configures the standby server as the new primary database. IoT FND Database HA works in single and cluster IoT FND server deployments.

Figure 1 IoT FND Server and Database HA



In addition to IoT FND Server and Database HA, IoT FND improves reliability by adding tunnel redundancy. This is achieved by defining multiple tunnels between one FAR and multiple ASRs. If one tunnel fails, the FAR routes traffic through another tunnel.

Figure 2 IoT FND Tunnel Redundancy



IoT FND HA addresses these failure scenarios:

Failure Type	Description
IoT FND server failure	If a server within a IoT FND server cluster fails, the load balancer routes traffic to the other servers in the cluster.
IoT FND database failures	If the primary database fails, the associated standby database becomes the primary database. This is transparent to the IoT FND servers. All IoT FND servers in the cluster connect to the new primary database.
Tunnel failure	If a tunnel fails, traffic flows through another tunnel.

Load Balancer

The Load Balancer (LB) plays a critical role in IoT FND HA, as it performs these tasks:

- Load balances traffic destined for IoT FND.
- Maintains heartbeats with servers in the cluster and detects any failure. If a IoT FND server fails, the LB directs traffic to other cluster members.

Cisco recommends using the Cisco ACE 4710 (Cisco ACE) as the load balancer in this deployment. See http://www.cisco.com/en/US/partner/products/ps7027/tsd_products_support_series_home.html for information on the Cisco ACE 4710.

Server Heartbeats

The LB maintains heartbeats with each IoT FND server in the cluster. In the health monitoring mechanism adopted by the IoT FND solution (there are alternate solutions), the heartbeats are regular GET messages to IoT FND on port 80. IoT FND expects an HTTP 200 OK response from an active IoT FND server.

You can configure these heartbeat parameters on the LB:

- Periodicity of probes—This is the number of seconds between heartbeats. The default value on the Cisco ACE is 15 seconds
- Number of retries—This is the number of times the LB tries to send a heartbeat to a non-responding IoT FND server before declaring it down. The default number of retries is 3.
- Regular checks after failure detection—The LB checks whether the server is back online at this time interval. The default failure detection check value is 60 seconds.

Database High Availability

IoT FND Database HA works in IoT FND single-server and cluster deployments. IoT FND HA uses Oracle Active Dataguard to deploy Oracle HA. To configure HA for the IoT FND Database, use the Oracle Recovery Manager (RMAN) and Dataguard Management CLI (DGMGRL).

The IoT FND Database HA configuration process involves:

- Configuring the primary and secondary databases the same on separate physical servers.

  Note: The secondary database server is also referred to as the standby database.

  Note: There is a possibility of losing some data during a database failover.

- Configuring data replication to be performed over SSL using an Oracle *wallet*. The wallet contains a self-signed certificate to facilitate quick deployment.

  Note: The Oracle wallet bundled with the IoT FND RPMs uses self-signed certificates. You can configure custom certificates and wallet to facilitate replication.

  Note: There is no performance impact when performing data replication over SSL.

- Using the sys user for replication and *not* cgms_dev.
- Configuring replication as asynchronous to prevent performance bottlenecks.

By default, IoT FND connects to the database using TCP over port 1522. Replication uses TCPS (TCP over SSL) on port 1622.

The scripts for configuring IoT FND Database HA are included in the IoT FND Oracle Database RPM package (cgms-oracle-*version_number*.x86_64.rpm). When you install the IoT FND Database, the HA scripts are located in $ORACLE_HOME/cgms/scripts/ha.

Tunnel Redundancy

To add another layer of redundancy to your IoT FND deployment, configure multiple tunnels to connect every FAR in a FAR tunnel provisioning group to multiple ASRs. For example, you could configure IoT FND to provision two tunnels for every FAR. One tunnel is active over the Cellular interface, while the redundant tunnel is configured to communicate with a second ASR over the WiMAX interfaces.

To configure tunnel redundancy, you need to:

1. Add ASRs to a tunnel provisioning group.
2. Modify the tunnel provisioning templates to include commands to create additional tunnels.
3. Define policies that determine the mapping between interfaces on the FAR and ASR interfaces:
   - Configuring Tunnel Provisioning Policies
   - Modifying the Tunnel Provisioning Templates for Tunnel Redundancy

HA Guidelines and Limitations

Note the following about IoT FND HA configurations:

- IoT FND HA does not include HA support for other network components like FARs, ASRs, and the load balancer.
- Zero service downtime is targeted by IoT FND HA, but it is not guaranteed.
- All IoT FND nodes must on the same subnet.
- All IoT FND nodes must run on similar hardware.
- All IoT FND nodes must run the same software version.
- Run the IoT FND setup script (/opt/cgms/bin/setupCgms.sh) on all the nodes.
- Run the DB migration script (/opt/cgms/bin/db-migrate) on only one node.
- The /opt/cgms/bin/print_cluster_view.sh script displays information about IoT FND cluster members.

HA Installation for FND

Be sure to enter the following information in the /opt/cgms/bin/cgms.conf file:

CLUSTER_BIND_ADDR= a.b.c.d

UDP_MULTICAST_ADDR= w.x.y.z

where CLUSTER_BIND_ADDR is the IP address of the server itself and UDP_MULTICAST_ADDR must be the same on all instances. It can be either an IPv4 multicast address or an IPv6 address which is not used in the network.

Configuring IoT FND Installations for HA

This section describes the various configuration settings for IoT FND HA installations, including the following sections:

- Setting Up IoT FND Database for HA
- Disabling IoT FND Database HA
- Load-Balancing Policies

- Running LB Configuration Example
- Configuring Tunnel Provisioning Policies
- Modifying the Tunnel Provisioning Templates for Tunnel Redundancy

Setting Up IoT FND Database for HA

To set up the IoT FND Database HA:

1. Set up the standby database (see Setting Up the Standby Database).

   Note: Always configure the standby database first.

   - The default SID for the standby server is **cgms_s** and *not* cgms.
   - Before setting up the standby server for HA, ensure that the environment variable $ORACLE_SID on the standby server is set to **cgms_s**.
   - The port is always 1522.

2. Set up the primary database (see Setting Up the Primary Database).

   - The default SID for the primary server is **cgms**.
   - Before setting up the primary server for HA, ensure that the environment variable $ORACLE_SID on the primary server is set to **cgms**.

3. Set up IoT FND for database HA (see Setting Up IoT FND for Database HA).

4. Set up the database Observer (see Setting Up the Observer).

Setting Up the Standby Database

To set up the standby database server for HA, run the setupStandbyDb.sh script. This script prompts for configuration information needed for the standby database, including the IP address of the primary database.

```
$ ./setupStandbyDb.sh
$ Are you sure you want to setup a standby database ? (y/n)? y

09-20-2012 13:59:18 PDT: INFO: User response: y
09-20-2012 13:59:18 PDT: INFO: CGMS_S database does not exist.
Enter the SYS DBA password. NOTE: This password should be same as the one set on the primary server:
Re-enter password for SYS DBA:
09-20-2012 13:59:58 PDT: INFO: User entered SYS DBA password.

Enter new password for CG-NMS database:
Re-enter new password CG-NMS database:
09-20-2012 14:00:09 PDT: INFO: User entered CG-NMS DB password.
Enter primary database server IP address: 192.168.1.12
09-20-2012 14:00:27 PDT: INFO: Cleaning up instance - cgms_s
DGMGRL for Linux: Version 11.2.0.3.0 - 64bit Production
…
Total System Global Area  329895936 bytes
Fixed Size    2228024 bytes
Variable Size  255852744 bytes
Database Buffers   67108864 bytes
Redo Buffers    4706304 bytes
...
```

```
09-20-2012 14:00:29 PDT: INFO: ========== CGMS_S Database Setup Completed Successfully ==========
```

Setting Up the Primary Database

To set up the primary database server for HA, run the setupHaForPrimary.sh script. This script prompts for configuration information needed for the primary database, including the IP address of the standby database.

```
$ ./setupHaForPrimary.sh
[oracle@pdb ha]$ ./setupHaForPrimary.sh
09-20-2012 13:58:39 PDT: INFO: ORACLE_BASE: /home/oracle/app/oracle
09-20-2012 13:58:39 PDT: INFO: ORACLE_HOME: /home/oracle/app/oracle/product/11.2.0/dbhome_1
09-20-2012 13:58:39 PDT: INFO: ORACLE_SID : cgms
09-20-2012 13:58:39 PDT: INFO: Make sure the above environment variables are what you expect

Are you sure you wish to configure high availability for this database server ? (y/n)? y

09-20-2012 13:58:45 PDT: INFO: User response: y
Enter standby database server IP address: 192.168.1.10
09-20-2012 13:58:56 PDT: INFO: Secondary listener reachable. Moving on with configuration
mkdir: cannot create directory `/home/oracle/app/oracle/oradata/cgms': File exists
09-20-2012 13:58:58 PDT: INFO: Reloading the listener to pick the new settings

LSNRCTL for Linux: Version 11.2.0.3.0 - Production on 20-SEP-2012 13:58:58

…
DGMGRL> 09-20-2012 14:14:54 PDT: INFO: Please start the 'Observer' on appropriate server for ha
monitoring
Total time taken to perform the operation: 975 seconds
09-20-2012 14:14:54 PDT: INFO: ==========  Completed Successfully ==========
```

Setting Up the Observer

The Observer should run on a separate server, but can be set up on the server hosting the standby database.

Note: The password required for running Observer is the same as the SYS DBA password. See Creating the IoT FND Oracle Database

To set up the Observer:

1. On a separate server, run the observer script.

```
$ ./manageObserver.sh start cgms_s password
$ DGMGRL for Linux: Version 11.2.0.3.0 - 64bit Production
...
Welcome to DGMGRL, type "help" for information.
DGMGRL> Connected.
DGMGRL> Observer started
```

2. Run the getHaStatus.sh script to verify that the database is set up for HA.

```
$ ./getHaStatus.sh
...
Configuration - cgms_dgconfig

  Protection Mode: MaxPerformance
  Databases:
    cgms   - Primary database
    cgms_s - (*) Physical standby database

Fast-Start Failover: ENABLED

Configuration Status:
SUCCESS
```

```
DGMGRL>
Database - cgms

  Role:          PRIMARY
  Intended State:  TRANSPORT-ON
  Instance(s):
    cgms

Database Status:
SUCCESS

DGMGRL>
Database - cgms_s

  Role:          PHYSICAL STANDBY
  Intended State:  APPLY-ON
  Transport Lag:   0 seconds
  Apply Lag:      0 seconds
  Real Time Query: OFF
  Instance(s):
    cgms_s

Database Status:
SUCCESS
```

Setting Up IoT FND for Database HA

To set up IoT FND for database HA:

1. Stop IoT FND.
2. Run the setupCgms.sh script.

   The script prompts you to change the database settings. Enter **y**. Then, the script prompts you to enter the primary database server information (IP address, port, and database SID). After that, the script prompts you to add another database server. Enter **y**. Then, the script prompts you to enter the standby database server information (IP address, port, and database SID), as follows:

   Note: IoT FND always uses port 1522 to communicate with the database. Port 1622 is only used by the database for replication.

```
# cd /opt/cgms/bin
# ./setupCgms.sh
09-13-2012 17:10:00 PDT: INFO: ========== CG-NMS Setup Started - 2012-09-13-17-10-00 ==========
09-13-2012 17:10:00 PDT: INFO: Log file: /opt/cgms/bin/../server/cgms/log/cgms_setup.log

Are you sure you want to setup CG-NMS (y/n)? y

09-13-2012 17:10:02 PDT: INFO: User response: y

Do you want to change the database settings (y/n)? y

09-13-2012 17:10:05 PDT: INFO: User response: y

Enter database server IP address [128.107.154.246]: 128.107.154.246
09-13-2012 17:11:02 PDT: INFO: Database server IP: 128.107.154.246

Enter database server port [1522]:
09-13-2012 17:11:07 PDT: INFO: Database server port: 1522
```

```
Enter database SID [cgms]:
09-13-2012 17:11:12 PDT: INFO: Database SID: cgms

Do you wish to configure another database server for this CG-NMS ? (y/n)? y

09-13-2012 17:11:18 PDT: INFO: User response: y
Enter database server IP address []: 128.107.154.20
09-13-2012 17:11:02 PDT: INFO: Database server IP: 128.107.154.20
Enter database server port []: 1522
09-13-2012 17:11:07 PDT: INFO: Database server port: 1522
Enter database SID []: cgms_s
09-13-2012 17:11:12 PDT: INFO: Database SID: cgms_s
09-13-2012 17:11:18 PDT: INFO: Configuring database settings. This may take a while. Please wait
...
09-13-2012 17:11:19 PDT: INFO: Database settings configured.

Do you want to change the database password (y/n)? y

09-13-2012 17:15:07 PDT: INFO: User response: y

Enter database password:
Re-enter database password:

09-13-2012 17:15:31 PDT: INFO: Configuring database password. This may take a while. Please wait
...
09-13-2012 17:15:34 PDT: INFO: Database password configured.

Do you want to change the keystore password (y/n)? n

09-13-2012 17:16:18 PDT: INFO: User response: n

Do you want to change the web application 'root' user password (y/n)? n

09-13-2012 17:16:34 PDT: INFO: User response: n

Do you want to change the FTP settings (y/n)? n

09-13-2012 17:16:45 PDT: INFO: User response: n
09-13-2012 17:16:45 PDT: INFO: ========== CG-NMS Setup Completed Successfully ==========
```

Disabling IoT FND Database HA

To disable IoT FND Database HA:

1. On the server running the Observer program, stop the Observer:

```
$ ./manageObserver.sh stop cgms_s password
DGMGRL for Linux: Version 11.2.0.3.0 - 64bit Production

Copyright (c) 2000, 2009, Oracle. All rights reserved.

Welcome to DGMGRL, type "help" for information.
DGMGRL> Connected.
DGMGRL> Done.
$ Observer stopped
```

2. On the standby IoT FND Database server, delete the standby database:

```
$ ./deleteStandbyDb.sh

Are you sure you want to delete the standby database ? All replicated data will be lost (y/n)? y

09-20-2012 14:27:02 PDT: INFO: User response: y
09-20-2012 14:27:02 PDT: INFO: Cleaning up instance - cgms_s
```

```
DGMGRL for Linux: Version 11.2.0.3.0 - 64bit Production

Copyright (c) 2000, 2009, Oracle. All rights reserved.

Welcome to DGMGRL, type "help" for information.
DGMGRL> Connected.
DGMGRL> Done.
DGMGRL> DGMGRL for Linux: Version 11.2.0.3.0 - 64bit Production

Copyright (c) 2000, 2009, Oracle. All rights reserved.

Welcome to DGMGRL, type "help" for information.
DGMGRL> Connected.
DGMGRL> Disabled.
DGMGRL> 09-20-2012 14:27:06 PDT: INFO: Removing dataguard configuration
DGMGRL for Linux: Version 11.2.0.3.0 - 64bit Production

Copyright (c) 2000, 2009, Oracle. All rights reserved.

Welcome to DGMGRL, type "help" for information.
DGMGRL> Connected.
DGMGRL> Removed configuration
DGMGRL> 09-20-2012 14:27:07 PDT: INFO: Stopping the database

SQL*Plus: Release 11.2.0.3.0 Production on Thu Sep 20 14:27:07 2012

Copyright (c) 1982, 2011, Oracle.  All rights reserved.


Connected to:
Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit Production
With the Partitioning, OLAP, Data Mining and Real Application Testing options

SQL> ORA-01109: database not open


Database dismounted.
ORACLE instance shut down.
SQL> Disconnected from Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit Production
With the Partitioning, OLAP, Data Mining and Real Application Testing options

LSNRCTL for Linux: Version 11.2.0.3.0 - Production on 20-SEP-2012 14:27:19

Copyright (c) 1991, 2011, Oracle.  All rights reserved.

Connecting to
(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=test-scale-15krpm)(PORT=1522))(CONNECT_DATA=(SERVER=DEDIC
ATED)(SERVICE_NAME=cgms_s)))
The command completed successfully
Cleaning up instance - cgms_s
09-20-2012 14:27:29 PDT: INFO: ==========  Completed Successfully ==========
```

3. On the primary IoT FND Database server, delete the HA configuration:

```
$ ./deletePrimaryDbHa.sh
Are you sure you want to delete the high availability configuration ? All replicated data will be
lost (y/n)? y

09-20-2012 14:25:25 PDT: INFO: User response: y
09-20-2012 14:25:25 PDT: INFO: Removing secondary configuration from primary

SQL*Plus: Release 11.2.0.3.0 Production on Thu Sep 20 14:25:25 2012
```

```
Copyright (c) 1982, 2011, Oracle.  All rights reserved.


Connected to:
Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit Production
With the Partitioning, OLAP, Data Mining and Real Application Testing options

SQL>
System altered.
...
SQL> Disconnected from Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit Production
With the Partitioning, OLAP, Data Mining and Real Application Testing options
09-20-2012 14:25:28 PDT: INFO: Removing data guard config files
09-20-2012 14:25:28 PDT: INFO: Removing standby redo logs
09-20-2012 14:25:29 PDT: INFO: Creating listener file
09-20-2012 14:25:29 PDT: INFO: Listener successfully configured.
09-20-2012 14:25:29 PDT: INFO: Recreating tnsnames ora file
09-20-2012 14:25:29 PDT: INFO: reloading the listener

LSNRCTL for Linux: Version 11.2.0.3.0 - Production on 20-SEP-2012 14:25:29

Copyright (c) 1991, 2011, Oracle.  All rights reserved.

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=test-scale-15krpm-db2)(PORT=1522)))
The command completed successfully

LSNRCTL for Linux: Version 11.2.0.3.0 - Production on 20-SEP-2012 14:25:30

Copyright (c) 1991, 2011, Oracle.  All rights reserved.

Starting /home/oracle/app/oracle/product/11.2.0/dbhome_1/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 11.2.0.3.0 - Production
System parameter file is /home/oracle/app/oracle/product/11.2.0/dbhome_1/network/admin/listener.ora
Log messages written to
/home/oracle/app/oracle/diag/tnslsnr/test-scale-15krpm-db2/cgmstns/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=test-scale-15krpm-db2)(PORT=1522)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=test-scale-15krpm-db2)(PORT=1522)))
STATUS of the LISTENER
------------------------
Alias                     cgmstns
Version                   TNSLSNR for Linux: Version 11.2.0.3.0 - Production
Start Date                20-SEP-2012 14:25:30
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File
/home/oracle/app/oracle/product/11.2.0/dbhome_1/network/admin/listener.ora
Listener Log File
/home/oracle/app/oracle/diag/tnslsnr/test-scale-15krpm-db2/cgmstns/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=test-scale-15krpm-db2)(PORT=1522)))
Services Summary...
Service "cgms" has 1 instance(s).
  Instance "cgms", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
09-20-2012 14:25:30 PDT: INFO: ==========  Completed Successfully ==========
```

Load-Balancing Policies

Table 1 describes the load-balancing policy for each type of traffic the LB supports:

Table 1

Traffic	Load Balancing Policy
HTTPS traffic to and from browsers and IoT FND API clients (IPv4; ports 80 and 443)	The LB uses Layer 7 load balancing for all traffic from Web browsers and IoT FND API clients. The LB uses stickiness for general HTTPS traffic.
For FAR IPv4 traffic going to ports 9121 and 9120: ■ Tunnel Provisioning on port 9120 over HTTPS ■ Regular registration and periodic on 9121 over HTTPS	The LB uses Layer 3 load balancing for all FAR traffic. This is the traffic from the FAR to IoT FND.
For IPv6 CSMP traffic to and from mesh endpoints (MEs): ■ UDP traffic over port 61624 – Registration – Periodic transmission of metrics – Firmware push – Configuration push ■ UDP traffic over port 61625 For outage notifications sent by MEs.	The LB uses Layer 3 load balancing for all ME traffic to port 61624, and outage messages to port 61625.

Running LB Configuration Example

The following is an example of the running configuration of a properly configured IoT FND LB:

```
# show running-config
Generating configuration....

ssh maxsessions 10

boot system image:c4710ace-t1k9-mz.A5_1_1.bin

hostname cgnmslb2
interface gigabitEthernet 1/1
  switchport access vlan 10
  no shutdown
interface gigabitEthernet 1/2
  description server-side
  switchport access vlan 11
  no shutdown
interface gigabitEthernet 1/3
  description client-side
  switchport access vlan 8
  no shutdown
interface gigabitEthernet 1/4
  switchport access vlan 55
  no shutdown
```

```
access-list ALL line 8 extended permit ip any any
access-list everyone line 8 extended permit ip any any
access-list everyone line 16 extended permit icmp any any
access-list ipv6_acl line 8 extended permit ip anyv6 anyv6
access-list ipv6_acl2 line 8 extended permit icmpv6 anyv6 anyv6



ip domain-lookup
ip domain-name cisco.com
ip name-server 171.68.226.120
ip name-server 171.70.168.183

probe http probe_cgnms-http
  port 80
  interval 15
  passdetect interval 60
  expect status 200 200
  open 1

rserver host 12-12-1-31
  ip address 12.12.1.31
  conn-limit max 4000000 min 4000000
  probe probe_cgnms-http
  inservice
rserver host 12-12-1-32
  ip address 12.12.1.32
  conn-limit max 4000000 min 4000000
  probe probe_cgnms-http
  inservice
rserver host 2002-cafe-server-202
  description realserver 2002:cafe:server::202
  ip address 2002::202
  conn-limit max 4000000 min 4000000
  probe probe_cgnms-http
  inservice
rserver host 2002-cafe-server-211
  ip address 2002:cafe:server::211
  conn-limit max 4000000 min 4000000
  probe probe_cgnms-http
  inservice

serverfarm host cgnms_2
  description cgnms-serverfarm
  probe probe_cgnms-http
  rserver 2002-cafe-server-202 61624
    conn-limit max 4000000 min 4000000
    inservice
  rserver 2002-cafe-server-211 61624
    conn-limit max 4000000 min 4000000
    inservice
serverfarm host cgnms_2_ipv4
  probe probe_cgnms-http
  rserver 12-12-1-31
    conn-limit max 4000000 min 4000000
    inservice
  rserver 12-12-1-32
    conn-limit max 4000000 min 4000000
    inservice

sticky ip-netmask 255.255.255.255 address source CGNMS_SRC_STICKY
  serverfarm cgnms_2_ipv4
```

```
class-map type management match-any remote_access
  2 match protocol xml-https any
  3 match protocol icmp any
  4 match protocol telnet any
  5 match protocol ssh any
  6 match protocol http any
  7 match protocol https any
  8 match protocol snmp any
class-map type management match-all ssh_allow_access
  2 match protocol ssh any
class-map match-any virtual-server-cgnms
  2 match virtual-address 2002:server:cafe::210 udp eq 61624
class-map match-any vs_cgnms_ipv4
  3 match virtual-address 12.12.1.101 tcp eq https
  4 match virtual-address 12.12.1.101 tcp eq 9120
  5 match virtual-address 12.12.1.101 tcp eq 9121
  6 match virtual-address 12.12.1.101 tcp eq 8443
  7 match virtual-address 12.12.1.101 tcp any

policy-map type management first-match remote_mgmt_allow_policy
  class remote_access
    permit

policy-map type loadbalance first-match virtual_cgnms_l7
  class class-default
    serverfarm cgnms_2
policy-map type loadbalance first-match vs_cgnms_l7_v4
  class class-default
    sticky-serverfarm CGNMS_SRC_STICKY

policy-map multi-match cgnms_policy_ipv6
  class virtual-server-cgnms
    loadbalance vip inservice
    loadbalance policy virtual_cgnms_l7
    loadbalance vip icmp-reply active
policy-map multi-match int1000
  class vs_cgnms_ipv4
    loadbalance vip inservice
    loadbalance policy vs_cgnms_l7_v4
    loadbalance vip icmp-reply active

interface vlan 8
  bridge-group 1
  access-group input everyone
  access-group input ipv6_acl
  no shutdown
interface vlan 10
  bridge-group 2
  access-group input everyone
  access-group input ipv6_acl
  service-policy input int1000
  no shutdown
interface vlan 11
  bridge-group 2
  access-group input everyone
  access-group input ipv6_acl
  no shutdown
interface vlan 55
  bridge-group 1
  access-group input everyone
  access-group input ipv6_acl
  service-policy input cgnms_policy_ipv6
  no shutdown

interface bvi 1
  ipv6 enable
  ip address 2002:server:cafe::206/64
  no shutdown
interface bvi 2
  ip address 12.12.1.100 255.255.255.0
  no shutdown

domain cisco.com

ip route 2011::/16 2002:server:cafe::101
ip route 2001:server:cafe::/64 2002:cafe::101
ip route 11.1.0.0 255.255.0.0 12.12.1.33
ip route 15.1.0.0 255.255.0.0 12.12.1.33
ip route 13.211.0.0 255.255.0.0 12.12.1.33

context VC_Setup1
  allocate-interface vlan 40
  allocate-interface vlan 50
  allocate-interface vlan 1000

username admin password 5 $1$CB34uAB9$BW8a3ijjxvBGttuGtTcST/  role Admin domain
default-domain
username www password 5 $1$q/YDKDp4$9PkZl1SBMQW7yZ7E.sOZA/  role Admin domain de
fault-domain

ssh key rsa 1024 force
```

Configuring Tunnel Provisioning Policies

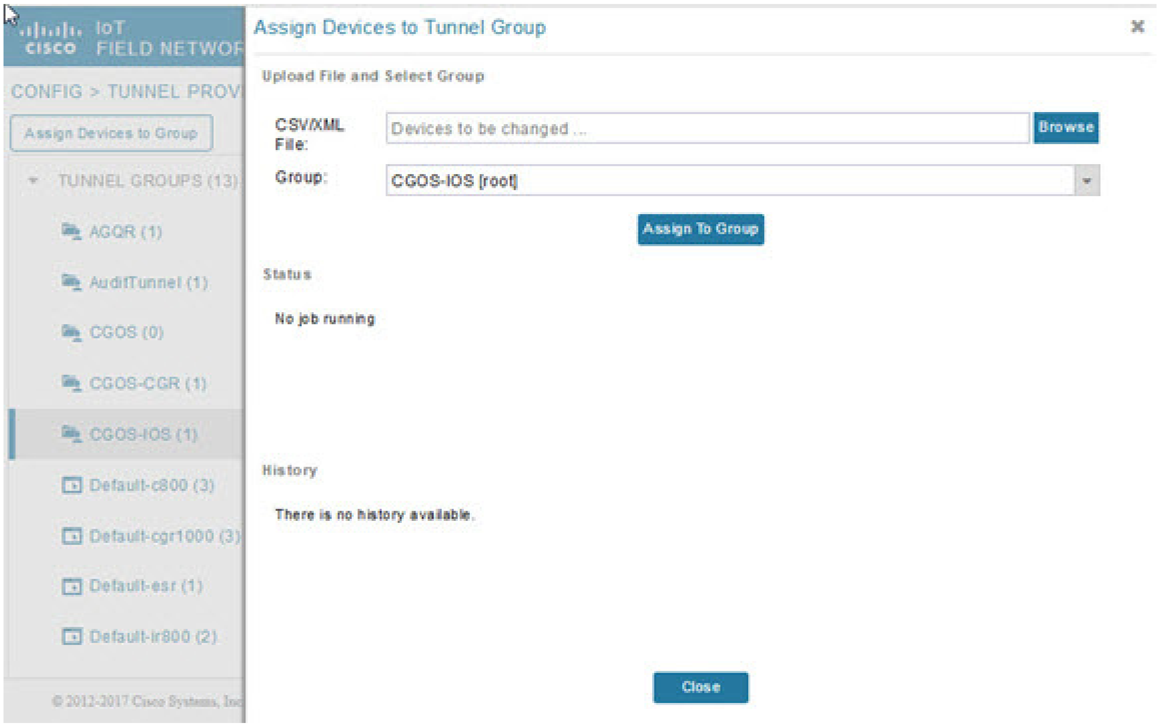
Use tunnel policies to configure multiple tunnels for a FAR. Each tunnel is associated with an interface on a FAR and an HER. If a tunnel provisioning group has one or more HERs, IoT FND displays a policy in the Tunnel Provisioning Policies tab (**Config > Tunnel Provisioning**). Use this policy to configure FAR-to-HER interface mapping.

To map FAR-to-HER interfaces in IoT FND:

1. Choose **CONFIG > Tunnel Provisioning**.
2. In the TUNNEL GROUPS pane, select a group to configure with tunnel redundancy.
3. Create a CSV or XML file that lists the HERs to add to the group in the format *EID, device type*, as follows:

   ```
   eid,deviceType
   asr-0, asr1000
   asr-1, asr1000
   asr-2, asr1000
   ```

4. Click **Assign Devices to Group** to import the file and add HERs to the group.



IoT FIELD NETWOR

CONFIG > TUNNEL PROV

Assign Devices to Group

TUNNEL GROUPS (13)

- AGQR (1)
- AuditTunnel (1)
- CGOS (0)
- CGOS-CGR (1)
- CGOS-IOS (1)
- Default-c800 (3)
- Default-cgr1000 (3)
- Default-esr (1)
- Default-ir800 (2)

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Assign Devices to Tunnel Group

Upload File and Select Group

CSV/XML File: Devices to be changed ... Browse

Group: CGOS-IOS [root]

Assign To Group

Status

No job running

History

There is no history available.

Close

Note: A HER can be a member of multiple tunnel provisioning groups.

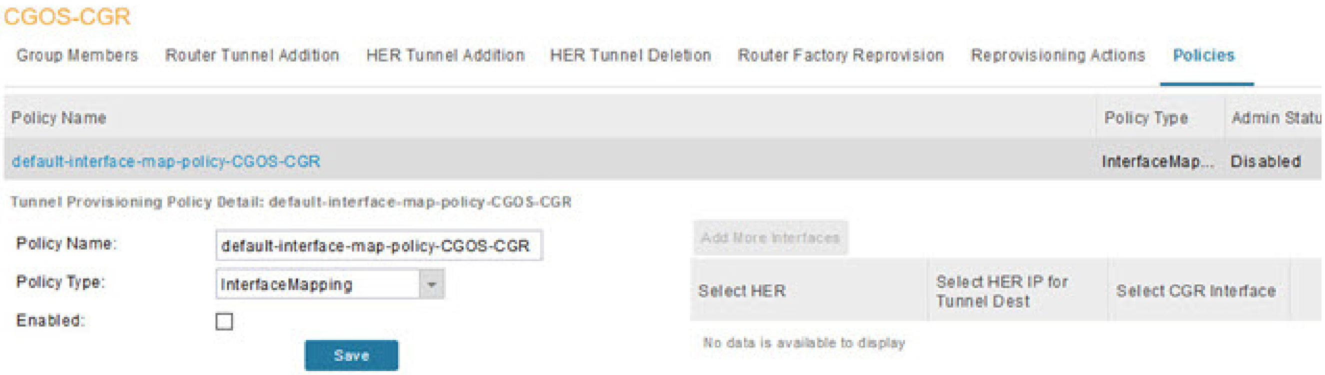
5. With the tunnel provisioning group selected, click the **Policies** tab.

   By default, IoT FND displays the **default-interface-mapping-policy-*tunnel-group*** name for the selected tunnel group within the Policy Name panel.

   Note: Interface-mapping is the only policy type currently supported in IoT FND.

   IoT FND displays one interface mapping entry for every HER in the group. You can add or remove interface mapping entries as needed.

6. Click the Policy Name link within the Policy Name Panel to open an entry panel. In the Policy Name field, enter the name of the policy.



CGOS-CGR

Group Members | Router Tunnel Addition | HER Tunnel Addition | HER Tunnel Deletion | Router Factory Reprovision | Reprovisioning Actions | Policies

Policy Name	Policy Type	Admin Statu
default-interface-map-policy-CGOS-CGR	InterfaceMap...	Disabled

Tunnel Provisioning Policy Detail: default-interface-map-policy-CGOS-CGR

Policy Name: default-interface-map-policy-CGOS-CGR

Policy Type: InterfaceMapping

Enabled: □

Save

Add More Interfaces

Select HER	Select HER IP for Tunnel Dest	Select CGR Interface

No data is available to display

To **add** an interface-mapping entry to the policy, click **Add More Interfaces** (button found above Select HER listing right-side of page). To **delete** an entry, click **Delete** (**X**) for that entry.

7. To configure an interface-mapping entry, click the Policy Name link, and complete the following as necessary:
    a. To select a different HER, click the currently selected HER and choose a different one from the **Select a HER** drop-down menu.
    b. To select the HER IP for the tunnel destination on the HER, click the selected interface and choose a different one from the **Select HER IP** drop-down menu.
    c. To select the FAR interface that maps to the selected HER interface, choose an interface from the **Select CGR Interface** drop-down menu.
    d. Click **Update**.
8. To enable the policy, check the **Enabled** check box.
9. Click **Save**.

Modifying the Tunnel Provisioning Templates for Tunnel Redundancy

After defining the tunnel provisioning policy for a tunnel provisioning group, modify the Field Area Router Tunnel Addition and the Head-End Router Tunnel Addition templates to include commands to establish the multiple tunnels defined in the policy.

Field Area Router Tunnel Addition Template Example

In this example, bold text indicates the changes made to the default Field Area Router Tunnel Addition template to create multiple tunnels:

```
<#--
  Configure a Loopback0 interface for the FAR. This is done first as features
  look for this interface and use it as a source.

  This is independent of policies
-->
interface Loopback0
  <#--
    Now obtain an IPv4 address that can be used to for this FAR's Loopback
    interface. The template API provides methods for requesting a lease from
    a DHCP server. The IPv4 address method requires a DHCP client ID and a link
    address to send in the DHCP request. The 3rd parameter is optional and
    defaults to "CG-NMS". This value is sent in the DHCP user class option.
    The API also provides the method "dhcpClientId". This method takes a DHCPv6
    Identity association identifier (IAID) and a DHCP Unique  IDentifier (DUID)
    and generates a DHCPv4 client identifier as specified in RFC 4361. This
    provides some consistency in how network elements are identified by the
    DHCP server.
  -->
  ip address ${far.ipv4Address(dhcpClientId(far.enDuid, 0), far.dhcpV4LoopbackLink).address}/32
  <#--
    Now obtain an IPv6 address that can be used to for this FAR's loopback
    interface. The method is similar to the one used for IPv4, except clients
    in DHCPv6 are directly identified by their DUID and IAID. IAIDs used for
    IPv4 are separate from IAIDs used for IPv6, so we can use zero for both
    requests.
  -->
  ipv6 address ${far.ipv6Address(far.enDuid, 0, far.dhcpV6LoopbackLink).address}/128
exit

<#-- Make certain the required features are enabled on the FAR. -->
feature crypto ike
feature ospf
feature ospfv3
feature tunnel
<#-- Features ike and tunnel must be enabled before ipsec. -->
feature crypto ipsec virtual-tunnel

<#--
  Toggle on/off the c1222r feature to be certain it uses the Loopback0
  interface as its source IP.
-->
no feature c1222r
feature c1222r

<#-- Configure Open Shortest Path First routing processes for IPv4 and IPv6. -->
router ospf 1
exit
router ospfv3 2
exit

<#--
  Now that OSPF has been configured complete the configuration of Loopback0.
-->
interface Loopback0
  ip router ospf 1 area ${far.ospfArea1!"1"}
  ipv6 router ospfv3 2 area ${far.ospfV3Area1!"0"}
exit

<#-- Configure Internet Key Exchange for use by the IPsec tunnel(s). -->
crypto ike domain ipsec
  identity hostname
  policy 1
    <#-- Use RSA signatures for the authentication method. -->
    authentication rsa-sig
    <#-- Use the 1536-bit modular exponential group. -->
    group 5
  exit
exit
crypto ipsec transform-set IPSecTransformSet esp-aes 128 esp-sha1-hmac
crypto ipsec profile IPSecProfile
  set transform-set IPSecTransformSet
exit

<#--
  Define template variables to keep track of the next available IAID (IPv4)
  and the next available tunnel interface number. We used zero when leasing
  addresses for Loopback0, so start the IAID at one.
-->
<#assign iaId = 1>
<#assign interfaceNumber = 0>

<#--
  The same logic is needed for each of the IPsec tunnels, so a macro is used
  to avoid duplicating configuration. The first parameter is the prefix to
  use when looking for the WAN interface on the FAR to use for the source of
  the tunnel. The second parameter is the OSPF cost to assign to the tunnel.
-->
<#macro configureTunnel interfaceNamePrefix destinationInterface her tunnelIndex ospfCost>
  <#--
    If an interface exists on the FAR whose name starts with the given prefix
    and an IPv4 address as been assigned to that interface then the IPsec
    tunnel can be configured, otherwise no tunnel will be configured. The
    template API interfaces method will return all interfaces whose name
    starts with the given prefix.
  -->
  <#assign wanInterface = far.interfaces(interfaceNamePrefix)>
```

```
 <#-- Check if an interface was found and it has an IPv4 address. -->
 <#if (wanInterface[0].v4.addresses[0].address)??>
  <#--
   Determine the HER destination address to use when configuring the tunnel.
   If the optional property "ipsecTunnelDestAddr1" has been set on this FAR
   then use the value of that property. Otherwise look for that same property
   on the HER. If the property is not set on the FAR or the HER, then fallback
   to using an address on the HER GigabitEthernet0/0/0 interface.
  -->
  <#assign destinationAddress = her.interfaces(destinationInterface)[0].v4.addresses[0].address>

  <#if !(destinationAddress??)>
   ${provisioningFailed("Unable to determine the destination address for IPsec tunnels")}
  </#if>
  interface Tunnel${interfaceNumber}
   <#assign interfaceNumber = interfaceNumber + 1>
   description IPsec tunnel to ${her.eid}
   <#--
    For a tunnel interface two addresses in their own tiny subnet are
    needed. The template API provides an ipv4Subnet method for leasing an
    IPv4 from a DHCP server. The parameters match those of ipv4Address,
    with a fourth optional parameter that can be used to specify the
    prefix length of the subnet to request. If not specified the prefix
    length requested will default to 31, which provides the two addresses
    needed for a point to point link.

    NOTE: If the DHCP server being used does not support leasing an IPv4
    subnet, then this call will have to be changed to use the ipv4Address
    method and the DHCP server will have to be configured to respond
    appropriately to the request made here and the second request that
    will have to be made when configuring the HER side of the tunnel.
    That may require configuring the DHCP server with reserved addresses
    for the client identifiers used in the calls.
   -->
   <#assign lease = far.ipv4Subnet(dhcpClientId(far.enDuid, tunnelIndex), far.dhcpV4TunnelLink)>
   <#assign iaId = iaId + 1>
   <#-- Use the second address in the subnet for this side of the tunnel. -->
   ip address ${lease.secondAddress}/${lease.prefixLength}
   ip ospf cost ${ospfCost}
   ip ospf mtu-ignore
   ip router ospf 1 area ${far.ospfArea1!"1"}
   tunnel destination ${destinationAddress}
   tunnel mode ipsec ipv4
   tunnel protection ipsec profile IPSecProfile
   tunnel source ${wanInterface[0].name}
   no shutdown
  exit
 </#if>
</#macro>

<#--
 Since we are doing policies for each tunnel here, the list of policies passed to this template can be
 iterated over to get the tunnel configuration viz interface mapping

 tunnelObject.ipSecTunnelDestInterface is the "interface on CGR"
 tunnelObject.ipSecTunnelSrcInterface is the "interface on HER"
 tunnelObject.her is the HER of interest
 -->

<#list far.tunnels("ipSec") as tunnelObject>
  <@configureTunnel tunnelObject.ipSecTunnelDestInterface tunnelObject.ipSecTunnelSrcInterface
tunnelObject.her tunnelObject.tunnelIndex 100/>  <----- Loop through policies (aka Tunnels)
</#list>

<#--
```

```
  Make certain provisioning fails if we were unable to configure any IPsec
  tunnels. For example this could happen if the interface properties are
  set incorrectly.
-->
<#if iaId = 1>
  ${provisioningFailed("Did not find any WAN interfaces to use as the source for IPsec tunnels")}
</#if>

<#--
  Configure an IPv6-in-IPv4 GRE tunnel to allow IPv6 traffic to reach the data
  center.
-->
<#macro configureGreTunnel destinationInterface her tunnelIndex>

<#assign destinationAddress = her.interfaces(destinationInterface)[0].v4.addresses[0].address>

<#if !(destinationAddress??)>
     ${provisioningFailed("Unable to determine the destination address for GRE tunnels")}
</#if>

interface Tunnel${interfaceNumber}
  <#assign interfaceNumber = interfaceNumber + 1>
  description GRE IPv6 tunnel to ${her.eid}
  <#--
    The ipv6Subnet method is similar to the ipv4Subnet method except instead
    of obtaining an IPv4 subnet it uses DHCPv6 prefix delegation to obtain an
    IPv6 prefix. The prefix length will default to 127, providing the two
    addresses needed for the point to point link. For the IAID, zero was used
    when requesting an IPv6 address for loopback0, so use one in this request.
  -->
  <#assign lease = far.ipv6Subnet(far.enDuid, tunnelIndex, far.dhcpV6TunnelLink)>
  ipv6 address ${lease.secondAddress}/${lease.prefixLength}
  ipv6 router ospfv3 2 area ${far.ospfV3Area1!"0"}
  ospfv3 mtu-ignore
  tunnel destination ${destinationAddress}
  tunnel mode gre ip
  tunnel source Loopback0
  no shutdown
exit

</#macro>

<#-- Loop through the policies for GRE tunnels -->
<#list far.tunnels("gre") as greTunnelObj>
    <@configureGreTunnel greTunnelObj.greDestInterface greTunnelObj.her greTunnelObj.tunnelIndex/>
</#list>
```

Head-End Router Tunnel Addition Template

In this example, bold text indicates the changes made to the default Head-End Router Tunnel Addition template to create multiple tunnels:

```
<#--
  Define template variables to keep track of the IAID (IPv4) that was used by
  the FAR template when configuring the other end of the tunnel. This template
  must use the same IAID in order to locate the same subnet that was leased by
  the FAR template so both endpoints are in the matching subnet.
-->
<#assign iaId = 1>

<#--
```

```
  The same logic is needed for each of the IPsec tunnels, so a macro is used.
-->
<#macro configureTunnel ipSecTunnelSrcInterface ipSecTunnelDestInterface her tunnelIndex ospfCost>
  <#--
    Only configure the HER tunnel end point if the FAR tunnel end point was
    configured. This must match the corresponding logic in the FAR tunnel
    template. The tunnel will not have been configured if the WAN interface
    does not exist on the FAR or does not have an address assigned to it.
  -->
  <#assign wanInterface = far.interfaces(ipSecTunnelDestInterface)>
  <#if (wanInterface[0].v4.addresses[0].address)??>
    <#-- Obtain the full interface name based on the prefix. -->
    <#assign interfaceName = wanInterface[0].name>
    <#--
      Locate a tunnel interface on the HER that is not in use. The template
      API provides an unusedInterfaceNumber method for this purpose. All of
      the parameters are optional. The first parameter is a name prefix
      identifying the type of interfaces, it defaults to "tunnel". The second
      parameter is a lower bound on the range the unused interface number must
      be in, it defaults to zero. The third parameter is the upper bound on
      the range, it defaults to max integer (signed). The method remembers
      the unused interface numbers it has returned while the template is
      being processed and excludes previously returned numbers. If no unused
      interface number meets the constraints an exception will be thrown.
    -->
    interface Tunnel${her.unusedInterfaceNumber()}
      description IPsec tunnel to ${far.eid}
      <#assign lease = far.ipv4Subnet(dhcpClientId(far.enDuid, tunnelIndex), far.dhcpV4TunnelLink)>
      <#assign iaId = iaId + 1>
      ip address ${lease.firstAddress} ${lease.subnetMask}
      ip ospf cost ${ospfCost}
      ip ospf mtu-ignore
      tunnel destination ${wanInterface[0].v4.addresses[0].address}
      tunnel mode ipsec ipv4
      tunnel protection ipsec profile IPSecProfile
      tunnel source ${ipSecTunnelSrcInterface}
      no shutdown
    exit
    router ospf 1
      network ${lease.prefix} ${lease.wildcardMask} area ${far.ospfArea1!"1"}
    exit
  </#if>
</#macro>

<#list far.tunnels("ipSec") as tunnelObject>
        <@configureTunnel tunnelObject.ipSecTunnelSrcInterface tunnelObject.ipSecTunnelDestInterface
tunnelObject.her tunnelObject.tunnelIndex 100/>
</#list>

<#--
  Configure an IPv6-in-IPv4 GRE tunnel to allow IPv6 traffic to reach the data
  center.
-->
<#macro configureGreTunnel greSrcInterface her tunnelIndex>
interface Tunnel${her.unusedInterfaceNumber()}
  description GRE IPv6 tunnel to ${far.eid}
  <#assign lease = far.ipv6Subnet(far.enDuid, tunnelIndex, far.dhcpV6TunnelLink)>
  ipv6 address ${lease.firstAddress}/${lease.prefixLength}
  ipv6 enable
  ipv6 ospf 2 area ${far.ospfV3Area1!"0"}
  ipv6 ospf mtu-ignore
  tunnel destination ${far.interfaces("Loopback0")[0].v4.addresses[0].address}
  tunnel mode gre ip
  tunnel source ${greSrcInterface}
exit
```

```
</#macro>

<#-- Loop through the policies for GRE tunnels -->
<#list far.tunnels("gre") as greTunnelObj>
        <@configureGreTunnel greTunnelObj.greSrcInterface greTunnelObj.her greTunnelObj.tunnelIndex/>
</#list>
```