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, and includes the following topics.

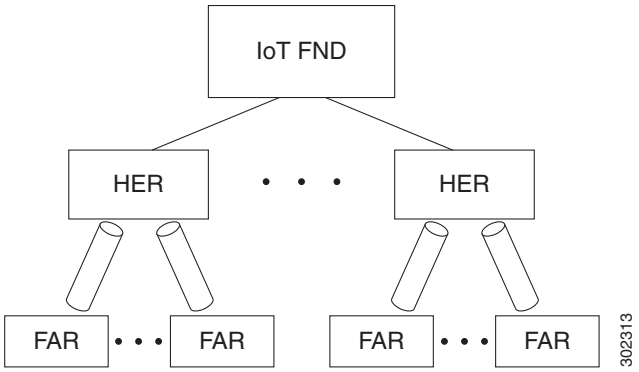
Overview

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.

Note: Beginning with IoT FND Release 3.1.x, you no longer need to configure IPSec Tunnel Provisioning between FARs and HERs (as shown in Figure 1) prior to deployment of the FAR in your network.

Instead you can 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.

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.

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).

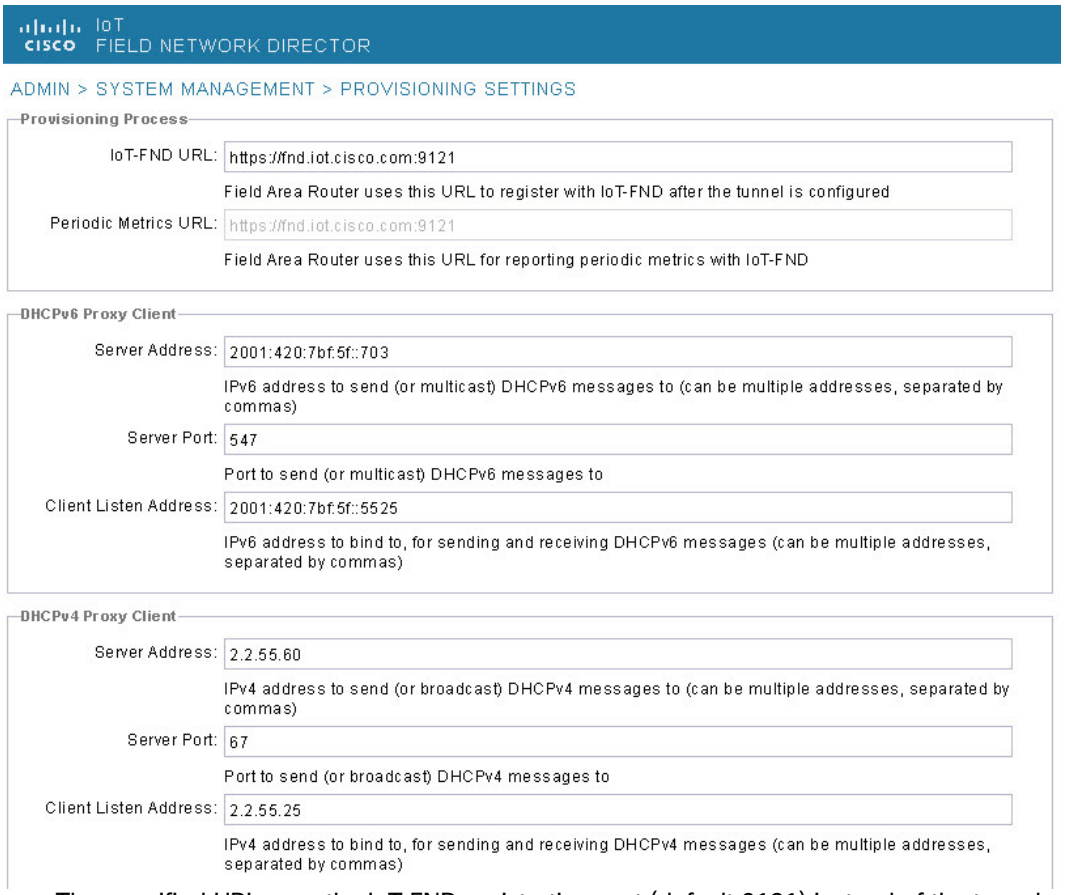
To configure IoT FND for tunnel provisioning:

		Notes
1.	(CG-OS CGRs) 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 4.0.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 4.0.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 4.0.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 in to 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**).



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 for FARs. By default, all FARs added to IoT FND (see Adding Devices in Bulk in the Performing Bulk Import Actions section of the of the in the Device Management chapter of the *Cisco IoT Field Network Director User Guide, 4.0x*)

Release 3.2.x) the appropriate default group: **default-cgr1000** or **default-c800**. Default groups contain the three templates IoT FND uses for tunnel provisioning.

Topics in this section include the following:

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, roll 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:

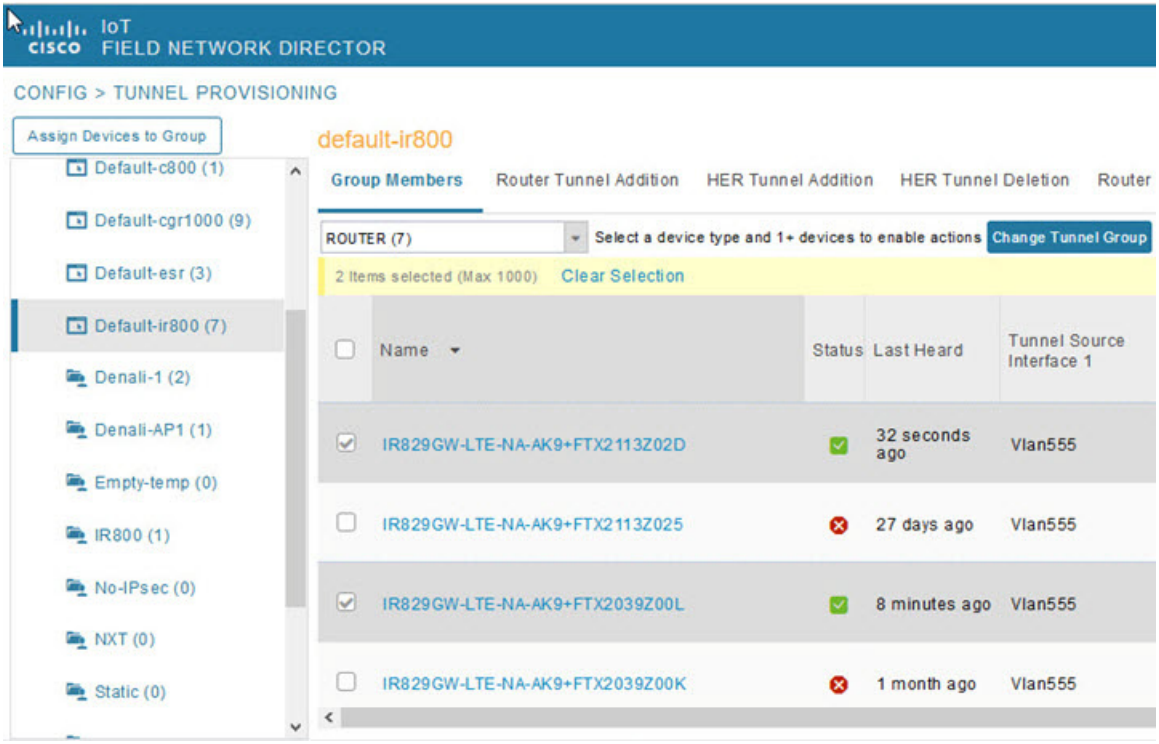
- Moving FARs to Another Group Manually
- Moving FARs to Another Group in Bulk

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.



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

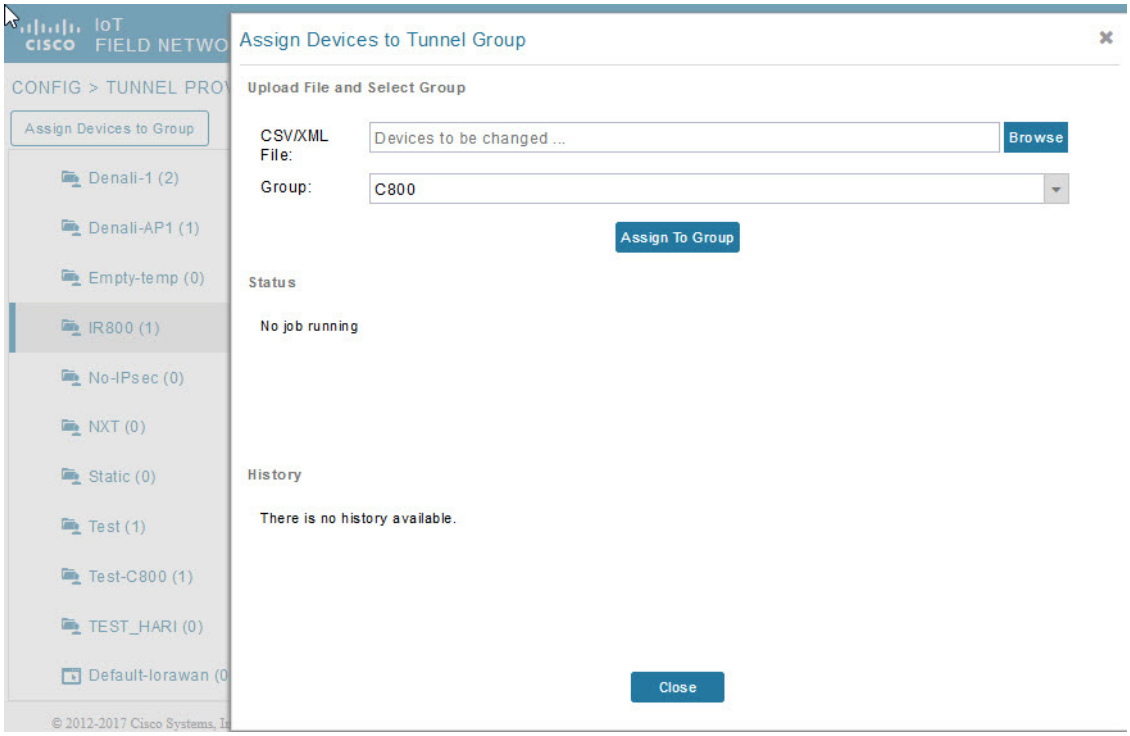
You can move FARs in bulk to another group by importing a CSV or XML file containing the names of the FARs to move. Ensure that the file contains entries in the format shown the following example:

```
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.



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

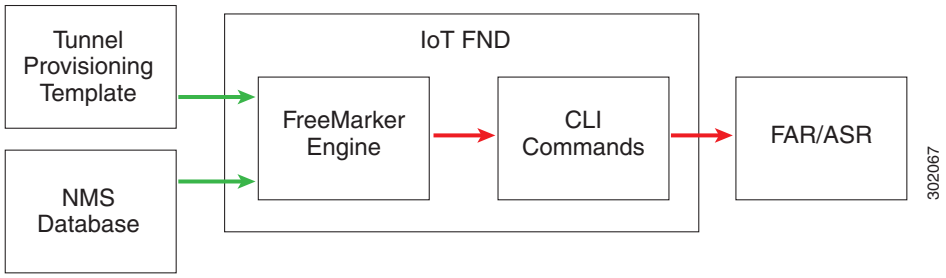
IoT FND has three default tunnel provisioning templates:

- 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



n 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 interfaces discovered from the device that with that 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.

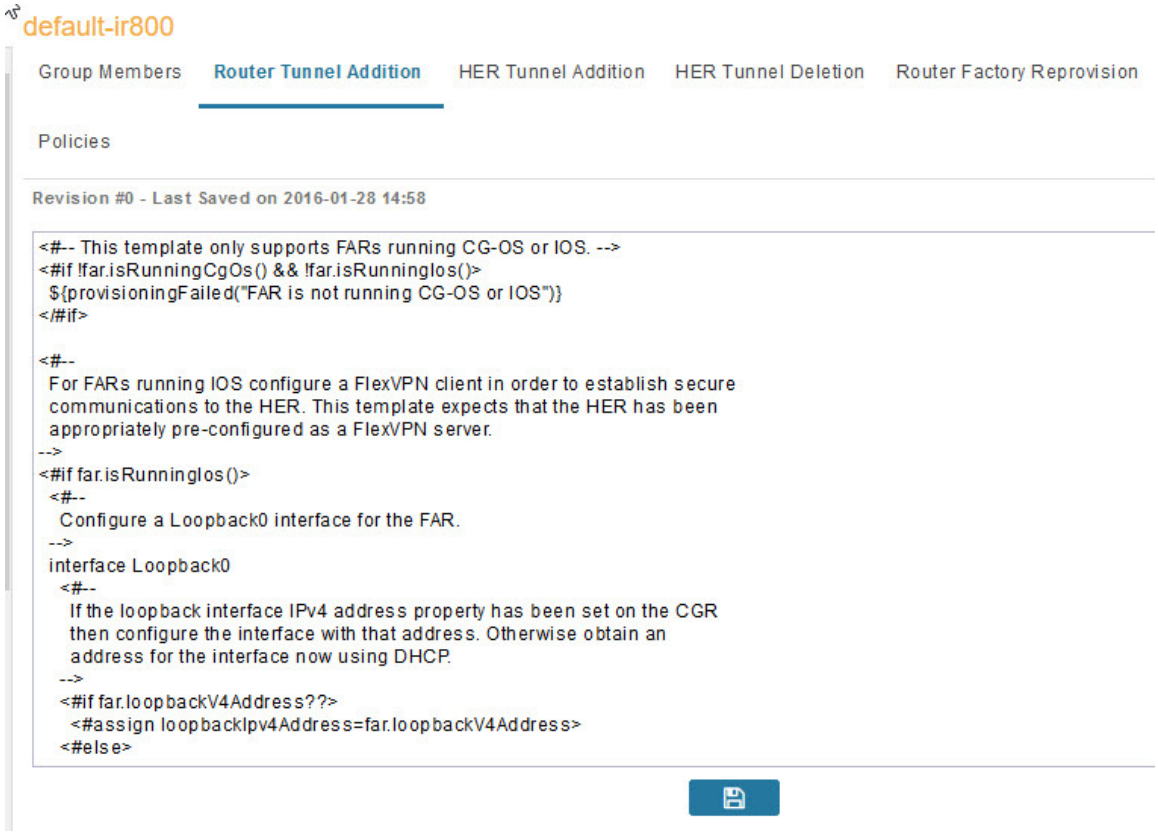
Table 4 Address References

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.



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

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.

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.

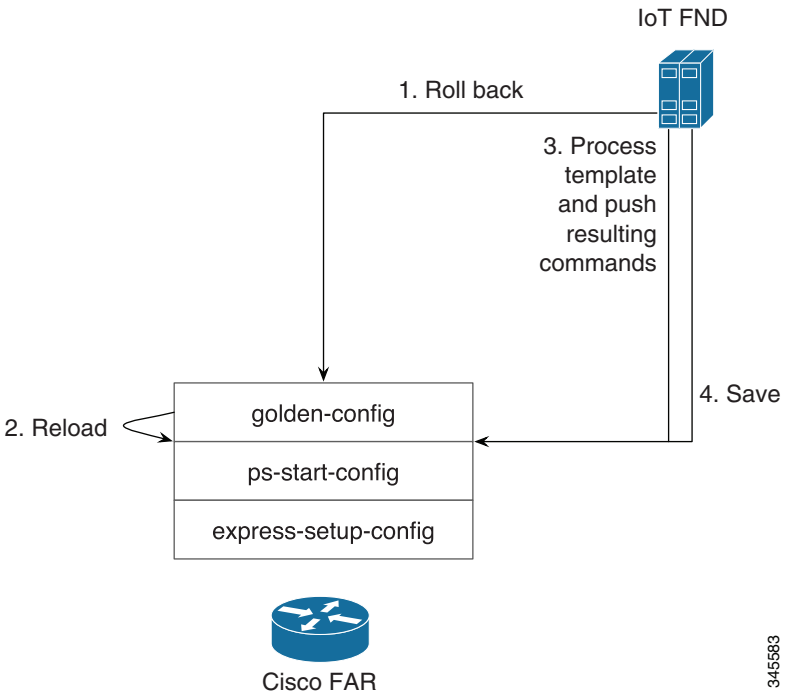
Tunnel Reprovisioning

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



Note: For CG-OS CGRs, a rollback results in a reload of the CGR. Also, when IoT FND rolls back a CGR, IoT FND removes the corresponding tunnel information from the HERs to which the CGR was connected.

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** tab.

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>
```