Simplified Cisco IoT FND Architecture

Tunnel management with a unique Pre-Shared Key (PSK) and the assignment of IP addresses using Cisco IoT FND IP Address Management (IPAM) aims to simplify the configuration process and reduce the number of components in Cisco IoT FND. In the simplified architecture, the PSK replaces existing security components such as CA, AAA, and RA, while the IPAM replaces the external DHCP server. This simplified architecture is supported only in greenfield deployments using VMs with a Postgres database, and is designed for router management only.

However, you have the discretion to use a unique PSK and the IPAM in the architecture. Cisco IoT FND continues to support existing PKI-based certificate communication between FAR and Cisco IoT FND, PKI-based certificates for tunnels between FAR and HER, and external DHCP servers for tunnel IP addressing.

Tunnel Management with Pre-Shared Key

A unique pre-shared key (PSK) solution is used for the tunnel management between FAR and HER, which significantly simplifies the authentication and authorization process in the headend infrastructure and allows the users to self-manage. The PSK is supported on all Cisco IOS and IOS-XE device types.

The table provides various scenarios where PSK can be used effectively in combination with either SUDI or a CA server in the greenfield deployment.

Deployment	Scenario	Recommendation
Greenfield deployment	Without CA server	• Use PSK for authentication and authorization of communication between FAR and HER. • Use SUDI for authentication and authorization of communication between FND and FAR.
	With CA server	Choose one of the following combinations: • Use PSK for authentication and authorization of communication between FAR and HER. • Use a custom CA certificate for authentication and authorization of communication between FND and FAR. (or) • Use a custom CA certificate for authentication and authorization of communication between both FAR and HER, FND and FAR.
Note In both scenarios, with or without CA server, it is mandatory to generate the IoT FND certificate from the CA server and install it on the IoT FND server (cgms_keystore).		

Note For the brownfield deployment, IoT FND continues to support CA, RA, and AAA for the FAR communication with FND and HER.

Configuring FND for Tunnel Management with PSK

Use the following steps to configure FND for managing tunnels with PSK.

Procedure

Step 1 Run the following script to configure FND with IPAM and PSK settings.

```
/opt/cgms/bin/setupCgms.sh
```

```
Do you want to change IPAM and PSK Settings (y/n)? y
```

Step 2 On entering "**y**", you are provided with a new option to select PSK scheme for IPsec tunnel management.

```
Do you want to manage Tunnels using Unique Pre-Shared Keys (y/n)? y

08-20-2023 12:43:03 IST: INFO: User response: y
08-20-2023 12:43:03 IST: INFO: FND Configured to manage Tunnels using Unique Pre-Shared Keys
08-20-2023 12:43:03 IST: INFO: ========== IoT-FND Setup Completed Successfully ==========
```

Step 3 On entering "**y**", FND is configured with PSK.

FND updates the Preferences table by setting the property `com.cisco.cgms.pnp.tunnelMgmtUsingPsk` as True. By default, this property is False.

Generating PSK

A unique pre-shared key is generated when you import a device through CSV or NB API. The pre-shared key is a 15-character alphanumeric string which is unique and generated randomly for each device. The generated key is encrypted and stored in the database for each router. For more information on tunnel management with PSK, see Workflow for Tunnel Management with PSK, on page 17.

Default Templates

The following default templates are available for the tunnel management.

Router Tunnel Addition Template

There are two default router addition templates available for authentication. Based on the configuration settings in `setupCgms.sh`, the default template is selected to manage tunnels using PSK or not.

A sample template for FlexVPN and DMVPN tunnel configuration is given below.

Note By default, the peer name is set to `her-tunnel` in `crypto ikev2 keyring FlexVPN_Keyring` and `Flexvpn_ikev2_profile`. Configure the peer name to match the name that is given in `identity local key-id` in the HER configuration.

```
<#-- This template only supports FARs running IOS. -->
<#if !far.isRunningIos()>
  ${provisioningFailed("FAR is not running 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()>
  <#assign sublist=far.eid?split("+")[0..1]>
  <#assign sn=sublist[1]>
  <#--
    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>
    <#elseif far.isIPAMForLoopbackSelected()??>
      <#assign loopbackIpv4Address=far.IPAMForLoopbackIpv4()>
    <#else>
      <#--
        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 "IoT-FND". 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.
      -->
      <#assign
loopbackIpv4Address=far.ipv4Address(dhcpClientId(far.enDuid,0),far.dhcpV4LoopbackLink).address>

    </#if>
    ip address ${loopbackIpv4Address} 255.255.255.255
    <#--
      If the loopback interface IPv6 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.loopbackV6Address??>
      <#assign loopbackIpv6Address=far.loopbackV6Address>
    <#elseif far.isIPAMForLoopbackSelected()??>
      <#assign loopbackIpv6Address=far.IPAMForLoopbackIpv6()>
    <#else>
      <#--
        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.
      -->
      <#assign
loopbackIpv6Address=far.ipv6Address(far.enDuid,0,far.dhcpV6LoopbackLink).address>
    </#if>
    ipv6 address ${loopbackIpv6Address}/128
  exit

  <#--
    Default to using FlexVPN for the tunnel configuration of FARs running IOS.
  -->
 <#if (far.useFlexVPN!"true") = "true">
    <#--
      IPv4 ACL which specifies the route(s) FlexVPN will push to the HER.
      We want the HER to know the route to the CGR's loopback interface.
    -->
    ip access-list standard FlexVPN_Client_IPv4_LAN
      permit ${loopbackIpv4Address}
    exit

    <#--
      IPv6 ACL which specifies the route(s) FlexVPN will push to the HER.
```

```
      We want the HER to know the route to the CGR's loopback interface.
      If a mesh has been configured on this CGR we want the HER to know the route to the
mesh.
    -->
    ipv6 access-list FlexVPN_Client_IPv6_LAN
      <#if far.meshPrefix??>
        permit ipv6 ${far.meshPrefix}/64 any
      </#if>
      sequence 20 permit ipv6 host ${loopbackIpv6Address} any
    exit

    <#--
      FlexVPN authorization policy that configures FlexVPN to push the CGR LAN's
      specified in the ACLs to the HER during the FlexVPN handshake.
    -->
    crypto ikev2 authorization policy FlexVPN_Author_Policy
      route set access-list FlexVPN_Client_IPv4_LAN
      route set access-list ipv6 FlexVPN_Client_IPv6_LAN
      route set interface
    exit

    crypto ikev2 proposal FlexVPN_IKEv2_Proposal
      encryption aes-cbc-256
      group 14
      integrity sha256
    exit
    crypto ikev2 policy FLexVPN_IKEv2_Policy
      proposal FlexVPN_IKEv2_Proposal
    exit

    <#-- FlexVPN authorization policy is defined locally. -->
    aaa authorization network FlexVPN_Author local

    crypto ikev2 keyring FlexVPN_Keyring
      peer her-tunnel
        address ${far.ipsecTunnelDestAddr1}
        identity key-id her-tunnel
        pre-shared-key ${far.mgmtVpnPsk}
      exit
    exit

    crypto ikev2 profile FlexVPN_IKEv2_Profile
      match identity remote key-id her-tunnel
      identity local fqdn ${sn}.cisco.com
      authentication remote pre-share
      authentication local pre-share
      keyring local FlexVPN_Keyring
      dpd 120 3 periodic
      aaa authorization group psk list FlexVPN_Author FlexVPN_Author_Policy
    exit

    <#--
      If the headend router is an ASR then use a different configuration for the
      transform set as some ASR models are unable to support the set we'd prefer
      to use.
    -->
    <#if her.pid?contains("ASR")>
      crypto ipsec transform-set FlexVPN_IPsec_Transform_Set esp-aes esp-sha-hmac
        mode tunnel
      exit
    <#else>
      crypto ipsec transform-set FlexVPN_IPsec_Transform_Set esp-aes esp-sha256-hmac
        mode tunnel
      exit
```

```
    </#if>

    crypto ipsec profile FlexVPN_IPsec_Profile
      set ikev2-profile FlexVPN_IKEv2_Profile
      set pfs group14
      set transform-set FlexVPN_IPsec_Transform_Set
    exit

    <#assign wanInterface=far.interfaces(far.tunnelSrcInterface1!"Cellular")>
    interface Tunnel0
      description IPsec tunnel to ${her.eid}
      ip unnumbered loopback0
      ipv6 unnumbered loopback0
      tunnel destination dynamic
      tunnel protection ipsec profile FlexVPN_IPsec_Profile
      tunnel source ${wanInterface[0].name}
    exit

    <#if !(far.ipsecTunnelDestAddr1??)>
     ${provisioningFailed("FAR property ipsecTunnelDestAddr1 must be set to the destination
address to connect this FAR's FlexVPN tunnel to")}
    </#if>
    crypto ikev2 client flexvpn FlexVPN_Client
      peer 1 ${far.ipsecTunnelDestAddr1}
      client connect Tunnel0
    exit
    ip http secure-client-auth
    no ip http tls-version TLSv1.2
  <#else>
    <#--
      Configure the tunnel using DMVPN.
    -->
    router eigrp 1
      network ${loopbackIpv4Address}
    exit
    ipv6 router eigrp 2
      no shutdown
    exit
    interface Loopback0
      ipv6 eigrp 2
    exit
    crypto ikev2 proposal DMVPN_IKEv2_Proposal
      encryption aes-cbc-256
      group 14
      integrity sha256
    exit
    crypto ikev2 policy DMVPN_IKEv2_Policy
      proposal DMVPN_IKEv2_Proposal
    exit
    crypto ikev2 keyring DMVPN_Keyring
      peer her-tunnel
        address ${far.ipsecTunnelDestAddr1}
        identity key-id her-tunnel
        pre-shared-key ${far.mgmtVpnPsk}
      exit
    exit
    crypto ikev2 profile DMVPN_IKEv2_Profile
      match identity remote key-id her-tunnel
      identity local fqdn ${sn}.cisco.com
      authentication remote pre-share
      authentication local pre-share
      keyring local DMVPN_Keyring
      dpd 120 3 periodic
    exit
```

```
    <#--
      If the headend router is an ASR then use a different configuration for the
      transform set as some ASR models are unable to support the set we'd prefer
      to use.
    -->
    <#if her.pid?contains("ASR")>
      crypto ipsec transform-set DMVPN_IPsec_Transform_Set esp-aes esp-sha-hmac
        mode tunnel
      exit
    <#else>
      crypto ipsec transform-set DMVPN_IPsec_Transform_Set esp-aes 256 esp-sha256-hmac
        mode tunnel
      exit
    </#if>
    crypto ipsec profile DMVPN_IPsec_Profile
      set ikev2-profile DMVPN_IKEv2_Profile
      set pfs group14
      set transform-set DMVPN_IPsec_Transform_Set
    exit
    <#if !(far.nbmaNhsV4Address??)>
      ${provisioningFailed("FAR property nbmaNhsV4Address has not been set")}
    </#if>
    <#if !(far.nbmaNhsV6Address??)>
      ${provisioningFailed("FAR property nbmaNhsV6Address has not been set")}
    </#if>
    <#assign wanInterface=far.interfaces(far.tunnelSrcInterface1!"Cellular")>
    interface Tunnel0
      <#assign lease=far.ipv4Address(dhcpClientId(far.enDuid,1),far.dhcpV4TunnelLink)>
      ip address ${lease.address} ${lease.subnetMask}
      ip nhrp map ${far.nbmaNhsV4Address} ${far.ipsecTunnelDestAddr1}
      ip nhrp map multicast ${far.ipsecTunnelDestAddr1}
      ip nhrp network-id 1
      ip nhrp nhs ${her.interfaces("Tunnel0")[0].v4.addresses[0].address}
      ipv6 address ${far.ipv6Address(far.enDuid,1,far.dhcpV6TunnelLink).address}/128
      ipv6 eigrp 2
      ipv6 nhrp map ${far.nbmaNhsV6Address}/128 ${far.ipsecTunnelDestAddr1}
      ipv6 nhrp map multicast ${far.ipsecTunnelDestAddr1}
      ipv6 nhrp network-id 1
      ipv6 nhrp nhs ${far.nbmaNhsV6Address}
      tunnel mode gre multipoint
      tunnel protection ipsec profile DMVPN_IPsec_Profile
      tunnel source ${wanInterface[0].name}
    exit
    router eigrp 1
      network ${lease.address}
    exit
  </#if>
</#if>
```

HER Tunnel Addition Template

Similar to Router Tunnel Addition templates, there are two default HER Tunnel Addition templates available. Based on the configuration settings in `setupCgms.sh`, the default template is selected to manage tunnels using PSK or not.

The following commands are pushed to HER for every router during device on-boarding (PnP). The configurations are added to a queue which are processed by a configurable number of threads and pushed to HER.

Note Ensure that the keyring name mentioned in "crypto ikev2 keyring FlexVPN_Keyring" and "FlexVPN_IKEv2_Profile" match the HER keyring name.

```
per-Router HER Config

<#-- This template only supports HERs running IOS or IOS XE. -->
<#if !her.isRunningIos() && !her.isRunningIosXe()>
  ${provisioningFailed("HER is not running IOS or IOS XE")}
</#if>

<#if far.isRunningIos()>
  <#assign sublist=far.eid?split("+")[0..1]>
  <#assign sn=sublist[1]>

  crypto ikev2 keyring FlexVPN_Keyring
    peer ${sn}
      identity fqdn ${sn}.cisco.com
      pre-shared-key ${far.mgmtVpnPsk}
   exit
  exit
</#if>
```

Router Bootstrap Configuration Template

Note For SUDI authentication, you must use `cgna initiator profile` as the tunnel profile.

Note Based on the device types, the following ports are used:

- For Cisco IOS-XE device types, use port 443.
- For Cisco IOS device types, use port 8443.

A sample router bootstrap configuration template:

```
<#assign sublist=far.eid?split("+")[0..1]>
<#assign pid=sublist[0]>
<#assign sn=sublist[1]>

hostname ${sn}
!
aaa new-model
!
!
aaa authentication login default local
aaa authorization exec default local
!
aaa session-id common
aaa password restriction
!
!
!
!
ip host fnd.iot.cisco.com <fnd ip address>
```

```
ip host tps.iot.cisco.com <tps ip address>
ip domain name cisco.com
!
password encryption aes
!
!
archive
  path bootflash:archive/
maximum 8
!
!
!
!
username admin privilege 15 password <router password>
!
!
no cdp run
!
!
!
!
interface Loopback999
 ip address <ip address for the interface> 255.255.255.255
!
!
ip forward-protocol nd
!
no ip http server
ip http tls-version TLSv1.2
ip http authentication aaa login-authentication default
ip http secure-server
ip http secure-port 443
ip http max-connections 5
ip http timeout-policy idle 600 life 86400 requests 3
ip http client connection timeout 5
ip http client connection retry 5
ip http client source-interface lo0
ip http client secure-trustpoint CISCO_IDEVID_SUDI

ip ssh time-out 60
ip ssh authentication-retries 2
crypto key generate rsa
ip ssh version 2
!
ipv6 unicast-routing
!
control-plane
!
!
line con 0
length 0
transport preferred none
escape-character 3
stopbits 1

!

line vty 6 15
session-timeout 10
exec-timeout 5 0
session-limit 2
transport input ssh
!
wsma agent exec
```

```
profile exec
!
wsma agent config
profile config
!
!wsma agent filesys
!
!wsma agent notify
!
!
wsma profile listener exec
transport https path /wsma/exec
!
wsma profile listener config
transport https path /wsma/config

event manager directory user policy "flash:/managed/scripts"
event manager policy no_config_replace.tcl type system authorization bypass
!
!
cgna gzip
!
!
cgna initiator-profile cg-nms-tunnel
 add-command show hosts | format flash:/managed/odm/cg-nms.odm
 add-command show interfaces | format flash:/managed/odm/cg-nms.odm
 add-command show version | format flash:/managed/odm/cg-nms.odm
 add-command show ipv6 dhcp | format flash:/managed/odm/cg-nms.odm
 add-command show ipv6 interface | format flash:/managed/odm/cg-nms.odm
 callhome-url https://tps.iot.cisco.com:9120/cgna/ios/config
 execution-url https://<ip address of Loopback999 interface>:443/wsma/config
 interval 10
 gzip
 post-commands
 active
```

ACL Configuration (Optional)

You can include ACL configuration in this template for additional security.

A sample ACL configuration:

```
access-list 10 permit <IP address of TPS>
access-list 10 deny any

interface gigabitEthernet 0/0/0
ip access-group 10 in
exit
```

Note In the above sample configuration, the communication with FAR is only through IP address of TPS until the tunnel is established.

After the tunnel is established, you can remove the ACL configuration.

To remove the ACL configuration, add the following commands in the Router Tunnel Addition Template:

```
no access-list 10
interface gigabitEthernet 0/0/0
no ip access-group 10 in
exit
```

HER Tunnel FlexVPN Configuration Template

A sample HER tunnel FlexVPN configuration template:

```
version 17.12
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
platform sslvpn use-pd
platform console virtual
!
hostname xxxxxxx
!
boot-start-marker
boot-end-marker
!
!
aaa new-model
!
!
aaa authentication login default local
aaa authentication login AUTH local
aaa authorization exec default local
aaa authorization network FlexVPN_Author local
aaa authorization network NET local !
!
aaa session-id common
clock timezone IST 0 0
!
!

ip domain name cisco.com
!
!
!
login on-success log
!
!
subscriber templating
vtp version 1
!
!
!
!
!
!
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
crypto pki trustpoint TP-self-signed-141726200
 enrollment selfsigned
 subject-name cn=IOS-Self-Signed-Certificate-141726200
 revocation-check none
 rsakeypair TP-self-signed-141726200
 hash sha256
!
crypto pki trustpoint SLA-TrustPoint
```

```
 enrollment pkcs12
 revocation-check crl
 hash sha256
!
!
crypto pki certificate chain TP-self-signed-141726200
 certificate self-signed 01
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
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  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxx
        quit
crypto pki certificate chain SLA-TrustPoint
 certificate ca 01
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
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  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
  xxxxxxxxxxxxxx
        quit
!
!
!
!
!
!
!
!
!
license udi pid C8000V sn 9OA9SRYYZVZ
license boot level network-advantage addon dna-advantage
memory free low-watermark processor 203066
diagnostic bootup level minimal
```

```
!
!
spanning-tree extend system-id
!
!
!
username xxxxxx privilege 15 password 0 xxxxxxxxxx
!
redundancy
!
crypto ikev2 authorization policy FlexVPN_Author_Policy
 route set interface
 route set access-list FlexVPN_Client_Default_IPv4_Route
!
crypto ikev2 redirect client
crypto ikev2 proposal FlexVPN_IKEv2_Proposal
 encryption aes-cbc-256
 integrity sha256
 group 14
!
crypto ikev2 policy FLexVPN_IKEv2_Policy
 proposal FlexVPN_IKEv2_Proposal
!
crypto ikev2 keyring FlexVPN_Keyring
 peer far1_sn
  identity fqdn far1_sn.cisco.com
  pre-shared-key GE39jy3Qe8Uo1Ro
!
 peer far2_sn
  identity fqdn far2_sn.cisco.com
  pre-shared-key LE73pj2Pk8Jh8Ui
!
 peer far3_sn
  identity fqdn far3_sn.cisco.com
  pre-shared-key FB86gn4Ns1Fm1Dj
!
!
!
crypto ikev2 profile FlexVPN_IKEv2_Profile
 match identity remote fqdn domain cisco.com
 identity local key-id CLUSTER-2
 authentication remote pre-share
 authentication local pre-share
 keyring local FlexVPN_Keyring
 dpd 120 3 periodic
 aaa authorization group psk list FlexVPN_Author FlexVPN_Author_Policy
 virtual-template 1 !
!
!
!
!
!
!
!
!
!
!
crypto isakmp invalid-spi-recovery
!
!
crypto ipsec transform-set FlexVPN_IPsec_Transform_Set esp-aes esp-sha256-hmac
 mode transport
!
crypto ipsec profile FlexVPN_IPsec_Profile
```

```
 set transform-set FlexVPN_IPsec_Transform_Set
 set pfs group14
 set ikev2-profile FlexVPN_IKEv2_Profile
 responder-only !
!
!
!
!
!
!
!
!
!
interface Loopback0
 ip address xx.xx.xx.xx 255.255.255.255
!
interface GigabitEthernet1
 ip address xx.xx.xx.xx 255.255.255.128
 negotiation auto
 no mop enabled
 no mop sysid
!
interface GigabitEthernet2
 ip address xx.xx.xx.xx 255.255.255.0
 negotiation auto
 no mop enabled
 no mop sysid
!
interface GigabitEthernet3
 no ip address
 shutdown
 negotiation auto
 no mop enabled
 no mop sysid
!
interface Virtual-Template1 type tunnel
 ip unnumbered Loopback0
 ip mtu 1200
 ip tcp adjust-mss 1240
 tunnel source GigabitEthernet2
 tunnel protection ipsec profile FlexVPN_IPsec_Profile
!
ip default-gateway xx.xx.xx.xx
ip forward-protocol nd
!
ip http server
ip http authentication local
ip http secure-server
ip http secure-active-session-modules none
ip http active-session-modules none
ip dns server
ip ssh bulk-mode 131072 !
!
ip access-list standard FlexVPN_Client_Default_IPv4_Route
 10 permit any
!
!
!
!
!
!
!
control-plane
!
```

```
!
mgcp behavior rsip-range tgcp-only
mgcp behavior comedia-role none
mgcp behavior comedia-check-media-src disable
mgcp behavior comedia-sdp-force disable !
mgcp profile default
!
!
!
!
!
!
line con 0
 stopbits 1
line aux 0
line vty 0 4
 password cisco123
 transport input ssh
!
!
netconf legacy
netconf ssh
!
!
!
!
!
End
```

HER Tunnel Deletion Template

Note Ensure that the keyring name mentioned in "crypto ikev2 keyring FlexVPN_Keyring" and "FlexVPN_IKEv2_Profile" match the HER keyring name.

A sample HER tunnel deletion template for HERs on Cisco IOS and Cisco IOS-XE.

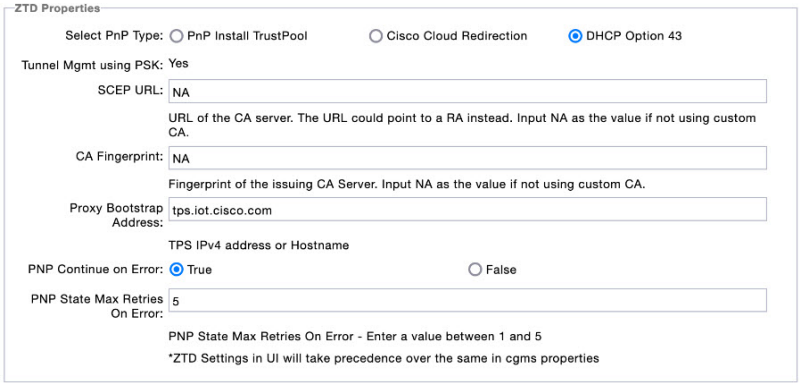
```
Remove Router PSK config from HER
<#-- This template only supports HERs running IOS or IOS XE. -->
<#if !her.isRunningIos() && !her.isRunningIosXe()>
  ${provisioningFailed("HER is not running IOS or IOS XE")}
</#if>

<#if far.isRunningIos()>
  <#assign sublist=far.eid?split("+")[0..1]>
  <#assign sn=sublist[1]>

  crypto ikev2 keyring FlexVPN_Keyring
    no peer ${sn}
  exit
</#if>
```

Configuring ZTD Properties

The ZTD Properties section allows you to manage the device certificates with either SUDI or a CA server. On configuring FND with PSK for tunnel management, by default, the devices use SUDI certificate for the communication with FND. However, if you want to manage using a CA server, provide details in the **SCEP URL** and **CA Fingerprint** fields (**ADMIN** > **SYSTEM MANAGEMENT** > **PROVISIONING SETTINGS**).



Changes To TCL Script

This section explains about the two different versions of a TCL script used for configuring a trustpoint in a network device managed using Cisco IoT FND. The trustpoint is part of the device Public Key Infrastructure (PKI), which handles certificates and cryptographic keys.

TCL Script For Cisco IOS XE Release 17.4.x And Lower Releases

Here's the original TCL script version released in Cisco IOS XE Release 17.4.x and lower releases:

```
set clist [ list "config terminal" \
                 "crypto pki trustpoint $tp_name" \
                 "serial-number none" \
                 "ip-address none" \
                 "password" \
                 "no subject-name" \
                 "subject-name $subject_name" \
                 "enrollment retry count $ZTD_SCEP_enrollment_retry_count" \
                 "enrollment retry period $ZTD_SCEP_enrollment_retry_period" \
                 "crypto pki enroll $tp_name" \
                 "end"]
```

Updated Script For Cisco IOS XE Release 17.9.x And Later Releases

Here's the updated TCL script starting from Cisco IOS XE Release 17.9.x and later releases:

```
set clist [ list "config terminal" \
                 "crypto pki trustpoint $tp_name" \
                 "serial-number none" \
                 "ip-address none" \
                 "no subject-name" \
                 "subject-name $subject_name" \
                 "enrollment retry count $ZTD_SCEP_enrollment_retry_count" \
                 "enrollment retry period $ZTD_SCEP_enrollment_retry_period" \
                 "end"]
```

Reason For The Changes

The script is modified to no longer use an empty password, aligning with the new PKI policy that recommends to migrate to strong type-6 encryption.

Note Starting from Cisco IOS XE Release 17.9.x and later releases, the Subject Alternative Name (SAN) is included with the Certificate Signing Request (CSR). For more information see, CSCsk85992.

Workflow for Tunnel Management with PSK

This section provides the workflow for tunnel management with PSK.

Staging

To stage the router with Cisco IoT FND TPS URL:

Procedure

Step 1 Configuring Cisco IoT FND for PSK-based tunnels differ for each deployment as given below.

For **VM deployment with Postgres DB**, as the cgms service will already be running on OVA installation, the cgms service is restarted using the steps below while executing `setupCgms.sh` script. In this deployment, user creates a new Tunnel Provisioning group for PSK based tunnel management configuration.

a) Stop the cgms service.

```
./fnd-container.sh stop
```

b) Run the following script to configure FND to create IPsec tunnels for management with PSK.

```
/opt/cgms/bin/setupCgms.sh
```

c) Start the cgms service.

```
./fnd-container.sh start
```

d) Create new groups in the tunnel provisioning to on board devices that use PSK tunnels.

Step 2 Generate a public CA signed server certificate for TPS and Cisco IoT FND using the existing CSR generation workflow.

Step 3 Configure FlexVPN on HER. For more information on the configuration, see HER Tunnel FlexVPN Configuration Template, on page 11.

Step 4 Import the device to Cisco IoT FND through CSV or NB API.

a) During the device import, set the **tunnelHerEid** property on FAR to know the associated HERs. Ensure to set this property for the PnP to continue, else, the PnP cannot proceed.

Cisco IoT FND generates a unique pre-shared key for each device and adds the generated key to the device property while storing in the database.

Step 5 Stage the router with Cisco IoT FND TPS URL using DHCP option 43 or PnP Install Trustpool / Cloud Redirection for PnP.

What to do next

Pnp Bootstrapping

PnP Bootstrapping

To bootstrap a device:

Before you begin

Staging.

Procedure

Step 1 Field area router (PnP agent) calls FND (through FND TPS).

Step 2 FND pushes the Trust Anchor (root certificate) to the device.

Step 3 To push the FAR PSK to the associated HER, a new state `CONFIGURING_HEADEND` is added in PnP.

Note
This state is executed only if IPsec tunnels are configured for management with PSK.

a) FND pushes the PSK to HER associated with the device in a separate batch process.

- On successful PSK configuration push on HER, an event is generated on FAR with the following message.

  ```
  PSK Tunnel configuration pushed successfully to HER
  ```

- On failure to push the PSK configuration on HER, an event is generated on FAR with the following message.

  ```
  PSK Tunnel configuration failed on HER
  ```

  Note
  FND keeps retrying (no limit) to push the configuration to HER until it succeeds as long as PnP requests come in.

Step 4 FND pushes the Bootstrap template to the device, which includes a tunnel creation profile and loopback IP configuration. For more information on the default templates, see Default Templates, on page 3.

a) Set the following commands in the bootstrap template for SUDI-based authentication.

```
no ip http secure-client-auth
ip http tls-version TLSv1.2
ip http client secure-trustpoint CISCO_IDEVID_SUDI
```

Use the `cgna initiator` profile as a tunnel creation profile. This is due to a platform limitation for Cisco IOS-XE device types, which does not support SUDI when the device is acting as a server in the TLS communication.

Step 5 On successful completion of PnP, the device status is marked as `Bootstrapped` in FND.

What to do next

Tunnel Provisioning, on page 18

Tunnel Provisioning

To push the PSK configuration to the router:

Before you begin

- Staging, on page 17
- PnP Bootstrapping, on page 18

Procedure

Step 1 Field area router calls FND (through FND TPS).

Authentication based on mTLS:

a) Validate the FND server based on the FND trust anchor.
b) Validate the field area router based on SUDI.

Step 2 FND pushes the PSK along with other tunnel configurations present in the Router Tunnel Addition template to the router and activates the registration profile.

a) Ensure that the following command is added in the Router Tunnel Addition template for the registration to work.

```
ip http secure-client-auth

no ip http tls-version TLSv1.2
```

What to do next

Device Configuration, on page 19

Device Configuration

To push device configuration to the router:

Before you begin

Complete the following workflows:

- Staging, on page 17
- PnP Bootstrapping, on page 18
- Tunnel Provisioning, on page 18

Procedure

Step 1 Field area router calls FND (through IPsec).

Authentication based on mTLS:

- Validate the FND server based on FND trust anchor.
- Validate the field area router based on SUDI.

Step 2 FND pushes the device configuration present in the Configuration Template to the router.

Step 3 On successful completion, the device is marked as `UP` in FND.

Pushing PSK Configuration to HER Cluster

This section explains the steps that are required to push the PSK configuration to HER in the cluster.

Pushing PSK Configuration to Existing HERs in the Cluster

Use the following steps to push the PSK configuration to the existing HERs in the cluster, which are added to the cluster before the tunnel establishment.

Procedure

Step 1 Import all HERs in the cluster to FND and have them managed with the device status as UP.

Step 2 For FND to be aware of the list of HERs in a cluster, add the list of HER eids separated by comma in the `tunnelhereid` property.

Step 3 On receiving a PnP request from a FAR, the `tunnelhereid` property is checked to get the list of HERs in the cluster.

Step 4 PSK configuration is pushed to each HER in the cluster.

- PnP continues if at least one of the HERs in the cluster receives the PSK configuration successfully.
- If the PSK configuration push fails on HERs, then correct the HER or replace it with a new HER by updating the `tunnelHerEid` property of the FAR.

The following events are generated for the PSK configuration push to HER in a cluster.

- If the PSK configuration push to HER is successful, then an event is generated for the router with the following message.

  ```
  "PSK Tunnel configuration pushed successfully to HER [**eid**]"
  ```

- If the PSK configuration push to HER fails, then an event is generated for the router with the following message.

  ```
  "PSK Tunnel configuration failed on HER [**eid**]".
  ```

Pushing PSK Configuration to New HER in the Cluster

Use the following steps to push the PSK configuration to a new HER, which is added to the cluster after the tunnel is established.

Note The addition or removal of HERs from the `tunnelHerEid` list is added to a table named `pending_tunnel_her_in_cluster` in the DB. FND has a separate thread that runs every five minutes to pick up the entries from the table and based on the `add_peer` flag, it either pushes the PSK configuration or removes the PSK configuration to or from the HER.

Procedure

Step 1 Import the new HER to FND and have it managed with the device status as UP.

Step 2 Update the FAR using **Change Device Properties** to add the new HER to the `tunnelhereid` property list.

Note
HER must be managed by FND before updating FAR using **Change Device Properties**.

Step 3 The PSK configuration is pushed to the new HER added to the `tunnelHerEid` property list and an associated event (success or failure) is generated on the FAR.

If any HER is removed from the `tunnelHerEid` property, then the PSK configuration of that HER is removed and an event is generated for successful configuration removal on the HER.

Viewing Events

This section provides information on the events generated on FAR and HER when pushing and removing PSK tunnel configuration.

- Viewing FAR Events
- Viewing HER Events

Viewing FAR Events

Use the following steps to view the events generated when pushing PSK tunnel configuration on HER during FAR onboarding.

1. Choose **DEVICES** > **FIELD DEVICES**.
2. Select the device on the right pane. The Device Info page appears.
3. Click the **Events** tab to view the following events.

Event Name	Severity Level	Description
PSK Tunnel Configuration Pushed to HER	INFO	On successful completion of pushing PSK tunnel configuration on HER.
PSK Tunnel Configuration on HER Failed	Major	On failure to push the PSK tunnel configuration on HER.

Viewing HER Events

Use the following steps to view the events generated when removing the PSK tunnel configuration from HER and FAR during FAR decommissioning.

1. Choose **DEVICES** > **HEAD-END ROUTERS**.

2. Select the HER on the right pane. The Device Info page appears.
3. Click the **Events** tab to view the following events.

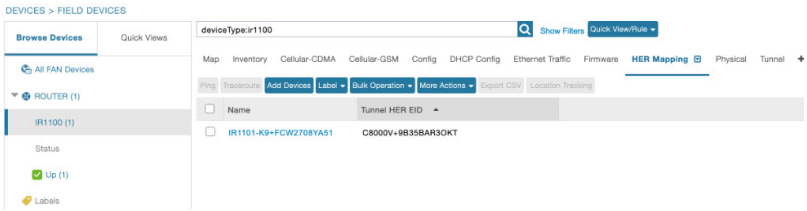
Event Name	Severity Level	Description
HER PSK Tunnel Configuration Removed for FAR	INFO	On successful removal of PSK configuration from HER.
HER PSK Tunnel Configuration Removal Failure for FAR	Major	On failure to remove the PSK configuration from HER. **Note** In this case, you should remove the PSK configuration from HER manually.

HER Mapping with FAR

Use the following steps to view the HERs associated with the FAR.

1. Choose **DEVICES** > **FIELD DEVICES**.
2. Select the device on the left pane.
3. Click the **HER Mapping** tab on the right pane.
4. The HER associated with the device appears under the **Tunnel HER EID** column.

   Use the filter option to search for HERs based on HER EID.



Decommissioning a Device

Whenever there is a device decommissioning, FND automatically removes the PSK configuration from HER using the HER deletion template which is available by default. If the HER is in a cluster, FND removes the PSK configuration from all HERs.

For information on HER deletion template, see HER Tunnel Deletion Template, on page 15.

For information on events generated during PSK configuration removal from HER, see Viewing HER Events, on page 21.

List of Ports used in Simplified IoT FND Architecture for Router only Deployments

The table provides the list of standard ports used in simplified IoT FND architecture.

Service	Port
GUI	443
Tunnel Provisioning	9120
TPS	9122
PostGreSql DB Server	5432
Influx	8086
Kapacitor	9092
WSMA (for IOS-XE)	443
WSMA (for Classic IOS)	8443
Registration + Periodic	9121
Bandwidth Op Mode	9124
PnP — HTTP	9125
Web Sockets — Device Communication	9121
DB Replication for HA	1622
SSH	22
NTP Server	123
SNMP (for polling)	161
SNMP (for notifications)	162
SSM Server	8445
FND Demo Mode	80
Syslog service	514

IPAM for Loopback

Loopback IP addresses for FAR devices forming tunnels was assigned by an external DHCP Server with FND acting as the DHCP client. IoT FND now generates the IPv4 and IPv6 addresses for the provided subnet while

forming the tunnels without relying on the third-party DHCP Server. The consumption of internal IP addresses applies only for first-time IoT FND installation and the users with administrative privileges only can access. This is supported only in root domain.

Procedure

Step 1 While setting up IoT FND, run the setupCgms.sh script on the IoT FND server and choose your preferred IP allocation method for loopback IPs in the user prompt. For more information about running the setupCgms.sh script, see Setting Up IoT FND.

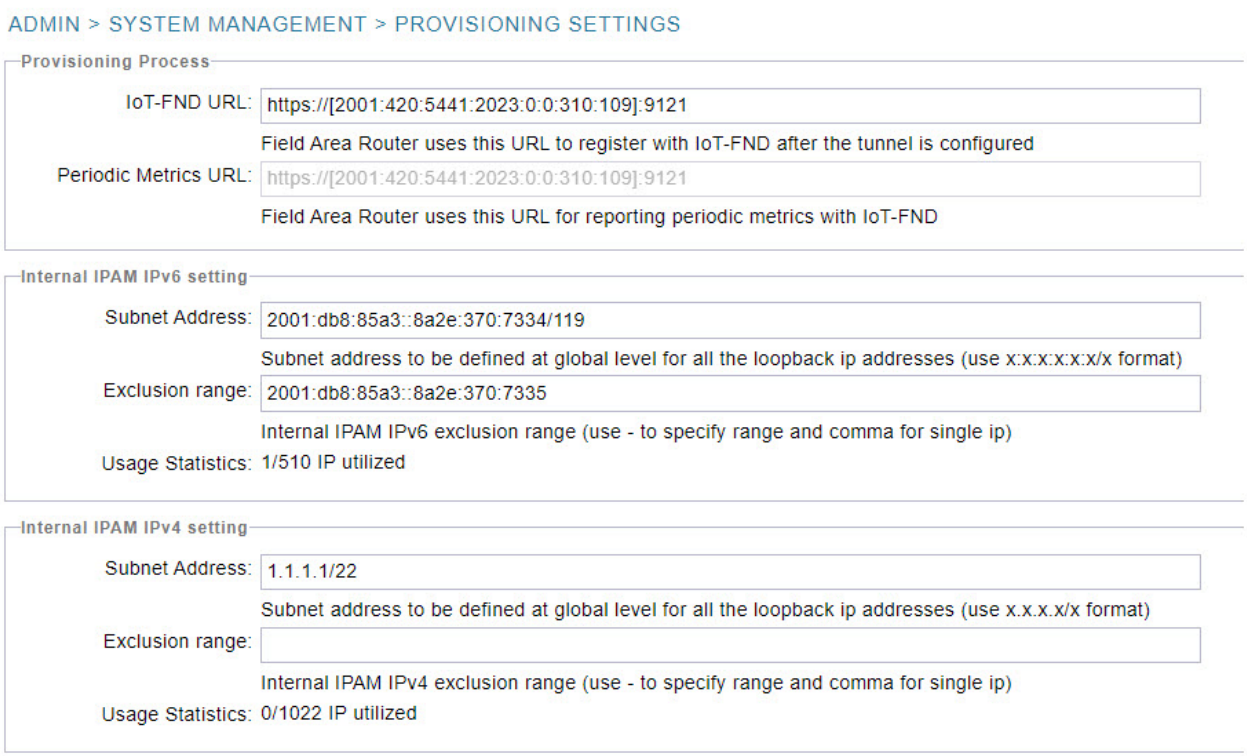
Step 2 If you choose IPAM, configure the subnet in the **Admin** > **System Management** > **Provisioning Settings** page.

Note
To configure the subnet range, set the limit in **ipam-ipv6-subnet-limit** or **ipam-ipv4-subnet-limit** property in cgms.properties file. The default values for the properties are 108 (generates around 1,048,576 IPv6) and 12 (generates around 1,048,576 IPv4) respectively.

Caution
Do not decrease the subnet size. If you intend to utilize more than 1 million IP addresses, we recommend consulting with Cisco for expert guidance and support.

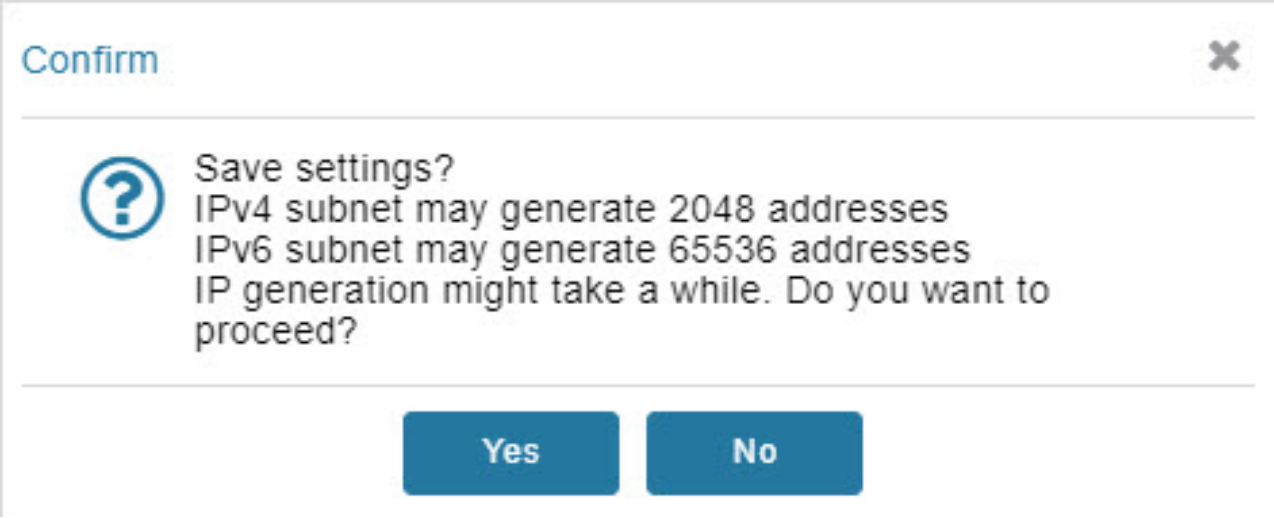
Step 3 Provide the exclusion range as a single IP address, a range, or a list of multiple IP addresses separated by commas. The Usage Statistics is a label that shows the IP addresses utilized for the provided subnet.

Note
Provide values in either or both of the IPAM IPv6 and IPAM IPv4 setting.



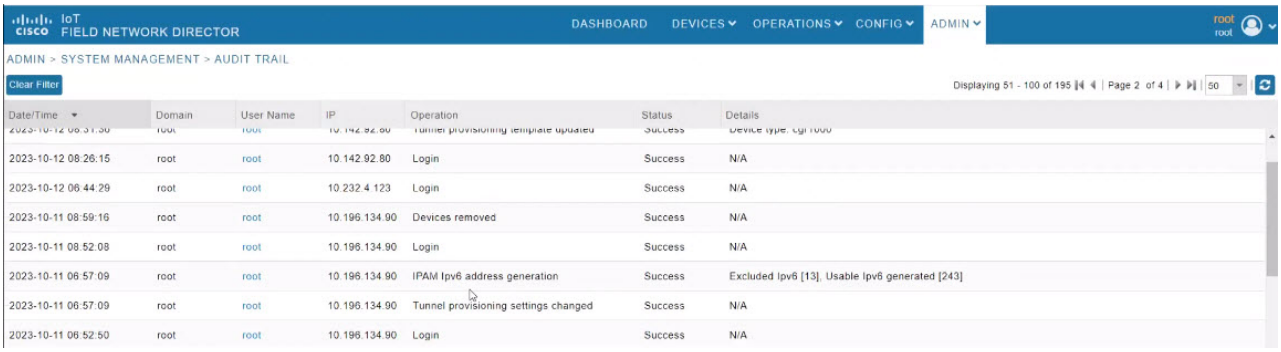
Step 4 Click the Disk icon to save changes. The following window pops up to show the probable IP addresses that will be generated.

Note
If you choose to modify the subnet after the warning, then IoT FND deletes all the existing ip addresses created under previous subnet except the one being used and generates fresh ip addreses for new subnet.



Step 5 Click **Yes**.

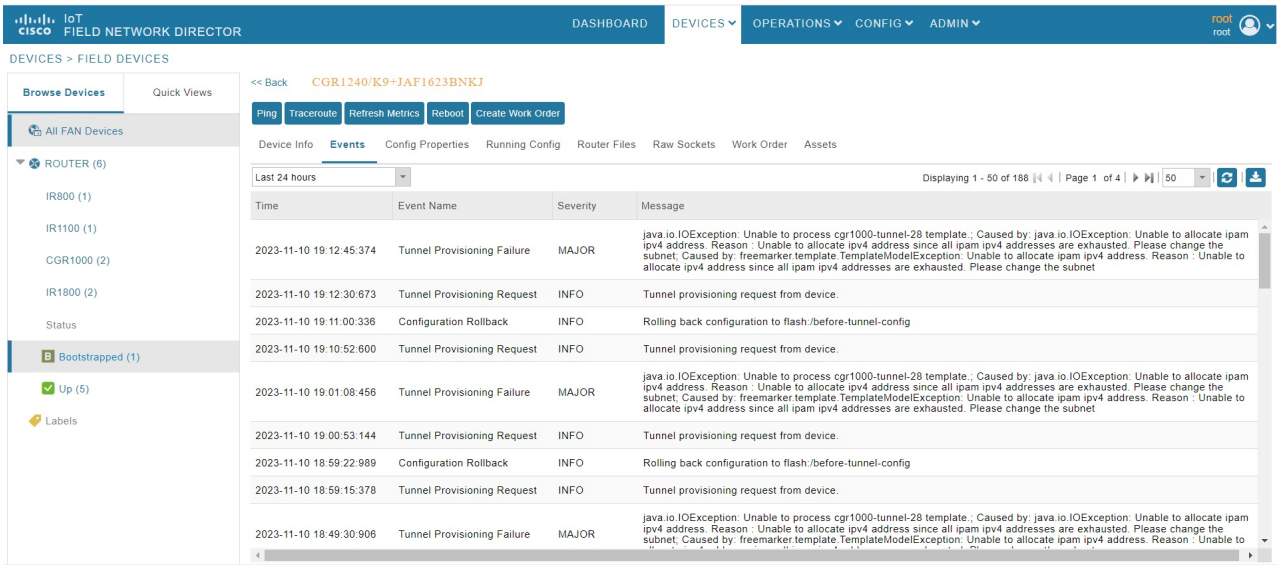
Step 6 Navigate to **ADMIN** > **SYSTEM MANAGEMENT** > **AUDIT TRAIL** page to check for the number of excluded IPs and the generated usable IPs.



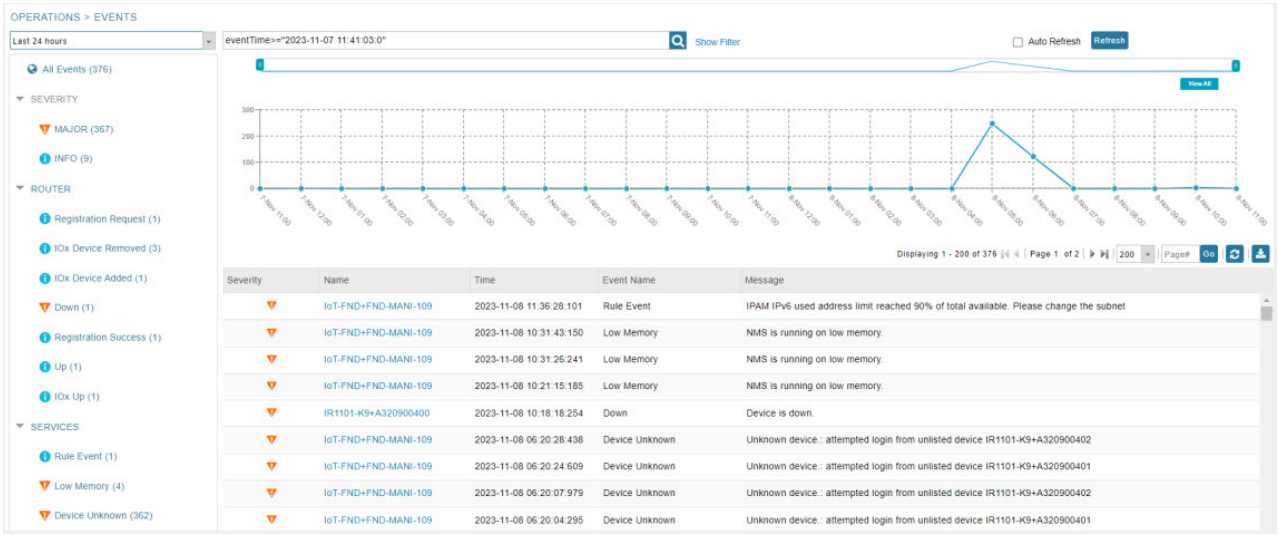
After configuring subnet settings and generating IP addresses, initiate the tunnel provisioning process.

Note
During tunnel provisioning, if the IP address is provided in the CSV in the `loopbackv4address` and `loopbackv6address` property when adding routers, it is utilized as the loopback IP address. In case the IP address is not provided in the CSV, then internal IP address is fetched.

If the tunnel provisioning fails as IP address lease exceeds, then the error message is seen in the **DEVICES** > **FIELD DEVICES** page under Events tab.



Note
In the **Operations** > **Events** page, check the event generated. A minor event is generated if the percentage of utilization crosses 80% of total generated IP. Similarly, a major event is generated if the percentage of utilization crosses 90% of total generated IP. You can configure the limit for major threshold in **ipam-ipAddress-pool-thresold-limit** property in cgms.properties file. The default value is set to 90, if not configured.



Once tunnels are assigned an IP address, the DB is also updated.

For tunnel reprovisioning, the router uses the same IP address.