OSPFv3 VRF-Lite/PE-CE

The OSPFv3 VRF-Lite/PE-CE feature adds Open Shortest Path First version 3 (OSPFv3) support for nondefault VPN routing and forwarding (VRF) instances. OSPFv3 can be used as a provider-edge-customer-edge (PE-CE) routing protocol as specified in RFC 6565, *OSPFv3 as a Provider Edge to Customer Edge (PE-CE) Routing Protocol*. OSPFv3 in a nondefault VRF instance supports routing of IPv4 and IPv6 address families.

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Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for OSPFv3 VRF-Lite/PE-CE

In Cisco IOS Release 15.2(2)S and later releases, OSPFv3 interface commands in the `ipv6 ospf` format are no longer supported in VRF interface configuration mode. You must configure them in the new format, `ospfv3`.

The `ospfv3` commands can have one of following formats:

- `ospfv3` — Applies to all OSPFv3 processes and address families on a given interface.
- `ospfv3 process-id` — Applies to an OSPFv3 process with the configured process ID and to both IPv4 and IPv6 address families.
- `ospfv3 process-id address-family-ID` — Applies to an OSPFv3 process with the configured process ID and the configured address family.
More specific commands take precedence over less specific commands, as shown in the following descending order:

1. Commands that specify a process ID and an address family.
2. Commands that specify only a process ID.
3. Commands that specify neither a process ID nor an address family.

In Cisco IOS Release 15.2(2)S and later releases, you cannot use the `ipv6 ospf router process-id` command to configure OSPFv3 VRF instances. You must configure the `router ospfv3 process-id` command in global configuration mode and specify the address family for the configured VRF in router configuration mode.

**Information About OSPFv3 VRF-Lite/PE-CE**

**Support for OSPFv3 VRF-Lite and PE-CE**

Open Shortest Path First version 3 (OSPFv3) operates in nondefault VPN routing and forwarding (VRF) instances for both IPv6 and IPv4 address families and, transports the routes across a Border Gateway Protocol (BGP) or a Multiprotocol Label Switching (MPLS) backbone. On the provider edge (PE) device, customer routes are installed together by OSPFv3 and BGP in a common VRF or address family and each protocol is configured to redistribute the routes of the other. BGP combines the prefixes redistributed into it with a route-distinguisher value defined for the VRF and advertises them to other MPLS-BGP speakers in the same autonomous system using the VPNv4 or VPNv6 address family as appropriate.

The OSPFv3 route selection algorithm prefers intra-area routes across the back-door link over inter-area routes through the MPLS backbone. Sham-links are a type of virtual link across the MPLS backbone that connect OSPFv3 instances on different PEs. OSPFv3 instances tunnel protocol packets through the backbone and form adjacencies. Because OSPFv3 considers the sham-link as an intra-area connection, sham-link serves as a valid alternative to an intra-area back-door link.

Domain IDs are used to determine whether the routes are internal or external. They describe the administrative domain of the OSPFv3 instance from which the route originates. Every PE has a 48-bit primary domain ID (which may be NULL) and zero or more secondary domain IDs.

**How to Configure VRF-Lite/PE-CE**

**Configuring a VRF in an IPv6 Address Family for OSPFv3**

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `vrf definition vrf-name`
4. `rd route-distinguisher`
5. `exit`
6. `router ospfv3 [process-id]`
### DETAILED STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| 1    | enable            | Enables privileged EXEC mode.  
  Example: 
  Device> enable |
| 2    | configure terminal| Enters global configuration mode.  
  Example:  
  Device# configure terminal |
| 3    | vrf definition vrf-name | Configures a VRF routing table and enters VRF configuration mode.  
  Example:  
  Device(config)# vrf definition vrfsample |
| 4    | rd route-distinguisher | Creates routing and forwarding tables for a VRF.  
  Example:  
  Device(config-vrf)# rd 10:1 |
| 5    | exit              | Exists VRF configuration mode and returns to global configuration mode.  
  Example:  
  Device(config-vrf)# exit |
| 6    | router ospfv3 [process-id] | Configures an OSPF routing process and enters router configuration mode.  
  Example:  
  Device(config)# router ospfv3 2 |
| 7    | address-family ipv6 [unicast] vrf vrf-name | Configures an instance of the OSPFv3 process in the VRF routing table for the IPv6 address family and enters router address family configuration mode.  
  Example:  
  Device(config-router)# address-family ipv6 unicast vrf vrfsample |
| 8    | end               | Exists router address family configuration mode and returns to privileged EXEC mode.  
  Example:  
  Device(config-router-af)# end |
Enabling an OSPFv3 IPv6 Address Family on a VRF Interface

SUMMARY STEPS

1. enable
2. configure terminal
3. interface type number
4. vrf forwarding vrf-name [downstream vrf-name2]
5. ipv6 enable
6. ospfv3 process-id {ipv4 | ipv6} area area-id [instance instance-id]
7. end

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example: Device# enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example: Device# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface type number</td>
<td>Specifies an interface type and number and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example: Device(config)# interface Serial6/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> vrf forwarding vrf-name [downstream vrf-name2]</td>
<td>Associates an interface with a VRF.</td>
</tr>
<tr>
<td>Example: Device(config-if)# vrf forwarding v1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> ipv6 enable</td>
<td>Enables IPv6 processing on the interface that is associated with the VRF.</td>
</tr>
<tr>
<td>Example: Device(config-if)# ipv6 enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> ospfv3 process-id {ipv4</td>
<td>ipv6} area area-id [instance instance-id]</td>
</tr>
<tr>
<td>Example: Device(config-if)# ospfv3 1 ipv6 area 0</td>
<td></td>
</tr>
</tbody>
</table>
Configuring a Sham-Link for OSPFv3 PE-CE

Before you begin
The OSPFv3 PE-CE feature supports direct forwarding on Border Gateway Protocol (BGP) routes.

Before you configure a sham-link, you must create a Multiprotocol Label Switching (MPLS) backbone, configure a device as an MPLS VPN PE device, and configure OSPFv3 as the provider-edge-customer-edge (PE-CE) protocol in a virtual routing and forwarding (VRF) instance.

SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `interface loopback interface-number`
4. `description string`
5. `vrf forwarding vrf-name`
6. `ipv6 address ipv6-address/prefix-length`
7. `ipv6 enable`
8. `end`
9. `router ospf process-id`
10. `address-family {ipv4 | ipv6} [unicast | multicast] [vrf vrf-name]`
11. `redistribute process-id [options]`
12. `area area-id sham-link source-address destination-address [cost number] [ttl-security hops hop-count]`
13. `end`

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><code>enable</code></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Device&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><code>configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Device# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><strong>interface loopback interface-number</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config)# interface loopback 0</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td><strong>description string</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config-if)# description Sham-link endpoint</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>vrf forwarding vrf-name</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config-if)# vrf forwarding vrf1</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>ipv6 address ipv6-address/prefix-length</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config-if)# ipv6 address 2001:DB8:0:ABCD::1/48</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>ipv6 enable</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config-if)# ipv6 enable</td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>end</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device# end</td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td><strong>router ospfv3 process-id</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config)# router ospfv3 1</td>
</tr>
<tr>
<td><strong>Step 10</strong></td>
<td>**address-family {ipv4</td>
</tr>
<tr>
<td><strong>Step 11</strong></td>
<td><strong>redistribute process-id [options]</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Device(config-router-af)# redistribute bgp 2</td>
</tr>
</tbody>
</table>
### Configuring a Domain ID for an OSPFv3 PE-CE

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `vrf definition vrf-name`
4. `rd route-distinguisher`
5. `exit`
6. `router ospfv3 [process-id]`
7. `address-family ipv6 [unicast] [vrf vrf-name]`
8. `domain-id type value hex-value`
9. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Device&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Device# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td><code>vrf definition vrf-name</code></td>
<td>Configures a VRF routing table and enters VRF configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>Device(config)# vrf definition vrfsample</code></td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 4</td>
<td><code>rd route-distinguisher</code></td>
<td>Creates routing and forwarding tables for a VRF.</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-vrf)# rd 10:1</td>
<td></td>
</tr>
<tr>
<td>Step 5</td>
<td><code>exit</code></td>
<td>Exists VRF configuration mode and returns to global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-vrf)# exit</td>
<td></td>
</tr>
<tr>
<td>Step 6</td>
<td><code>router ospfv3 [process-id]</code></td>
<td>Enters router configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config)# router ospfv3 2</td>
<td></td>
</tr>
<tr>
<td>Step 7</td>
<td><code>address-family ipv6 [unicast] [vrf vrf-name]</code></td>
<td>Configures an instance of the OSPFv3 process in the VRF routing table for the IPv6 address family and enters address family configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-router)# address-family ipv6 unicast vrf vrfsample</td>
<td></td>
</tr>
<tr>
<td>Step 8</td>
<td><code>domain-id type value hex-value</code></td>
<td>Configures the BGP domain ID.</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-router-af)# domain-id type 0205 value 800EFFFF12AB</td>
<td></td>
</tr>
<tr>
<td>Step 9</td>
<td><code>end</code></td>
<td>Exists router address family mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Device(config-router-af)# end</td>
<td></td>
</tr>
</tbody>
</table>

### Configuring VRF-Lite Capability for OSPFv3

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `vrf definition vrf-name`
4. `rd route-distinguisher`
5. `exit`
6. `router ospfv3 [process-id]`
7. `address-family ipv6 [unicast] [vrf vrf-name]`
8. `capability vrf-lite`
9. `end`
## DETAILED STEPS

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** | enable | Enables privileged EXEC mode.  
  **Example:**  
  Device> enable |  
  • Enter your password if prompted. |
| **Step 2** | configure terminal | Enters global configuration mode. |
| **Example:** | Device# configure terminal | |
| **Step 3** | vrf definition vrf-name | Configures a VRF routing table and enters VRF configuration mode. |
| **Example:** | Device(config)# vrf definition vrfsample | |
| **Step 4** | rd route-distinguisher | Creates routing and forwarding tables for a VRF. |
| **Example:** | Device(config-vrf)# rd 10:1 | |
| **Step 5** | exit | Exists VRF configuration mode and returns to global configuration mode. |
| **Example:** | Device(config-vrf)# exit | |
| **Step 6** | router ospfv3 [process-id] | Enables router configuration mode for the IPv4 or IPv6 address family. |
| **Example:** | Device(config)# router ospfv3 2 | |
| **Step 7** | address-family ipv6 [unicast] [vrf vrf-name] | Configures an instance of the OSPFv3 process in the VRF routing table for the IPv6 address family and enters address family configuration mode. |
| **Example:** | Device(config-router)# address-family ipv6 unicast vrf vrfsample | |
| **Step 8** | capability vrf-lite | Applies the multi-VRF capability to the OSPF process. |
| **Example:** | Device(config-router-af)# capability vrf-lite | |
| **Step 9** | end | Exists router address family mode and returns to privileged EXEC mode. |
| **Example:** | Device(config-router-af)# end | |
Example: Configuring a Provider Edge Device to Provide IPv6 and IPv4 Routing

The following example shows how to configure a provider edge (PE) device to provide IPv6 and IPv4 routing for a user on VRF “v1” and IPv6 routing for a user on VRF “v2”:

```plaintext
vrf definition v1
  rd 1:1
  route-target export 100:1
  route-target import 100:1
  address-family ipv4
    exit-address-family
  address-family ipv6
    exit-address-family
vrf definition v2
  rd 2:2
  route-target export 200:2
  route-target import 200:2
  address-family ipv6
    exit-address-family
  interface Loopback1
    vrf forwarding v1
    ipv6 address 2001:DB8:0:ABCD::1/48
  interface Serial5/0
    vrf forwarding v2
    no ip address
    ipv6 address 2001:DB8:0:ABCD::3/48
    ospfv3 1 ipv6 area 1
  interface Serial6/0
    vrf forwarding v1
    ip address 10.0.0.1 255.255.255.0
    ipv6 enable
    ospfv3 1 ipv6 area 0
    ospfv3 1 ipv4 area 10.1.1.1
  router ospfv3
    log-adjacency-changes detail
    address-family ipv4 unicast vrf v1
      router-id 10.2.2.2
      redistribute bgp 1
      exit-address-family
    address-family ipv6 unicast vrf v1
      router-id 2001:DB8:1:1::1
      domain-id type 0205 value 11111122222
      area 0 sham-link 2001:DB8:0:ABCD::5 2001:DB8:0:ABCD::7
      redistribute bgp 1
      exit-address-family
```
address-family ipv6 unicast vrf v2
  router-id 2001:DB8:1::3
  redistribute bgp 1
  exit

router bgp 1
  bgp router-id 10.3.3.3
  no bgp default ipv4-unicast
  neighbor 10.0.0.4 remote-as 1
  neighbor 10.0.0.4 update-source Loopback0

address-family ipv4
  exit-address-family

address-family vpnv4
  neighbor 10.0.0.4
  neighbor 10.0.0.4 send-community extended
  exit-address-family

address-family vpnv6
  neighbor 10.0.0.4 activate
  neighbor 10.0.0.4 send-community extended
  exit-address-family

address-family ipv4 vrf v1
  redistribute ospfv3 1
  exit-address-family

address-family ipv6 vrf v1
  redistribute ospf 1
  exit-address-family

address-family ipv6 vrf v2
  redistribute ospf 1
  exit-address-family

Example: Configuring a Provider Edge Device for VRF-Lite

vrf definition v1
  rd 1:1
  !
address-family ipv4
  exit-address-family

address-family ipv6
  exit-address-family

vrf definition v2
  rd 2:2
  !
address-family ipv6
  exit-address-family

interface FastEthernet0/0
  no ip address
  !
interface FastEthernet0/0.100
  encapsulation dot1Q 100
vrf forwarding v1
ip address 192.168.1.1 255.255.255.0
ipv6 enable
ospfv3 1 ipv6 area 0
ospfv3 1 ipv4 area 0
!
interface FastEthernet0/0.200
encapsulation dot1Q 200
vrf forwarding v2
ipv6 enable
ospfv3 1 ipv6 area 0
!
interface FastEthernet0/1
vrf forwarding v1
ip address 10.1.1.1 255.255.255.0
ipv6 enable
ospfv3 1 ipv6 area 1
ospfv3 1 ipv4 area 0
no keepalive
!
interface FastEthernet0/2
vrf forwarding v2
no ip address
ipv6 address 2001:DB8:1::1
ipv6 enable
ospfv3 1 ipv6 area 1
!
router ospfv3 1
!
address-family ipv6 unicast vrf v2
router-id 192.168.2.1
capability vrf-lite
exit-address-family
!
address-family ipv4 unicast vrf v1
router-id 192.168.1.4
capability vrf-lite
exit-address-family
!
address-family ipv6 unicast vrf v1
router-id 192.168.1.1
capability vrf-lite
exit-address-family
!

Additional References for OSPFv3 VRF-Lite/PE-CE

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<td>Cisco IOS Master Command List, All Releases</td>
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<tr>
<td>OSPF commands</td>
<td>Cisco IOS IP Routing: OSPF Command Reference</td>
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RFCs

<table>
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<tr>
<th>RFC</th>
<th>Title</th>
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<td>RFC 5838</td>
<td>Support of Address Families in OSPFv3</td>
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<tr>
<td>RFC 6565</td>
<td>OSPFv3 as a Provider Edge to Customer Edge (PE-CE) Routing Protocol</td>
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Technical Assistance

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<td>The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

**Feature Information for OSPFv3 VRF-Lite/PE-CE**

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
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<tbody>
<tr>
<td>OSPFv3 VRF-Lite/PE-CE</td>
<td>Cisco IOS XE Release 3.6S</td>
<td>The OSPFv3 VRF-Lite/PE-CE feature adds OSPFv3 support for nondefault VRF instances. The following commands were introduced or modified: <strong>area sham-link</strong> (OSPFv3), <strong>capability vrf-lite</strong> (OSPFv3).</td>
</tr>
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