Implementing Tunneling for IPv6

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This module describes how to configure overlay tunneling techniques used by the Cisco IOS XE software to support the transition from IPv4-only networks to integrated IPv4- and IPv6-based networks. Tunneling encapsulates IPv6 packets in IPv4 packets and uses the IPv4 network as a link-layer mechanism.

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 at the end of this module.

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 Implementing Tunneling for IPv6

- The IPv6 rapid deployment (6RD) feature is supported in an ethernet-only topology.
- IPv6 VRF is not supported with the 6RD feature.
- The Cisco ASR 1000 Series Aggregation Services Routers support as many as 2000 6RD tunnel interfaces.

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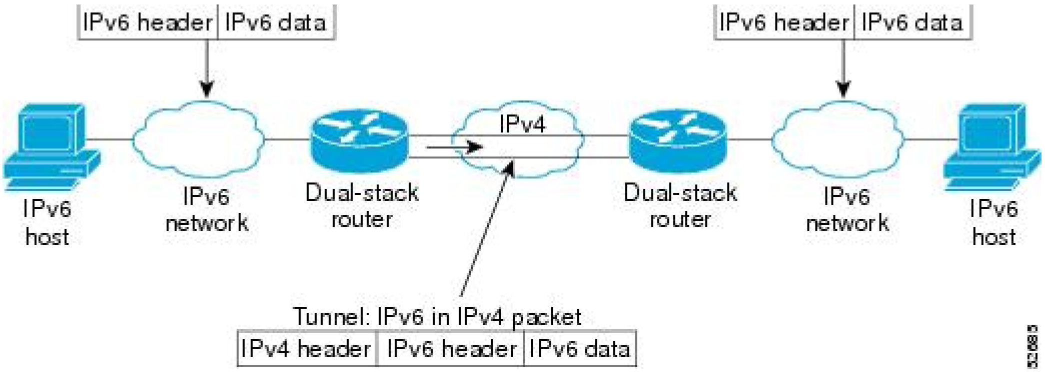
Information About Implementing Tunneling for IPv6

Overlay Tunnels for IPv6

Overlay tunneling encapsulates IPv6 packets in IPv4 packets for delivery across an IPv4 infrastructure (a core network or the Internet (see the figure below). By using overlay tunnels, you can communicate with isolated IPv6 networks without upgrading the IPv4 infrastructure between them. Overlay tunnels can be configured between border routers or between a border router and a host; however, both tunnel endpoints must support both the IPv4 and IPv6 protocol stacks. IPv6 supports the following types of overlay tunneling mechanisms:

- Manual
- Generic routing encapsulation (GRE)
- IPv4-compatible
- 6to4
- Intrasite Automatic Tunnel Addressing Protocol (ISATAP)

Figure 1 Overlay Tunnels



Note Overlay tunnels reduce the maximum transmission unit (MTU) of an interface by 20 octets (assuming the basic IPv4 packet header does not contain optional fields). A network using overlay tunnels is difficult to troubleshoot. Therefore, overlay tunnels connecting isolated IPv6 networks should not be considered as a final IPv6 network architecture. The use of overlay tunnels should be considered as a transition technique toward a network that supports both the IPv4 and IPv6 protocol stacks or just the IPv6 protocol stack.

Use the table below to help you determine which type of tunnel you want to configure to carry IPv6 packets over an IPv4 network.

Table 1 Suggested Usage of Tunnel Types to Carry IPv6 Packets over an IPv4 Network

Tunneling Type	Suggested Usage	Usage Notes
Manual	Simple point-to-point tunnels that can be used within a site or between sites	Can carry IPv6 packets only.
GRE- and IPv4- compatible	Simple point-to-point tunnels that can be used within a site or between sites	Can carry IPv6, Connectionless Network Service (CLNS), and many other types of packets.
IPv4- compatible	Point-to-multipoint tunnels	Uses the ::/96 prefix. We do not now recommend using this tunnel type.
6to4	Point-to-multipoint tunnels that can be used to connect isolated IPv6 sites	Sites use addresses from the 2002::/16 prefix.
6RD	IPv6 service is provided to customers over an IPv4 network by using encapsulation of IPv6 in IPv4.	Prefixes can be from the SP’s own address block.
ISATAP	Point-to-multipoint tunnels that can be used to connect systems within a site	Sites can use any IPv6 unicast addresses.

Individual tunnel types are discussed in detail in this document. We recommend that you review and understand the information about the specific tunnel type that you want to implement. When you are familiar with the type of tunnel you need, see the table below for a summary of the tunnel configuration parameters that you may find useful.

Table 2 Tunnel Configuration Parameters by Tunneling Type

Tunneling Type	Tunnel Configuration Parameter			
Tunnel Mode	Tunnel Source	Tunnel Destination	Interface Prefix or Address	
Manual	ipv6ip	An IPv4 address, or a reference to an interface on which IPv4 is configured.	An IPv4 address.	An IPv6 address.
GRE/IPv4	gre ip		An IPv4 address.	An IPv6 address.
IPv4- compatible	ipv6ip auto-tunnel		Not required. These are all point-to-multipoint tunneling types. The IPv4 destination address	Not required. The interface address is generated as ::*tunnel-source*/96.

Tunneling Type	Tunnel Configuration Parameter			
6to4	ipv6ip 6to4		is calculated, on a per-packet basis, from the IPv6 destination.	An IPv6 address. The prefix must embed the tunnel source IPv4 address
6RD	ipv6ip 6rd			An IPv6 address.
ISATAP	ipv6ip isatap			An IPv6 prefix in modified eui-64 format. The IPv6 address is generated from the prefix and the tunnel source IPv4 address.

IPv6 Manually Configured Tunnels

A manually configured tunnel is equivalent to a permanent link between two IPv6 domains over an IPv4 backbone. The primary use is for stable connections that require regular secure communication between two edge routers or between an end system and an edge router, or for connection to remote IPv6 networks.

An IPv6 address is manually configured on a tunnel interface, and manually configured IPv4 addresses are assigned to the tunnel source and the tunnel destination. The host or router at each end of a configured tunnel must support both the IPv4 and IPv6 protocol stacks. Manually configured tunnels can be configured between border routers or between a border router and a host.

GRE IPv4 Tunnel Support for IPv6 Traffic

IPv6 traffic can be carried over IPv4 GRE tunnels using the standard GRE tunneling technique that is designed to provide the services necessary to implement any standard point-to-point encapsulation scheme. As in IPv6 manually configured tunnels, GRE tunnels are links between two points, with a separate tunnel for each link. The tunnels are not tied to a specific passenger or transport protocol, but in this case carry IPv6 as the passenger protocol with the GRE as the carrier protocol and IPv4 or IPv6 as the transport protocol.

The primary use of GRE tunnels is for stable connections that require regular secure communication between two edge routers or between an edge router and an end system. The edge routers and the end systems must be dual-stack implementations.

GRE has a protocol field that identifies the passenger protocol. GRE tunnels allow Intermediate System-to-Intermediate System (IS-IS) or IPv6 to be specified as a passenger protocol, which allows both IS-IS and IPv6 traffic to run over the same tunnel. If GRE did not have a protocol field, it would be impossible to distinguish whether the tunnel was carrying IS-IS or IPv6 packets. The GRE protocol field is why it is desirable that you tunnel IS-IS and IPv6 inside GRE.

Automatic 6to4 Tunnels

An automatic 6to4 tunnel allows isolated IPv6 domains to be connected over an IPv4 network to remote IPv6 networks. The key difference between automatic 6to4 tunnels and manually configured tunnels is that the tunnel is not point-to-point; it is point-to-multipoint. In automatic 6to4 tunnels, routers are not configured in pairs because they treat the IPv4 infrastructure as a virtual nonbroadcast multiaccess (NBMA) link. The IPv4 address embedded in the IPv6 address is used to find the other end of the automatic tunnel.

An automatic 6to4 tunnel may be configured on a border router in an isolated IPv6 network, which creates a tunnel on a per-packet basis to a border router in another IPv6 network over an IPv4 infrastructure. The tunnel destination is determined by the IPv4 address of the border router extracted from the IPv6 address that starts with the prefix 2002::/16, where the format is 2002:*border-router-IPv4-address* ::/48. Following the embedded IPv4 address are 16 bits that can be used to number networks within the site. The border router at each end of a 6to4 tunnel must support both the IPv4 and IPv6 protocol stacks. 6to4 tunnels are configured between border routers or between a border router and a host.

The simplest deployment scenario for 6to4 tunnels is to interconnect multiple IPv6 sites, each of which has at least one connection to a shared IPv4 network. This IPv4 network could be the global Internet or a corporate backbone. The key requirement is that each site have a globally unique IPv4 address; the Cisco software uses this address to construct a globally unique 6to4/48 IPv6 prefix. As with other tunnel mechanisms, appropriate entries in a Domain Name System (DNS) that map between hostnames and IP addresses for both IPv4 and IPv6 allow the applications to choose the required address.

IPv6 Rapid Deployment Tunnels

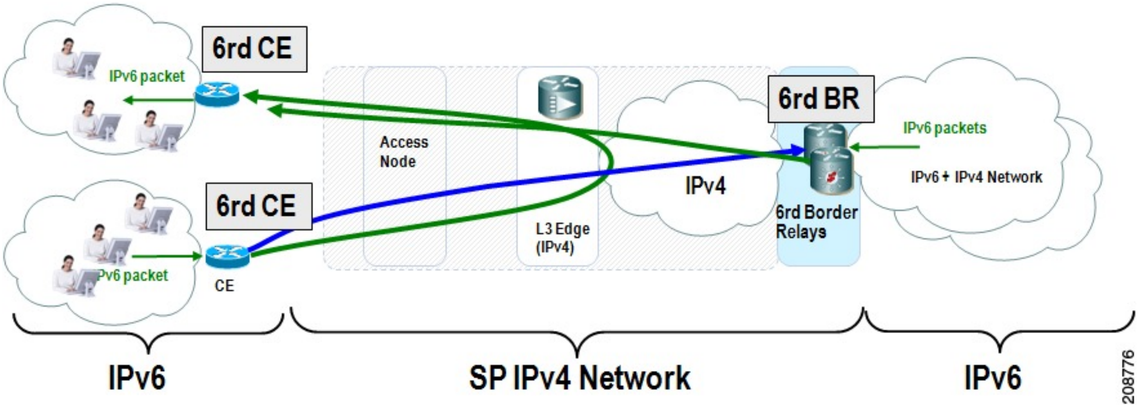
The 6RD feature is an extension of the 6to4 feature. The 6RD feature allows a service provider (SP) to provide a unicast IPv6 service to customers over its IPv4 network by using encapsulation of IPv6 in IPv4.

The main differences between 6RD and 6to4 tunneling are as follows:

- 6RD does not require addresses to have a 2002::/16 prefix; therefore, the prefix can be from the SP’s own address block. This function allows the 6RD operational domain to be within the SP network. From the perspective of customer sites and the general IPv6 internet connected to a 6RD-enabled SP network, the IPv6 service provided is equivalent to native IPv6.
- All 32 bits of the IPv4 destination need not be carried in the IPv6 payload header. The IPv4 destination is obtained from a combination of bits in the payload header and information on the router. Furthermore, the IPv4 address is not at a fixed location in the IPv6 header as it is in 6to4.

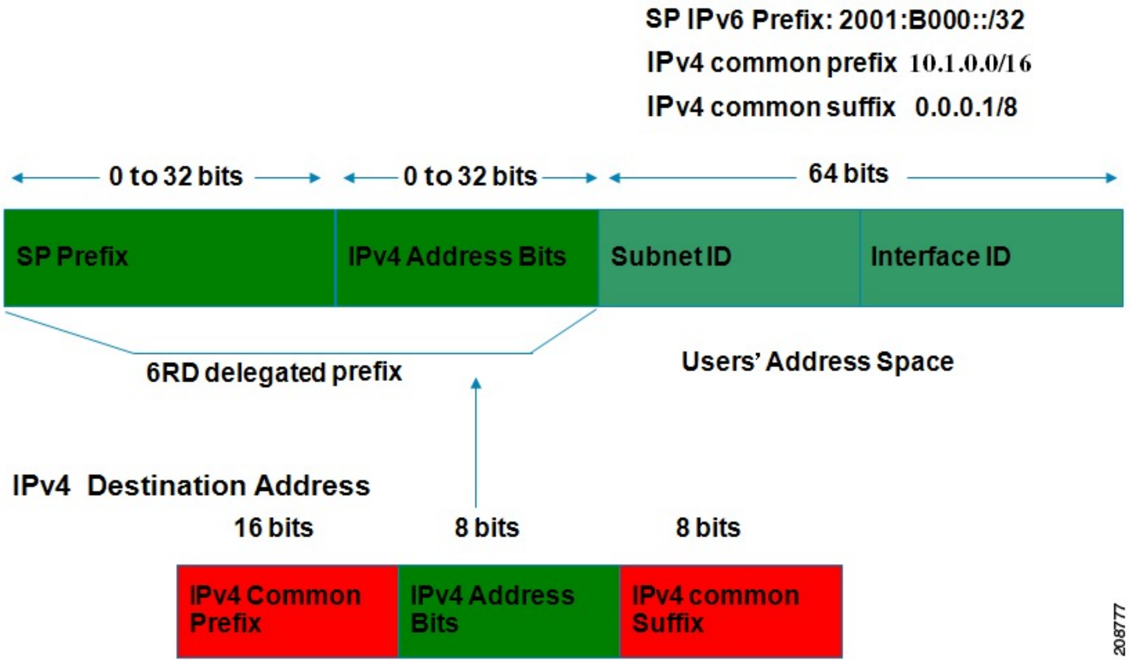
The 6RD SP prefix was selected by the SP for the IPv6 deployment shown in the figure below. The 6RD delegated prefix is derived from the SP prefix and the IPv4 address bits, and is used by the CE for hosts within its site.

Figure 2 6RD Deployment



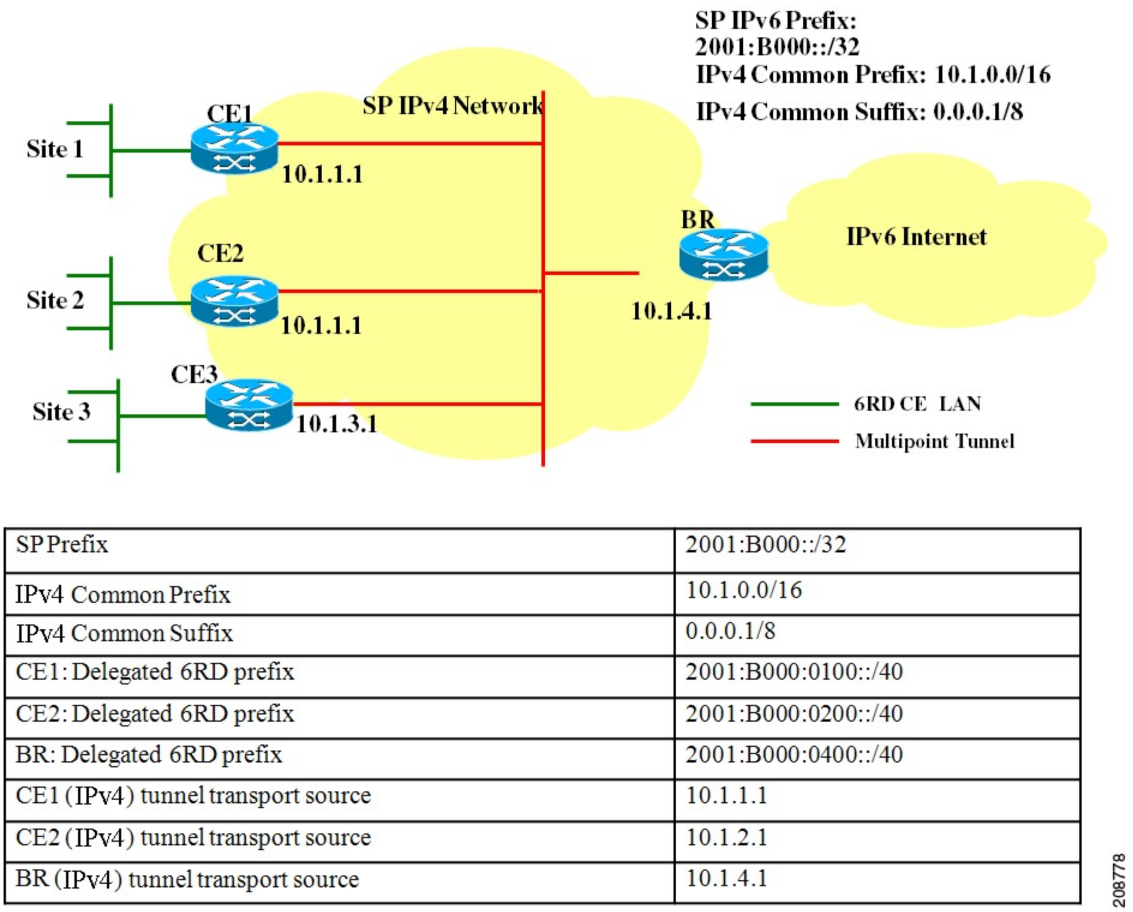
The figure below shows how 6RD prefix delegation works.

Figure 3 6RD Prefix Delegation Explanation



The figure below shows a 6RD prefix delegation topology.

Figure 4 **6RD Prefix Delegation and Explanation**



SP Prefix	2001:B000::/32
IPv4 Common Prefix	10.1.0.0/16
IPv4 Common Suffix	0.0.0.1/8
CE1: Delegated 6RD prefix	2001:B000:0100::/40
CE2: Delegated 6RD prefix	2001:B000:0200::/40
BR: Delegated 6RD prefix	2001:B000:0400::/40
CE1 (IPv4) tunnel transport source	10.1.1.1
CE2 (IPv4) tunnel transport source	10.1.2.1
BR (IPv4) tunnel transport source	10.1.4.1

ISATAP Tunnels

ISATAP is an automatic overlay tunneling mechanism that uses the underlying IPv4 network as a NBMA link layer for IPv6. ISATAP is designed for transporting IPv6 packets *within* a site where a native IPv6 infrastructure is not yet available; for example, when sparse IPv6 hosts are deployed for testing. ISATAP tunnels allow individual IPv4 or IPv6 dual-stack hosts within a site to communicate with other such hosts on the same virtual link, basically creating an IPv6 network using the IPv4 infrastructure.

The ISATAP router provides standard router advertisement network configuration support for the ISATAP site. This feature allows clients to automatically configure themselves as they would do if they were connected to a GigabitEthernet or FastEthernet. It can also be configured to provide connectivity out of the site. ISATAP uses a well-defined IPv6 address format composed of any unicast IPv6 prefix (/64), which can be link local, or global (including 6to4 prefixes), enabling IPv6 routing locally or on the Internet. The IPv4 address is encoded in the last 32 bits of the IPv6 address, enabling automatic IPv6-in-IPv4 tunneling.

Although the ISATAP tunneling mechanism is similar to other automatic tunneling mechanisms, such as IPv6 6to4 tunneling, ISATAP is designed for transporting IPv6 packets *within* a site, not *between* sites.

ISATAP uses unicast addresses that include a 64-bit IPv6 prefix and a 64-bit interface identifier. The interface identifier is created in modified EUI-64 format in which the first 32 bits contain the value

000:5EFE to indicate that the address is an IPv6 ISATAP address. The table below describes an ISATAP address format.

Table 3 IPv6 ISATAP Address Format

64 Bits	32 Bits	32 Bits
link local or global IPv6 unicast prefix	0000:5EFE	IPv4 address of the ISATAP link

As shown in the table above, an ISATAP address consists of an IPv6 prefix and the ISATAP interface identifier. This interface identifier includes the IPv4 address of the underlying IPv4 link. The following example shows what an actual ISATAP address would look like if the prefix is 2001:DB8:1234:5678::/64 and the embedded IPv4 address is 10.173.129.8. In the ISATAP address, the IPv4 address is expressed in hexadecimal as 0AAD:8108:

2001:DB8:1234:5678:0000:5EFE:0AAD:8108

How to Implement Tunneling for IPv6

Configuring Manual IPv6 Tunnels

With manually configured IPv6 tunnels, an IPv6 address is configured on a tunnel interface, and manually configured IPv4 addresses are assigned to the tunnel source and the tunnel destination. The host or router at each end of a configured tunnel must support both the IPv4 and IPv6 protocol stacks.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *tunnel-number*
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits/prefix-length*
5. **tunnel source** {*ip-address*| *interface-t ype interface-number*}
6. **tunnel destination** *ip-address*
7. **tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *tunnel-number* **Example:** `Router(config)# interface tunnel 0`	Specifies a tunnel interface and number, and enters interface configuration mode.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits*/*prefix-length* **Example:** `Router(config-if)# ipv6 address 3ffe:b00:c18:1::3/127`	Specifies the IPv6 network assigned to the interface and enables IPv6 processing on the interface. **Note** Refer to the Implementing IPv6 Addressing and Basic Connectivity module for more information on configuring IPv6 addresses.

Step 5	**tunnel source** {*ip-address*| *interface-t ype interface-number*}
	Example:
	`Router(config-if)# tunnel source gigabitethernet 0/0/0`
		Specifies the source IPv4 address or the source interface type and number for the tunnel interface.
		• If an interface is specified, the interface must be configured with an IPv4 address.

Step 6	**tunnel destination** *ip-address* **Example:** `Router(config-if)# tunnel destination 192.168.30.1`	Specifies the destination IPv4 address or hostname for the tunnel interface.

	Command or Action	Purpose
Step 7	**tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap** **Example:** `Router(config-if)# tunnel mode ipv6ip`	Specifies a manual IPv6 tunnel. **Note** The **tunnel mode ipv6ip** command specifies IPv6 as the passenger protocol and IPv4 as both the encapsulation and transport protocol for the manual IPv6 tunnel. • The **auto-tunnel** keyword is not supported on Cisco ASR 1000 series routers.

Configuring GRE IPv6 Tunnels

GRE tunnels can be configured to run over an IPv6 network layer and to transport IPv6 packets in IPv6 tunnels and IPv4 packets in IPv6 tunnels.

When GRE IPv6 tunnels are configured, IPv6 addresses are assigned to the tunnel source and the tunnel destination. The tunnel interface can have either IPv4 or IPv6 addresses assigned (this is not shown in the task). The host or router at each end of a configured tunnel must support both the IPv4 and IPv6 protocol stacks.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *tunnel-number*
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits/prefix-length*
5. **tunnel source** {*ip-address* | *ipv6-address* | *interface-type interface-number*}
6. **tunnel destination** {*host-name* | *ip-address* | *ipv6-address*}
7. **tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre**| **gre multipoint** | **gre ipv6** | **ipip** [**decapsulate-any**] | **iptalk** | **ipv6** | **mpls** | **nos**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface tunnel** *tunnel-number* **Example:** `Router(config)# interface tunnel 0`	Specifies a tunnel interface and number, and enters interface configuration mode.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits*/ *prefix-length* **Example:** `Router(config-if)# ipv6 address 3ffe:b00:c18:1::3/127`	Specifies the IPv6 network assigned to the interface and enables IPv6 processing on the interface.

Step 5	**tunnel source** {*ip-address* | *ipv6-address* | *interface-type interface-number*}
	Example:
	`Router(config-if)# tunnel source gigabitethernet 0/0/0`
		Specifies the source IPv4 address or the source interface type and number for the tunnel interface.
		• If an interface is specified, the interface must be configured with an IPv4 address.

Step 6	**tunnel destination** {*host-name* | *ip-address* | *ipv6-address*}
	Example:
	`Router(config-if)# tunnel destination 2001:DB8:1111:2222::1/64`
		Specifies the destination IPv4 address or hostname for the tunnel interface.

Step 7	**tunnel mode** {**aurp** | **cayman** | **dvmrp** | **eon** | **gre**| **gre multipoint** | **gre ipv6** | **ipip** [**decapsulate-any**] | **iptalk** | **ipv6** | **mpls** | **nos** **Example:** `Router(config-if)# tunnel mode gre ipv6`	Specifies a GRE IPv6 tunnel. **Note** The **tunnel mode gre ipv6**command specifies GRE as the encapsulation protocol for the tunnel.

Configuring Automatic 6to4 Tunnels

With 6to4 tunnels, the tunnel destination is determined by the border router IPv4 address, which is concatenated to the prefix 2002::/16 in the format 2002:*border-router-IPv4-address* ::/48. The border router at each end of a 6to4 tunnel must support both the IPv4 and IPv6 protocol stacks.

Note The configuration of only one IPv4-compatible tunnel and one 6to4 IPv6 tunnel is supported on a router. If you choose to configure both of those tunnel types on the same router, we strongly recommend that they do not share the same tunnel source.

The reason that a 6to4 tunnel and an IPv4-compatible tunnel cannot share an interface is that both of them are NBMA "point-to-multipoint" access links and only the tunnel source can be used to reorder the packets from a multiplexed packet stream into a single packet stream for an incoming interface. So when a packet with an IPv4 protocol type of 41 arrives on an interface, that packet is mapped to an IPv6 tunnel interface based on the IPv4 address. However, if both the 6to4 tunnel and the IPv4-compatible tunnel share the same source interface, the router is not able to determine the IPv6 tunnel interface to which it should assign the incoming packet.

IPv6 manually configured tunnels can share the same source interface because a manual tunnel is a "point-to-point" link, and both the IPv4 source and IPv4 destination of the tunnel are defined.

>

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *tunnel-number*
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits*/*prefix-length*
5. **tunnel source** {*ip-address*| *interface-t ype interface-number*}
6. **tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap**
7. **exit**
8. **ipv6 route** [**vrf** *vrf-name*] *ipv6-prefix* / *prefix-length*{*ipv6-address* | *interface-type interface-number* [*ipv6-address*]} [**nexthop-vrf** [*vrf-name1* | **default**]] [*administrative-distance*] [*administrative-multicast-distance* | **unicast** | **multicast**] [*next-hop-address*] [**tag** *tag*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface tunnel** *tunnel-number* **Example:** `Router(config)# interface tunnel 1`	Specifies a tunnel interface and number, and enters interface configuration mode.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits*/*prefix-length* **Example:** `Router(config-if)# ipv6 address 3ffe:b00:c18:1::3/127`	Specifies the IPv6 network assigned to the interface and enables IPv6 processing on the interface.

Step 5	**tunnel source** {*ip-address*| *interface-t ype interface-number*}
	Example:
	`Router(config-if)# tunnel source loopback 1`
		Specifies the source interface type and number for the tunnel interface.

Step 6	**tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap** **Example:** `Router(config-if)# tunnel mode ipv6ip 6rd`	Configures a static IPv6 tunnel interface. • The **auto-tunnel** keyword is not supported on Cisco ASR 1000 series routers.
Step 7	**exit** **Example:** `Router(config-if) exit`	Exits interface configuration mode, and enters global configuration mode.
Step 8	**ipv6 route** [**vrf** *vrf-name*] *ipv6-prefix* / *prefix-length*{*ipv6-address* | *interface-type interface-number* [*ipv6-address*]} [**nexthop-vrf** [*vrf-name1* | **default**]] [*administrative-distance*] [*administrative-multicast-distance* | **unicast** | **multicast**] [*next-hop-address*] [**tag** *tag*] **Example:** `Router(config)# ipv6 route 2002::/16 tunnel 0`	Configures a static route for the IPv6 6to4 prefix 2002::/16 to the specified tunnel interface. **Note** When configuring a 6to4 overlay tunnel, you must configure a static route for the IPv6 6to4 prefix 2002::/16 to the 6to4 tunnel interface. • The tunnel number specified in the **ipv6 route** command must be the same tunnel number specified in the **interface tunnel** command.

Configuring 6RD Tunnels

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *tunnel-number*
4. **tunnel source** {*ip-address*| *interface-t ype interface-number*}
5. **tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap**]
6. **tunnel 6rd prefix** *ipv6-prefix* / *prefix-length*
7. **tunnel 6rd ipv4** {**prefix-length** *length*} {**suffix-length** *length*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *tunnel-number* **Example:** `Router(config)# interface tunnel 1`	Specifies a tunnel interface and number, and enters interface configuration mode.

Step 4	**tunnel source** {*ip-address*| *interface-t ype interface-number*}
	Example:
	`Router(config-if)# tunnel source loopback 1`
		Specifies the source interface type and number for the tunnel interface.

Step 5	**tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap**] **Example:** `Router(config-if)# tunnel mode ipv6ip 6rd`	Configures a static IPv6 tunnel interface. • The **auto-tunnel** keyword is not supported on Cisco ASR 1000 series routers.

	Command or Action	Purpose
Step 6	**tunnel 6rd prefix** *ipv6-prefix* / *prefix-length* **Example:** `Router(config-if)# tunnel 6rd prefix 2001:B000::/32`	Specifies the common IPv6 prefix on IPv6 rapid 6RD tunnels.

Step 7	**tunnel 6rd ipv4** {**prefix-length** *length*} {**suffix-length** *length*}
	Example:
	`Router(config-if)# tunnel 6rd ipv4 prefix-length 16 suffix 8`
		Specifies the prefix length and suffix length of the IPv4 transport address common to all the 6RD routers in a domain.

Configuring ISATAP Tunnels

The **tunnel source** command used in the configuration of an ISATAP tunnel must point to an interface with an IPv4 address configured. The ISATAP IPv6 address and prefix (or prefixes) advertised are configured as for a native IPv6 interface. The IPv6 tunnel interface must be configured with a modified EUI-64 address because the last 32 bits in the interface identifier are constructed using the IPv4 tunnel source address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *tunnel-number*
4. **ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits/prefix-length*
5. **no ipv6 nd ra suppress**
6. **tunnel source** {*ip-address*| *interface-type interface-number*}
7. **tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. - Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *tunnel-number* **Example:** `Router(config)# interface tunnel 1`	Specifies a tunnel interface and number, and enters interface configuration mode.
Step 4	**ipv6 address** {*ipv6-address* / *prefix-length* | *prefix-name sub-bits*/*prefix-length* **Example:** `Router(config-if)# ipv6 address 2001:DB8:6301::/64 eui-64`	Specifies the IPv6 address assigned to the interface and enables IPv6 processing on the interface.
Step 5	**no ipv6 nd ra suppress** **Example:** `Router(config-if)# no ipv6 nd ra suppress`	Sending of IPv6 router advertisements is disabled by default on tunnel interfaces. This command reenables the sending of IPv6 router advertisements to allow client autoconfiguration.

Step 6	**tunnel source** {*ip-address*| *interface-type interface-number*}
	Example:
	`Router(config-if)# tunnel source gigabitethernet 1/0/1`
		Specifies the source interface type and number for the tunnel interface.
		Note The interface type and number specified in the **tunnel source** command must be configured with an IPv4 address.

Step 7	**tunnel mode ipv6ip** [**6rd** | **6to4** | **auto-tunnel** | **isatap** **Example:** `Router(config-if)# tunnel mode ipv6ip isatap`	Specifies an IPv6 overlay tunnel using a ISATAP address. • The **auto-tunnel** keyword is not supported on Cisco ASR 1000 series routers.

Verifying IPv6 Tunnel Configuration and Operation

SUMMARY STEPS

1. **enable**
2. **show interfaces tunnel** *number* [**accounting**]
3. **ping** [*protocol*] *destination*
4. **show ip route** [*address*[*mask*]]
5. **show tunnel 6rd** [*interface-type interface-number*
6. **show tunnel 6rd destination** *ipv6-prefix tunnel-interface interface-number*
7. **show tunnel 6rd prefix** *ipv4-destination tunnel-interface interface-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show interfaces tunnel** *number* [**accounting**] **Example:** `Router# show interfaces tunnel 0`	(Optional) Displays tunnel interface information. • Use the *number* argument to display information for a specified tunnel.
Step 3	**ping** [*protocol*] *destination* **Example:** `Router# ping 10.0.0.1`	(Optional) Diagnoses basic network connectivity.
Step 4	**show ip route** [*address*[*mask*]] **Example:** `Router# show ip route 10.0.0.2`	(Optional) Displays the current state of the routing table. **Note** Only the syntax relevant for this task is shown.
Step 5	**show tunnel 6rd** [*interface-type interface-number* **Example:** `Router# show tunnel 6rd tunnel 1`	Displays 6RD information about a tunnel.

	Command or Action	Purpose
Step 6	**show tunnel 6rd destination** *ipv6-prefix tunnel-interface interface-number* **Example:** `Router# show tunnel 6rd destination 2001:B000:300:: tunnel 1`	Translates and displays a 6RD prefix to the corresponding IPv4 destination.
Step 7	**show tunnel 6rd prefix** *ipv4-destination tunnel-interface interface-number* **Example:** `Router# show tunnel 6rd prefix 10.1.4.1 tunnel 1`	Translates and displays an IPv4 destination address to the corresponding 6RD prefix.

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Examples

- Sample Output from the show interfaces tunnel Command, page 18
- Sample Output from the ping Command When Checking the Local Endpoint, page 19
- Sample Output from the show ip route Command, page 19
- Sample Output from the ping Command When Checking the Remote Endpoint, page 19

Sample Output from the show interfaces tunnel Command

This example uses a generic example suitable for both IPv6 manually configured tunnels and IPv6 over IPv4 GRE tunnels. In the example, two routers are configured to be endpoints of a tunnel. Router A has GigabitEthernet interface 0/0/0 configured as tunnel interface 0 with an IPv4 address of 10.0.0.1 and an IPv6 prefix of 2001:DB8:1111:2222::1/64. Router B has GigabitEthernet interface 0/0/0 configured as tunnel interface 1 with an IPv4 address of 10.0.0.2 and an IPv6 prefix of 2001:DB8:1111:2222::2/64. To verify that the tunnel source and destination addresses are configured, use the **show interfaces tunnel** command on Router A.

```
RouterA# show interfaces tunnel 0
Tunnel0 is up, line protocol is up
  Hardware is Tunnel
  MTU 1514 bytes, BW 9 Kbit, DLY 500000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 10.0.0.1 (GigabitEthernet0/0/0), destination 10.0.0.2, fastswitch TTL 255
  Tunnel protocol/transport GRE/IP, key disabled, sequencing disabled
  Tunnel TTL 255
  Checksumming of packets disabled,  fast tunneling enabled
  Last input 00:00:14, output 00:00:04, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue :0/0 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
```

```
     4 packets input, 352 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     8 packets output, 704 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

Sample Output from the ping Command When Checking the Local Endpoint

To check that the local endpoint is configured and working, use the **ping** command on Router A:

```
RouterA# ping 2001:DB8:1111:2222::2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:1111:2222::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/20 ms
```

Sample Output from the show ip route Command

To check that a route exists to the remote endpoint address, use the **show ip route** command:

```
RouterA# show ip route 10.0.0.2
Routing entry for 10.0.0.0/24
  Known via "connected", distance 0, metric 0 (connected, via interface)
  Routing Descriptor Blocks:
  * directly connected, via GigabitEthernet0/0/0
      Route metric is 0, traffic share count is 1
```

Sample Output from the ping Command When Checking the Remote Endpoint

To check that the remote endpoint address is reachable, use the **ping** command on Router A.

Note The remote endpoint address may not be reachable using the **ping** command because of filtering, but the tunnel traffic may still reach its destination.

```
RouterA# ping 10.0.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/21/28 ms
```

To check that the remote IPv6 tunnel endpoint is reachable, use the **ping** command again on Router A. The same note on filtering also applies to this example.

```
RouterA# ping 1::2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1::2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/20 ms
```

These steps may be repeated at the other endpoint of the tunnel.

Configuration Examples for Implementing Tunneling for IPv6

- Example: Configuring 6RD Tunnels, page 22
- Example: Configuring IPv4-Compatible IPv6 Tunnels, page 22
- Example: Configuring ISATAP Tunnels, page 23

Example: Configuring Manual IPv6 Tunnels

The following example configures a manual IPv6 tunnel between router A and router B. In the example, tunnel interface 0 for both router A and router B is manually configured with a global IPv6 address. The tunnel source and destination addresses are also manually configured.

Router A Configuration

```
interface gigabitethernet 0/0/0
 ip address 192.168.99.1 255.255.255.0
interface tunnel 0
 ipv6 address 3ffe:b00:c18:1::3/127
 tunnel source gigabitethernet 0/0/0
 tunnel destination 2001:DB8:1111:2222::1/64
 tunnel mode ipv6ip
```

Router B Configuration

```
interface gigabitethernet 0/0/0
 ip address 192.168.30.1 255.255.255.0
interface tunnel 0
 ipv6 address 3ffe:b00:c18:1::2/127
 tunnel source gigabitethernet 0/0/0
 tunnel destination 2001:DB8:1111:2222::2/64
 tunnel mode ipv6ip
```

Example Configuring GRE Tunnels

The following example configures a GRE tunnel running both IS-IS and IPv6 traffic between router A and router B:

Router A Configuration

```
ipv6 unicast-routing
clns routing
!
interface tunnel 0
 no ip address
 ipv6 address 2001:DB8:1111:2222::1/64
 ipv6 router isis
 tunnel source GigabitEthernet 0/0/0
 tunnel destination 10.0.0.2
 tunnel mode gre ipv6
!
interface GigabitEthernet0/0/0
 ip address 10.0.0.1 255.255.255.0
!
router isis
 net 49.0000.0000.000a.00
```

Router B Configuration

```
ipv6 unicast-routing
clns routing
!
interface tunnel 0
```

```
 no ip address
 ipv6 address 2001:DB8:1111:2222::2/64
 ipv6 router isis
 tunnel source GigabitEthernet 0/0/0
 tunnel destination 10.0.0.1
 tunnel mode gre ipv6
!
interface GigabitEthernet0/0/0
 ip address 10.0.0.2 255.255.255.0
!
router isis
 net 49.0000.0000.000b.00
 address-family ipv6
 redistribute static
 exit-address-family
```

- Example: Tunnel Destination Address for IPv6 Tunnel, page 21

Example: Tunnel Destination Address for IPv6 Tunnel

```
Router(config
)
#
interface Tunnel0
Router(config
-if)
#
ipv6 address 2001:1:1::1/48
Router(config
-if)
#
tunnel source GigabitEthernet 0/0/0
Router(config
-if)
#
tunnel destination 10.0.0.2
Router(config
-if)
#
tunnel mode gre ipv6
Router(config
-if)
#
exit
!
Router(config
)
#
interface GigabitEthernet0/0/0
Router(config
-if)
#
ip address 10.0.0.1 255.255.255.0
Router(config
-if)
#
exit
!
Router(config
)
#
ipv6 unicast-routing
Router(config
)
#
router isis

Router(config
)
#
net 49.0000.0000.000a.00
```

Example: Configuring 6to4 Tunnels

The following example configures a 6to4 tunnel on a border router in an isolated IPv6 network. The IPv4 address is 192.168.99.1, which translates to the IPv6 prefix of 2002:c0a8:6301::/48. The IPv6 prefix is subnetted into 2002:c0a8:6301::/64 for the tunnel interface: 2002:c0a8:6301:1::/64 for the first IPv6 network, and 2002:c0a8:6301:2::/64 for the second IPv6 network. The static route ensures that any other traffic for the IPv6 prefix 2002::/16 is directed to tunnel interface 0 for automatic tunneling.

```
interface GigabitEthernet0/0/0
 description IPv4 uplink
 ip address 192.168.99.1 255.255.255.0
!
interface GigabitEthernet1/0/0
 description IPv6 local network 1
 ipv6 address 2002:c0a8:6301:1::1/64
!
interface GigabitEthernet2/0/0
 description IPv6 local network 2
 ipv6 address 2002:c0a8:6301:2::1/64
!
interface Tunnel0
 description IPv6 uplink
 no ip address
 ipv6 address 2002:c0a8:6301::1/64
 tunnel source GigabitEthernet0/0/0
 tunnel mode ipv6ip 6to4
!
ipv6 route 2002::/16 tunnel 0
```

Example: Configuring 6RD Tunnels

The following example shows the running configuration of a 6RD tunnel and the corresponding output of the **show tunnel 6rd** command:

```
interface Tunnel1
 ipv6 address 2001:B000:100::1/32
 tunnel source loopback 1
 tunnel mode ipv6ip 6rd
 tunnel 6rd prefix 2001:B000::/32
 tunnel 6rd ipv4 prefix-len 16 suffix-len 8
end
Router# show tunnel 6rd tunnel 1
Interface Tunnel1:
  Tunnel Source: 10.1.1.1
  6RD: Operational, V6 Prefix: 2001:B000::/32
  V4 Common Prefix Length: 16, Value: 10.1.0.0
  V4 Common Suffix Length: 8, Value: 0.0.0.1
```

Example: Configuring IPv4-Compatible IPv6 Tunnels

The following example configures an IPv4-compatible IPv6 tunnel that allows Border Gateway Protocol (BGP) to run between a number of routers without having to configure a mesh of manual tunnels. Each router has a single IPv4-compatible tunnel, and multiple BGP sessions can run over each tunnel, one to each neighbor. GigabitEthernet interface 0/0/0 is used as the tunnel source. The tunnel destination is automatically determined by the IPv4 address in the low-order 32 bits of an IPv4-compatible IPv6 address. Specifically, the IPv6 prefix 0:0:0:0:0:0 is concatenated to an IPv4 address (in the format 0:0:0:0:0:0:A.B.C.D or ::A.B.C.D) to create the IPv4-compatible IPv6 address. GigabitEthernet interface 0/0/0 is configured with a global IPv6 address and an IPv4 address (the interface supports both the IPv6 and IPv4 protocol stacks).

Multiprotocol BGP is used in the example to exchange IPv6 reachability information with the peer 10.67.0.2. The IPv4 address of GigabitEthernet interface 0/0/0 is used in the low-order 32 bits of an IPv4-

compatible IPv6 address and is also used as the next-hop attribute. Using an IPv4-compatible IPv6 address for the BGP neighbor allows the IPv6 BGP session to be automatically transported over an IPv4-compatible tunnel.

```
interface tunnel 0
 tunnel source GigabitEthernet 0/0/0
 tunnel mode ipv6ip auto-tunnel
interface Gigabitethernet 0/0/0
 ip address 10.27.0.1 255.255.255.0
 ipv6 address 3000:2222::1/64
router bgp 65000
 no synchronization
 no bgp default ipv4-unicast
neighbor ::10.67.0.2 remote-as 65002
address-family ipv6
 neighbor ::10.67.0.2 activate
 neighbor ::10.67.0.2 next-hop-self
 network 2001:2222:d00d:b10b::/64
```

Example: Configuring ISATAP Tunnels

The following example shows the tunnel source defined on GigabitEthernet 0/0/0 and the **tunnel mode** command used to configure the ISATAP tunnel. Router advertisements are enabled to allow client autoconfiguration.

```
ipv6 unicast-routing
interface tunnel 1
 tunnel source Gigabitethernet 0/0/0
 tunnel mode ipv6ip isatap
 ipv6 address 2001:DB8::/64 eui-64
 no ipv6 nd ra suppress
 exit
```

Additional References

Related Documents

Related Topic	Document Title
IPv6 addressing and connectivity	*IPv6 Configuration Guide*
Cisco IOS commands	Master Commands List, All Releases
IPv6 commands	IPv6 Command Reference
Cisco IOS IPv6 features	IPv6 Feature Mapping

Standards and RFCs

Standard/RFC	Title
RFCs for IPv6	IPv6 RFCs

Technical Assistance

Description	Link
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.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Implementing Tunneling for IPv6

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.

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.

Table 4 Feature Information for Implementing Tunneling for IPv6

Feature Name	Releases	Feature Information
IPv6 Tunneling--6RD IPv6 Rapid Deployment	Cisco IOS XE Release 3.1S	The 6RD feature allows a service provider to provide a unicast IPv6 service to customers over its IPv4 network by using encapsulation of IPv6 in IPv4.
IPv6 Tunneling--Automatic 6to4 Tunnels	Cisco IOS XE Release 2.1	An automatic 6to4 tunnel allows isolated IPv6 domains to be connected over an IPv4 network to remote IPv6 networks.
IPv6 Tunneling--Automatic IPv4-Compatible Tunnels	Cisco IOS XE Release 2.1	Automatic IPv4-compatible tunnels use IPv4-compatible IPv6 addresses.
IPv6 Tunneling--IP over IPv6 GRE Tunnels	Cisco IOS XE Release 2.4	GRE tunnels are links between two points, with a separate tunnel for each link.
IPv6 Tunneling--IPv4 over IPv6 Tunnels	Cisco IOS XE Release 2.1	IPv6 supports this feature

Feature Name	Releases	Feature Information
IPv6 Tunneling--IPv6 over IPv4 GRE Tunnels	Cisco IOS XE Release 2.1	GRE tunnels are links between two points, with a separate tunnel for each link. The tunnels are not tied to a specific passenger or transport protocol, but in this case carry IPv6 as the passenger protocol with the GRE as the carrier protocol and IPv4 or IPv6 as the transport protocol.
IPv6 Tunneling--ISATAP Tunnel Support	Cisco IOS XE Release 2.1 Cisco IOS XE Release 3.3SG	ISATAP is an automatic overlay tunneling mechanism that uses the underlying IPv4 network as a NBMA link layer for IPv6.
IPv6 Tunneling--Manually Configured IPv6 over IPv4 Tunnels	Cisco IOS XE Release 2.1	A manually configured tunnel is equivalent to a permanent link between two IPv6 domains over an IPv4 backbone.
IPv6 Switching: CEFv6 Switched Configured IPv6 over IPv4 Tunnels	Cisco IOS XE Release 3.3SG	Supports CEF switching of IPv6 auto 6to4 tunnels.

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