IP Routing Configuration

1 Configuring RIP

1.1 Overview

Routing Information Protocol (RIP) is a unicast routing protocol applied on IPv4 networks. RIP-enabled routers exchange routing information to obtain routes to remote networks.

As an Interior Gateway Protocol (IGP), RIP can run only within the autonomous system (AS) and is applicable to small-sized networks whose longest path involves less than 16 hops.

Protocols and Standards

- RFC1058: Defines RIPv1.
- RFC2453: Defines RIPv2.

1.2 Applications

Application	Description
Basic RIP Application	The routing information is automatically maintained through RIP on a small-sized network.

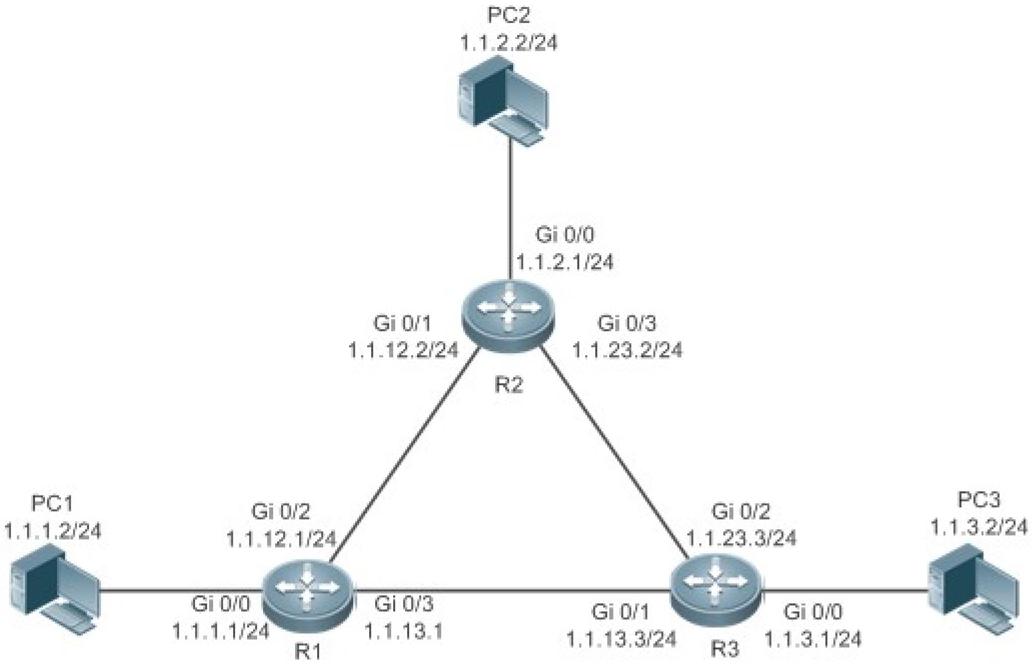
1.2.1 Basic RIP Application

Scenario

On a network with a simple structure, you can configure RIP to implement network interworking. Configuring RIP is simpler than configuring other IGP protocols like Open Shortest Path First (OSPF). Compared with static routes, RIP can dynamically adapt to the network structure changes and is easier to maintain.

As shown in Figure 1-1, to implement interworking between PC1, PC2, and PC3, you can configure RIP routes on R1, R2, and R3.

Figure 1-1



Deployment

- Configure IP addresses and gateways on three PCs.
- Configure IP addresses and subnet masks on three routers.
- Configure RIP on three routers.

1.3 Features

Basic Concepts

↘ IGP and EGP

IGP runs within an AS. For example, RIP is a type of IGP.

Exterior Gateway Protocol (EGP) runs between ASs.

↘ Classful Routing Protocol and Classless Routing Protocol

Protocols can be classified based on the type of routes supported:

- Classful routing protocol: It supports classful routes. For example, RIPv1 is a classful routing protocol.
- Classless routing protocol: It supports classless routes. For example, RIPv2 is a classless routing protocol.

Overview

Feature	Description
RIPv1 and RIPv2	RIP is available in two versions: RIPv1 and RIPv2.
Exchanging Routing Information	By exchanging routing information, RIP-enabled devices can automatically obtain routes to a remote network and update the routes in real time.
Routing Algorithm	RIP is a protocol based on the distance-vector algorithm. It uses the vector addition method to compute the routing information.
Avoiding Route Loops	RIP uses functions, such as split horizon and poison reverse, to avoid route loops.
Security Measures	RIP uses functions, such as authentication and source address verification, to ensure protocol security.
Reliability Measures	RIP uses functions, such as bidirectional forwarding detection (BFD) correlation, fast reroute, and graceful restart (GR), to enhance reliability of the protocol.

1.3.1 RIPv1 and RIPv2

Two RIP versions are available: RIPv1 and RIPv2.

Working Principle

↘ RIPv1

RIPv1 packets are broadcast. The broadcast address is 255.255.255.255, and the UDP port ID is 520.
RIPv1 cannot identify the subnet mask, and supports only classful routes.

↘ RIPv2

RIPv2 packets are multicast. The multicast address is 224.0.0.9, and the UDP port ID is 520. RIPv2 can identify the subnet mask, and supports classless routes, summarized route, and supernetting routes. RIPv2 supports plain text authentication and message digest 5 (MD5) authentication.

Related Configuration

↘ Enabling the RIP Process

The RIP process is disabled by default.

Run the **router rip** command to enable the RIP process.

You must enable the RIP process on a device; otherwise, all functions related to RIP cannot take effect.

↘ Running RIP on an Interface

By default, RIP does not run on an interface.

Run the **network** command to define an address range. RIP runs on interfaces that belong to this address range.

After RIP runs on an interface, RIP packets can be exchanged on the interface and RIP can learn routes to the network segments directly connected to the device.

↘ Defining the RIP Version

By default, an interface receives RIPv1 and RIPv2 packets, and sends RIPv1 packets.

Run the **version** command to define the version of RIP packets sent or received on all interfaces.

Run the **ip rip send version** command to define the version of RIP packets sent on an interface.

Run the **ip rip receive version** command to define the version of RIP packets received on an interface.

- If the versions of RIP running on adjacent routers are different, the RIPv1-enabled router will learn incorrect routes.

↘ Preventing an Interface from Sending or Receiving Packets

By default, a RIP-enabled interface is allowed to send and receive RIP packets.

Run the **no ip rip receive enable** command to prevent an interface from receiving RIP packets.

Run the **no ip rip send enable** command to prevent an interface from sending RIP packets.

Run the **passive-interface** command to prevent an interface from sending broadcast or multicast RIP packets.

↘ Configuring the Mode for Sending RIP Packets

By default, broadcast RIPv1 packets and multicast RIPv2 are sent.

Run the **ip rip v2-broadcast** command to send broadcast RIPv2 packets on an interface.

Run the **neighbor** command to send unicast RIP packets to a specified neighbor router.

1.3.2 Exchanging Routing Information

Compared with static routing, the dynamic routing protocol has a significant advantage, that is, by exchanging routing information, devices can automatically obtain routes to a remote network and update the routes in real time.

Working Principle

↘ Initialization

After RIP is enabled on a router, the router sends a request packet to its neighbor router, requesting for all routing information, that is, the routing table. After receiving the request message, the neighbor router returns a response packet containing the local routing table. After receiving the response packet, the router updates the local routing table, and sends an update packet to the neighbor router, informing the neighbor router of the route update information. After receiving the update packet, the neighbor router updates the local routing table, and sends the update packet to other adjacent routers. After a series of updates, all routers can obtain and retain the latest routing information.

↘ Periodical Update

By default, periodical update is enabled for RIP. Adjacent routers exchange complete routing information with each other every 30s (update timer), that is, the entire routing table is sent to neighbor routers. One update packet contains at most 25 routes. Therefore, a lot of update packets may be required to send the entire routing table. You can set the sending delay between update packets to avoid loss of routing information.

- For every non-local route, if the route is not updated within 180s (invalid timer), the metric of the route is changed to 16 (unreachable). If the route is still not updated in the next 120s (flush timer), the route is deleted from the routing table.

Triggered Updates

After the triggered updates function is enabled, periodical update is automatically disabled. When routing information changes on a router, the router immediately sends routes related to the change (instead of the complete routing table) to the neighbor router, and use the acknowledgment and retransmission mechanisms to ensure that the neighbor router receives the routes successfully. Compared with periodical update, triggered updates help reduce flooding and accelerates route convergence.

Events that can trigger update include router startup, interface status change, changes in routing information (such as the metric), and reception of a request packet.

Route Summarization

When sending routing information to a neighbor router, the RIP-enabled router summarizes subnet routes that belong to the same classful network into a route, and sends the route to the neighbor router. For example, summarize 80.1.1.0/24 (metric=2) and 80.1.2.0/24 (metric=3) into 80.0.0.0/8 (metric=2), and set the metric of the summarized route to the optimum metric.

Only RIPv2 supports route summarization. Route summarization can reduce the size of the routing table and improve the efficiency of routing information exchange.

Supernetting Route

If the subnet mask length of a route is smaller than the natural mask length, this route is called supernetting route.
For example, in the 80.0.0.0/6 route, as 80.0.0.0 is a Class A network address and the natural mask is 8 bits, 80.0.0.0/6 route is a supernetting route.

Only RIPv2 supports supernetting routes.

Default Route

In the routing table, a route to the destination network 0.0.0.0/0 is called default route.

The default route can be learned from a neighbor router, or sent to a neighbor router.

Route Redistribution

For RIP, other types of routes (such as direct routes, static routes, and routes of other routing protocols) are called external routes.

External routes (excluding the default route) can be redistributed to RIP and advertised to neighbors.

Route Filtering

Filtering conditions can be configured to limit the routing information exchanged between adjacent routers.
Only the routing information that meets filtering conditions can be sent or received.

Related Configuration

Sending Delay Between Update Packets

By default, the update packets are sent continuously without any delay.

Run the **output-delay** command to set the sending delay between update packets.

RIP Timers

By default, the update timer is 30s, the invalid timer is 180s, and the flush timer is 120s.

Run the **timers basic** command to modify durations of the RIP timers.

Increasing the duration of the flush timer can reduce the route flapping. Decreasing the duration of the flush timer helps accelerate route convergence.

The durations of RIP timers must be consistent on adjacent routers. Unless otherwise required, you are advised not to modify the RIP timers.

Triggered Updates

By default, periodical update is enabled.

Run the **ip rip triggered** command to enable triggered updates on the interface and disable periodical update.

Run the **ip rip triggered retransmit-timer** command to modify the retransmission interval of update packets. The default value is 5s.

Run the **ip rip triggered retransmit-count** command to modify the maximum retransmission times of update packets. The default value is 36.

Route Summarization

By default, route summarization is automatically enabled if an interface is allowed to send RIPv2 packets.

Run the **no auto-summary** command to disable route summarization.

Run the **ip rip summary-address** command to configure route summarization on an interface.

Supernetting Route

By default, supernetting routes can be sent if an interface is allowed to send RIPv2 packets.

Run the **no ip rip send supernet-routes** command to prevent the sending of supernetting routes.

Default Route

Run the **ip rip default-information** command to advertise the default route to neighbors on an interface.

Run the **default-information originate** command to advertise the default route to neighbors from all interfaces.

Route Redistribution

Run the **redistribute** command to redistribute external routes (excluding the default route) to RIP and advertise them to neighbors.

Route Filtering

Run the **distribute-list out** command to set filtering rules to limit the routing information sent by the device.

Run the **distribute-list in** command to set filtering rules to limit the routing information received by the device.

1.3.3 Routing Algorithm

RIP is a protocol based on the distance-vector algorithm. It uses the vector addition method to compute the routing information.

Working Principle

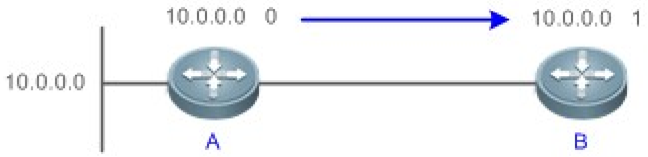
Distance-Vector Algorithm

RIP is a protocol based on the distance-vector algorithm. The distance-vector algorithm treats a route as a vector that consists of the destination network and distance (metric). The router obtains a route from its neighbor and adds the distance vector from itself to the neighbor to the route to form its own route.

RIP uses the hop count to evaluate the distance (metric) to the destination network. By default, the hop count from a router to its directly connected network is 0, the hop count from a router to a network that can be reached through the router is 1, and so on. That is, the metric is equal to the number of routers from the local network to the destination network. To restrict the convergence time, RIP stipulates that the metric must be an integer between 0 and 15. If the metric is equal to or greater than 16, the destination network or host is unreachable. For this reason, RIP cannot be applied on a large-scale network.

As shown in Figure 1-2, Router A is connected to the network 10.0.0.0. Router B obtains the route (10.0.0.0,0) from Router A and adds the metric 1 to the route to obtain its own route ((10.0.0.0,1), and the next hop points to Router A.

Figure 1-2

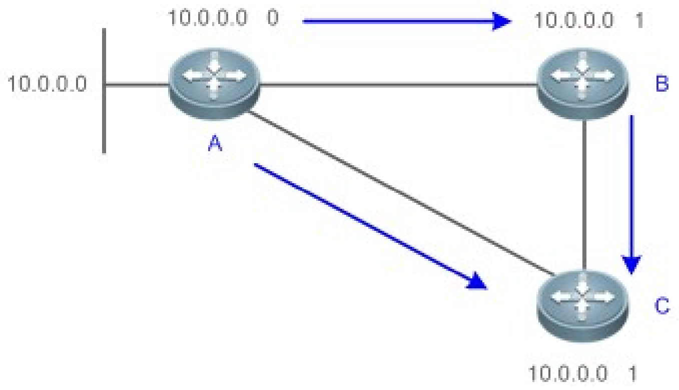


Selecting the Optimum Route

RIP selects an optimum route based on the following principle: If multiple routes to the same destination network is available, a router preferentially selects the route with the smallest metric.

As shown in Figure 1-3, Router A is connected to the network 10.0.0.0. Router C obtains the route (10.0.0.0,0) from Router A and the route (10.0.0.0,1) from Router B. Router C will select the route that is obtained from Router A and add metric 1 to this route to form its own route (10.0.0.0,1), and the next hop points to Router A.

Figure 1-3



- When routes coming from different sources exist on a router, the route with the smallest distance is preferentially selected.

Route Source	Default Distance
Directly-connected network	0
Static route	1
OSPF route	110
RIP route	120
Unreachable route	255

Related Configuration

Modifying the Distance

By default, the distance of a RIP route is 120.

Run the **distance** command to modify the distance of a RIP route.

Modifying the Metric

For a RIP route that is proactively discovered by a device, the default metric is equal to the number of hops from the local network to the destination network. For a RIP router that is manually configured (default route or redistributed route), the default metric is 1.

Run the **offset-list in** command to increase the metric of a received RIP route.

Run the **offset-list out** command to increase the metric of a sent RIP route.

Run the **default-metric** command to modify the default metric of a redistributed route.

Run the **redistribute** command to modify the metric of a route when the route is redistributed.

Run the **default-information originate** command to modify the metric of a default route when the default route is introduced.

Run the **ip rip default-information** command to modify the metric of a default route when the default route is created.

1.3.4 Avoiding Route Loops

RIP uses functions, such as split horizon and poison reverse, to avoid route loops.

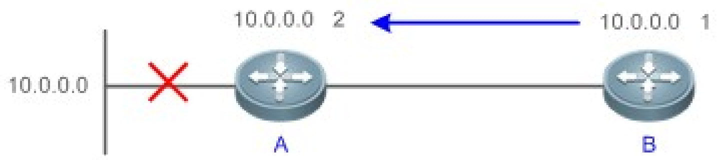
Working Principle

↘ Route Loop

A RIP route loop occurs due to inherent defects of the distance-vector algorithm.

As shown in Figure 1-4, Router A is connected to the network 10.0.0.0, and sends an update packet every 30s. Router B receives the route 10.0.0.0 from Router A every 30s. If Router A is disconnected from 10.0.0.0, the route to 10.0.0.0 will be deleted from the routing table on Router A. Next time, the update packet sent by Router A no longer contains this route. As Router B does not receive an update packet related to 10.0.0.0, Router B determines that the route to 10.0.0.0 is valid within 180s and uses the Update packet to send this route to Router A. As the route to 10.0.0.0 does not exist on Router A, the route learned from Router B is added to the routing table. Router B determines that data can reach 10.0.0.0 through Router A, and Router A determines that data can reach 10.0.0.0 through Router B. In this way, a route loop is formed.

Figure 1-4

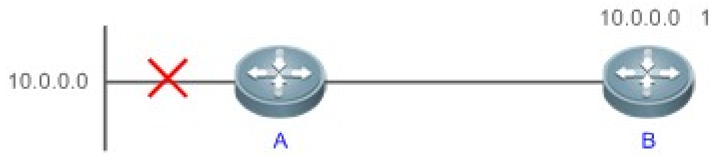


↘ Split Horizon

Split horizon can prevent route loops. After split horizon is enabled on an interface, a route received on this interface will not be sent out from this interface.

As shown in Figure 1-5, after split horizon is enabled on the interface between Router A and Router B, Router B will not send the route 10.0.0.0 back to Router A. Router B will learn 180s later that 10.0.0.0 is not reachable.

Figure 1-5



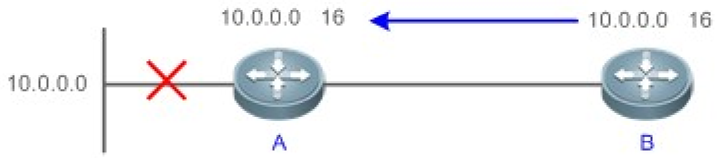
↘ Poison Reverse

Poison reverse can also prevent route loops. Compared with slit horizon, poison reverse is more reliable, but brings more protocol packets, which makes network congestion more severe.

After poison reverse is enabled on an interface, a route received from this interface will be sent out from this interface again, but the metric of this router will be changed to 16 (unreachable).

As shown in Figure 1-6, after learning the route 10.0.0.0 from Router A, Router B sets the metric of this route to 16 and sends the route back to Router A. After this route becomes invalid, Router B advertises the route 10.0.0.0 (metric = 16) to Router A to accelerate the process of deleting the route from the routing table.

Figure 1-6



Related Configuration

↘ Split Horizon

By default, split horizon is enabled.

Run the **no ip rip split-horizon** command to disable split horizon.

↘ Poison Reverse

By default, poison reverse is disabled.

Run the **ip rip split-horizon poisoned-reverse** command to enable poison reverse. (After poison reverse is enabled, split horizon is automatically disabled.)

1.3.5 Security Measures

RIP uses functions, such as authentication and source address verification, to ensure protocol security.

Working Principle

↘ Authentication

RIPv2 supports authentication, but RIPv1 does not.

After authentication is enabled on an interface, the routing information cannot be exchanged between adjacent devices if authentication fails. The authentication function is used to prevent unauthorized devices from accessing the RIP routing domain.

RIPv2 supports plain text authentication and MD5 authentication.

↘ Source Address Verification

When a RIP-enabled device receives an Update packet, it checks whether the source IP address in the packet and the IP address of the inbound interface are in the same network segment. If not, the device drops the packet.
Source address verification is used to ensure that RIP routing information is exchanged only between adjacent routing devices.

- On an unnumbered IP interface, source address verification is not performed (not configurable).
- If the triggered updates function is enabled, source address verification is automatically enabled (not configurable).

- If split horizon is disabled, source address verification is automatically enabled (not configurable).

Related Configuration

Authentication

By default, authentication is disabled.

Run the **ip rip authentication mode text** command to enable plain text authentication on an interface.

Run the **ip rip authentication mode md5** command to enable MD5 authentication on an interface.

Run the **ip rip authentication text-password** command to set the password for plain text authentication on an interface.

Run the **ip rip authentication key-chain** command to reference the key in the configured key chain as the authentication key on an interface.

Source Address Verification

By default, source address verification is enabled.

Run the **no validate-update-source** command to disable source address verification.

1.3.6 Reliability Measures

RIP uses functions and GR, to enhance reliability of the protocol.

Working Principle

GR

GR ensures uninterrupted data transmission when the protocol is restarted. If RIP is restarted on a GR-enabled device, the forwarding table before restart will be retained and a request packet will be sent to the neighbor so that the route can be learned again. During the GR period, RIP completes re-convergence of the route. After the GR period expires, RIP updates the forwarding entry and advertises the routing table to the neighbor.

Related Configuration

GR

By default, GR is disabled.

Run the **graceful-restart** command to enable the GR function.

1.4 Configuration

Configuration	Description and Command	
Configuring RIP Basic Functions	● (Mandatory) It is used to build a RIP routing domain.	
	router rip	Enables a RIP routing process and enters routing process configuration mode.

Configuration	Description and Command	
	network	Runs RIP on interfaces in the specified address range.
	version	Defines the RIP version.
	ip rip split-horizon	Enables split horizon or poison reverse on an interface.
	passive-interface	Configures a passive interface.
Controlling Interaction of RIP Packets	● (Optional) This configuration is required if you wish to change the default mechanism for sending or receiving RIP packets.	
	neighbor	Sends unicast RIP packets to a specified neighbor.
	ip rip v2-broadcast	Sends broadcast RIPv2 packets on an interface.
	ip rip receive enable	Allows the interface to receive RIP packets.
	ip rip send enable	Allows the interface to send RIP packets.
	ip rip send version	Defines the version of RIP packets sent on an interface.
	ip rip receive version	Defines the version of RIP packets received on an interface.
Enabling Triggered Updates	● Optional.	
	ip rip triggered	Enables triggered updates on an interface.
Enabling Source Address Verification	● Optional.	
	validate-update-source	Enables source address verification.
Enabling Authentication	● (Optional) Only RIPv2 supports authentication.	
	ip rip authentication mode	Enables authentication and sets the authentication mode on an interface.
	ip rip authentication text-password	Configures the password for plain text authentication on an interface.
	ip rip authentication key-chain	Configures the authentication key chain on an interface.
Enabling Route Summarization	● (Optional) Only RIPv2 supports route summarization.	
	auto-summary	Enables automatic summarization of RIP routes.
	ip rip summary-address	Configures route summarization on an interface.
Enabling Supernetting	● (Optional) Only RIPv2 supports supernetting routes.	

Configuration	Description and Command	
Routes	**ip rip send supernet-routes**	Enables advertisement of RIP supernetting routes on an interface
Advertising the Default Route or External Routes	● Optional.	
	ip rip default-information	Advertises the default route to neighbors on an interface.
	default-information originate	Advertises the default route to neighbors.
	redistribute	Redistributes routes and advertises external routes to neighbors.
Setting Route Filtering Rules	● Optional.	
	distribute-list in	Filters the received RIP routing information.
	distribute-list out	Filters the sent RIP routing information.
Modifying Route Selection Parameters	● Optional.	
	distance	Modifies the administrative distance (AD) of a RIP route.
	offset-list	Increases the metric of a received or sent RIP route.
	default-metric	Configures the default metric of an external route redistributed to RIP.
Modifying Timers	● Optional.	
	timers basic	Modifies the update timer, invalid timer, and flush timer.
	output-delay	Sets the sending delay between RIP route update packets.
Enabling GR	● Optional.	
	graceful-restart	Configures the GR restarter capability.

1.4.1 Configuring RIP Basic Functions

Configuration Effect

- Build a RIP routing domain on the network.
- Routers in the domain obtain routes to a remote network through RIP.

Notes

- IPv4 addresses must be configured.

- IPv4 unicast routes must be enabled.

Configuration Steps

Enabling a RIP Routing Process

- Mandatory.
- Unless otherwise required, this configuration must be performed on every router in the RIP routing domain.

Associating with the Local Network

- Mandatory.
- Unless otherwise required, this configuration must be performed on every router in the RIP routing domain.
- Unless otherwise required, the local network associated with RIP should cover network segments of all L3 interfaces.

Defining the RIP Version

- If RIPv2 functions (such as the variable length subnet mask and authentication) are required, enable the RIPv2.
- Unless otherwise required, you must define the same RIP version on every router.

Enabling Split Horizon or Poison Reverse

- By default, split horizon is enabled and poison reverse is disabled.
- Unless otherwise required, enable split horizon on every interface connected to the broadcast network, such as the Ethernet. (Retain the default setting.)
- Unless otherwise required, enable split horizon on every interface connected to the point-to-point (P2P) network, such as the PPP and HDLC. (Retain the default setting.)
- It is recommended that split horizon and poison reverse be disabled on an interface connected to a non-broadcast multi-access (NBMA) network, such as FR and X.25; otherwise, some devices may fail to learn the complete routing information.
- If the secondary IP address is configured for an interface connected to a non-broadcast, it is recommended that split horizon and poison reverse be disabled.

Configuring a Passive Interface

- If you want to suppress Update packets on a RIP interface, configure the interface as a passive interface.
- Use the passive interface to set the boundary of the RIP routing domain. The network segment of the passive interface belongs to the RIP routing domain, but RIP packets cannot sent over the passive interface.
- If RIP routes need to be exchanged on an interface (such as the router interconnect interface) in the RIP routing domain, this interface cannot be configured as a passive interface.

Verification

- Check the routing table on a router to verify that the route to a remote network can be obtained through RIP.

Related Commands

↘ Enabling a RIP Routing Process

Command Syntax	**router rip**
Parameter Description	N/A
Command Mode	Global configuration mode
Configuration Usage	This command is used to create a RIP routing process and enter routing process configuration mode.

↘ Associating with the Local Network

Command Syntax	**network** *network-number* [*wildcard*]
Parameter Description	*network-number*: Indicates the number of a network. *wildcard*: Defines the IP address comparison bit. **0** indicates accurate matching, and **1** indicates that no comparison is performed.
Command Mode	Routing process configuration mode
Configuration Usage	RIP can run and learn direct routes and RIP packets can be exchanged only on an interface covered by **network**. If **network** 0.0.0.0 255.255.255.255 is configured, all interfaces are covered. If *wildcard* is not configured, the classful address range is used by default, that is, the interfaces whose addresses fall into the classful address range participate in RIP operations.

↘ Defining the RIP Version

Command Syntax	**version** { **1** | **2** }
Parameter Description	**1**: Indicates RIPv1. **2**: Indicates RIPv2.
Command Mode	Global configuration mode
Configuration Usage	This command takes effect on the entire router. You can run this command to define the version of RIP packets sent or received on all interfaces.

↘ Enabling Split Horizon

Command	**ip rip split-horizon** [**poisoned-reverse**]

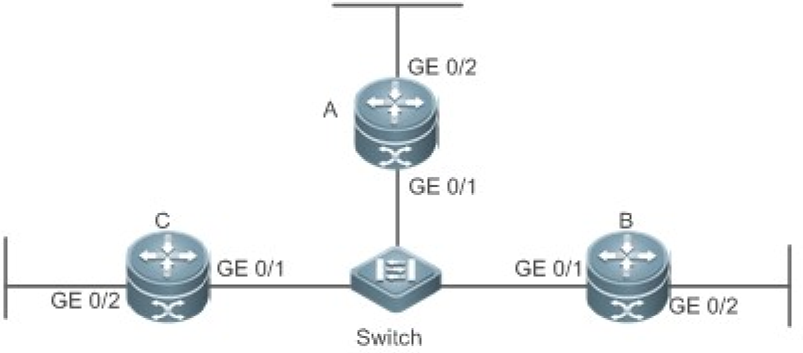
Syntax	
Parameter Description	**poisoned-reverse**: Indicates poison reverse.
Command Mode	Interface configuration mode
Configuration Usage	After poison reverse is enabled, split horizon is automatically disabled.

Configuring a Passive Interface

Command Syntax	**passive-interface** { **default** | *interface-type interface-num* }
Parameter Description	**default:** Indicates all interfaces. ***interface-type interface-num*****:** Specifies an interface.
Command Mode	Routing process configuration mode
Configuration Usage	First, run the **passive-interface default** command to configure all interfaces as passive interfaces. Then, run the **no passive-interface** *interface-type interface-num* command to cancel the interfaces used for interconnection between routers in the domain.

Configuration Example

Building a RIP Routing Domain

<table>
<tr><td><b>Scenario</b>
<b>Figure 1-7</b></td><td>


<table>
<tr><td><b>Remarks</b></td><td>The interface IP addresses are as follows:
A: GE0/1 110.11.2.1/24 GE0/2 155.10.1.1/24
B: GE0/1 110.11.2.2/24 GE0/2 196.38.165.1/24
C: GE0/1 110.11.2.3/24 GE0/2 117.102.0.1/16</td></tr>
</table>
</td></tr>
<tr><td><b>Configuration Steps</b></td><td>● Configure the interface IP addresses on all routers.
● Configure the RIP basic functions on all routers.</td></tr>
</table>

A	A# configure terminal A(config)# interface GigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)# ip address 110.11.2.1 255.255.255.0 A(config-if-GigabitEthernet 0/1)# exit A(config)# interface GigabitEthernet 0/2 A(config-if-GigabitEthernet 0/2)# ip address 155.10.1.1 255.255.255.0 A(config)# router rip A(config-router)# version 2 A(config-router)# network 0.0.0.0 255.255.255.255 A(config-router)# passive-interface default A(config-router)# no passive-interface GigabitEthernet 0/1
B	B# configure terminal B(config)# interface GigabitEthernet 0/1 B(config-if-GigabitEthernet 0/1)# ip address 110.11.2.2 255.255.255.0 B(config-if-GigabitEthernet 0/1)# exit B(config)# interface GigabitEthernet 0/2 B(config-if-GigabitEthernet 0/2)# ip address 196.38.165.1 255.255.255.0 B(config-if-GigabitEthernet 0/2)# exit B(config)# router rip B(config-router)# version 2 B(config-router)# network 0.0.0.0 255.255.255.255 B(config-router)# passive-interface default B(config-router)# no passive-interface GigabitEthernet 0/1
C	C# configure terminal C(config)# interface GigabitEthernet 0/1 C(config-if-GigabitEthernet 0/1)# ip address 110.11.2.3 255.255.255.0 C(config-if-GigabitEthernet 0/1)# exit C(config)# interface GigabitEthernet 0/2 C(config-if-GigabitEthernet 0/2)# ip address 117.102.0.1 255.255.0.0 C(config-if-GigabitEthernet 0/2)# exit C(config)# router rip

	C(config-router)# version 2 C(config-router)#no auto-summary C(config-router)# network 0.0.0.0 255.255.255.255 C(config-router)# passive-interface default C(config-router)# no passive-interface GigabitEthernet 0/1
Verification	Check the routing tables on Router A, Router B, and Router C. Verify that RIP learns the routes to remote networks (contents marked in blue).
A	A# show ip route Codes: C - connected, S - static, R - RIP, B - BGP O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default Gateway of last resort is no set C 110.11.2.0/24 is directly connected, GigabitEthernet 0/1 C 110.11.2.1/32 is local host. R 117.0.0.0/8 [120/1] via 110.11.2.2, 00:00:47, GigabitEthernet 0/1 C 155.10.1.0/24 is directly connected, GigabitEthernet 0/2 C 155.10.1.1/32 is local host. C 192.168.217.0/24 is directly connected, VLAN 1 C 192.168.217.233/32 is local host. R 196.38.165.0/24 [120/1] via 110.11.2.3, 00:19:18, GigabitEthernet 0/1

B	B# show ip route
	
	Codes: C - connected, S - static, R - RIP, B - BGP
	        O - OSPF, IA - OSPF inter area
	        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
	        E1 - OSPF external type 1, E2 - OSPF external type 2

```
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    110.11.2.0/24 is directly connected, GigabitEthernet 0/1
C    110.11.2.2/32 is local host.
R    155.10.0.0/16 [120/1] via 110.11.2.1, 00:15:21, GigabitEthernet 0/1
C    196.38.165.0/24 is directly connected, GigabitEthernet 0/2
C    196.38.165.1/32 is local host.
R    117.0.0.0/8 [120/1] via 110.11.2.2, 00:00:47, GigabitEthernet 0/1
```

C

```
C# show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    110.11.2.0/24 is directly connected, GigabitEthernet 0/1
C    110.11.2.3/32 is local host.
C    117.102.0.0/16 is directly connected, GigabitEthernet 0/2
C    117.102.0.1/32 is local host.
R    155.10.0.0/16 [120/1] via 110.11.2.1, 00:20:55, GigabitEthernet 0/1
R    196.38.165.0/24 [120/1] via 110.11.2.3, 00:19:18, GigabitEthernet 0/1
```

Common Errors

- The IPv4 address is not configured on an interface.
- The RIP version is not defined on a device, or the RIP version on the device is different from that on other routers.
- The address range configured by the **network** command does not cover a specific interface.

- The **wildcard** parameter in the **network** command is not correctly configured. **0** indicates accurate matching, and **1** indicates that no comparison is performed.
- The interface used for interconnection between devices is configured as a passive interface.

1.4.2 Controlling Interaction of RIP Packets

Configuration Effect

Change the default running mechanism of RIP through configuration and manually control the interaction mode of RIP packets, including:

- Allowing or prohibiting the sending of unicast RIP packets to a specified neighbor on an interface
- Allowing or prohibiting the sending of unicast RIPv2 packets instead of broadcast packets to a specified neighbor on an interface
- Allowing or prohibiting the receiving of RIP packets on an interface
- Allowing or prohibiting the sending of RIP packets on an interface
- Allowing or prohibiting the receiving of RIP packets of a specified version on an interface
- Allowing or prohibiting the sending of RIP packets of a specified version on an interface

Notes

- The RIP basic functions must be configured.
- On an interface connecting to a neighbor device, the configured version of sent RIP packets must be the same as the version of received RIP packets.

Configuration Steps

↘ Sending Unicast RIP Route Update Packets to a Specified Neighbor

- Configure this function if you wish that only some of devices connected to an interface can receive the updated routing information.
- By default, RIPv1 uses the IP broadcast address (255.255.255.255) to advertise the routing information, whereas RIPv2 uses the multicast address (224.0.0.9) to advertise the routing information. If you do not wish all devices on the broadcast network or NBMA network to receive routing information, configure the related interface as the passive interface and specify the neighbors that can receive the routing information. This command does not affect the receiving of RIP packets. RIPv2 packets are broadcast on an interface.
- Unless otherwise required, this function must be enabled on a router that sends the unicast Update packets.

↘ Broadcasting RIPv2 Packets on an Interface

- This function must be configured if the neighbor router does not support the receiving of multicast RIPv2 packets.
- Unless otherwise required, this function must be configured on every router interface that broadcasts RIPv2 packets.

↘ Allowing an Interface to Receive RIP Packets

- This function is enabled by default, and must be disabled if an interface is not allowed to receive RIP packets.
- Unless otherwise required, this function must be configured on every router interface that is not allowed to receive RIP packets.

↘ Allowing an Interface to Send RIP Packets

- This function is enabled by default, and must be disabled if an interface is not allowed to send RIP packets.
- Unless otherwise required, this function must be configured on every router interface that is not allowed to send RIP packets.

↘ Allowing an Interface to Send RIP Packets of a Specified Version

- This function must be configured if the version of RIP packets that can be sent on an interface is required to be different from the global configuration.
- Unless otherwise required, this function must be configured on every router interface that is allowed to send RIP packets of a specified version.

↘ Allowing an Interface to Receive RIP Packets of a Specified Version

- This function must be configured if the version of RIP packets that can be received on an interface is required to be different from the global configuration.
- Unless otherwise required, this function must be configured on every router interface that is allowed to receive RIP packets of a specified version.

Verification

Run the **debug ip rip packet** command to verify the packet sending result and packet type.

Related Commands

↘ Sending Unicast RIP Route Update Packets to a Specified Neighbor

Command Syntax	**neighbor** *ip-address*
Parameter Description	*ip-address:* Indicates the IP address of the neighbor. It should be the address of the network directly connected to the local device.
Command Mode	Routing process configuration mode
Configuration Usage	Generally, you can first run the **passive-interface** command in routing process configuration mode to configure the related interface as a passive interface, and then specify the neighbors that can receive the routing information. This command does not affect the receiving of RIP packets. After an interface is configured as a passive interface, the interface does not send the request packets even after the device is restarted.

↘ Broadcasting RIPv2 Packets on an Interface

Command Syntax	**ip rip v2-broadcast**
Parameter Description	N/A
Command Mode	Interface configuration mode
Configuration Usage	The default behavior is determined by the configuration of the **version** command. The configuration result of this command can overwrite the default configuration of the **version** command. This command affects the behavior of sending RIP packets on the current interface, and the interface is allowed to send RIPv1 and RIPv2 packets simultaneously. If this command does not contain any parameter, the behavior of receiving RIP packets is determined by the configuration of the **version** command.

Allowing an Interface to Receive RIP Packets

Command Syntax	**ip rip receive enable**
Parameter Description	N/A
Command Mode	Interface configuration mode
Configuration Usage	To prohibit the receiving of RIP packets on an interface, use the **no** form of this command. This command takes effect only on the current interface. You can use the **default** form of the command to restore the default setting, that is, allowing the interface to receive RIP packets.

Allowing an Interface to Send RIP Packets

Command Syntax	**ip rip send enable**
Parameter Description	N/A
Command Mode	Interface configuration mode
Configuration Usage	To prohibit the sending of RIP packets on an interface, use the **no** form of this command in interface configuration mode. This command takes effect only on the current interface. You can use the **default** form of the command to restore the default setting, that is, allowing the interface to send RIP packets.

Allowing an Interface to Send RIP Packets of a Specified Version

Command Syntax	**ip rip send version** [**1**] [**2**]
Parameter	**1**: Indicates that only RIPv1 packets are sent.

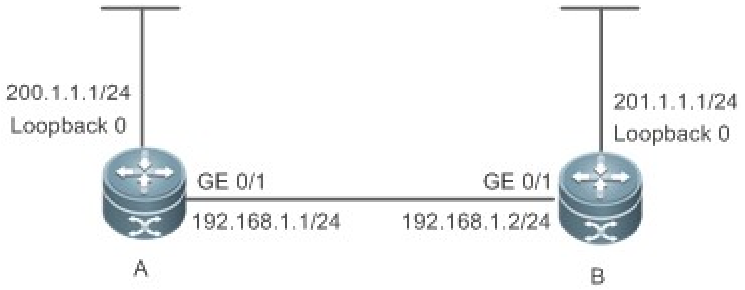
Description	**2**: Indicates that only RIPv2 packets are sent.
Command Mode	Interface configuration mode
Configuration Usage	The default behavior is determined by the configuration of the **version** command. The configuration result of this command can overwrite the default configuration of the **version** command. This command affects the behavior of sending RIP packets on the current interface, and the interface is allowed to send RIPv1 and RIPv2 packets simultaneously. If this command does not contain any parameter, the behavior of receiving RIP packets is determined by the configuration of the **version** command.

Allowing an Interface to Receive RIP Packets of a Specified Version

Command Syntax	**ip rip receive version** [**1**] [**2**]
Parameter Description	**1**: Indicates that only RIPv1 packets are received. **2**: Indicates that only RIPv2 packets are received.
Command Mode	Interface configuration mode
Configuration Usage	The default behavior is determined by the configuration of the **version** command. The configuration result of this command can overwrite the default configuration of the **version** command. This command affects the behavior of receiving RIP packets on the current interface, and the interface is allowed to receive RIPv1 and RIPv2 packets simultaneously. If this command does not contain any parameter, the behavior of receiving RIP packets is determined by the configuration of the **version** command.

Configuration Example

Prohibiting an Interface from Sending RIP Packets

Scenario **Figure 1-8**	 200.1.1.1/24 Loopback 0 GE 0/1 192.168.1.1/24 A 201.1.1.1/24 Loopback 0 GE 0/1 192.168.1.2/24 B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Prohibit the sending of RIP packets on an interface of Router A.
A	A# configure terminal A(config)# interface GigabitEthernet 0/1 Orion Alpha A28X(config-if-GigabitEthernet 0/1)# no ip rip send enable
Verification	Run the **debug ip rip packet send** command on Router A, and verify that packets cannot be sent.
A	A# debug ip rip packet recv *Nov 4 08:19:31: %RIP-7-DEBUG: [RIP] Prepare to send BROADCAST response... *Nov 4 08:19:31: %RIP-7-DEBUG: [RIP] Building update entries on GigabitEthernet 0/1 *Nov 4 08:19:31: %RIP-7-DEBUG: 117.0.0.0/8 via 0.0.0.0 metric 1 tag 0 *Nov 4 08:19:31: %RIP-7-DEBUG: [RIP] Interface GigabitEthernet 0/1 is disabled to send RIP packet!

Common Errors

A compatibility error occurs because the RIP version configured on the neighbor is different from that configured on the local device.

1.4.3 Enabling Triggered Updates

Configuration Effect

- Enable the RIP triggered updates function, after which RIP does not periodically send the route update packets.

Notes

- The RIP basic functions must be configured.
- It is recommended that split horizon with poisoned reverse be enabled; otherwise, invalid routing information may exist.
- Ensure that the triggered updates function is enabled on every router on the same link; otherwise, the routing information cannot be exchanged properly.

Configuration Steps

↘ Enabling Triggered Updates

- This function must be enabled if demand circuits are configured on the WAN interface.
- The triggered updates function can be enabled in either of the following cases: (1) The interface has only one neighbor; (2) The interface has multiple neighbors but the device interacts with these neighbors in unicast mode.
- It is recommended that triggered updates be enabled on a WAN interface (running the PPP, Frame Relay, or X.25 link layer protocol) to meet the requirements of demand circuits.
- If the triggered updates function is enabled on an interface, source address verification is performed no matter whether the source address verification function is enabled by the **validate-update-source** command.
- Unless otherwise required, triggered updates must be enabled on demand circuits of every router.

Verification

When the RIP triggered updates function is enabled, RIP cannot periodically send the route update packets. RIP sends the route update packets to the WAN interface only in one of the following cases:

- A route request packet is received.
- The RIP routing information changes.
- The interface state changes.
- The router is started.

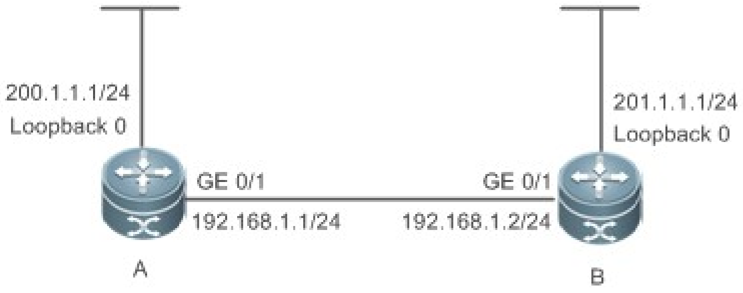
Related Commands

↘ Enabling Triggered Updates

Command Syntax	**ip rip triggered** { **retransmit-timer** *timer* | **retransmit-count** *count* }
Parameter Description	**retransmit-timer** *timer***:** Configures the interval at which the update request or update response packet is retransmitted. The default value is 5s. The value ranges from 1 to 3,600. **retransmit-count** *count***:** Configures the maximum retransmission times of the update request or update response packet. The default value is 36. The value ranges from 1 to 3,600.
Command Mode	Interface configuration mode
Configuration Usage	You can run the **ip rip triggered** command to enable the RIP triggering function. When this function is enabled, the RIP periodical update function is automatically disabled. Therefore, the acknowledgment and retransmission mechanisms must be used to ensure that the Update packets are successfully sent or received on the WAN. You can use the **retransmit-timer** and **retransmit-count** parameters to specify the retransmission interval and maximum retransmission times of the request and update packets.

Configuration Example

Enabling Triggered Updates

Scenario **Figure 1-9**	 200.1.1.1/24 Loopback 0 GE 0/1 192.168.1.1/24 A 201.1.1.1/24 Loopback 0 GE 0/1 192.168.1.2/24 B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● On Router A, enable the RIP triggered updates function, and set the retransmission interval and maximum retransmission times of the request and update packets to 10s and 18, respectively.
A	A# configure terminal A(config)# interface GigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)# encapsulation ppp A(config-if-GigabitEthernet 0/1)# ip rip triggered A(config-if-GigabitEthernet 0/1)# ip rip triggered retransmit-timer 10 A(config-if-GigabitEthernet 0/1)# ip rip triggered retransmit-count 18 A(config-if-GigabitEthernet 0/1)# ip rip split-horizon poisoned-reverse A(config)# router rip A(config-router)# network 192.168.1.0 A(config-router)# network 200.1.1.0
B	B# configure terminal B(config)# interface GigabitEthernet 0/1 B(config-if-GigabitEthernet 0/1)# encapsulation ppp B(config-if-GigabitEthernet 0/1)# ip rip triggered B(config-if-GigabitEthernet 0/1)# ip rip split-horizon poisoned-reverse B(config)# router rip B(config-router)# network 192.168.1.0 B(config-router)# network 201.1.1.0

Verification	On Router A and Router B, check the RIP database and verify that the corresponding routes are permanent.
A	A# sho ip rip database 201.1.1.0/24 auto-summary 201.1.1.0/24 [1] via 192.168.12.2 GigabitEthernet 0/1 06:25 permanent
B	B# sho ip rip database 200.1.1.0/24 auto-summary 200.1.1.0/24 [1] via 192.168.12.1 GigabitEthernet 0/1 06:25 permanent

Common Errors

- The triggered updates function is enabled when the RIP configurations at both ends of the link are consistent.
- The triggered updates function is not enabled on all routers on the same link.

1.4.4 Enabling Source Address Verification

Configuration Effect

- The source address of the received RIP route update packet is verified.

Notes

- The RIP basic functions must be configured.

Configuration Steps

Enabling Source Address Verification

- This function is enabled by default, and must be disabled when source address verification is not required.
- After split horizon is disabled on an interface, the RIP routing process will perform source address verification on the Update packet no matter whether the **validate-update-source** command is executed in routing process configuration mode.
- For an IP unnumbered interface, the RIP routing process does not perform source address verification on the Update packet no matter whether the **validate-update-source** command is executed in routing process configuration mode.
- Unless otherwise required, this function must be disabled on every router that does not requires source address verification.

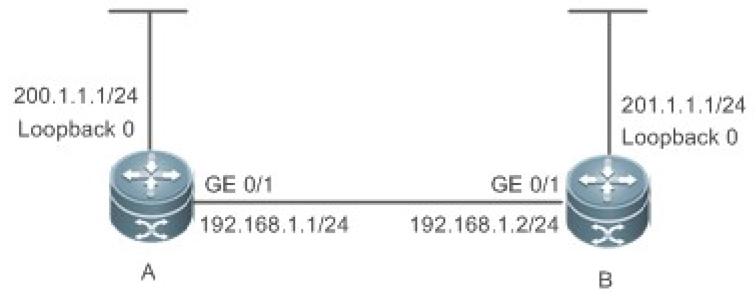
Verification

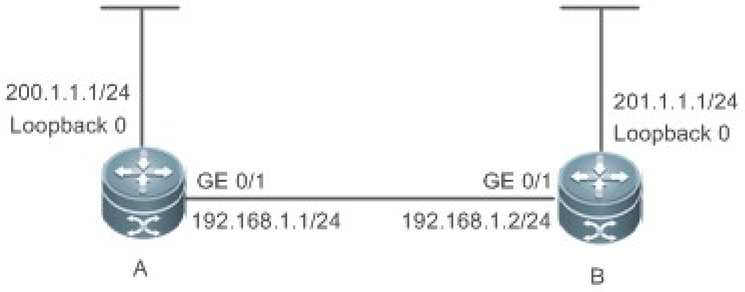
Only the route update packets coming from the same IP subnet neighbor are received.

Related Commands

Command Syntax	**validate-update-source**
Parameter Description	N/A
Command Mode	Routing process configuration mode
Configuration Usage	Source address verification of the Update packet is enabled by default. After this function is enabled, the source address of the RIP route update packet is verified. The purpose is to ensure that the RIP routing process receives only the route update packets coming from the same IP subnet neighbor.

Configuration Example

Scenario **Figure 1-10**	 200.1.1.1/24 Loopback 0 GE 0/1 192.168.1.1/24 A GE 0/1 192.168.1.2/24 201.1.1.1/24 Loopback 0 B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Disable source address verification of Update packets on all routers.
A	A# configure terminal A(config)# router rip A(config-router)# no validate-update-source
B	B# configure terminal B(config)# router rip B(config-router)# no validate-update-source
Verification	● On Router A, check the routing table and verify that the entry 201.1.1.0/24 is loaded. ● On Router B, check the routing table and verify that the entry 200.1.1.0/24 is loaded.
A	A# show ip route rip R 201.1.1.0/24 [120/1] via 192.168.2.2, 00:06:11, GigabitEthernet 0/1
B	B# show ip route rip

Scenario **Figure 1-10**	 200.1.1.1/24 Loopback 0 201.1.1.1/24 Loopback 0 GE 0/1 192.168.1.1/24 GE 0/1 192.168.1.2/24 A B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Disable source address verification of Update packets on all routers.
A	A# configure terminal A(config)# router rip A(config-router)# no validate-update-source
B	B# configure terminal B(config)# router rip B(config-router)# no validate-update-source
Verification	● On Router A, check the routing table and verify that the entry 201.1.1.0/24 is loaded. ● On Router B, check the routing table and verify that the entry 200.1.1.0/24 is loaded.
	R 200.1.1.0/24 [120/1] via 192.168.1.1, 00:06:11, GigabitEthernet 0/1

1.4.5 Enabling Authentication

Configuration Effect

- Prevent learning unauthenticated and invalid routes and advertising valid routes to unauthorized devices, ensuring stability of the system and protecting the system against intrusions.

Notes

- The RIP basic functions must be configured.
- Only RIPv2 supports authentication of RIP packets, and RIPv1 does not.

Configuration Steps

Enabling Authentication and Specifying the Key Chain Used for RIP Authentication

- This configuration is mandatory if authentication must be enabled.
- If the key chain is already specified in the interface configuration, run the **key chain** command in global configuration mode to define the key chain; otherwise, authentication of RIP packets may fail.

- Unless otherwise required, this configuration must be performed on every router that requires authentication.

↘ Defining the RIP Authentication Mode

- This configuration is mandatory if authentication must be enabled.
- The RIP authentication modes configured on all devices that need to directly exchange RIP routing information must be the same; otherwise, RIP packets may fail to be exchanged.
- If plain text authentication is used, but the key chain for plain text authentication is not configured or associated, authentication is not performed. Similarly, if MD5 authentication is used, but the key chain is not configured or associated, authentication is not performed.
- Unless otherwise required, this configuration must be performed on every router that requires authentication.

↘ Enabling RIP Plain Text Authentication and Configuring the Key Chain

- This configuration is mandatory if authentication must be enabled.
- If RIP plain text authentication should be enabled, use this command to configure the key chain for plain text authentication. Alternatively, you can obtain the key chain for plain text authentication by associating the key chain. The key chain obtained using the second method takes precedence over that obtained using the first method.
- Unless otherwise required, this configuration must be performed on every router that requires authentication.

Verification

- RIP plain text authentication provides only limited security because the password transferred through the packet is visible.
- RIP MD5 authentication can provide higher security because the password transferred through the packet is encrypted using the MD5 algorithm.
- Routes can be learned properly if the correct authentication parameters are configured.
- Routes cannot be learned if the incorrect authentication parameters are configured.

Related Commands

↘ Enabling Source Address Verification

Command Syntax	**ip rip authentication key-chain** *name-of-keychain*
Parameter Description	*name-of-keychain*: Specifies the name of the key chain used for RIP authentication.
Command Mode	Interface configuration mode
Configuration Usage	The specified key chain must be defined by the **key chain** command in global configuration mode in advance.

↘ Defining the RIP Authentication Mode

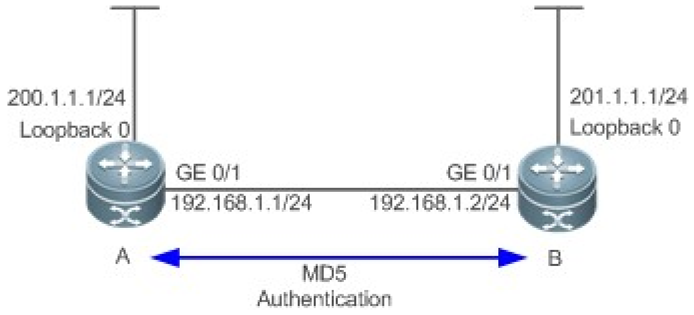
Command Syntax	**ip rip authentication mode** { **text** | **md5** }
Parameter Description	**text:** Indicates that the RIP authentication mode is plain text authentication. **md5:** Indicates that the RIP authentication mode is MD5 authentication.
Command Mode	Interface configuration mode
Configuration Usage	For all devices that need to directly exchange the RIP routing information, the RIP authentication mode of these devices must be the same.

Enabling RIP Plain Text Authentication and Configuring the Key Chain

Command Syntax	**ip rip authentication text-password** [**0** | **7**] *password-string*
Parameter Description	**0**: Indicates that the key is displayed in plain text. **7**: Indicates that the key is displayed in cipher text. *password-string*: Indicates the key chain used for plain text authentication. The key chain is a string of 1 to 16 bytes.
Command Mode	Interface configuration mode
Configuration Usage	This commands takes effect only in plain text authentication mode.

Configuration Example

Configuring RIP Basic Functions and Enabling MD5 Authentication

Scenario **Figure 1-11**	 200.1.1.1/24 Loopback 0 201.1.1.1/24 Loopback 0 GE 0/1 192.168.1.1/24 GE 0/1 192.168.1.2/24 A B MD5 Authentication
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Configure the authentication type and MD5 authentication key on all routers.
A	A# configure terminal A(config)# key chain hello A(config-keychain)# key 1

	A(config-keychain-key)# key-string world A(config-keychain-key)# exit A(config-keychain)# exit A(config)# interface GigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)# ip rip authentication mode md5 A(config-if-GigabitEthernet 0/1)# ip rip authentication key-chain hello
B	B# configure terminal B(config)# key chain hello B(config-keychain)# key 1 B(config-keychain-key)# key-string world B(config-keychain-key)# exit B(config-keychain)# exit B(config)# interface GigabitEthernet 0/1 B(config-if-GigabitEthernet 0/1)# ip rip authentication mode md5 B(config-if-GigabitEthernet 0/1)# ip rip authentication key-chain hello
Verification	● On Router A, check the routing table and verify that the entry 201.1.1.0/24 is loaded. ● On Router B, check the routing table and verify that the entry 200.1.1.0/24 is loaded.
A	A# show ip route rip R 201.1.1.0/24 [120/1] via 192.168.1.2, 00:06:11, GigabitEthernet 0/1
B	A# show ip route rip R 200.1.1.0/24 [120/1] via 192.168.1.1, 00:06:11, GigabitEthernet 0/1

Common Errors

- The keys configured on routers that need to exchange RIP routing information are different.
- The authentication modes configured on routers that need to exchange RIP routing information are different.

1.4.6 Enabling Route Summarization

Configuration Effect

Reduce the size of the routing table, improve the routing efficiency, avoid route flapping to some extent, and improve scalability and effectiveness of the network.

- If a summarized route exists, subroutes included by the summarized route cannot be seen in the routing table, which greatly reduces the size of the routing table.

- Advertising a summarized route is more efficient than advertising individual routes because: (1) A summarized route is processed first when RIP looks through the database; (2) All subroutes are ignored when RIP looks through the database, which reduces the processing time required.

Notes

- The RIP basic functions must be configured.
- The range of supernetting routes is larger than that of the classful network. Therefore, the automatic route summarization function is invalid for supernetting routes.
- RIPv1 always performs automatic route summarization. If the detailed routes should be advertised, you must set the RIP version to RIPv2.

Configuration Steps

↘ Enabling Automatic Route Summarization

- This function is enabled by default.
- To learn specific subnet routes instead of summarized network routes, you must disable automatic route summarization.
- You can disable automatic route summarization only in RIPv2. RIPv1 always performs automatic route summarization.

↘ Configuring RIP Route Summarization on an Interface

- This function must be configured if it is required to summarize classful subnets.
- The **ip rip summary-address** command is used to summarize an address or a subnet under a specified interface. RIP automatically summarizes to the classful network boundary. Each classful subnet can be configured only in the **ip rip summary-address** command.
- The summary range configured in this command cannot be supernetting routes, that is, the configured subnet mask length cannot be smaller than the natural mask length of the network.
- Unless otherwise required, this configuration should be performed on a router that requires classful subnet summarization.

Verification

Verify that the routes are summarized in the routing table of the peer end.

Related Commands

↘ Enabling Automatic Route Summarization

Command Syntax	**auto-summary**
Parameter Description	N/A

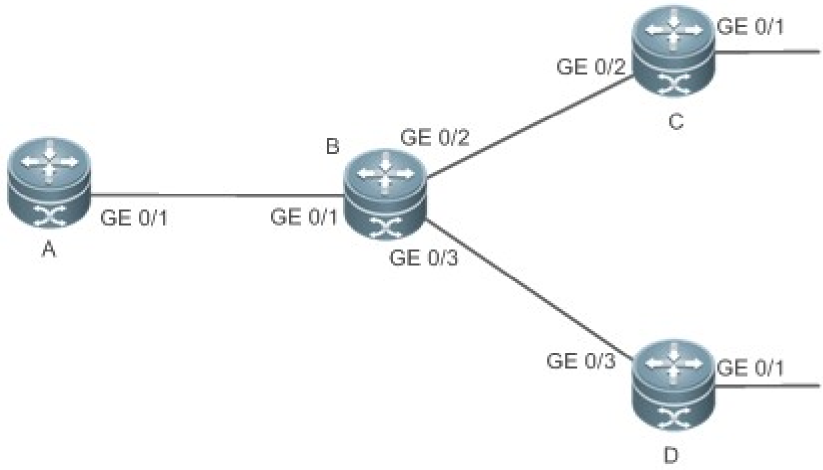
Command Mode	Routing process configuration mode
Configuration Usage	Route summarization is enabled by default for RIPv1 and RIPv2. You can disable automatic route summarization only in RIPv2. RIPv1 always performs automatic route summarization.

Configuring RIP Route Summarization on an Interface

Command Syntax	**ip rip summary-address** *ip-address ip-network-mask*
Parameter Description	*ip-address*: Indicates the IP address to be summarized. *ip-network-mask*: Indicates the subnet mask of the IP address to be summarized.
Command Mode	Interface configuration mode
Configuration Usage	This command is used to summarize an address or a subnet under a specified interface.

Configuration Example

Configuring Route Summarization

Scenario **Figure 1-12**	 GE 0/1 GE 0/2 C B GE 0/2 A GE 0/1 GE 0/1 GE 0/3 GE 0/3 GE 0/1 D **Remarks** The interface IP addresses are as follows: A: GE0/1 192.168.1.1 B: GE0/1 192.168.1.2 GE0/2 172.16.2.1 GE0/3 172.16.3.1 C: GE0/2 172.16.2.2 GE0/3 172.16.4.2 D: GE0/2 172.16.3.2 GE0/3 172.16.5.2
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Configure route summarization on Router B.

	`B# configure terminal`
	`B(config)# interface GigabitEthernet 0/1`
	`B(config-if-GigabitEthernet 0/1)# ip rip summary-address 172.16.0.0 255.255.0.0`
	`B(config)# router rip`
	`B(config-router)# version 2`
	`B(config-router)# no auto-summary`

Verification	Check the routing table on Router A, and verify that the entry 172.16.0.0/16 is generated.

	`A# show ip route rip`
	`R 172.16.0.0/16 [120/2] via 192.168.1.2, 00:01:04, GigabitEthernet 0/1`

Common Errors

- RIP basic functions are not configured or fail to be configured.

1.4.7 Enabling Supernetting Routes

Configuration Effect

- Allow RIP to send RIP supernetting routes on a specified interface.

Notes

- The RIP basic functions must be configured.

Configuration Steps

↘ Enabling Supernetting Routes

- If a supernetting route is detected when a RIPv1-enabled router monitors the RIPv2 route response packets, the router will learn an incorrect route because RIPv1 ignores the subnet mask in the routing information of the packet. In this case, the **no** form of the command must be used on the RIPv2-enabled router to prohibit advertisement of supernetting routes on the related interface. This command takes effect only on the current interface.
- The command is effective only when RIPv2 packets are sent on the interface, and is used to control the sending of supernetting routes.

Verification

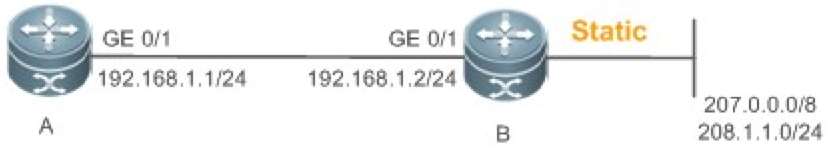
Verify that the peer router cannot learn the supernetting route.

Related Commands

Command Syntax	**ip rip send supernet-routes**
Parameter Description	N/A
Command Mode	Interface configuration mode
Configuration Usage	By default, an interface is allowed to send RIP supernetting routes.

Configuration Example

↘ Disabling Supernetting Routes

Scenario **Figure 1-13**	 GE 0/1 192.168.1.1/24 A GE 0/1 192.168.1.2/24 B Static 207.0.0.0/8 208.1.1.0/24
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Prohibit the sending of RIP supernetting routes on the GigabitEthernet 0/1 interface of Router B.
	B# configure terminal B(config)# ip route 207.0.0.0 255.0.0.0 Null 0 B(config)# ip route 208.1.1.0 255.255.255.0 Null 0 B(config)# router rip B(config-router)# redistribute static B(config)# interface GigabitEthernet 0/1 B(config-if-GigabitEthernet 0/1)# no ip rip send supernet-routes
Verification	Check the routing table on Router A, and verify that Router A can learn only the non-supernetting route 208.1.1.0/24, but not the supernetting route 207.0.0.0/8.
	A#show ip route rip R 208.1.1.0/24 [120/1] via 192.168.1.2, 00:06:11, GigabitEthernet 0/1

1.4.8 Advertising the Default Route or External Routes

Configuration Effect

- In the RIP domain, introduce a unicast route of another AS so that the unicast routing service to this AS can be provided for users in the RIP domain.
- In the RIP domain, inject a default route to another AS so that the unicast routing service to this AS can be provided for users in the RIP domain.

Notes

- The RIP basic functions must be configured.
- Route redistribution cannot introduce default routes of other protocols to the RIP routing domain.

Configuration Steps

↘ Advertising the Default Route to Neighbors

This function must be enabled if it is required to advertise the default route to neighbors.

By default, a default route is not generated, and the metric of the default route is 1.

If the RIP process can generate a default route using this command, RIP does not learn the default route advertised by the neighbor.

Unless otherwise required, this configuration should be performed on a router that needs to advertise the default route.

↘ Advertising the Default Route to Neighbors on an Interface

This function must be enabled if it is required to advertise the default route to neighbors on a specified interface.

By default, a default route is not configured and the metric of the default route is 1.

After this command is configured on an interface, a default route is generated and advertised through this interface.

Unless otherwise required, this configuration should be performed on a router that needs to advertise the default route.

↘ Redistributes Routes and Advertises External Routes to Neighbors

This function must be enabled if routes of other protocols need to be redistributed.

By default,

- If OSPF redistribution is configured, redistribute the routes of all sub-types of the OSPF process.
- In other cases, redistribute all external routes.
- The metric of a redistributed route is 1 by default.
- The route map is not associated by default.

During route redistribution, it is not necessary to convert the metric of one routing protocol to the metric of another routing protocol because different routing protocols use completely different metric measurement methods. RIP measures the metric based on the hop count, and OSPF measures the metric based on the bandwidth. Therefore, the computed metrics cannot be compared with each other. During route redistribution, however, it is necessary to configure a symbolic metric; otherwise, route redistribution fails.

Unless otherwise required, this configuration should be performed on a router that needs to redistribute routes.

Verification

- On a neighbor device, verify that a default route exists in the RIP routing table.
- On the local and neighbor devices, verify that external routes (routes to other ASs) exist in the RIP routing table.

Related Commands

↘ Advertising the Default Route to Neighbors

Command Syntax	**default-information originate** [**always**] [**metric** *metric-value*] [**route-map** *map-name*]
Parameter Description	**always:** Enables RIP to generate a default route no matter whether the local router has a default route. **metric** *metric-value:* Indicates the initial metric of the default route. The value ranges from 1 to 15.

	route-map *map-name:* Indicates the associated route map name. By default, no route map is associated.
Command Mode	Routing process configuration mode
Configuration Usage	If a default route exists in the routing table of a router, RIP does not advertise the default route to external entities by default. You need to run the **default-information originate** command in routing process configuration mode to advertise the default route to neighbors. If the **always** parameter is selected, the RIP routing process advertises a default route to neighbors no matter the default route exists, but this default route is not displayed in the local routing table. To check whether the default route is generated, run the **show ip rip database** command to check the RIP routing information database. To further control the behavior of advertising the RIP default route, use the **route-map** parameter. For example, run the **set metric** rule to set the metric of the default route. You can use the **metric** parameter to set the metric of the advertised default value, but the priority of this configuration is lower than that of the set metric rule of the **route-map** parameter. If the **metric** parameter is not configured, the default route uses the default metric configured for RIP. You still need to run the **default-information originate** command to introduce the default route generated by **ip default-network** to RIP.

Advertising the Default Route to Neighbors on an Interface

Command Syntax	**ip rip default-information** { **only** | **originate** } [**metric** *metric-value*]
Parameter Description	**only**: Indicates that only the default route is advertised. **originate**: Indicates that the default route and other routes are advertised. **metric** *metric-value:* Indicates the metric of the default route. The value ranges from 1 to 15.
Command Mode	Interface configuration mode
Configuration Usage	If you configure the **ip rip default-information** command for the interface, and the **default-information originate** command for the RIP process, only the default route configured for the interface is advertised. So far as **ip rip default-information** is configured for one interface, RIP does not learn the default route advertised by the neighbor.

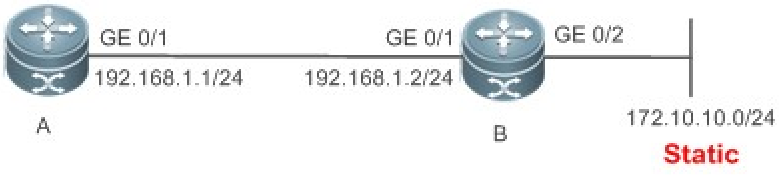
Redistributes Routes and Advertises External Routes to Neighbors

Command Syntax	**redistribute** { **connected** | **ospf** *process-id* | **static** } [**match** { **internal | external** [**1 | 2**] **| nssa-external** [**1 | 2**] }] [**metric** *metric-value*] [**route-map** *route-map-name*]
Parameter Description	**connected**: Indicates redistribution from direct routes. **ospf** *process-id*: Indicates redistribution from OSPF. *process-id* indicates the OSPF process ID. The

	value ranges from 1 to 65535. **static**: Indicates redistribution from static routes. **match**: Used only when OSPF routes are redistributed. Only the routes that match the filtering conditions are redistributed. **metric** *metric-value*: Sets the metric of the redistributed route. The value ranges from 1 to 16. **route-map** *route-map-name*: Sets the redistribution filtering rules.
Command Mode	Routing process configuration mode
Configuration Usage	If you configure redistribution of OSPF routes without specifying the **match** parameter, OSPF routes of all sub-types can be distributed by default. The latest setting of the **match** parameter is used as the initial **match** parameter. Only routes that match the sub-types can be redistributed. You can use the **no** form of the command to restore the default value of **match**. The configuration rules for the **no** form of the **redistribute** command are as follows: 1. If some parameters are specified in the **no** form of the command, default values of these parameters will be restored. 2. If no parameter is specified in the **no** form of the command, the entire command will be deleted.

Configuration Example

↘ Redistributing Routes and Advertising External Routes to Neighbors

Scenario **Figure 1-14**	 GE 0/1 192.168.1.1/24 A GE 0/1 192.168.1.2/24 B GE 0/2 172.10.10.0/24 Static
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● On Router B, configure redistribution of static routes.
B	B# configure terminal B(config)# router rip B(config-router)# redistribute static
Verification	On Router A, check the routing table and verify that the entry 172.10.10.0/24 is loaded.
	A# show ip route rip R 172.10.10.0/24 [120/1] via 192.168.1.2, 00:06:11, GigabitEthernet 0/1

1.4.9 Setting Route Filtering Rules

Configuration Effect

- Routes that do not meet filtering criteria cannot be loaded to the routing table, or advertised to neighbors. In this way, users within the network can be prevented from accessing specified destination networks.

Notes

- The RIP basic functions must be configured.
- In regard to the filtering rules of sent routes, you must configure route redistribution first, and then filter the redistributed routes.

Configuration Steps

↘ Filtering the Received RIP Routing Information

- This function must be configured if it is required to filter received routing information.
- To refuse receiving some specified routes, you can configure the route distribution control list to process all the received route update packets. If no interface is specified, route update packets received on all interfaces will be processed.
- Unless otherwise required, this configuration should be performed on a router that requires route filtering.

↘ Filtering the Sent RIP Routing Information

- This function must be configured if it is required to filter the redistributed routing information that is sent.
- If this command does not contain any optional parameter, route update advertisement control takes effect on all interfaces. If the command contains the interface parameter, route update advertisement control takes effect only on the specified interface. If the command contains other routing process parameters, route update advertisement control takes effect only on the specified routing process.
- Unless otherwise required, this configuration should be performed on a router that requires route filtering.

Verification

- Run the **show ip route rip** command to verify that the routes that have been filtered out are not loaded to the routing table.

Related Commands

↘ Filtering the Received RIP Routing Information

Command Syntax	**distribute-list** { [*access-list-number* | *name*] | **prefix** *prefix-list-name* [**gateway** *prefix-list-name*] } **in** [*interface-type interface-number*]
Parameter Description	*access-list-number* | *name*: Specifies the access list. Only routes permitted by the access list can be received. **prefix** *prefix-list-name*: Uses the prefix list to filter routes.

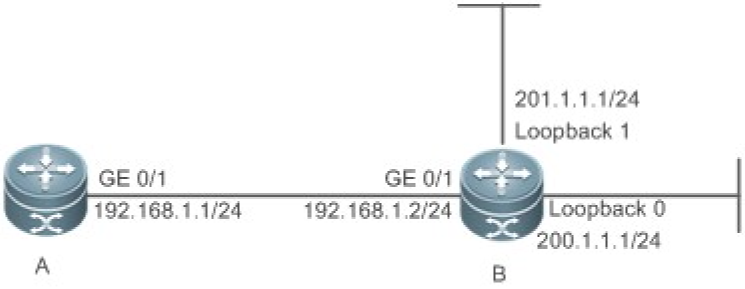
	gateway *prefix-list-name*: Uses the prefix list to filter the route sources. *interface-type interface-number*: Indicates that the distribution list is applied to the specified interface.
Command Mode	Routing process configuration mode
Configuration Usage	N/A

↘ Filtering the Sent RIP Routing Information

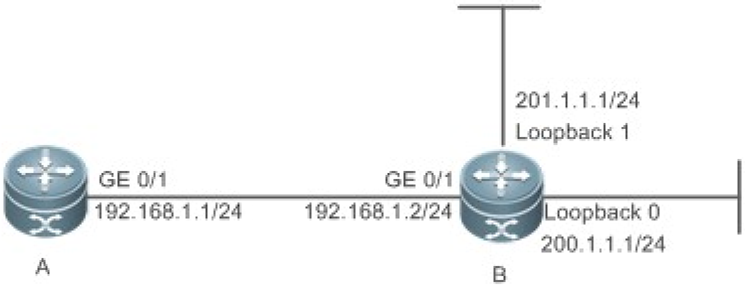
Command Syntax	**distribute-list** { [*access-list-number* | *name*] | **prefix** *prefix-list-nam*e } **out** [*interface* **| [connected**] **| ospf** *process-id* **| rip | static**]]
Parameter Description	*access-list-number* | *name*: Specifies the access list. Only routes permitted by the access list can be sent. **prefix** *prefix-list-name*: Uses the prefix list to filter routes. *Interface*: Applies route update advertisement control only on the specified interface. **connected**: Applies route update advertisement control only on direct routes introduced through redistribution. **ospf** *process-id*: Applies route update advertisement control only on the routes introduced from OSPF. *process-id* specifies an OSPF process. **rip**: Applies route update advertisement control only on RIP routes. **static**: Applies route update advertisement control only on static routes introduced through redistribution.
Command Mode	Routing process configuration mode
Configuration Usage	N/A

Configuration Example

↘ Filtering the Received RIP Routing Information

Scenario **Figure 1-15**	 201.1.1.1/24 Loopback 1 GE 0/1 192.168.1.1/24 GE 0/1 192.168.1.2/24 Loopback 0 200.1.1.1/24 A B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Enable the RIP routing process to control routes received over the GigabitEthernet 0/1 port and receive only the route 200.1.1.0.
A	A# configure terminal A(config)# router rip A(config-router)# distribute-list 10 in GigabitEthernet 0/1 A(config-router)# no auto-summary A(config)# access-list 10 permit 200.1.1.0 0.0.0.255
Verification	On Router A, check the routing table and verify that only the entry 200.1.1.0/24 exists.
A	A# show ip route rip R 200.1.1.0/24 [120/1] via 192.168.1.2, 00:06:11, GigabitEthernet 0/1

↘ Filtering the Sent RIP Routing Information

Scenario **Figure 1-16**	 201.1.1.1/24 Loopback 1 GE 0/1 192.168.1.1/24 GE 0/1 192.168.1.2/24 Loopback 0 200.1.1.1/24 A B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Enable the RIP routing process to advertise only the route 200.1.1.0/24.
B	B# configure terminal

	B(config)# router rip B(config-router)# redistribute connected B(config-router)# distribute-list 10 out B(config-router)# version 2 B(config)# access-list 10 permit 200.1.1.0 0.0.0.255
Verification	Check the routing table on Router A, and verify that route in the 200.1.1.0 network segment exists.
A	A# show ip route rip R 200.1.1.0/24 [120/1] via 192.168.1.2, 00:06:11, GigabitEthernet 0/1

Common Errors

- Filtering fails because the filtering rules of the access list are not properly configured.

1.4.10 Modifying Route Selection Parameters

Configuration Effect

- Change the RIP routes to enable the traffic pass through specified nodes or avoid passing through specified nodes.
- Change the sequence that a router selects various types of routes so as to change the priorities of RIP routes.

Notes

- The RIP basic functions must be configured.

Configuration Steps

Modifying the Administrative Distance of a RIP Route

- Optional.
- This configuration is mandatory if you wish to change the priorities of RIP routes on a router that runs multiple unicast routing protocols.

Increasing the Metric of a Received or Sent RIP Route

- Optional.
- Unless otherwise required, this configuration should be performed on a router where the metrics of routes need to be adjusted.

Configuring the Default Metric of an External Route Redistributed to RIP

- Optional.
- Unless otherwise required, this configuration must be performed on an ASBR to which external routes are introduced.

Verification

Run the **show ip rip** command to display the administrative distance currently configured. Run the **show ip rip data** command to display the metrics of redistributed routes to verify that the configuration takes effect.

Related Commands

↘ Modifying the Administrative Distance of a RIP Route

Command Syntax	**distance** *distance* [*ip-address wildcard*]
Parameter Description	*distance*: Sets the administrative distance of a RIP route. The value is an integer ranging from 1 to 255. *ip-address*: Indicates the prefix of the source IP address of the route. *wildcard*: Defines the IP address comparison bit. **0** indicates accurate matching, and **1** indicates that no comparison is performed.
Command Mode	Routing process configuration mode
Configuration Usage	Run this command to configure the administrative distance of a RIP route.

↘ Increasing the Metric of a Received or Sent RIP Route

Command Syntax	**offset-list** { *access-list-number* | *name* } { **in** | **out** } *offset* [*interface-type interface-number*]
Parameter Description	*access-list-number* | *name*: Specifies the access list. **In**: Uses the ACL to modify the metric of a received route. **out**: Uses the ACL to modify the metric of a sent route. *offset*: Indicates the offset of the modified metric. The value ranges from 0 to 16. *interface-type*: Uses the ACL on the specified interface. *interface-number*: Specifies the interface number.
Command Mode	Routing process configuration mode
Configuration Usage	Run this command to increase the metric of a received or sent RIP route. If the interface is specified, the configuration takes effect only on the specified interface; otherwise, the configuration takes effect globally.

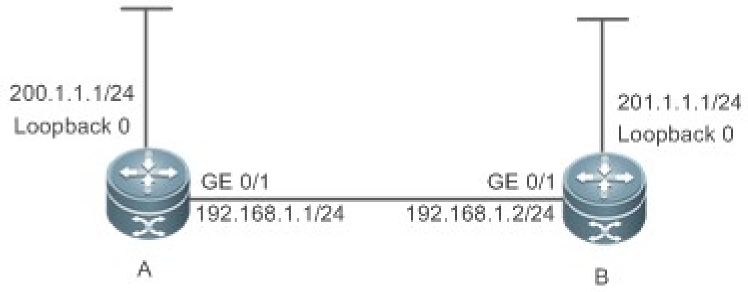
↘ Configuring the Default Metric of an External Route Redistributed to RIP

Command Syntax	**default-metric** *metric-value*
Parameter Description	*metric-value:* Indicates the default metric. The valid value ranges from 1 to 16. If the value is equal to or greater than 16, the switch determines that this route is unreachable.

Command Mode	Routing process configuration mode
Configuration Usage	This command must be used together with the routing protocol configuration command **redistribute**.

Configuration Example

Increasing the Metric of a Received or Sent RIP Route

<table>
<tr><td><b>Scenario</b>
<b>Figure 1-17</b></td><td>


</td></tr>
<tr><td><b>Configuration Steps</b></td><td>

- Configure the interface IP addresses on all routers. (Omitted)
- Configure the RIP basic functions on all routers. (Omitted)
- Increase by 7 the metric of each RIP route in the range specified by ACL 7.
- Increase by 7 the metric of each learned RIP route in the range specified by ACL 8.

</td></tr>
<tr><td><b>A</b></td><td>

```
A# configure terminal
A(config)# access-list 7 permit host 200.1.1.0
A(config)# access-list 8 permit host 201.1.1.0
A(config)# router rip
A(config-router)# offset-list 7 out 7
A(config-router)# offset-list 8 in 7
```

</td></tr>
<tr><td></td><td></td></tr>
<tr><td><b>Verification</b></td><td>Check the routing table on Router A and Router B to verify that the metrics of RIP routes are 8.</td></tr>
<tr><td><b>A</b></td><td>

```
A# show ip route rip
R    201.1.1.0/24 [120/8] via 192.168.1.2, 00:06:11, GigabitEthernet 0/1
```

</td></tr>
<tr><td><b>B</b></td><td>

```
B# show ip route rip
R    200.1.1.0/24 [120/8] via 192.168.1.1, 00:06:11, GigabitEthernet 0/1
```

</td></tr>
</table>

1.4.11 Modifying Timers

Configuration Effect

- Change the duration of RIP timers to accelerate or slow down the change of the protocol state or occurrence of an event.

Notes

- The RIP basic functions must be configured.
- Modifying the protocol control parameters may result in protocol running failures. Therefore, you are advised not to modify the timers.

Configuration Steps

↘ Modifying the Update Timer, Invalid Timer, and Flush Timer

This configuration must be performed if you need to adjust the RIP timers.

By adjusting the timers, you can reduce the convergence time and fault rectification time of the routing protocol. For routers connected to the same network, values of the three RIP timers must be the same. Generally, you are advised not to modify the RIP timers unless otherwise required.

Setting timers to small values on a low-speed link brings risks because a lot of Update packets consume the bandwidth. You can set timers to small values generally on the Ethernet or a 2 Mbps (or above) link to reduce the convergence time of network routes.

Unless otherwise required, this configuration should be performed on a router where RIP timers need to be modified.

↘ Setting the Sending Delay Between RIP Route Update Packets

This configuration must be performed if you need to adjust the sending delay between RIP Update packets.

Run the **output-delay** command to increase the sending delay between packets on a high-speed device so that a low-speed device can receive and process all Update packets.

Unless otherwise required, this configuration should be performed on a router where the sending delay needs to be adjusted.

Verification

Run the **show ip rip** command to display the current settings of RIP timers.

Related Commands

↘ Modifying the Update Timer, Invalid Timer, and Flush Timer

Command Syntax	**timers basic** *update invalid flush*
Parameter Description	*update*: Indicates the route update time in second. It defines the interval at which the device sends the route update packet. Each time an Update packet is received, the invalid timer and flush timer are reset.

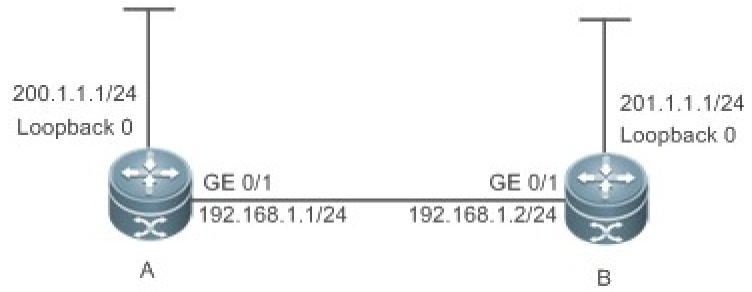
	By default, a routing update packet is sent every 30s. *invalid*: Indicates the route invalid time in second, counted from the last time when a valid update packet is received. It defines the time after which the route in the routing list becomes invalid because the route is not updated. The duration of the invalid timer must be at least three times the duration of the update timer. If no Update packet is received before the invalid timer expires, the corresponding route enters the invalid state. If the Update packet is received before the invalid timer expires, the timer is reset. The default duration of the invalid timer is 180s. *flush*: Indicates the route flushing time in second, counted from the time when the RIP route enters the invalid state. When the flush timer expires, the route in the invalid state will be deleted from the routing table. The default duration of the flush timer is 120s.
Command Mode	Routing process configuration mode
Configuration Usage	By default, the update timer is 30s, the invalid timer is 180s, and the flush timer is 120s.

↘ Setting the Sending Delay Between RIP Route Update Packets

Command Syntax	**output-delay** *delay*
Parameter Description	*delay:* Sets the sending delay between packets in ms. The value ranges from 8 to 50.
Command Mode	Interface configuration mode
Configuration Usage	Normally, a RIP route update packet is 512 bytes long and can contain 25 routes. If the number of routes to be updated exceeds 25, more than one update packet will be sent as fast as possible. When a high-speed device sends a lot of update packets to a low-speed device, the low-speed device may not be able to process all update packets in time, causing a loss of routing information. In this case, you need to run the **output-delay** command to increase the sending delay between packets on a high-speed device so that a low-speed device can receive and process all update packets.

Configuration Example

↘ Setting the Sending Delay Between RIP Route Update Packets

Scenario **Figure 1-18**	 200.1.1.1/24 Loopback 0 GE 0/1 192.168.1.1/24 A 201.1.1.1/24 Loopback 0 GE 0/1 192.168.1.2/24 B
Configuration Steps	● Configure the interface IP addresses on all routers. (Omitted) ● Configure the RIP basic functions on all routers. (Omitted) ● Configure the sending delay of update packets on Router A.
A	A# configure terminal A(config)# router rip A(config-router)# output-delay 30
Verification	Capture packets on Router A and compare the sending time of update packets before and after the configuration, and verify that a delay of 30 ms is introduced.

Common Errors

For routers connected to the same network, values of the three RIP timers are not the same.

1.4.12 Enabling GR

Configuration Effect

- When a distributed route switches services from the active board to the standby board, traffic forwarding continues and is not interrupted.
- When the RIP process is being restarted, traffic forwarding continues and is not interrupted.

Notes

- The RIP basic functions must be configured.
- The GR period is at least twice the RIP route update period.
- During the RIP GR process, ensure that the network environment is stable.

Configuration Steps

↘ Configuring the GR Restarter Capability

This configuration must be performed if RIP needs to be gracefully restarted to ensure data forwarding during hot standby switchover.

The GR function is configured based on the RIP process. You can configure different parameters for different RIP processes based on the actual conditions.

The GR period is the maximum time from restart of the RIP process to completion of GR. During this period, the forwarding table before the restart is retained, and the RIP route is restored so as to restore the RIP state before the restart. After the restart period expires, RIP exits from the GR state and performs common RIP operations.

Unless otherwise required, this configuration should be performed on every router that needs to be gracefully restarted.

Verification

- Run the **show ip rip** command to display the GR state and configured time.
- Trigger a hot standby switchover, and verify that data forwarding is not interrupted.

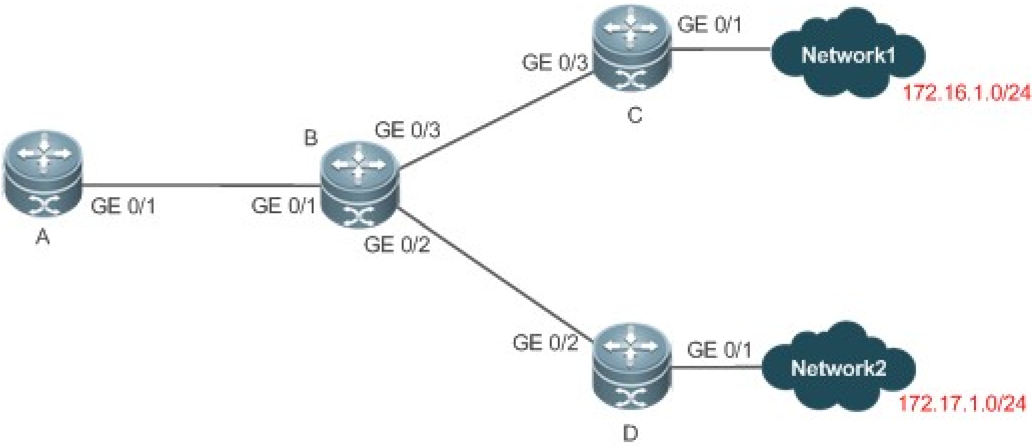
Related Commands

↘ Configuring the GR Restarter Capability

Command Syntax	**graceful-restart** [**grace-period** *grace-period*]
Parameter Description	**graceful-restart**: Enables the GR function. **grace-period**: Explicitly configures the grace period. *grace-period*: Indicates the GR period. The value ranges from 1s to 1800s. The default value is twice the update time or 60s, whichever is the smaller.
Command Mode	Routing process configuration mode
Configuration Usage	This command allows you to explicitly modify the GR period. Note that GR must be completed after the update timer of the RIP route expires and before the invalid timer of the RIP route expires. An inappropriate GR period cannot ensure uninterrupted data forwarding during the GR process. A typical case is as follows: If the GR period is longer than the duration of the invalid timer, GR is not completed when the invalid timer expires. The route is not re-advertised to the neighbor, and forwarding of the route of the neighbor stops after the invalid timer expires, causing interruption of data forwarding on the network. Unless otherwise required, you are advised not to adjust the GR period. If it is necessary to adjust the GR period, ensure that the GR period is longer than the duration of the update timer but shorter than the duration of the invalid timer based on the configuration of the **timers basic** command.

Configuration Example

↘ Configuring the GR Restarter Capability

<table>
<tr><td><b>Scenario</b>
<b>Figure 1-19</b></td><td>

<table>
<tr><td><b>Remarks</b></td><td>The interface IP addresses are as follows:
A: GE 0/1 192.168.1.1
B: GE 0/1 192.168.1.1 GE 0/2 192.168.2.1   GE 0/3 192.168.3.1
C: GE 0/1 192.168.4.2 GE 0/3 192.168.3.2
D: GE 0/1 192.168.5.2 GE 0/2 192.168.2.2</td></tr>
</table></td></tr>
<tr><td><b>Configuration Steps</b></td><td>● Configure the interface IP addresses on all routers. (Omitted)
● Configure the RIP basic functions on all routers. (Omitted)
● On Router B, enable the GR function.</td></tr>
<tr><td></td><td>B# configure terminal
B(config)# router rip
B(config-router)# graceful-restart grace-period 90</td></tr>
<tr><td></td><td></td></tr>
<tr><td><b>Verification</b></td><td>● Trigger a hot standby switchover on Router B, and verify that the routing tables of destination Network 1 and Network 2 remain unchanged on Router A during the switchover.
● Trigger a hot standby switchover on Router B, ping destination Network 1 from Router A, and verify that traffic forwarding is not interrupted during the switchover.</td></tr>
</table>

1.5 Monitoring

Displaying

Description	Command
Displays the basic information about a RIP process.	**show ip rip**
Displays the RIP routing table.	**show ip rip database** [*network-number network-mask*] [**count**]

Displays information about external routes redistributed by RIP.	**show ip rip external** [**connected**] | **ospf** *process-id* | **static**]
Displays the RIP interface information.	**show ip rip interface** [*interface-type interface-number*]
Displays the RIP neighbor information.	**show ip rip peer** [*ip-address*]

Debugging

- System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs events that occur when the RIP process is running.	**debug ip rip event**
Debugs interaction with the NSM process.	**debug ip rip nsm**
Debugs the sent and received packets.	**debug ip rip packet** [**interface** *interface-type interface-number* | **recv** | **send**]
Debugs the RIP GR process.	**debug ip rip restart**
Debugs the route changes of the RIP process.	**debug ip rip route**

2 Configuring RIPng

2.1 Overview

RIP next generation (RIPng) is a unicast routing protocol that applies to IPv6 networks. RIPng-enabled routers exchange routing information to obtain routes to remote networks.

As an Interior Gateway Protocol (IGP), RIPng can run only within the autonomous system (AS) and is applicable to small-sized networks with routes no more than 16 hops.

Protocols and Standards

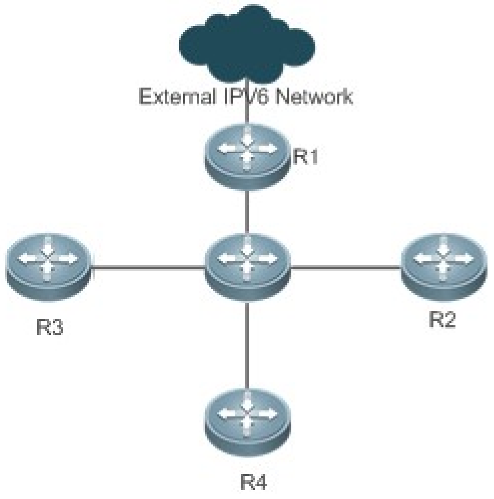
- RFC2080: Defines the RIPng.

2.2 Application

RIPng is generally used on some small-sized networks, such as office networks of small companies.

As shown in the following figure, the company builds an IPv6 network, on which all routers support IPv6. The network is small in size, but the workload is still heavy if the network is maintained manually. In this case, RIPng can be configured to adapt to topological changes of the small-sized network, which reduces the workload.

Figure 4-1



2.3 Features

Basic Concepts

IGP and EGP

IGP runs within an AS. For example, RIPng is a type of IGP.

Exterior Gateway Protocol (EGP) runs between ASs. For example, BGP is a type of EGP.

Feature

Feature	Description
RIPng and RIP	RIPng is an extension of RIPv2 on the basis of IPv6. Both are similar in functions and configurations.
Exchanging Routing Information	By exchanging routing information, RIPng-enabled devices can automatically obtain routes to a remote network and update routes in real time.
Routing Algorithm	RIPng is a protocol based on the distance-vector algorithm. It uses the vector addition method to compute the routing information.
Avoiding Route Loops	RIPng uses functions, such as split horizon and poison reverse, to avoid route loops.

2.3.1 RIPng and RIP

RIP applies to IPv4 networks. Two RIP versions are available, including RIPv1 and RIPv2.

RIPng is an extension of RIPv2 on the basis of IPv6. Both are similar in functions and configurations.

Working Principle

↘ RIPv2

RIPv2 packets are multicast. The multicast address is 224.0.0.9, and the UDP port ID is 520. RIPv2 can identify the subnet mask.

↘ RIPng

RIPng packets are multicast. The multicast address is FF02::9, the source address is FE80::/10, and the UDP port ID is 521. RIPng can identify the subnet mask.

- This chapter describes functions and configurations of RIPng. For details about RIPv2, see "Configuring RIP".

Related Configuration

↘ Enabling the RIPng Process

By default, the RIPng process is disabled.

Run the **ipv6 router rip** command to enable the RIPng process.

You must enable the RIPng process on a device; otherwise, all functions related to RIPng cannot take effect.

↘ Running RIPng on an Interface

By default, RIPng does not run on an interface.

Run the **ipv6 rip enable** command to run RIPng on an interface.

After RIPng runs on an interface, RIPng packets can be exchanged on the interface and RIPng can learn routes to the network segments directly connected to the device.

↘ Prohibiting an Interface from Sending or Receiving Packets

By default, a RIPng-enabled interface is allowed to send and receive RIPng packets.

Run the **passive-interface** command to prohibit an interface from sending RIPng packets.

2.3.2 Exchanging Routing Information

Compared with static routing, the dynamic routing protocol has a significant advantage, that is, by exchanging routing information, devices can automatically obtain routes to a remote network and update the routes in real time.

Working Principle

↘ Initialization

After RIPng is enabled on a router, the router sends a request packet to its neighbor router, requesting for all routing information, that is, the routing table. After receiving the request message, the neighbor router returns a response packet containing the local routing table. After receiving the response packet, the router updates the local routing table, and sends an update packet to the neighbor router, informing the neighbor router of the route update information. After receiving the update packet, the neighbor router updates the local routing table, and sends the update packet to other adjacent routers. After a series of updates, all routers can obtain and retain the latest routing information.

↘ Periodical Update

By default, periodical update is enabled for RIPng. Adjacent routers exchange complete routing information with each other every 30s (update timer), that is, the entire routing table is sent to neighbor routers.

- For every non-local route, if the route is not updated within 180s (invalid timer), the metric of the route is changed to 16 (unreachable). If the route is still not updated in the next 120s (flush timer), the route is deleted from the routing table.

↘ Default Route

In the routing table, a route to the destination network ::/0 is called default route.

The default route can be learned from a neighbor router, or sent to a neighbor router.

↘ Route Redistribution

For RIPng, other types of routes (such as direct routes, static routes, and routes of other routing protocols) are called external routes.

External routes (excluding the default route) can be redistributed to RIPng and advertised to neighbors.

↘ Route Filtering

Filtering conditions can be configured to limit the routing information exchanged between adjacent routers.

Only the routing information that meets filtering conditions can be sent or received.

Related Configuration

RIPng Timers

By default, the update timer is 30s, the invalid timer is 180s, and the flush timer is 120s.

Run the **timers basic** command to modify durations of RIPng timers.

Increasing the duration of the flush timer can reduce the route flapping. Decreasing the duration of the flush timer helps accelerate route convergence.

The durations of RIPng timers must be consistent on adjacent routers. Unless otherwise required, you are advised not to modify the RIPng timers.

Default Route

Run the **ipv6 rip default-information** command to advertise the default route to neighbors on an interface.

Route Redistribution

Run the **redistribute** command to redistribute external routes (excluding the default route) to RIPng and advertise them to neighbors.

Route Filtering

Run the **distribute-list out** command to set filtering rules to limit the routing information sent by the device.

Run the **distribute-list in** command to set filtering rules to limit the routing information received by the device.

2.3.3 Routing Algorithm

RIPng is a protocol based on the distance-vector algorithm. It uses the vector addition method to compute the routing information.

Working Principle

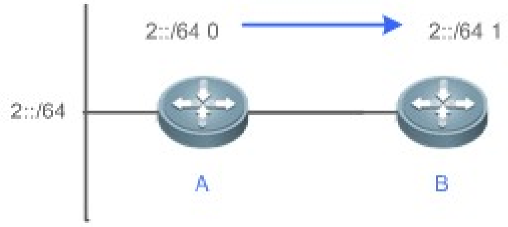
Distance-Vector Algorithm

RIPng is a protocol based on the distance-vector algorithm. The distance-vector algorithm treats a route as a vector that consists of the destination network and distance (metric). The router obtains a route from its neighbor and adds the distance vector from itself to the neighbor to the route to form its own route.

RIPng uses the hop count to evaluate the distance (metric) to the destination network. By default, the hop count from a router to its directly connected network is 0, the hop count from a router to a network that can be reached through a router is 1, and so on. That is, the metric is equal to the number of routers from the local network to the destination network. To restrict the convergence time, RIPng stipulates that the metric must be an integer between 0 and 15. If the metric is equal to or greater than 16, the destination network or host is unreachable. For this reason, RIPng cannot be applied to a large-scale network.

As shown in the following figure, Router A is connected to the network 2::/64. Router B obtains the route (2::/64, 0) from Router A and adds the metric 1 to the route to obtain its own route (2::/64, 1), and the next hop points to Router A.

Figure 4-2

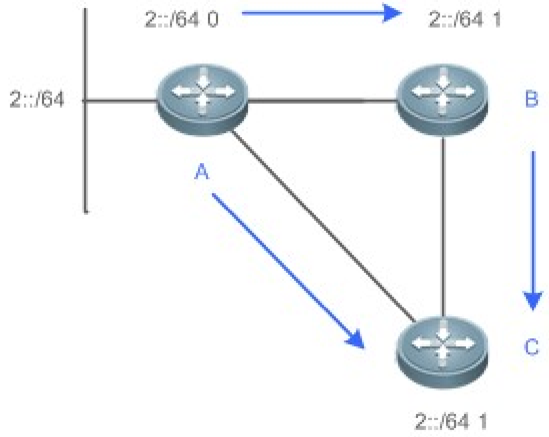


↘ Selecting the Optimum Route

RIPng selects an optimum route based on the following principle: If multiple routes to the same destination network is available, a router preferentially selects the route with the smallest metric.

As shown in the following figure, Router A is connected to the network 2::/64. Router C obtains the route (2::/64, 0) from Router A and the route (2::/64, 1) from Router B. Router C will select the route that is obtained from Router A and add metric 1 to this route to form its own route (2::/64, 1), and the next hop points to Router A.

Figure 4-3



- When routes coming from different sources exist on a router, the route with the smaller distance is preferentially selected.

Route Source	Default Distance
Directly-connected network	0
Static route	1
OSPF route	110
RIPng route	120
Unreachable route	255

Related Configuration

↘ Modifying the Distance

By default, the distance of a RIPng route is 120.

Run the **distance** command to modify the distance of a RIPng route.

↘ Modifying the Metric

For a RIPng route that is proactively discovered by a device, the default metric is equal to the number of hops from the local network to the destination network. The metric offset of the interface is 1.

For a RIPng router that is manually configured (default route or redistributed route), the default metric is 1.

Run the **ipv6 rip metric-offset** command to modify the metric offset of the interface.

Run the **default-metric** command to modify the default metric of an external route (redistributed route).

Run the **redistribute** command to modify the metric of an external route (redistributed route) when advertising this route.

Run the **ipv6 rip default-information** command to modify the metric of a default route when advertising the default route.

2.3.4 Avoiding Route Loops

RIPng uses functions, such as split horizon and poison reverse, to avoid route loops.

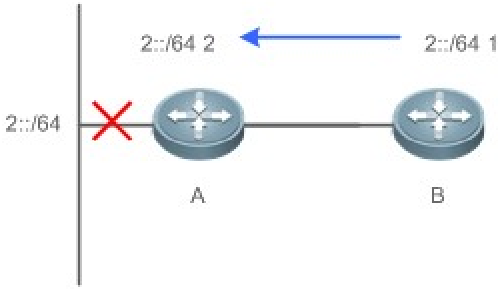
Working Principle

↘ Route Loop

A RIPng route loop occurs due to inherent defects of the distance-vector algorithm.

As shown in the following figure, Router A is connected to the network 2::/64, and sends an update packet every 30s. Router B receives the route to 2::/64 from Router A every 30s. If Router A is disconnected from 2::/64, the route to 2::/64 will be deleted from the routing table on Router A. Next time, the update packet sent by Router A no longer contains this route. As Router B does not receive an update packet related to 2::/64, Router B determines that the route to 2::/64 is valid within 180s and uses the update packet to send this route to Router A. As the route to 2::/64 does not exist on Router A, the route learned from Router B is added to the routing table. Router B determines that data can reach 2::/64 through Router A, and Router A determines that data can reach 2::/64 through Router B. In this way, a route loop is formed.

Figure 4-4

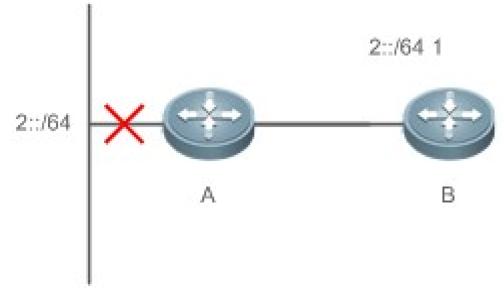


↘ Split Horizon

Split horizon can prevent route loops. After split horizon is enabled, a route received on this interface will not be sent out from this interface.

As shown in the following figure, after split horizon is enabled on Router B, Router B will not send the route to 2::/64 back to Router A. Router B will learn 180s later that 2::/64 is not reachable.

Figure 4-5



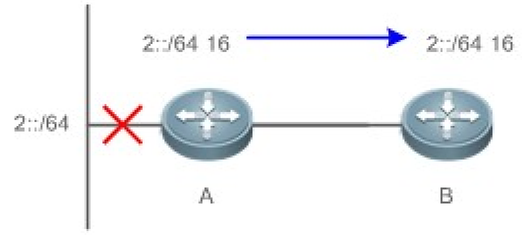
↘ Poison Reverse

Poison reverse can also prevent route loops. Compared with slit horizon, poison reverse is more reliable, but brings more protocol packets, which makes network congestion more severe.

After poison reverse is enabled on an interface, a route received from this interface will be sent out from this interface again, but the metric of this router will be changed to 16 (unreachable).

As shown in the following figure, after poison reverse is enabled on Router A, if Route A detects a disconnection from 2::/64, Router A will not delete the route to 2::/64. Instead, Router A changes the number of hops to 16, and advertises the route through the update packet. On receiving the update packet, Router B learns that 2::/64 is not reachable.

Figure 4-6



Related Configuration

↘ Split Horizon

By default, split horizon is enabled.

Run the **no split-horizon** command to disable split horizon.

Poison Reverse

By default, poison reverse is disabled.

Run the **split-horizon poisoned-reverse** command to enable poison reverse. (After poison reverse is enabled, split horizon is automatically disabled.)

2.4 Configuration

Configuration	Related Commands	
Configuring RIPng Basic Functions	● (Mandatory) It is used to build a RIPng routing domain.	
	ipv6 router rip	Enables a RIPng routing process and enters routing process configuration mode.
	ipv6 rip enable	Runs RIPng on an interface.
	split-horizon	Enables split horizon or poison reverse.
	passive-interface	Configures a passive interface.
Advertising the Default Route or External Routes	● Optional.	
	ipv6 rip default-information	Advertise the default route to neighbors on an interface.
	redistribute	Redistributes routes and advertising external routes to neighbors.
Setting Route Filtering Rules	● Optional.	
	distribute-list in	Filters the received RIPng routing information.
	distribute-list out	Filters the sent RIPng routing information.
Modifying Route Selection Parameters	● Optional.	
	distance	Modifies the administrative distance of a RIPng route.
	ipv6 rip metric-offset	Modifies the metric offset on an interface.
	default-metric	Configure the default metric for route redistribution.
Modifying Timers	● Optional.	
	timers	Modifies the update timer, invalid timer, and flush timer of RIPng.

2.4.1 Configuring RIPng Basic Functions

Configuration Effect

- Build a RIPng routing domain on the network.

- Routers in the domain obtain routes to a remote network through RIPng.

Notes

- IPv6 addresses must be configured.
- IPv6 unicast routes must be enabled.

Configuration Steps

↘ Enabling a RIPng Routing Process

- Mandatory.
- Unless otherwise required, perform this configuration on every router in the RIPng routing domain.

↘ Running RIPng on an Interface

- Mandatory.
- Unless otherwise required, perform this configuration on every interconnected interface of routers in the RIPng routing domain.

↘ Enabling Split Horizon or Poison Reverse

- By default, split horizon is enabled and poison reverse is disabled.
- Unless otherwise required, enable split horizon on every interface connected to the broadcast network, such as the Ethernet. (Retain the default setting.)
- Unless otherwise required, enable split horizon on every interface connected to the point-to-point (P2P) network, such as the PPP and HDLC. (Retain the default setting.)
- It is recommended that split horizon and poison reverse be disabled on an interface connected to a non-broadcast multi-access network, such as FR and X.25; otherwise, some devices cannot learn the complete routing information.
- If the secondary IP address is configured for an interface connected to a non-broadcast, it is recommended that split horizon and poison reverse be disabled.

↘ Configuring a Passive Interface

- This configuration is recommended.
- Use the passive interface to set the boundary of the RIPng routing domain. The network segment of the passive interface belongs to the RIPng routing domain, but RIPng packets cannot be sent over the passive interface.
- If RIPng routes need to be exchanged on an interface (such as the router interconnect interface) in the RIPng routing domain, this interface cannot be configured as a passive interface.

Verification

- Check the routing table on a router to verify that the route to a remote network can be obtained through RIPng.

Related Commands

↘ Enabling a RIPng Routing Process

Command	**ipv6 router rip**

Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	This command is used to create a RIPng routing process and enter routing process configuration mode.

Running RIPng on an Interface

Command	**ipv6 rip enable**
Parameter Description	N/A
Command Mode	Interface configuration mode
Usage Guide	The configuration for running the RIPng on an interface is different from that of RIPv2. In RIPv2, the **network** command is configured in routing process configuration mode to define an IP address range. If the IP address of an interface belongs to this IP address range, RIP automatically runs on this interface.

Enabling Split Horizon

Command	**split-horizon** [**poisoned-reverse**]
Parameter Description	**poisoned-reverse**: Indicates that the split horizon function contains the poison reverse function.
Command Mode	Routing process configuration mode
Usage Guide	Run the **show ipv6 rip** command to check whether split horizon is enabled. The configuration is different from that of RIPv2. In RIPv2, the split horizon function is configured in interface configuration mode.

Configuring a Passive Interface

Command	**passive-interface** { **default** | *interface-type interface-num* }
Parameter Description	**default:** Indicates all interfaces. ***interface-type interface-num*****:** Specifies an interface.
Command Mode	Routing process configuration mode
Usage Guide	First, run the **passive-interface default** command to configure all interfaces as passive interfaces. Then, run the **no passive-interface** *interface-type interface-num* command so that the interfaces used for interconnection between routers in the domain are not passive interface.

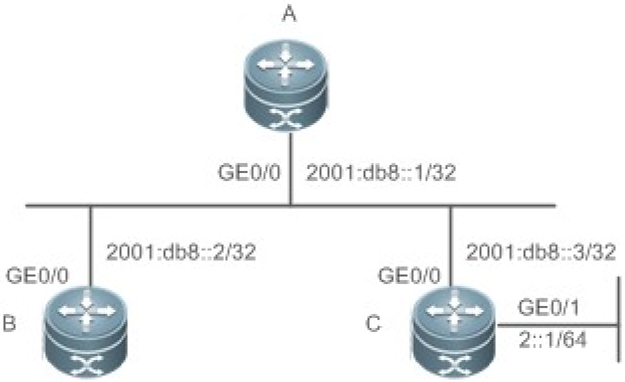
Displaying the IP Routing Table

Command	**show ipv6 route**

Parameter Description	N/A
Command Mode	Privileged EXEC mode or global configuration mode
Usage Guide	Check whether the routing table contains any route to a remote network that is learned through RIPng.

Configuration Example

↘ Building a RIPng Routing Domain

Scenario	 A GE0/0 2001:db8::1/32 2001:db8::2/32 GE0/0 B 2001:db8::3/32 GE0/0 C GE0/1 2::1/64
Configuration Steps	● Configure IPv6 addresses on all routers. ● Enable RIPng on all routers.
A	A# configure terminal Enter configuration commands, one per line. End with CNTL/Z. A(config)# ipv6 router rip A(config-router)# exit A(config)# interface GigabitEthernet 0/0 A(config-if-GigabitEthernet 0/0)# ipv6 address 2001:db8::1/32 A(config-if-GigabitEthernet 0/0)# ipv6 rip enable
B	B# configure terminal Enter configuration commands, one per line. End with CNTL/Z. B(config)# ipv6 router rip B(config-router)# exit B(config)# interface GigabitEthernet 0/0

```
B(config-if-GigabitEthernet 0/0)# ipv6 address 2001:db8::2/32

B(config-if-GigabitEthernet 0/0)# ipv6 rip enable
```

C

```
C# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.

C(config)# ipv6 router rip

C(config-router)# exit

C(config)# interface GigabitEthernet 0/0

C(config-if-GigabitEthernet 0/0)#

C(config-if-GigabitEthernet 0/0)# ipv6 address 2001:db8::3/32

C(config-if-GigabitEthernet 0/0)# ipv6 rip enable

C(config)# interface GigabitEthernet 0/1

C(config-if-GigabitEthernet 0/1)# ipv6 address 2::1/64

C(config-if-GigabitEthernet 0/1)# ipv6 rip enable
```

Verification

Check the routing tables on Router A, Router B, and Router C. The routing tables should contain routes to a remote network that are learned through RIPng.

A

```
A# show ipv6 route


IPv6 routing table name - Default - 6 entries

Codes:  C - Connected, L - Local, S - Static

    R - RIP, O - OSPF, B - BGP, I - IS-IS, V - Overflow route

    N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

    E1 - OSPF external type 1, E2 - OSPF external type 2

    SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

    IA - Inter area


R       2::/64 [120/2] via FE80::2D0:F8FF:FEFB:D521, GigabitEthernet 0/0

C       2001:DB8::/32 via GigabitEthernet 0/0, directly connected

L       2001:DB8::1/128 via GigabitEthernet 0/0, local host

C       FE80::/10 via ::1, Null0

C       FE80::/64 via GigabitEthernet 0/0, directly connected

L       FE80::2D0:F8FF:FEFB:E7CE/128 via GigabitEthernet 0/0, local host
```

B

```
B# show ipv6 route


IPv6 routing table name - Default - 6 entries

Codes:  C - Connected, L - Local, S - Static

        R - RIP, O - OSPF, B - BGP, I - IS-IS, V - Overflow route

        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

        E1 - OSPF external type 1, E2 - OSPF external type 2

        SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

        IA - Inter area


R      2::/64 [120/2] via FE80::2D0:F8FF:FEFB:D521, GigabitEthernet 0/0

C      2001:DB8::/32 via GigabitEthernet 0/0, directly connected

L      2001:DB8::2/128 via GigabitEthernet 0/0, local host

C      FE80::/64 via GigabitEthernet 0/0, directly connected

L      FE80::2D0:F8FF:FEFB:C9BA/128 via GigabitEthernet 0/0, local host
```

C

```
Orion Alpha A28X# show ipv6 route


IPv6 routing table name - Default - 9 entries

Codes:  C - Connected, L - Local, S - Static

        R - RIP, O - OSPF, B - BGP, I - IS-IS, V - Overflow route

        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

        E1 - OSPF external type 1, E2 - OSPF external type 2

        SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

        IA - Inter area


C      2::/64 via GigabitEthernet 0/1, directly connected

L      2::2/128 via GigabitEthernet 0/1, local host

C      2001:DB8::/32 via GigabitEthernet 0/0, directly connected

L      2001:DB8::3/128 via GigabitEthernet 0/0, local host

C      FE80::/10 via ::1, Null0

C      FE80::/64 via GigabitEthernet 0/0, directly connected
```

	L FE80::2D0:F8FF:FEFB:D521/128 via GigabitEthernet 0/0, local host C FE80::/64 via GigabitEthernet 0/1, directly connected L FE80::2D0:F8FF:FEFB:D521/128 via GigabitEthernet 0/1, local host

- The 29 series products do not support ISIS and BGP.

Common Errors

- The IPv6 address is not configured on an interface.
- The interface used for interconnection between devices is configured as a passive interface.

2.4.2 Advertising the Default Route or External Routes

Configuration Effect

- In the RIPng domain, introduce a unicast route of another AS so that the unicast routing service to this AS can be provided for users in the RIPng domain.
- In the RIPng domain, inject a default route to another AS so that the unicast routing service to this AS can be provided for users in the RIPng domain.

Notes

- The RIPng basic functions must be configured.

Configuration Steps

Configuring External Route Redistribution

- Optional.
- Perform this configuration if external routes of the RIPng domain should be introduced to the AS border router (ASBR).

Generating a Default Route

- Optional.
- Perform this configuration if the default route should be introduced to an ASBR so that other routers in the RIPng domain access other AS domains through this ASBR by default.

Verification

- Run the **show ipv6 route rip** command on a non-ASBR to check whether the external routes of the domain and default route have been loaded.

Related Commands

Advertising the Default Route to Neighbors on an Interface

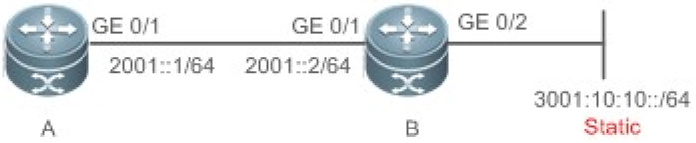
Command	**ipv6 rip default-information** { **only**|**originate** } [**metric** *metric-value*]

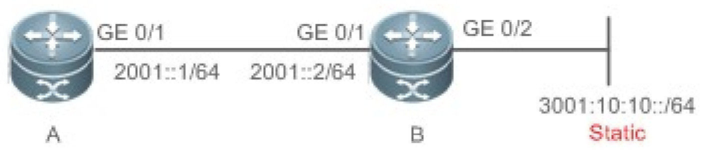
Parameter Description	**only**: Advertises only IPv6 default route. **originate**: Advertises the IPv6 default route and other routes. **metric** *metric-valu*e: Indicates the metric of the default route. The value ranges from 1 to 15. The default value is 1.
Command Mode	Interface configuration mode
Usage Guide	After this command is configured on the interface, an IPv6 default route is advertised to the external devices through this interface, but the route itself is not added to the route forwarding table or the device and the RIPng route database. To prevent occurrence of a route loop, once this command is configured on an interface, RIPng refuses to receive the default route updates advertised by neighbors.

↘ Redistributing Routes and Advertising External Routes to Neighbors

Command	**redistribute** { **connected** | **ospf** *process-id* | **static** } [**metric** *metric-value* | **route-map** *route-map-name*]
Parameter Description	**Connected**: Indicates redistribution from direct routes. **ospf** *process-id*: Indicates redistribution from OSPF. *process-id* indicates the OSPF process ID. The value ranges from 1 to 65535. **static**: Indicates redistribution from static routes. **metric** *metric-valu*e: Sets the metric of the route redistributed to the RIPng domain. **route-map** *route-map-name*: Sets the redistribution filtering rules.
Command Mode	Routing process configuration mode
Usage Guide	During route redistribution, it is not necessary to convert the metric of one routing protocol to the metric of another routing protocol because different routing protocols use completely different metric measurement methods. RIP measures the metric based on the hop count, and OSPF measures the metric based on the bandwidth. Therefore, the computed metrics cannot be compared with each other.

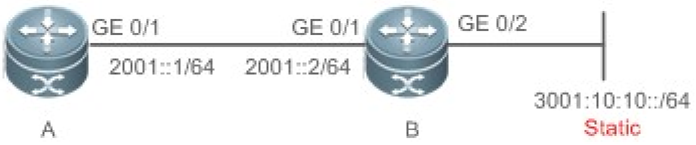
Configuration Example

Scenario	 GE 0/1 2001::1/64 A GE 0/1 2001::2/64 B GE 0/2 3001:10:10::/64 Static
Configuration Steps	● Configure the interface IPv6 addresses on all routers. (Omitted) ● Configure the RIPng basic functions on all routers. (Omitted) ● On Router B, configure redistribution of static routes. ● On the GE0/1 interface of Router A, configure advertisement of the default route.

Scenario	 GE 0/1 2001::1/64 GE 0/1 2001::2/64 GE 0/2 3001:10:10::/64 Static A B
A	A# configure terminal A(config)# interface GigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)# ipv6 rip default-information originate
B	B# configure terminal B(config)# ipv6 router rip B(config-router)# redistribute static
Verification	● Check the routing tables on Router A and Router B, and confirm that Router A can learn the route 3001:10:10::/64, and Router B can learn the default route ::/0.

A	A# show ipv6 route rip
	
	IPv6 routing table name - Default - 17 entries
	Codes: C - Connected, L - Local, S - Static
	        R - RIP, O - OSPF, B - BGP, I - IS-IS
	        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
	        E1 - OSPF external type 1, E2 - OSPF external type 2
	        SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
	        IA - Inter area
	R 3001:10:10::/64 [120/2] via FE80::2D0:F8FF:FE22:334A, GigabitEthernet 0/1

B	B# show ipv6 route rip
	
	IPv6 routing table name - Default - 17 entries
	Codes: C - Connected, L - Local, S - Static
	        R - RIP, O - OSPF, B - BGP, I - IS-IS
	        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
	        E1 - OSPF external type 1, E2 - OSPF external type 2
	        SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

Scenario	 GE 0/1 GE 0/1 GE 0/2 2001::1/64 2001::2/64 3001:10:10::/64 Static A B
	IA - Inter area R ::/0 [120/2] via FE80::21A:A9FF:FE41:5B06, GigabitEthernet 0/1

- The 29 series products do not support ISIS and BGP.

2.4.3 Setting Route Filtering Rules

Configuration Effect

- Routes that do not meet filtering criteria cannot be loaded to the routing table, or advertised to neighbors. In this way, users within the network can be prevented from accessing specified destination networks.

Notes

- The RIPng basic functions must be configured.

Configuration Steps

↘ Filtering the Received RIP Routing Information

- To refuse receiving some specified routes, you can configure the route distribution control list to process all the received route update packets. If no interface is specified, route update packets received on all interfaces will be processed.

↘ Filtering the Sent RIP Routing Information

- If this command does not contain any optional parameter, route update advertisement control takes effect on all interfaces. If the command contains the interface parameter, route update advertisement control takes effect only on the specified interface. If the command contains other routing process parameters, route update advertisement control takes effect only on the specified routing process.

Verification

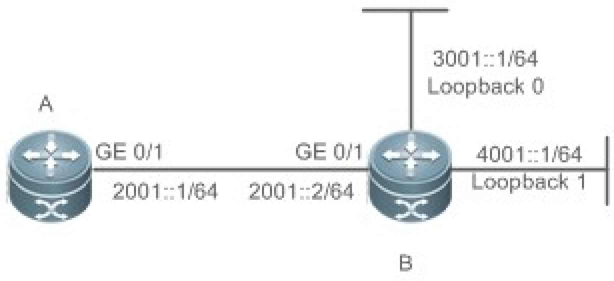
- Run the **show ipv6 route rip** command to check that the routes that have been filtered out are not loaded to the routing table.

Related Commands

Command	**distribute-list prefix-list** *prefix-list-name* { **in** | **out** } [*interface-type interface-name*]
Parameter Description	**prefix-list** *prefix-list-name:* Indicates the name of the prefix list, which is used to filter routes. **in** | **out:** Specifies update routes (received or sent routes) that are filtered.

	interface-type interface-name: Indicates that the distribution list is applied to the specified interface.
Command Mode	Routing process configuration mode
Usage Guide	N/A

Configuration Example

Scenario	 3001::1/64 Loopback 0 A GE 0/1 GE 0/1 4001::1/64 Loopback 1 2001::1/64 2001::2/64 B
Configuration Steps	● Configure the interface IPv6 addresses on all routers. (Omitted) ● Configure the RIPng basic functions on all routers. (Omitted) ● On router A, configure route filtering.
A	A# configure terminal A(config)# ipv6 prefix-list hello permit 4001::/64 A(config)# ipv6 router rip A(config-router)# distribute-list prefix-list hello in
Verification	● Check that Router A can learn only the route to 4001::/64.

A	A# show ipv6 route rip
	IPv6 routing table name - Default - 17 entries
	Codes: C - Connected, L - Local, S - Static
	        R - RIP, O - OSPF, B - BGP, I - IS-IS
	        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
	        E1 - OSPF external type 1, E2 - OSPF external type 2
	        SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
	        IA - Inter area
	R 4001::/64 [120/2] via FE80::2D0:F8FF:FE22:334A, GigabitEthernet 0/1

- The 29 series products do not support ISIS and BGP.

2.4.4 Modifying Route Selection Parameters

Configuration Effect

- Change the RIPng routes to enable the traffic pass through specified nodes or avoid passing through specified nodes.
- Change the sequence that a router selects various types of routes so as to change the priorities of RIPng routes.

Notes

- The RIPng basic functions must be configured.

Configuration Steps

Modifying the Administrative Distance of a RIPng Route

- Optional.
- Perform this configuration if you wish to change the priorities of RIPng routes on a router that runs multiple unicast routing protocols.

Modifying the Metric Offset on an Interface

- Optional.
- Unless otherwise required, perform this configuration on a router where the metrics of routes need to be adjusted.

Configuring the Default Metric of an External Route Redistributed to RIPng

- Optional.
- Unless otherwise required, perform this configuration on an ASBR to which external routes are introduced.

Verification

- Run the **show ipv6 rip** command to display the administrative distance of RIPng routes.
- Run the **show ipv6 rip data** command to display the metrics of external routes redistributed to RIPng.

Related Commands

Modifying the Administrative Distance of a RIPng Route

Command	**distance** *distance*
Parameter Description	*distance*: Sets the administrative distance of a RIPng route. The value is an integer ranging from 1 to 254.
Command Mode	Routing process configuration mode
Usage Guide	Run this command to set the administrative distance of a RIPng route.

Modifying the Metric Offset on an Interface

Command	**ipv6 rip metric-offset** *value*

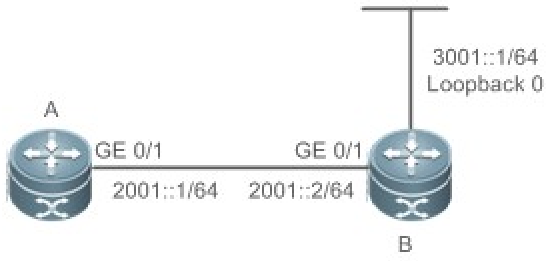
Parameter Description	*value*: Indicates the interface metric offset. The value ranges from 1 to 16.
Command Mode	Routing process configuration mode
Usage Guide	Before a route is added to the routing table, the metric of the route must be added with the metric offset set on the interface. You can control the use of a route by setting the interface metric offset.

Configuring the Default Metric of an External Route Redistributed to RIPng

Command	**default-metric** *metric*
Parameter Description	*metric*: Indicates the default metric. The valid value ranges from 1 to 16. If the value is equal to or greater than 16, the swtich determines that this route is unreachable.
Command Mode	Global configuration mode
Usage Guide	If the metric is not specified during redistribution of a routing protocol process, RIPng uses the metric defined by the **default-metric** command. If the metric is specified, the metric defined by the **default-metric** command is overwritten by the specified metric. If this command is not configured, the value of **default-metric** is 1.

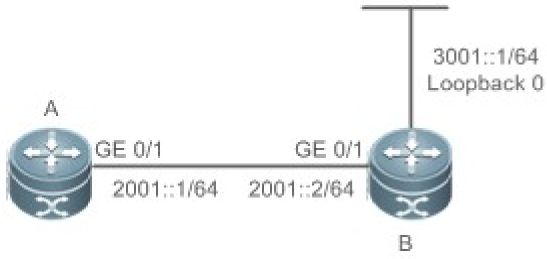
Configuration Example

Modifying the Administrative Distance of a RIPng Route

Scenario	 3001::1/64 Loopback 0 A GE 0/1 GE 0/1 2001::1/64 2001::2/64 B
Configuration Steps	● Configure the interface IPv6 addresses on all routers. (Omitted) ● Configure the RIPng basic functions on all routers. (Omitted) ● On Router A, set the administrative distance of a RIPng route to 160.

	`A# configure terminal`
	`A(config)# ipv6 router rip`
	`A(config-router)# distance 160`

Verification	● On Router A, check whether the administrative distance of a RIPng route is 160.
	`A# show ipv6 route rip | in 3001::/64`

Scenario	 3001::1/64 Loopback 0 A GE 0/1 GE 0/1 2001::1/64 2001::2/64 B
Configuration Steps	● Configure the interface IPv6 addresses on all routers. (Omitted) ● Configure the RIPng basic functions on all routers. (Omitted) ● On Router A, set the administrative distance of a RIPng route to 160.

	`A# configure terminal`
	`A(config)# ipv6 router rip`
	`A(config-router)# distance 160`

Verification	● On Router A, check whether the administrative distance of a RIPng route is 160.
	`R     3001::/64 [160/2] via FE80::2D0:F8FF:FE22:334A, GigabitEthernet 0/1`

2.4.5 Modifying Timers

Configuration Effect

- Change the duration of RIPng timers to accelerate or slow down the change of the protocol state or occurrence of an event.

Notes

- The RIPng basic functions must be configured.
- Modifying the protocol control parameters may result in protocol running failures. Therefore, you are advised not to modify the timers.

Configuration Steps

↘ Modifying the Update Timer, Invalid Timer, and Flush Timer

- Mandatory.
- Unless otherwise required, perform this configuration on a router where RIPng timers need to be modified.

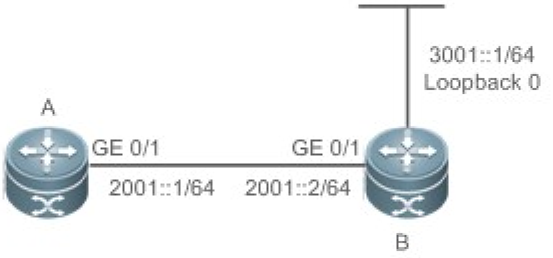
Verification

- Run the **show ipv6 rip** command to display settings of timers.

Related Commands

Command	**timers** *update invalid flush*
Parameter Description	*Update:* Indicates the route update time in second. It defines the interval at which the device sends the route update packet. Each time an update packet is received, the invalid timer and flush timer are reset. By default, a route update packet is sent every 30s. *Invalid:* Indicates the route invalid time in second, counted from the last time when a valid update packet is received. It defines the time after which the route in the routing list becomes invalid because the route is not updated. The duration of the invalid timer must be at least three times the duration of the update timer. If no update packet is received before the invalid timer expires, the corresponding route enters the invalid state. If the update packet is received before the invalid timer expires, the timer is reset. The default duration of the invalid timer is 180s. *Flush:* Indicates the route flushing time in second, counted from the time when the RIPng route enters the invalid state. When the flush timer expires, the route in the invalid state will be deleted from the routing table. The default duration of the flush timer is 120s.
Command Mode	Routing process configuration mode
Usage Guide	By default, the update timer is 30s, the invalid timer is 180s, and the flush timer is 120s.

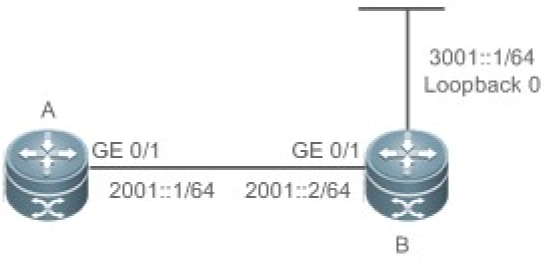
Configuration Example

Scenario	 3001::1/64 Loopback 0 A GE 0/1 GE 0/1 2001::1/64 2001::2/64 B
Configuration Steps	● Configure the interface IPv6 addresses on all routers. (Omitted) ● Configure the RIPng basic functions on all routers. (Omitted) ● On Router A, configure the update timer, invalid timer, and flush timer.

B	`B# configure terminal`
	`B(config)# ipv6 router rip`
	`B(config-router)# timers 10 30 90`

Verification	● On Router B, check the settings of RIPng timers.

B	`B# show ipv6 rip`
	`Routing Protocol is "RIPng"`
	` Sending updates every 10 seconds with +/-50%, next due in 12 seconds`

Scenario	 3001::1/64 Loopback 0 A GE 0/1 GE 0/1 2001::1/64 2001::2/64 B

```
Timeout after 30 seconds, garbage collect after 90 seconds
Outgoing update filter list for all interface is: not set
Incoming update filter list for all interface is: not set
Default redistribution metric is 1
Default distance is 120
Redistribution:
   Redistributing protocol connected
Default version control:  send version 1, receive version 1
Interface                Send   Recv
   GigabitEthernet 0/1   1      1
Routing Information Sources:
   Gateway: fe80::2d0:f8ff:fe22:334a  Distance: 120
   Last Update: 00:00:02   Bad Packets: 0   Bad Routes: 0
```

Common Errors

- Settings of RIPng timers on devices connected to the same network are inconsistent. Consequently, routes cannot be learned properly.

2.5 Monitoring

Displaying

Description	Command
Displays information about the RIPng process.	**show ipv6 rip**
Displays the RIPng routing table.	**show ipv6 rip database**

Debugging

- System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs RIPng.	**debug ipv6 rip** [interface *interface-type interface-num* | nsm | restart

3 Managing Routes

3.1 Overview

The network service module (NSM) manages the routing table, consolidates routes sent by various routing protocols, and selects and sends preferred routes to the routing table. Routes discovered by various routing protocols are stored in the routing table. These routes are generally classified by source into three types:

- Direct route: It is the route discovered by a link-layer protocol and is also called interface route.
- Static route: It is manually configured by the network administrator. A static route is easy to configure and less demanding on the system, and therefore applicable to a small-sized network that is stable and has a simple topology. However, when the network topology changes, the static route must be manually reconfigured and cannot automatically adapt to the topological changes.
- Dynamic route: It is the route discovered by a dynamic routing protocol.

3.2 Applications

Application	Description
Basic Functions of the Static Route	Manually configure a route.
Floating Static Route	Configure a standby route in the multipath scenario.
Load Balancing Static Route	Configure load balancing static routes in the multipath scenario.

3.2.1 Basic Functions of the Static Route

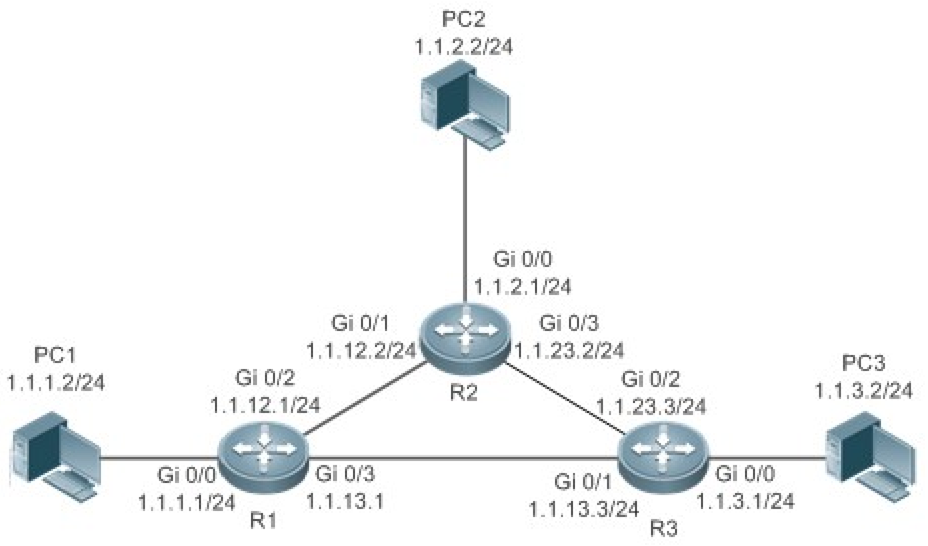
Scenario

On a network with a simple topology, you can configure only static routes to implement network interworking. Appropriate configuration and use of static routes can improve the network performance and guarantee the bandwidth for important network applications.

As shown in Figure 5-1, to implement interworking between PC 1, PC 2, and PC 3, you can configure static routes on R 1, R 2, and R 3.

- On R 1, configure a route to the network segment of PC 2 through R 2, and a route to the network segment of PC 3 through R 3.
- On R 2, configure a route to the network segment of PC 1 through R 1, and a route to the network segment of PC 3 through R 3.
- On R 3, configure a route to the network segment of PC 1 through R 1, and a route to the network segment of PC 2 through R 2.

Figure 5-1



Deployment

- Configure the address and subnet mask of each interface.
- Configure static routes on R 1, R 2, and R 3.

3.2.2 Floating Static Route

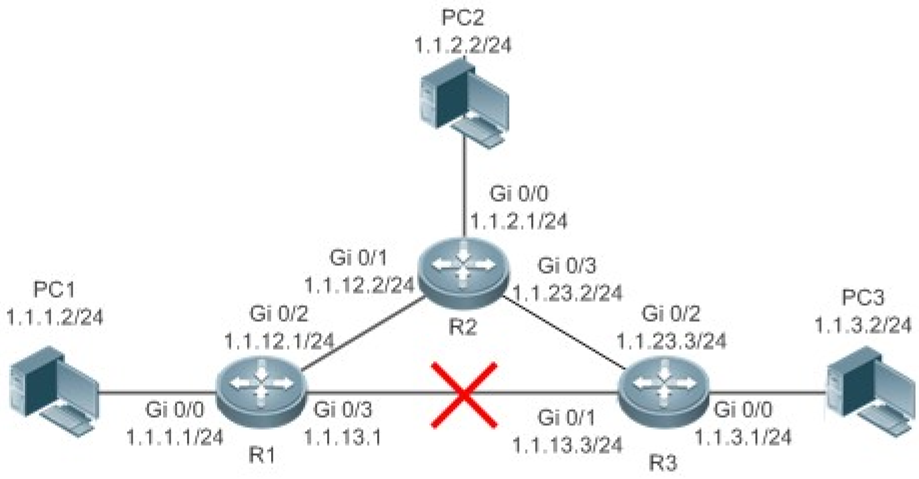
Scenario

If no dynamic routing protocol is configured, you can configure floating static routes to implement dynamic switching of routes to prevent communication interruption caused by the network connection failures.

As shown in Figure 5-2, to prevent communication interruption caused by a line failure between R 1 and R 3, you can configure a floating static route respectively on R 1 and R 3. Normally, packets are forwarded on a path with a small administrative distance. If a link on this path is down, the route is automatically switched to the path with a large administrative distance.

- On R1, configure two routes to the network segment of PC 3, including a route through R 3 (default distance = 1) and a route through R 2 (default distance = 2).
- On R 3, configure two routes to the network segment of PC 1, including a route through R 1 (default distance = 1) and a route through R 2 (default distance = 2).

Figure 5-2



Deployment

- Configure the address and subnet mask of each interface.
- Configure static routes on R 1, R 2, and R 3.

3.2.3 Load Balancing Static Route

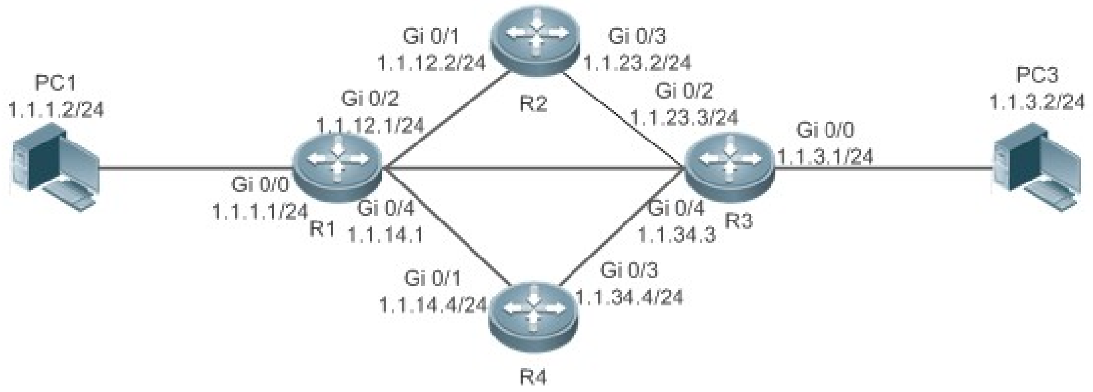
Scenario

If there are multiple paths to the same destination, you can configure load balancing routes. Unlike floating routes, the administrative distances of load balancingroutes are the same. Packets are distributed among these routes based on the balanced forwarding policy.

As shown in Figure 5-3, load balancing routes are configured respectively on R 1 and R 3 so that packets sent to the network segment of PC 3 or PC 1 are balanced between two routes, including a route through R 2 and a route through R 4.

- On R 1, configure two routes to the network segment of PC 3, including a route through R 2 and a route through R 4.
- On R 3, configure two routes to the network segment of PC 1, including a route through R 2 and a route through R 4.

Figure 5-3



Remarks	On the switch, the load is balanced based on the source IP address by default. Run the **aggregateport load-balance** command to configure the load balancing mode of ECMP route.

Deployment

- Configure the address and subnet mask of each interface.
- Configure static routes on R 1, R 2, R 3, and R 4.
- Configure the load balancing policy on R 1 and R 3.

3.3 Features

Feature	Description
Route Computation	Generate a valid route on a device.
Optimal Route Selection	Select an optimal route to forward packets.
Default Route	Forward all packets and help reduce the size of a routing table.
Route Reliability	Quickly detect a route failure and recover communication.

3.3.1 Route Computation

Routing Function

Routing functions are classified into IPv4 and IPv6 routing functions. If the routing functionsare disabled, a device is equivalent to a host and cannot forward routes.

Dynamic Route

A dynamic routing protocol learns remote routes and dynamically updates routes by exchanging routes with neighbors. If a neighbor is the next hop of a route and this neighbor fails, the route fails as well.

Static Route

On a network with a simple topology, you can configure only static routes to implement network interworking.
Appropriate configuration and use of static routes can improve the network performance and guarantee the bandwidth for important network applications.

Whether a static route is active is computed based on the status of the local interface. When the exit interface of a static route is located at layer 3 (L3) and is in Up status (the link status is Up and the IP address is configured), this route is active and can be used for packet forwarding.

3.3.2 Optimal Route Selection

Administrative Distance

When multiple routing protocols generate routes to the same destination, the priorities of these routes can be determined based on the administrative distance. A smaller administrative distance indicates a higher priority.

Equal-Cost Route

If multiple routes to the same destination have different next hops but the same administrative distance, these routes are mutually equal-cost routes. Packets are distributed among these routes to implement load balancing based on the balanced forwarding policy.

On a specific device, the total number of equal-cost routes is limited. Routes beyond the limit do not participate in packet forwarding.

Floating Route

If multiple routes to the same destination have different next hops and different administrative distances, these routes are mutually floating routes. The route with the smallest administrative distance will be first selected for packet forwarding. If this route fails, a route with a larger administrative distance is further selected for forwarding, thus preventing communication interruption caused by a network line failure.

3.3.3 Default Route

In the forwarding routing table, the route with the destination network segment 0.0.0.0 and the subnet mask 0.0.0.0 is the default route. Packets that cannot be forwarded by other routes will be forwarded by the default route.
The default route can be statically configured or generated by a dynamic routing protocol.

Default Gateway

On a L2 switch, the **ip default gateway** command is configured to generate a default route.

Static Default Route

On a L3 switch, a static route with the network segment 0.0.0.0 and the subnet mask 0.0.0.0 is configured to generate the default route.

Default Network

The default network is configured to generate a default route. If the **ip default-network** command is configured to specify a network (a classful network, such as a Class A, B, or C network), and this network exists in the routing table, the router will use this network as the default network and the next hop of this network is the default gateway. As the network specified by the **ip default-network** command is a classful one, if this command is used to identify a subnet in a classful network, the router automatically generates a static route of the classful network instead of any default route.

3.3.4 Route Reliability

When a device on a network is faulty, some routes become unreachable, resulting in traffic interruption.
If connectivity of the next hop can be detected in real time, the route can be re-computed when a fault occurs, or traffic can be switched over to the standby route.

3.4 Configuration

Configuration Item	Description and Command	
Configuring a Static Route	● (Mandatory) It is used to configure a static route entry.	
	ip route	Configures an IPv4 static route.
	ipv6 route	Configures an IPv6 static route.
Configuring a Default Route	● (Optional) It is used to configure the default gateway.	
	ip default gateway	Configures an IPv4 default gateway on a L2 device.
	ipv6 default gateway	Configures an IPv6 default gateway on a L2 device.
	ip route 0.0.0.0 0.0.0.0 *gateway*	Configures an IPv4 default gateway on a L3 device.
	ipv6 route ::/0 *ipv6-gateway*	Configures an IPv6 default gateway on a L3 device.
	ip default network	Configures an IPv4 default network on a L3 device.
Configuring Route Limitations	● (Optional) It is used to limit the number of equal-cost routes and number of static routes, or disable routing.	
	maximum-paths	Configures the maximum number of equal-cost routes.

Configuration Item	Description and Command	
	ip static route-limit	Configures the maximum number of IPv4 static routes.
	ipv6 static route-limit	Configures the maximum number of IPv6 static routes.
	no ip routing	Disables IPv4 routing.
	noipv6 unicast-routing	Disables IPv6 routing.

3.4.1 Configuring a Static Route

Configuration Effect

- Generate a static route in the routing table. Use the static route to forward packets to a remote network.

Notes

- Static routes cannot be configured on a L2 switch.
- If the **no ip routing** command is configured on a L3 switch, you cannot configure IPv4 static routes on this switch, and existing IPv4 static routes will also be deleted. Before the device is restarted, reconfiguring the **ip routing** command can recover the deleted IPv4 static routes. After the device is restarted, deleted IPv4 static routes cannot be recovered.
- If the **no ipv6 unicast- routing** command is configured on a L3 switch, you cannot configure IPv6 static routes on this switch, and existing IPv6 static routes will also be deleted. Before the device is restarted, reconfiguring the **ipv6 unicast- routing** command can recover the deleted IPv6 static routes. After the device is restarted, deleted IPv6 static routes cannot be recovered.

Configuration Steps

↘ Configuring a Static IPv4 Route

Configure the following command on an IPv4-enabled router.

Command	**ip route** *networknet-mask* {*ip-address* | *interface* [*ip-address*]} [*distance*] [**tag** *tag*] [**permanent** [**weight** *number*] [**description***description-text*] [**disabled** | **enabled**]	
Parameter Description	*network*	Indicates the address of the destination network.
	net-mask	Indicates the mask of the destination network.
	ip-address	(Optional) Indicates the next-hop address of the static route. You must specify at least one of *ip-address* and *interface,* or both of them. If *ip-address* is not specified, a static direct route is configured.
	interface	(Optional) Indicates the next-hop exit interface of the static route. You must specify at least one of *ip-address* and *interface,* or both of them. If *interface* is not specified, a

		recursive static direct route is configured. The exit interface is obtained by the next hop in the routing table.
	distance	(Optional) Indicates the administrative distance of the static route. The administrative distance is 1 by default.
	tag	(Optional) Indicates the tag of the static route. The tag is 0 by default.
	permanent	(Optional) Indicates the flag of the permanent route. The static route is not a permanent route by default.
	weight *number*	(Optional) Indicates the weight of the static route. The weight is 1 by default.
	description*description-text*	(Optional) Indicates the description of the static route. By default, no description is configured. *description-text* is a string of one to 60 characters.
	disabled/enabled	(Optional) Indicates the enable flag of the static route. The flag is enabled by default.
Defaults	By default, no static route is configured.	
Command Mode	Global configuration mode	
Usage Guide	The simplest configuration of this command is **ip route** *networknet-maskip-address.*	

Configuring an IPv6 Static Route

Configure the following command on an IPv6-enabled router.

Command	**ipv6 route** *ipv6-prefix/prefix-length* { *ipv6-address* [*interface* [*ipv6-address* [*distance*] [**weight***number*] [**description***description-text*]	
Parameter Description	*ipv6-prefix*	Indicates the IPv6 prefix, which must comply with the address expression specified in RFC4291.
	prefix-length	Indicates the length of the IPv6 prefix. Note that a slash (/) must be added in front of the length.
	ipv6-address	(Optional) Indicates the next-hop address of the static route. You must specify at least one of *ipv6-address* and *interface,* or both of them. If *ipv6-address* is not specified, a static direct route is configured.
	interface	(Optional) Indicates the next-hop exit interface of the static route. You must specify at least one of *ipv6-address* and *interface,* or both of them. If *interface* is not specified, a recursive static direct route is configured. The exit interface is obtained by the next hop in the routing table.
	distance	(Optional) Indicates the administrative distance of the static route. The administrative distance is 1 by default.
	weight *number*	(Optional) Indicates the weight of the static route, which must be specified when you configure equal-cost routes. The weight ranges from 1 to 8. When the weights of all

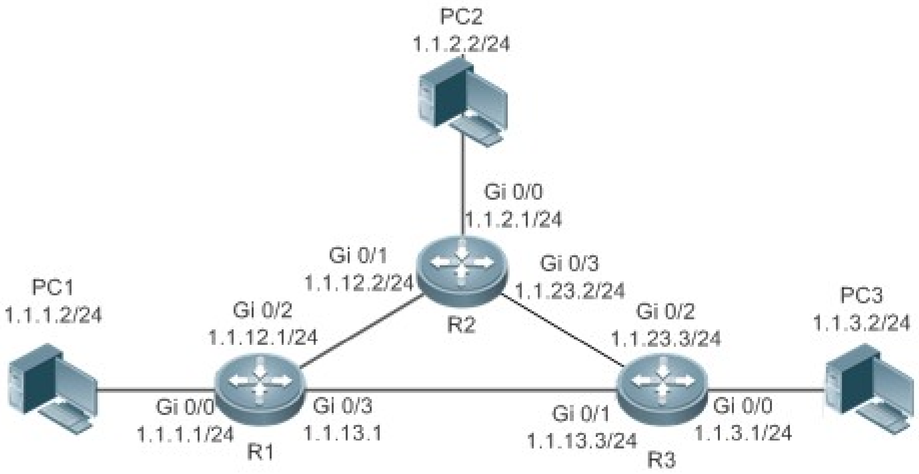
		equal-costroutes of a route are summed up, the sum cannot exceed the maximum number of equal-cost routes that can be configured for the route. Weighting of equal-cost routes of a route indicates the traffic ratio of these routes. The weight is 1 by default.
	description*description-text*	(Optional) Indicates the description of the static route. By default, no description is configured. *description-text* is a string of one to 60 characters.
Defaults	By default, no static route is configured.	
Command Mode	Global configuration mode	
Usage Guide	The simplest configuration of this command is **ipv6 route***ipv6-prefix* / *prefix-lengthipv6-address.*	

Verification

- Run the **show ip route** command to display the IPv4 routing table and check whether the configured IPv4 static route takes effect.
- Run the **show ipv6 route** command to display the IPv6 routing table and check whether the configured IPv6 static route takes effect.

Configuration Example

↘ Configuring Static Routes to Implement Interworking of the IPv4 Network

Scenario **Figure 5-4**	 PC2 1.1.2.2/24 Gi 0/0 1.1.2.1/24 Gi 0/1 1.1.12.2/24 Gi 0/3 1.1.23.2/24 R2 PC1 1.1.1.2/24 Gi 0/2 1.1.12.1/24 Gi 0/2 1.1.23.3/24 PC3 1.1.3.2/24 Gi 0/0 1.1.1.1/24 R1 Gi 0/3 1.1.13.1 Gi 0/1 1.1.13.3/24 R3 Gi 0/0 1.1.3.1/24
Configuration Steps	● Configure interface addresses on each device.
R1	R1#configure terminal R1(config)#interface gigabitEthernet 0/0 R1(config-if-GigabitEthernet 0/0)# ip address 1.1.1.1 255.255.255.0

	R1(config-if-GigabitEthernet 0/0)# exit R1(config)#interface gigabitEthernet 0/2 R1(config-if-GigabitEthernet 0/2)# ip address 1.1.12.1 255.255.255.0 R1(config-if-GigabitEthernet 0/0)# exit R1(config)#interface gigabitEthernet 0/3 R1(config-if-GigabitEthernet 0/3)# ip address 1.1.13.1 255.255.255.0
R2	R2#configure terminal R2(config)#interface gigabitEthernet 0/0 R2(config-if-GigabitEthernet 0/0)# ip address 1.1.2.1 255.255.255.0 R2(config-if-GigabitEthernet 0/0)# exit R2(config)#interface gigabitEthernet 0/1 R2(config-if-GigabitEthernet 0/1)# ip address 1.1.12.2 255.255.255.0 R2(config-if-GigabitEthernet 0/0)# exit R2(config)#interface gigabitEthernet 0/3 R2(config-if-GigabitEthernet 0/3)# ip address 1.1.23.2 255.255.255.0
R3	R3#configure terminal R3(config)#interface gigabitEthernet 0/0 R3(config-if-GigabitEthernet 0/0)# ip address 1.1.3.1 255.255.255.0 R3(config-if-GigabitEthernet 0/0)# exit R3(config)#interface gigabitEthernet 0/1 R3(config-if-GigabitEthernet 0/1)# ip address 1.1.13.3 255.255.255.0 R3(config-if-GigabitEthernet 0/0)# exit R3(config)#interface gigabitEthernet 0/2 R3(config-if-GigabitEthernet 0/2)# ip address 1.1.23.3 255.255.255.0
	● Configure static routes on each device.
R1	R1#configure terminal R1(config)#ip route 1.1.2.0 255.255.255.0 GigabitEthernet 0/2 1.1.12.2 R1(config)# ip route 1.1.3.0 255.255.255.0 GigabitEthernet 0/3 1.1.13.3
R2	R2#configure terminal R2(config)#ip route 1.1.1.0 255.255.255.0 GigabitEthernet 0/1 1.1.12.1 R2(config)# ip route 1.1.3.0 255.255.255.0 GigabitEthernet 0/3 1.1.23.3

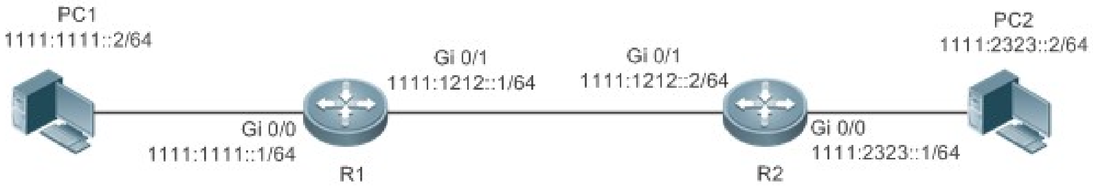
R3	R3#configure terminal R3(config)#ip route 1.1.2.0 255.255.255.0 GigabitEthernet 0/2 1.1.23.2 R3(config)# ip route 1.1.1.0 255.255.255.0 GigabitEthernet 0/1 1.1.13.1
Verification	● Display the routing table.
R1	R1# show ip route Codes: C - Connected, L - Local, S - Static R - RIP, O - OSPF, B - BGP, I - IS-IS N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 IA - Inter area, * - candidate default Gateway of last resort is no set C 1.1.1.0/24 is directly connected, GigabitEthernet 0/0 C 1.1.1.1/32 is local host. S 1.1.2.0/24 [1/0] via 1.1.12.2, GigabitEthernet 0/2 S 1.1.3.0/24 [1/0] via 1.1.13.3, GigabitEthernet 0/2 C 1.1.12.0/24 is directly connected, GigabitEthernet 0/2 C 1.1.12.1/32 is local host. C 1.1.13.0/24 is directly connected, GigabitEthernet 0/3 C 1.1.13.1/32 is local host.

R2	R2# show ip route
	Codes: C - Connected, L - Local, S - Static
	        R - RIP, O - OSPF, B - BGP, I - IS-IS
	        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
	        E1 - OSPF external type 1, E2 - OSPF external type 2
	        SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
	        IA - Inter area, * - candidate default
	
	Gateway of last resort is no set

	S 1.1.1.0/24 [1/0] via 1.1.12.1, GigabitEthernet 0/0 C 1.1.2.0/24 is directly connected, GigabitEthernet 0/0 C 1.1.2.1/32 is local host. S 1.1.3.0/24 [1/0] via 1.1.23.3, GigabitEthernet 0/3 C 1.1.12.0/24 is directly connected, GigabitEthernet 0/1 C 1.1.12.2/32 is local host. C 1.1.23.0/24 is directly connected, GigabitEthernet 0/3 C 1.1.23.2/32 is local host.
R3	R3# show ip route Codes: C - Connected, L - Local, S - Static R - RIP, O - OSPF, B - BGP, I - IS-IS N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 IA - Inter area, * - candidate default Gateway of last resort is no set S 1.1.1.0/24 [1/0] via 1.1.13.1, GigabitEthernet 0/2 S 1.1.2.0/24 [1/0] via 1.1.23.2, GigabitEthernet 0/2 C 1.1.3.0/24 is directly connected, GigabitEthernet 0/0 C 1.1.3.1/32 is local host. C 1.1.13.0/24 is directly connected, GigabitEthernet 0/1 C 1.1.13.3/32 is local host. C 1.1.23.0/24 is directly connected, GigabitEthernet 0/2 C 1.1.23.3/32 is local host.

- The 29 series products do not support ISIS and BGP.

Configuring Static Routes to Implement Interworking of the IPv6 Network

Scenario **Figure 5-5**	 PC1 1111:1111::2/64 Gi 0/0 1111:1111::1/64 R1 Gi 0/1 1111:1212::1/64 Gi 0/1 1111:1212::2/64 R2 Gi 0/0 1111:2323::1/64 PC2 1111:2323::2/64
Configuration Steps	● Configure interface addresses on each device.
R1	R1#configure terminal R1(config)#interface gigabitEthernet 0/0 R1(config-if-GigabitEthernet 0/0)# ipv6 address 1111:1111::1/64 R1(config-if-GigabitEthernet 0/0)# exit R1(config)#interface gigabitEthernet 0/1 R1(config-if-GigabitEthernet 0/1)# ipv6 address 1111:1212::1/64
R2	R2#configure terminal R2(config)#interface gigabitEthernet 0/0 R2(config-if-GigabitEthernet 0/0)#ipv6 address 1111:2323::1/64 R2(config-if-GigabitEthernet 0/0)# exit R2(config)#interface gigabitEthernet 0/1 R2(config-if-GigabitEthernet 0/1)# ipv6 address 1111:1212::2/64
	● Configure static routes on each device.
R1	R1#configure terminal R1(config)# ipv6 route 1111:2323::0/64 gigabitEthernet 0/1
R2	R2#configure terminal R2(config)#ipv6 route 1111:1111::0/64 gigabitEthernet 0/1
Verification	● Display the routing table.
R1	R1# show ipv6 route IPv6 routing table name - Default - 10 entries Codes: C - Connected, L - Local, S - Static R - RIP, O - OSPF, B - BGP, I - IS-IS

```
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       IA - Inter area

C      1111:1111::/64 via GigabitEthernet 0/0, directly connected
L      1111:1111::1/128 via GigabitEthernet 0/0, local host
C      1111:1212::/64 via GigabitEthernet 0/1, directly connected
L      1111:1212::1/128 via GigabitEthernet 0/1, local host
S      1111:2323::/64 [1/0] via GigabitEthernet 0/1, directly connected
C      FE80::/10 via ::1, Null0
C      FE80::/64 via GigabitEthernet 0/0, directly connected
L      FE80::2D0:F8FF:FEFB:C092/128 via GigabitEthernet 0/0, local host
C      FE80::/64 via GigabitEthernet 0/1, directly connected
L      FE80::2D0:F8FF:FEFB:C092/128 via GigabitEthernet 0/1, local host
```

R2

```
R2# show ipv6 route

IPv6 routing table name - Default - 10 entries
Codes:  C - Connected, L - Local, S - Static
       R - RIP, O - OSPF, B - BGP, I - IS-IS
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       IA - Inter area

C      1111:2323::/64 via GigabitEthernet 0/0, directly connected
L      1111:2323::1/128 via GigabitEthernet 0/0, local host
C      1111:1212::/64 via GigabitEthernet 0/1, directly connected
L      1111:1212::1/128 via GigabitEthernet 0/1, local host
S      1111:1111::/64 [1/0] via GigabitEthernet 0/1, directly connected
C      FE80::/10 via ::1, Null0
```

	C FE80::/64 via GigabitEthernet 0/0, directly connected L FE80::2D0:F8FF:FEFB:C092/128 via GigabitEthernet 0/0, local host C FE80::/64 via GigabitEthernet 0/1, directly connected L FE80::2D0:F8FF:FEFB:C092/128 via GigabitEthernet 0/1, local host

- The 29 series products do not support ISIS and BGP.

Common Errors

- The link on the interface is not up.
- No IP address is configured for the interface.

3.4.2 Configuring a Default Route

Configuration Effect

- Generate a default route in the routing table. The default route is used to forward packets that cannot be forwarded by other routes.

Notes

- On a L2 switch, run the **ip default gateway** or **ipv6 default gateway** command to configure the default gateway.
- On a L3 switch, run the **ip route** 0.0.0.0 0.0.0.0 *gateway*or **ipv6 route** ::/0 *ipv6-gateway*command to configure the default gateway.
- If the **no ip routing** or **no ipv6 unicast- routing** command is configured on a L3 switch, you can run the **ip default gateway** or **ipv6 default gateway** command to configure the default gateway.

Configuration Steps

Configuring the IPv4 Gateway on a L2 Switch

Command	**ip default-gateway***gateway*
Parameter Description	*gateway* indicates the IPv4 gateway address.
Defaults	By default, no static default route is configured.
Command Mode	Global configuration mode
Usage Guide	N/A

Configuring the IPv6 Gateway on a L2 Switch

Command	**ipv6 default-gateway***gateway*

Parameter Description	*gateway*	indicates the IPv6 gateway address.
Defaults	By default, no static default route is configured.	
Command Mode	Global configuration mode	
Usage Guide	N/A	

Configuring the IPv4 Default Gateway on a L3 Switch

Command	**ip route 0.0.0.00.0.0.0**{*ip-address* | *interface* [*ip-address*]} [*distance*] [**tag** *tag*] [**permanent**] [**weight** *number*] [**description***description-text*] [**disabled** | **enabled**]	
Parameter Description	**0.0.0.0**	Indicates the address of the destination network.
	0.0.0.0	Indicates the mask of the destination network.
	ip-address	(Optional) Indicates the next-hop address of the static route. You must specify at least one of *ip-address* and *interface,* or both of them. If *ip-address* is not specified, a static direct route is configured.
	interface	(Optional) Indicates the next-hop exit interface of the static route. You must specify at least one of *ip-address* and *interface,* or both of them. If *interface* is not specified, a recursive static direct route is configured. The exit interface is obtained by the next hop in the routing table.
	distance	(Optional) Indicates the administrative distance of the static route. The administrative distance is 1 by default.
	tag	(Optional) Indicates the tag of the static route. The tag is 0 by default.
	permanent	(Optional) Indicates the flag of the permanent route. The static route is not a permanent route by default.
	weight *number*	(Optional) Indicates the weight of the static route. The weight is 1 by default.
	description*description-text*	(Optional) Indicates the description of the static route. By default, no description is configured. *description-text* is a string of one to 60 characters.
	disabled /enabled	(Optional) Indicates the enable flag of the static route. The flag is enabled by default.
Defaults	By default, no static default route is configured.	
Command Mode	Global configuration mode	
Usage Guide	The simplest configuration of this command is **ip route0.0.0.0 0.0.0.0** *ip-address.*	

Configuring the IPv6 Default Gateway on a L3 Switch

Command	**ipv6 route::/0** { *ipv6-address* | *interface* [*ipv6-address* } [*distance*] [**weight***number*] [**description***description-text*]

Parameter Description	**::**	Indicates the IPv6 prefix, which must comply with the address expression specified in RFC4291.
	0	Indicates the length of the IPv6 prefix. Note that a slash (/) must be added in front of the length.
	Ipv6-address	(Optional) Indicates the next-hop address of the static route. You must specify at least one of *ipv6-address* and *interface,* or both of them. If *ipv6-address* is not specified, a static direct route is configured.
	interface	(Optional) Indicates the next-hop exit interface of the static route. You must specify at least one of *ipv6-address* and *interface,* or both of them. If *interface* is not specified, a recursive static direct route is configured. The exit interface is obtained by the next hop in the routing table.
	distance	(Optional) Indicates the administrative distance of the static route. The administrative distance is 1 by default.
	weight *number*	(Optional) Indicates the weight of the static route, which must be specified when you configure equal-cost routes. The weight ranges from 1 to 8. When the weights of all equal-cost routes of a route are summed up, the sum cannot exceed the maximum number of equal-cost routes that can be configured for the route. Weighting of equal-cost routes of a route indicates the traffic ratio of these routes. The weight is 1 by default.
	description*description-text*	(Optional) Indicates the description of the static route. By default, no description is configured. *description-text* is a string of one to 60 characters.
Defaults	By default, no static default route is configured.	
Command Mode	Global configuration mode	
Usage Guide	The simplest configuration of this command is **ipv6 route** ::/0 *ipv6-gateway.*	

Configuring the IPv4 Default Network on a L3 Switch

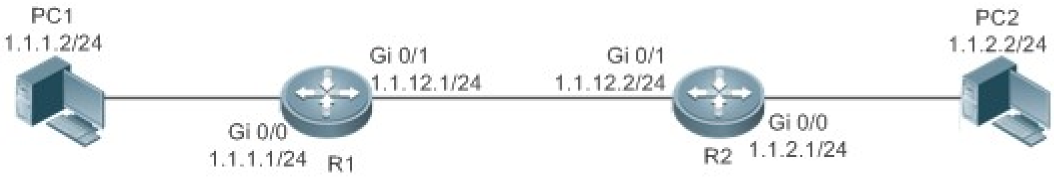
Command	**ip default-network** *network*	
Parameter Description	*network*	Indicates the address of the network. (The network must be a Class A, B, or C network.)
Defaults	By default, no default network is configured.	
Command Mode	Global configuration mode	
Usage Guide	If the network specified by the **ip default-network** command exists, a default route is generated and the next hop to this network is the default gateway. If the network specified by the **ip default-network** command does not exist, the default route is not generated.	

Verification

- On a L2 switch (or a L3 switch where routing is disabled), run the **show ip redirects** or **show ipv6 redirects** command to display the default gateway.
- On a L3 switch where routing is enabled, run the **show ip route** or **show ipv6 route** command to display the default route.

Configuration Example

↘ Configuring IPv4 Default Routes on L3 Switches to Implement Network Interworking

Scenario **Figure 5-6**	 PC1 1.1.1.2/24 Gi 0/1 1.1.12.1/24 Gi 0/1 1.1.12.2/24 PC2 1.1.2.2/24 Gi 0/0 1.1.1.1/24 R1 Gi 0/0 1.1.2.1/24 R2
Configuration Steps	● Configure IP addresses on L3 devices.
R1	R1#configure terminal R1(config)#interface gigabitEthernet 0/0 R1(config-if-GigabitEthernet 0/0)# ip address 1.1.1.1 255.255.255.0 R1(config-if-GigabitEthernet 0/0)# exit R1(config)#interface gigabitEthernet 0/1 R1(config-if-GigabitEthernet 0/1)# ip address 1.1.12.1 255.255.255.0 R1(config-if-GigabitEthernet 0/0)# exit
R2	R2#configure terminal R2(config)#interface gigabitEthernet 0/0 R2(config-if-GigabitEthernet 0/0)# ip address 1.1.2.1 255.255.255.0 R2(config-if-GigabitEthernet 0/0)# exit R2(config)#interface gigabitEthernet 0/1 R2(config-if-GigabitEthernet 0/1)# ip address 1.1.12.2 255.255.255.0 R2(config-if-GigabitEthernet 0/0)# exit
R1	● Configure an IPv6 default gateway on R 1. R1#configure terminal R1(config)#ip route 0.0.0.0 0.0.0.0 GigabitEthernet 0/1 1.1.12.2

R2	R2#configure terminal R2(config)#ip route 0.0.0.0 0.0.0.0 GigabitEthernet 0/1 1.1.12.1
Verification	● Display the routing table.
R1	R1# show ip route Codes: C - Connected, L - Local, S - Static R - RIP, O - OSPF, B - BGP, I - IS-IS N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 SU - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 IA - Inter area, * - candidate default Gateway of last resort is 1.1.12.2 S* 0.0.0.0/0 [1/0] via 1.1.12.2, GigabitEthernet 0/1 C 1.1.1.0/24 is directly connected, GigabitEthernet 0/0 C 1.1.1.1/32 is local host. C 1.1.12.0/24 is directly connected, GigabitEthernet 0/1 C 1.1.12.1/32 is local host.

3.4.3 Configuring Route Limitations

Configuration Effect

- Limit the number of equal-cost routes and number of static routes, or disable routing.

Notes

Route limitations cannot be configured on a L2 switch.

Configuration Steps

↘ Configuring the Maximum Number of Equal-Cost Routes

Command	**maximum-paths***number*	
Parameter Description	*number*	Indicates the maximum number of equal-cost routes. The value ranges from 1 to 32.
Defaults	By default, the number of equal cost routes is 32.	
Command	Global configuration mode	

Mode	
Usage Guide	Run this command to configure the maximum number of next hops in the equal-cost route. In load balancing mode, the number of routes on which traffic is balanced does not exceed the configured number of equal-cost routes.

Configuring the Maximum Number of IPv4 Static Routes

Command	**ip static route-limit***number*
Parameter Description	*number* Indicates the upper limit of routes. The value ranges from 1 to 10,000.
Defaults	By default, a maximum of 1,024 IP static routes can be configured.
Command Mode	Global configuration mode
Usage Guide	Run this command to configure the maximum number of IPv4 static routes. If the maximum number of IPv4 static routes is reached, no more IPv4 static route can be configured.

Configuring the Maximum Number of IPv6 Static Routes

Command	**ipv6 static route-limit***number*
Parameter Description	*number* Indicates the upper limit of routes. The value ranges from 1 to 10,000.
Defaults	By default, a maximum of 1,000 IPv6 static routes can be configured.
Command Mode	Global configuration mode
Usage Guide	Run this command to configure the maximum number of IPv6 static routes. If the maximum number of IPv6 static routes is reached, no more IPv6 static route can be configured.

Disabling IPv4 Routing

Command	**no ip routing**
Parameter Description	N/A
Defaults	By default, IPv4 routing is enabled.
Command Mode	Global configuration mode
Usage Guide	Run this command to disable IPv4 routing. If the device functions only as a bridge or a voice over IP (VoIP) gateway, the device does not need to use the IPv4 routing function of the switch software. In this case, you can disable the IPv4 routing function of the switch software.

Disabling IPv6 Routing

Command	**no ipv6 unicast-routing**
Parameter Description	N/A
Defaults	By default, IPv6 routing is enabled.
Command Mode	Global configuration mode
Usage Guide	Run this command to disable IPv6 routing. If the device functions only as a bridge or a VoIP gateway, the device does not need to use the IPv6 routing function of the switch software. In this case, you can disable the IPv6 routing function of the switch software.

3.5 Monitoring

Displaying

Description	Command
Displays the IPv4 routing table.	**show ip route**
Displays the IPv6 routing table.	**show ipv6route**

Debugging

- System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs IPv4 route management.	**debug nsm kernel ucast- v4**
Debugs IPv6 route management.	**debug nsm kernel ucast-v6**
Debugs default network management.	**debug nsm kernel default-network**
Debugs internal events of route management.	**debug nsm events**
Debugs sending of route management and routing protocol messages.	**debug nsm packet send**
Debugs receiving of route management and routing protocol messages.	**debug nsm packet recv**

4 Configuring Keys

4.1 Overview

Keys are a kind of parameters that are used in algorithms for conversion from plain text to cipher text or from cipher text to plain text.

Plain text and cipher text authentication are supported for packet authentication in a routing protocol, during which keys need to be used.

- At present, keys are used only for RIP and ISIS packet authentication.

4.2 Applications

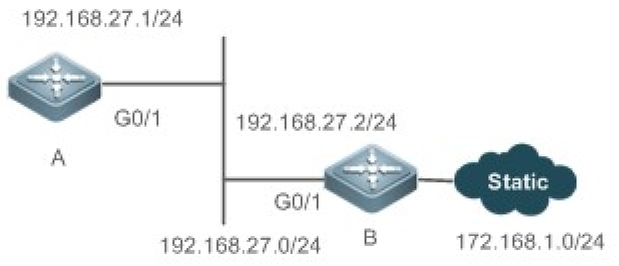
Application	Description
RIP Authentication	RIP uses keys for packet authentication.

4.2.1 RIP Authentication

Scenario

Network devices run RIP and use the MD5 authentication mode to increase the protocol security.

Figure 6-1



Deployment

- Configure a key chain on A. Configure RIP to enable packet authentication and use the key chain.
- Configure a key chain on B. Configure RIP to enable packet authentication and use the key chain.

4.3 Features

Overview

Feature	Description
Key Chain	Provide a tool for authentication in a routing protocol.

4.3.1 Key Chain

Working Principle

A key chain may contain multiple different keys. Each key contains the following attributes:

- Key ID: Identifies a key. In the current key chain, keys and IDs are mapped in the one-to-one manner.
- Authentication string: Indicates a set of key characters used for verifying the consistency of authentication strings in a routing protocol.
- Lifetime: Specifies the lifetime of the current key for sending or receiving packets. Different authentication keys can be used in different periods.

Related Configuration

↘ Creating a Key Chain and a Key

In the global configuration mode, run the **key chain** *key-chain-name* command to define a key chain and enter the key chain configuration mode.

In the key chain configuration mode, run the **key** *key-id* command to define a key and enter the key chain key configuration mode.

↘ Configuring an Authentication String

In the key chain key configuration mode, run the **key-string** [**0**|**7**] *text* command to specify an authentication string.

- A plain text authentication string is configured by default. The value **0** indicates that a plain text authentication key is configured.
- The value **7** indicates that a cipher text authentication string is configured.
- The encryption authentication service is disabled by default. You can run the **service password-encryption** command to enable the encryption service to forcibly convert plain text authentication into cipher text.

↘ Configuring Lifetime

In the key chain key configuration mode, you can configure the lifetime of a key chain in the receiving and sending directions.

- **accept-lifetime** *start-time* { **infinite** | *end-time* | **duration** *seconds* }: Configures the lifetime of a key chain in the receiving direction.
- **send-lifetime** *start-time* { **infinite** | *end-time* | **duration** *seconds* }: Configures the lifetime of a key chain in the sending direction.

4.4 Configuration

Configuration	Description and Command	
Configuring a Key Chain	● (Mandatory) It is used to create a key.	
	key chain	Creates a key chain.
	key	Configures a key ID.
	key-string	Configures a key string.
	accept-lifetime	Configures the lifetime in the receiving direction.
	send-lifetime	Configures the lifetime in the sending direction.

4.4.1 Configuring a Key Chain

Configuration Effect

- Define a key chain to be used by a routing protocol.

Notes

- A key chain can take effect only after it is associated with a routing protocol.

Configuration Steps

Creating a Key Chain

- This configuration is mandatory if a key chain needs to be used.
- If there is no special requirement, you should perform this configuration on all routers for which routing protocol authentication needs to be performed.

Configuring a Key ID

- This configuration is mandatory if a key chain needs to be used.
- If there is no special requirement, you should perform this configuration on all routers for which routing protocol authentication needs to be performed.

Configuring a Key String

- This configuration is mandatory if a key chain needs to be used.
- If there is no special requirement, you should perform this configuration on all routers for which routing protocol authentication needs to be performed.

Configure the Lifetime in the Receiving Direction

- Optional.

- If the lifetime in the sending direction is not configured, the key chain will be always effective.

Configure the Lifetime in the Sending Direction

- Optional.
- If the lifetime in the sending direction is not configured, the key chain will be always effective.

Verification

- Use keys in a routing protocol and observe the neighborship established by the routing protocol. If the keys are inconsistent, the neighborship fails to be established.

Related Commands

Configuring a Key Chain

Command	**key chain** *key-chain-name*
Parameter Description	*key-chain-name*: Indicates the name of a key chain.
Command Mode	Global configuration mode
Usage Guide	To make a key chain take effect, you must configure at least one key.

Configuring a Key ID

Command	**key** *key-id*
Parameter Description	*key-id*: Indicates the authentication key ID in a key chain, ranging from 0 to 2,147,483,647.
Command Mode	Key chain configuration mode.
Usage Guide	-

Configuring a Key Authentication String

Command	**key-string** [**0**|**7**] *text*
Parameter Description	**0:** Specifies that the key is displayed in plain text. **7:** Specifies that the key is displayed in cipher text. ***text***: Specifies the authentication string characters.
Command Mode	Key chain key configuration mode.
Usage Guide	-

Configuring the Lifetime in the Sending Direction

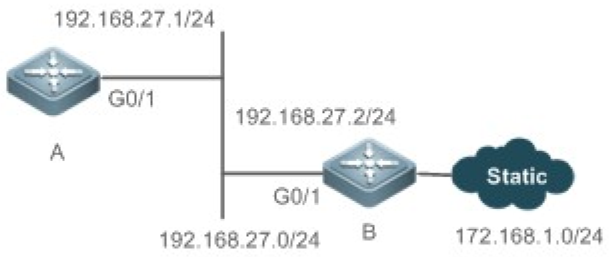
Command	**send-lifetime** *start-time* {**infinite** | *end-time* | **duration** *seconds*}
Parameter Description	***start-time***: Indicates the start time of the lifetime. **infinite:** Indicates that the key is always effective. ***end-time***: Indicates the end time of the lifetime, which must be later than start-time. **duration *seconds***: Specifies the duration from the start time to the end time, ranging from 1 to 2,147,483,646.
Command Mode	Key chain key configuration mode.
Usage Guide	Run this command to define the lifetime of the key in the sending direction.

Configuring the Lifetime in the Receiving Direction

Command	**accept-lifetime** *start-time* **{infinite |** *end-time* **| duration** *seconds***}**
Parameter Description	***start-time***: Indicates the start time of the lifetime. **infinite:** Indicates that the key is always effective. ***end-time***: Indicates the end time of the lifetime, which must be later than start-time. **duration *seconds***: Specifies the duration from the start time to the end time, ranging from 1 to 2,147,483,646.
Command Mode	Key chain key configuration mode.
Usage Guide	Run this command to define the lifetime of the key in the receiving direction.

Configuration Example

Configuring a Key Chain and Using the Key Chain in RIP Packet Authentication

Scenario **Figure 6-2**	 192.168.27.1/24 G0/1 A 192.168.27.2/24 G0/1 Static 192.168.27.0/24 B 172.168.1.0/24
Configuration Steps	● Configure a key on all routers. ● Configure RIP on all routers. ● Enable RIP authentication on all routers.
A	A>enable A#configure terminal

```
A(config)#key chain ripchain
A(config-keychain)#key 1
A(config-keychain-key)#key-string Hello
A(config-keychain-key)#accept-lifetime 16:30:00 Oct 1 2013 duration 43200
A(config-keychain-key)#send-lifetime 16:30:00 Oct 1 2013 duration 43200
A(config-keychain-key)#exit
A(config-keychain)#key 2
A(config-keychain-key)#key-string World
A(config-keychain-key)#accept-lifetime 04:00:00 Oct 2 2013 infinite
A(config-keychain-key)#send-lifetime 04:00:00 Oct 2 2013 infinite
A(config-keychain-key)#exit
A(config)#interface gigabitEthernet 0/1
A(config-if)#ip address 192.168.27.1 255.255.255.0
A(config-if)#ip rip authentication key-chain ripchain
A(config-if)#ip rip authentication mode md5
A(config-if)#exit
A(config)#router rip
A(config-router)#version 2
A(config-router)#network 192.168.27.0
```

B

```
B>enable
B#configure terminal
B(config)#key chain ripchain
B(config-keychain)#key 1
B(config-keychain-key)#key-string Hello
B(config-keychain-key)#accept-lifetime 16:30:00 Oct 1 2013 duration 43200
B(config-keychain-key)#send-lifetime 16:30:00 Oct 1 2013 duration 43200
B(config-keychain-key)#exit
B(config-keychain)#key 2
B(config-keychain-key)#key-string World
B(config-keychain-key)#accept-lifetime 04:00:00 Oct 2 2013 infinite
B(config-keychain-key)#send-lifetime 04:00:00 Oct 2 2013 infinite
```

	B(config-keychain-key)#exit B(config)#interface gigabitEthernet 0/1 B(config-if)#ip address 192.168.27.2 255.255.255.0 B(config-if)#ip rip authentication key-chain ripchain B(config-if)#ip rip authentication mode md5 B(config-if)#exit B(config)#router rip B(config-router)#version 2 B(config-router)#network 192.168.27.0 B(config-router)#redistribute static
Verification	Run the **show ip route rip** command to check whether router A can receive an RIP route from router B.
A	A(config)#show ip route rip R 172.168.0.0/16 [120/1] via 192.168.27.2, 00:05:16, GigabitEthernet 0/1

Common Errors

- A key is not correctly associated with a routing protocol, which causes that authentication does not take effect.
- The keys configured on multiple routers are not consistent, which causes authentication failure.

4.5 Monitoring

Displaying

Description	Command
Displays the configurations of a key chain.	**show key chain** [*key-chain-name*]

5 Configuring Routing Policies

5.1 Overview

Routing policies are a policy set for changing the packet forwarding path or routing information and are often implemented by a filtering list and a route map. Routing policies are flexibly and widely applied in the following methods:

- Use a filtering list in a routing protocol to filter or modify routing information.
- Use a route map in a routing protocol to filter or modify routing information. Where, the route map can further use a filtering list.
- Use a route map in policy-based routing (PBR) to control packet forwarding or modify packet fields.

5.2 Applications

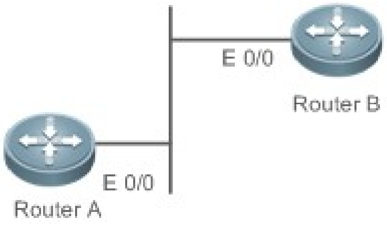
Application	Description
Route Filtering	Use a filtering list in a routing protocol to filter the routing information sent or received by the protocol.
Route Re-distribution	Use a route map in a routing protocol to filter or modify routing information and re-distribute RIP routes to OSPF. Only RIP routes with 4 hops can be re-distributed.

5.2.1 Route Filtering

By default, a routing protocol advertises and learns all routing information. When a filtering list is used, the routing protocol advertises only required routes or receives only required routing information.

Scenario

Figure 7-1



As shown in Figure 7-1, router A has routes to 3 networks: 10.0.0.0, 20.0.0.0 and 30.0.0.0.

Configure a filtering list on the routers to achieve the following purposes:

- Filter the sent routing information on router A to filter routes that router A does not need to send.

- Filter the received routing information on router B to filter routes that router B does not need to learn.

Deployment

- Filter the sent routing information 30.0.0.0 on router A.
- Filter the received routing information 20.0.0.0 on router B to ensure that router B learns only routing information 10.0.0.0.

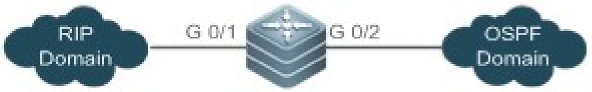
5.2.2 Route Re-distribution

By default, route re-distribution will re-distribute all routing information in a routing protocol to another routing protocol. All routing attributes will also be inherited. You can use a route map to perform conditional control for re-distribution between two routing protocols, including:

- Specify the range for re-distributing routes and re-distribute only routing information that meets certain rules.
- Set the attributes of routes generated by re-distribution.

Scenario

Figure 7-2



As shown in Figure 7-2, configure route re-distribution on the devices to achieve the following purposes:

- Re-distribute only RIP routes with 4 hops to OSPF.
- In the OSPF routing domain, the initial metric of this route is 40, the route type is the external route type-1 and the route tag value is set to 40.

Deployment

- Configure a route with 4 hops in the route map rip_to_ospf: match, and set the initial metric of this route to 40, the route type to the external route type-1 and the route tag value to 40.
- Configure route re-distribution to re-distribute RIP routes to OSPF and use the route map rip_to_ospf.

5.3 Features

Overview

Feature	Description
Filtering List	Define a group of lists based on a route attribute, which can be used by a routing protocol for route filtering.
Route Map	A policy defines "if certain conditions are matched, you can perform certain processing actions".

5.3.1 Filtering List

Filtering lists are a group of lists defined based on a routing attribute and are a tool for filtering routing policies. Independent filtering lists are meaningless and can be used to filter routes only when they are applied in a routing protocol.

Working Principle

Based on different routing attributes, filtering lists are classified into the following types:

↘ Access Control List (ACL)

ACLs comprise IPv4 and IPv6 ACLs. When defining ACLs, you can specify IPv4/IPv6 addresses and masks to match the destination network segment or next-hop addresses of routing information.

For description about ACLs, see the *ACL Configuration Guide*.

↘ Address Prefix List (prefix-list)

Similar to ACLs, prefix-lists, including IPv4 prefix-lists and IPv6 prefix-lists, are used to match destination network segments of routing information during route filtering.

Related Configuration

↘ Creating an ACL

By default, no ACL is configured and no policy is set.

In the global configuration mode, run the **ip access-list** { **extended** | **standard** } { *id* | *name* } command to create an IPv4 ACL.

You can set multiple policies in an ACL, sorted by their sequence numbers. Policies have two working modes: permit and deny.

↘ Creating a Prefix-List

By default, no prefix-list is configured and no entry is set.

In the global configuration mode, run the **ip prefix-list** *prefix-list-name* [**seq** *seq-number*] { **deny** | **permit** } *ip-prefix* [**ge** *minimum-prefix-length*] [**le** *maximum-prefix-length*] command to create an IPv4 prefix-list and add a prefix entry to the list.

You can set multiple entries in the prefix-list, sorted by their sequence numbers. Entries have two working modes: permit and deny.

Run the **ip prefix-list** *prefix-list-name* **description** *descripton-text* command to add description to the prefix-list.

Run the **ip prefix-list sequence-number** command to enable the sorting function for the prefix-list.

↘ Creating an Extcommunity-List

By default, no excommunity-list is configured and no entry is set.

In the global configuration mode, run the **ip extcommunity-list** {*standard-list* **| standard** *list-name* } { **permit | deny** } [**rt** *value*] [**soo** *value*] command to create a standard extcommunity list and add an entry to the list.

Run the **ip extcommunity-list** {*expanded-list* | **expanded** *list-name* } { **permit | deny** } [*regular-expression*] command to create an extcommunity list and add an entry to the list.

You can also run the **ip extcommunity-list** {*expanded-list* | **expanded** *list-name*| *standard-list* | **standard** *list-name* } command to create an extcommunity list and enter the configuration mode of **ip extcommunity-list** to add entries.

You can set multiple entries in the extcommunity-list. Entries have two working modes: permit and deny.

5.3.2 Route Map

A policy is a "match …, set…" statement, which indicates that "if certain conditions are matched, you can perform some processing actions".

Working Principle

↘ Executing policies

A route map may contain multiple policies. Each policy has a corresponding sequence number. A smaller sequence number means a higher priority. Policies are executed based on their sequence numbers. Once the matching condition of a policy is met, the processing action for this policy needs to be performed and the route map exits. If no matching condition of any policy is met, no processing action will be performed.

↘ Working Modes Of Policies

Policies have two working modes:

- permit: When the matching condition of a policy is met, the processing action for this policy will be performed and the route map will exit.
- deny: When the matching condition of a policy is met, the processing action for this policy will not be performed and the route map will exit.

↘ Matching Conditions Of Policies

The matching condition of a policy may contain 0, 1 or more match rules.

- If the matching condition contains 0 match rule, no packet will be matched.
- If the matching condition contains one or more match rules, all rules must be matched.

↘ Processing Action for a Policy

The processing action of a policy may contain 0, 1 or more set rules.

- If the processing action contains 0 set rule, no processing action will be performed and the route map will directly exit.
- If the processing action contains one or more set rules, all processing actions will be performed and then the route map will exit.

- If set rules have different priorities, the set rule with the highest priority will take effect.

Related Configuration

Creating a Route Map (Policy)

By default, no route map is configured and no policy is set.

In the global configuration mode, you can run the **route-map** *route-map-name* [**permit** | **deny**] [*sequence-number*] command to create a route map and add a policy to the route map.

You can set multiple policies in a route map. Each policy uses different sequence numbers.

Setting Matching Conditions of a Policy

By default, no match rule is set (that is, the matching condition of a policy contains 0 match rule).

In the route map mode, run the **match** command to set match rules. One **match** command is mapped to one match rule.

switch provides abundant **match** commands for setting flexible matching conditions.

Command	Description
match interface	Uses the output interface of a route as the matching condition.
match ip address	Uses the destination IPv4 address of a route as the matching condition.
match ip next-hop	Uses the next-hop IPv4 address of a route as the matching condition.
match ip route-source	Uses the source IPv4 address of a route as the matching condition.
match ipv6 address	Uses the destination IPv6 address of a route as the matching condition.
match ipv6 next-hop	Uses the next-hop IPv6 address of a route as the matching condition.
match ipv6 route-source	Uses the source IPv6 address of a route as the matching condition.
match metric	Uses the metric of a route as the matching condition.
match route-type	Uses the type of a route as the matching condition.
match tag	Uses the tag value of a route as the matching condition.

Setting the Processing Actions of a Policy

By default, no set rule is configured (that is, the processing action of a policy contains 0 set rule).

In the route map mode, run the **set** command to configure set rules. One **set** command is mapped to one set rule.

switch provides abundant **set** commands for setting flexible processing actions.

Command	Description
set ip default nexthop	Specifies the default next hop of a route. This command has a lower priority than a common route and a higher priority than **set default interface**.
set ip dscp	Modifies the **dscp** field of an IP packet.
set ip global next-hop	Specifies the next hop of a route, which belongs to a global VRF.
set ip precedence	Modifies the **precedence** field of an IP packet.
set ip tos	Modifies the **tos** field of an IP packet.

Command	Description
set level	Sets the destination area type to which a route will be directed.
set metric	Modifies the metric value of a route.
set metric-type	Sets the metric type of a route.
set next-hop	Sets the next-hop IP address of a route.
set tag	Sets the tag value of a route.

5.4 Configuration

Configuration	Description and Command	
Configuring a Route Map	● (Optional) It is used to define a policy.	
	route-map	Creates a policy (route map).
	match	Sets the matching conditions of the policy.
	set	Sets the processing actions of the policy.
Configuring a Filtering List	● (Optional) It is used to define a filtering list.	
	ip as-path	Defines AS path filtering rules.
	ip community-list	Defines a community list.
	ip prefix-list	Creates a prefix-list.
	ip prefix-list description	Adds description to a prefix-list.
	ip prefix-list sequence-number	Enables the sorting function for a prefix-list.
	Ipv6 prefix-list	Creates an IPv6 prefix-list.
	ipv6 prefix-list description	Adds description to an IPv6 prefix-list.
	ipv6 prefix-list sequence-number	Enables the sorting function for an IPv6 prefix-list.

5.4.1 Configuring a Route Map

Configuration Effect

- Define a set of routing policies to be used by routing protocols or PBR.

Notes

- If a **match** command uses an ACL to define packet matching conditions, the ACL must be configured.
- The following **match** commands cannot be configured at the same time:

The Following match Commands	Cannot Be Configured with the Following match Commands At the Same Time
match ip address	**match ip prefix-list**
match ipv6 address	**match ipv6 prefix-list**
match ip next-hop	**match ip next-hop prefix-list**
match ipv6 next-hop	**match ipv6 next-hop prefix-list**
match ip route-source	**match ip route-source prefix-list**
match ipv6 route-source	**match ipv6 route-source prefix-list**

- The following **set** commands cannot be configured at the same time:

The Following set Commands	Cannot Be Configured with the Following set Commands At the Same Time
set ip dscp	**set ip tos**
set ip dscp	**set ip precedence**

Configuration Steps

↘ Creating a Policy (Route Map)

- Mandatory.
- Perform this configuration on a device to which a policy needs to be applied.

↘ Setting Matching Conditions of a Policy

- Optional.
- If no match rule is configured, no packet will be matched.
- If multiple match rules are configured, all the match rules must be matched.
- Perform this configuration on a device to which a policy needs to be applied.

↘ Setting the Processing Actions of a Policy

- Optional.
- If no set rule is configured, no processing action will be performed.
- If multiple set rules are configured, all set rules must be executed (if the set rules have different priorities, the set rule with the highest priority takes effect).
- Perform this configuration on a device to which a policy needs to be applied.

Verification

- Check the configurations of the route map.

Related Commands

Creating a Policy (Route Map)

Command	**route-map** *route-map-name* [{ **permit** | **deny** } *sequence*]
Parameter Description	*route-map-name*: Indicates the name of a route map, comprising not more than 32 characters. permit: Specifies the working mode of this policy as permit, which is the default mode. deny: Specifies the working mode of this policy as deny. The default mode is permit. *sequence*: Specifies the sequence number of this policy. A smaller value means a higher priority. The default value is 10.
Command Mode	Global configuration mode
Usage Guide	If this route map is unavailable, this command will create a route map and add a policy to the route map. If this route map is available, this command will add a policy to the route map.

Command	**match interface** *interface-type interface-number* [*…interface-type interface-number*]
Parameter Description	*interface-type interface-number*: Indicates the interface type and interface number.
Command Mode	Route map configuration mode
Usage Guide	This match rule is used to match the next-hop output interface of a route or a packet.

Command	**match ip address** { *access-list-number* [*access-list-number...* | *access-list-name...*] | *access-list-name* [*access-list-number...*| *access-list-name*] | **prefix-list** *prefix-list-name* [*prefix-list-name...*] }
Parameter Description	*access-list-number*: Indicates the access list number. For a standard access list, the value ranges are 1 to 99 and 1300 to 1999. For an extended access list, the value ranges are 100 to 199 and 2000 to 2699. *access-list-name*: Indicates the access list name. **prefix-list** *prefix-list-name*: Indicates the name of a prefix-list to be matched.
Command Mode	Route map configuration mode
Usage Guide	This match rule matches the destination IPv4 address of a packet or route by using an ACL or a prefix-list. An ACL and a prefix-list cannot be configured at the same time.

Command	**match ip next-hop** { *access-list-number* [*access-list-number...* | *access-list-name...*] | *access-list-name* [*access-list-number...* | *access-list-name*] | **prefix-list** *prefix-list-name* [*prefix-list-name...*] }
Parameter Description	*access-list-number*: Indicates the access list number. For a standard access list, the value ranges are 1 to 99 and 1300 to 1999. For an extended access list, the value ranges are 100 to 199 and 2000 to 2699.

	access-list-name: Indicates the access list name. **prefix-list** *prefix-list-name*: Indicates the name of a prefix-list to be matched.
Command Mode	Route map configuration mode
Usage Guide	This match rule matches the next-hop IPv4 address of a route by using an ACL or a prefix-list. An ACL and a prefix-list cannot be configured at the same time.

Command	**match ip route-source** { *access-list-number* [*access-list-number...* | *access-list-name...*] | *access-list-name* [*access-list-number...* | *access-list-name*] | **prefix-list** *prefix-list-name* [*prefix-list-name...*] }
Parameter Description	*access-list-number*: Indicates the access list number. For a standard access list, the value ranges are 1 to 99 and 1300 to 1999. For an extended access list, the value ranges are 100 to 199 and 2000 to 2699. *access-list-name*: Indicates the access list name. **prefix-list** *prefix-list-name*: Indicates the name of a prefix-list to be matched.
Command Mode	Route map configuration mode
Usage Guide	This match rule matches the source IPv4 address of a route by using an ACL or a prefix-list. An ACL and a prefix-list cannot be configured at the same time.

Command	**match ipv6 address** { *access-list-name* | **prefix-list** *prefix-list-name* }
Parameter Description	*access-list-name*: Indicates the access list name. **prefix-list** *prefix-list-name*: Indicates the name of an IPv6 prefix-list to be matched.
Command Mode	Route map configuration mode
Usage Guide	This match rule matches the destination IPv6 address of a packet or route by using an ACL or a prefix-list. An ACL and a prefix list cannot be configured at the same time.

Command	**match ipv6 next-hop** { *access-list-name* | **prefix-list** *prefix-list-name* }
Parameter Description	*access-list-name*: Indicates the access list name. **prefix-list** *prefix-list-name*: Indicates the name of an IPv6 prefix-list to be matched.
Command Mode	Route map configuration mode
Usage Guide	This match rule matches the next-hop IPv6 address of a route by using an ACL or a prefix-list. An ACL and a prefix-list cannot be configured at the same time.

Command	**match ipv6 route-source** { *access-list-name* | **prefix-list** *prefix-list-name* }

Parameter Description	*access-list-name*: Indicates the access list name. **prefix-list** *prefix-list-name*: Indicates the name of an IPv6 prefix-list to be matched.
Command Mode	Route map configuration mode
Usage Guide	This match rule matches the source IPv6 address of a route by using an ACL or a prefix-list. An ACL and a prefix-list cannot be configured at the same time.

Command	**match metric** *metric*
Parameter Description	*metric*: Indicates the metric value of a route, ranging from 0 to 4,294,967,295.
Command Mode	Route map configuration mode
Usage Guide	This match rule is used to match the metric value of a route.

Command	**match route-type** { **static** | **connect** | **rip** | **local** | **internal** | **external** [**type-1** | **type-2**]
Parameter Description	**static:** Indicates a static route. **connect:** Indicates a direct route. **rpi**: Indicates a RIP route. **local**: Indicates a route locally generated. **Internal**: Indicates an internal OSPF route. **external**: Indicates an external route (that of BGP or OSPF). **type-1** | **type-2**: Indicates type-1 or type-2 external route of OSPF.
Command Mode	Route map configuration mode
Usage Guide	This match rule is used to match the type of a route.

Command	**match tag** *tag* [*…tag*]
Parameter Description	*tag*: Indicates the tag value of a route.
Command Mode	Route map configuration mode
Usage Guide	This match rule is used to match the tag value of a route.

Setting the Processing Actions of a Policy

Command	**set ipdefault next-hop** *ip-address* [*weight*] [*…ip-address* [*weight*]]
Parameter Description	*ip-address*: Indicates the next-hop IP address. *weight*: Indicates the weight of this next hop.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to specify the default next hop of a route.

Command	**set ip dscp** *dscp_value*
Parameter Description	*dscp_value*: Sets the DSCP value in the IP header of an IP packet.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to modify the dscp field of an IP packet.

Command	**set ip next-hop** *ip-address* [*weight*] [*…ip-address* [*weight*]]
Parameter Description	*ip-address*: Indicates the next-hop IP address. *weight*: Indicates the weight of this next hop.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to specify the next hop of a route.

Command	**set ip precedence** { *number* | **critical** | **flash** | **flash-override** | **immediate** | **internet** | **network** | **priority** | **routine** }
Parameter Description	*number*: Indicates the priority of the IP header with a number, ranging from 0 to 7. 7: critical 6: flash 5: flash-override 4: immediate 3: internet 2: network 1: priority 0: routine **critical** | **flash** | **flash-override** | **immediate** | **internet** | **network** | **priority** | **routine**: priority of an IP header.

Command Mode	Route map configuration mode
Usage Guide	This set rule is used to modify the **precedence** field of an IP packet header.

Command	**set ip tos** { *number* | **max-reliability | max-throughput | min-delay | min-monetary-cost | normal** }
Parameter Description	*number*: Indicates the TOS value of an IP header with a number, ranging from 0 to 15. 2: **max-reliability** 4: **max-throughput** 8: **min-delay** 1: **min-monetary-cost** 0: **normal** **max-reliability | max-throughput | min-delay | min-monetary-cost | normal**: priority of an IP header.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to modify the tos field of an IP packet.

Command	**set ipv6 default next-hop** *global-ipv6-address* [*weight*] [*global-ipv6-address* [*weight*] *...*]
Parameter Description	*global-ipv6-address*: Indicates the next-hop IPv6 address for packet forwarding. The next-hop router must be a neighbor router. *weight*: Indicates the weight in the load balancing mode, ranging from 1 to 8. A larger value means larger packet traffic to be shared by the next hop.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to specify the default next hop IPv6 address of a route.

Command	**set ipv6 next-hop** *global-ipv6-address* [*weight*] [*global-ipv6-address* [*weight*] *...*]
Parameter Description	*global-ipv6-address*: Indicates the next-hop IPv6 address for packet forwarding. The next-hop router must be a neighbor router. *weight*: Indicates the weight in the load balancing mode, ranging from 1 to 8. A larger value means larger packet traffic to be shared by the next hop.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to specify the next hop IPv6 address of a route.

Command	**set ipv6 precedence** { *number* | **critical** | **flash** | **flash-override** | **immediate** | **internet** | **network** | **priority** | **routine** }
Parameter Description	*number*: Indicates the priority of the IP header with a number, ranging from 0 to 7. 7: critical 6: flash 5: flash-override 4: immediate 3: internet 2: network 1: priority 0: routine **critical** | **flash** | **flash-override** | **immediate** | **internet** | **network** | **priority** | **routine**: priority of an IP header.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to set the priority of an IPv6 packet header.

Command	**set level** {**stub-area** | **backbone** }
Parameter Description	**stub-area**: Indicates that the re-distribution route is advertised to OSPF Stub Area. **backbone**: Indicates that the re-distribution route is advertised to the OSPF backbone area.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to set the destination area type to which a route will be redirected.

Command	**set metric** [+ *metric-value* | **-** *metric-value* | *metric-value*]
Parameter Description	+: Increases (based on the metric value of the original route). -: Decreases (based on the metric value of the original route). *metric-value*: Sets the metric value of a re-distribution route. A larger value means a lower priority.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to modify the metric value of a route.

Command	**set metric-type** *type*
Parameter Description	*type*: Sets the type of a re-distribution route. The default type of an OSPF re-distribution route is type-2.
Command	Route map configuration mode

Mode	
Usage Guide	This set rule is used to set the metric type.

Command	**set next-hop** *ip-address*
Parameter Description	*ip-address*: Indicates the next-hop IP address.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to set the next-hop IP address.

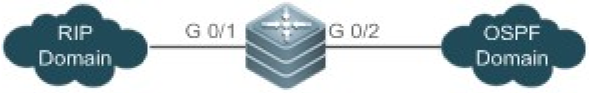
Command	**set tag** *tag*
Parameter Description	*tag*: Sets the tag of a re-distribution route.
Command Mode	Route map configuration mode
Usage Guide	This set rule is used to set the tag value of a route.

Displaying the Configurations of a Route Map

Command	**show route-map** [*name*]
Parameter Description	***name***: Specifies a route map.
Command Mode	Privilege, global and interface configuration modes
Usage Guide	Run the **show route-map** command to display the configurations of a route map. If an ACL is used when a route map is configured, you can run the **show access-list** command to display the configurations of the ACL.

Configuration Example

Using a Route Map in Route Re-distribution to Filter and Modify Routing Information

Scenario **Figure 7-3**	As shown in Figure 7-3, a device is connected to both an OSPF routing domain and RIP routing domain. 
	● Re-distribute only RIP routes with 4 hops to OSPF. In the OSPF route domain, if the route type is the external route type-1, set the tag value of the route to 40. ● Re-distribute only OSPF routes with the tag value 10 to RIP. In the RIP route domain, set the initial metric value of this route to 10.

Configuration Steps

- Configure the route map redrip: Match a route with 4 hours, set the initial metric value of the route to 40, set the route type to the external route type-1, and set the tag value of the route to 40.
- Configure the route map redospf: match a route with the tag value 10 and set the initial metric value of the route to 10.
- Configure re-distribution of the RIP route to OSPF and apply the route map redrip.
- Configure re-distribution of the OSPF route to RIP and apply the route map redospf.

```
Orion Alpha A28X(config)# route-map redrip permit 10
Orion Alpha A28X(config-route-map)# match metric 4
Orion Alpha A28X(config-route-map)# set metric-type type-1
Orion Alpha A28X(config-route-map)# set tag 40
Orion Alpha A28X(config-route-map)# exit
Orion Alpha A28X(config)# route-map redospf permit 10
Orion Alpha A28X(config-route-map)# match tag 10
Orion Alpha A28X(config-route-map)# set metric 10
Orion Alpha A28X(config-route-map)# exit
Orion Alpha A28X(config)# router ospf 1
Orion Alpha A28X(config-router)# redistribute rip subnets route-map redrip
Orion Alpha A28X(config-router)# exit
Orion Alpha A28X(config)# router rip
Orion Alpha A28X(config-router)# redistribute ospf 1 route-map redospf
Orion Alpha A28X(config-router)# exit
```

Verification

- Check the configurations of the route map to verify the policy rules.
- Check the OSPF routing information library to verify that the rules matching the policy rules are re-distributed.

```
Orion Alpha A28X# show route-map
route-map redrip, permit, sequence 10
 Match clauses:
   metric 4
 Set clauses:
   metric 40
   metric-type type-1
   tag 40
```

```
route-map redospf, permit, sequence 10
 Match clauses:
  tag 10
 Set clauses:
  metric 10
```

```
Orion Alpha A28X# show ip ospf database external

            OSPF Router with ID (192.100.1.9) (Process ID 1)

                AS External Link States

 LS age: 5
 Options: 0x2 (-|-|-|-|-|-|E|-)
 LS Type: AS-external-LSA
 Link State ID: 192.168.199.0 (External Network Number)
 Advertising Router: 192.100.1.9
 LS Seq Number: 80000001
 Checksum: 0x554d
 Length: 36
 Network Mask: /24
       Metric Type: 1
       TOS: 0
       Metric: 4
       Forward Address: 0.0.0.0
       External Route Tag: 40
```

5.4.2 Configuring a Filtering List

Configuration Effect

- Define a set of route filtering rules to be used by routing protocols.

Notes

- A configured filtering list can take effect only after it is associated with a routing protocol.

Configuration Steps

↘ Configuring a Prefix-List

- To filter address prefixes, you should perform this configuration.
- If there is no special requirement, you should perform this configuration on a route for which filtering based on a prefix-list needs to be performed.

↘ Configuring a Community List

- To filter community attributes, you should perform this configuration.
- If there is no special requirement, you should perform this configuration on a route for which community attributes need to be filtered.

Verification

- Check whether the filtering list is correctly configured.
- Check the routing table to verify that routes can be correctly filtered.

Related Commands

↘ Defining a Community List

Command	**ip community-list** { { **standard** | **expanded** } *community-list-name* | *community-list-number* } { **permit** | **deny** } [*community-number..*]
Parameter Description	**standard:** Indicates a standard community list. **expanded:** Indicates an extended community list. ***community-list-name*****:** Indicates the community list name, comprising not more than 80 characters. ***community-list-number*****:** Indicates the community list number. For a standard community list, the value ranges from 1 to 99. For an extended community list, the value ranges from 100 to 199. **permit:** Permits access. **deny:** Denies access. ***community-number*****:** Indicates the community attribute value.
Command Mode	Global configuration mode
Usage Guide	Use this command to define a community list used for BGP.

↘ Defining an Extcommunity List

Command	**ip extcommunity-list** {*expanded-list* | **expanded** *list-name* } { **permit | deny** } [*regular-expression*]
Parameter	***expand-list*****:** Indicates an extended extcommunity list, ranging from 100 to 199. One extcommunity list

Description	may contain multiple rules. ***standard-list*:** Indicates a standard extcommunity list, ranging from 1 to 99. One extcommunity list may contain multiple rules. ***expanded list-name*:** Indicates the name of an extended extcommunity, comprising not more than 32 characters. When using this parameter, you enter the extcommunity list configuration mode. ***standard list-name*:** Indicates the name of a standard extcommunity list, comprising not more than 32 characters. When using this parameter, you enter the extcommunity list configuration mode. **permit:** Defines an extcommunity rule for permitting. **deny:** Defines an extcommunity rule for denying. ***regular-expression*:** (optional) Defines a matching template that is used to match an extcommunity. ***sequence-number*:** (Optional) Defines the sequence number of a rule, ranging from 1 to 2,147,483,647. If no sequence number is specified, the sequence number automatically increases by 10 when a rule is added by default. The initial number is 10. **rt:** (Optional) Sets the RT attribute value. This command can be used only for the standard extcommunity configuration, but not for the extended extcommunity configuration. **soo:** (Optional) Sets the SOO attribute value. This command can be used only for the standard extcommunity configuration, but not for the extended extcommunity configuration. ***value*:** Indicates the value of an extended community (extend_community_value).
Command Mode	Global configuration mode and ip extcommunity-list configuration mode
Usage Guide	-

Creating a Prefix-List

Command	**ip prefix-list** *prefix-list-name* [**seq** *seq-number*] { **deny** | **permit** } *ip-prefix* [**ge** *minimum-prefix-length*] [**le** *maximum-prefix-length*]
Parameter Description	***prefix-list-name***: Indicates the prefix-list name. *seq-number*: Assigns a sequence number to an prefix-list entry, ranging from 1 to 2,147,483,647. If this command does not contain the sequence number, the system will assign a default sequence number to the prefix-list entry. The default sequence number of the first entry is 5. Subsequently, the default sequence number of each entry not assigned with a value is the first multiple of 5 greater than the previous sequence number. **deny:** Denies access when certain conditions are matched. **permit:** Permits access when certain conditions are matched. ***ip-prefix*:** Configures the IP address and mask, ranging from 0 to 32 digits. ***minimum-prefix-length*:** Specifies the minimum range (namely, the start length of a range). ***maximum-prefix-length*:** Specifies the maximum range (namely, the end length of a range).
Command Mode	Global configuration mode

Usage Guide	-

↘ Adding Description to a Prefix-List

Command	**ip prefix-list** *prefix-list-name* **description** *descripton-text*
Parameter Description	***prefix-list-name***: Indicates the prefix-list name. *descripton-text*: Describes the prefix-list.
Command Mode	Global configuration mode
Usage Guide	-

↘ Enabling the Sorting Function for a Prefix-List

Command	**ip prefix-list sequence-number**
Parameter Description	**-**
Command Mode	Global configuration mode
Usage Guide	-

↘ Creating an IPv6 Prefix-List

Command	**ipv6 prefix-list** *prefix-list-name* [**seq** *seq-number*] { **deny** | **permit** } *ipv6-prefix* [**ge** *minimum-prefix-length*] [**le** *maximum-prefix-length*]
Parameter Description	***prefix-list-name*****:** Indicates the prefix-list name. ***seq-number*****:** Assigns a sequence number to an prefix-list entry, ranging from 1 to 2,147,483,647. If this command does not contain the sequence number, the system will assign a default sequence number to the prefix-list entry. The default sequence number of the first entry is 5. Subsequently, the default sequence number of each entry not assigned with a value is the first multiple of 5 greater than the previous sequence number. **deny:** Denies access when certain conditions are matched. **permit:** Permits access when certain conditions are matched. ***ipv6-prefix*****:** Configures the IP address and mask, ranging from 0 to 128 digits. ***minimum-prefix-length*****:** Specifies the minimum range (namely, the start length of a range). ***maximum-prefix-length*****:** Specifies the maximum range (namely, the end length of a range).
Command Mode	Global configuration mode
Usage Guide	-

↘ Adding Description to an IPv6 Prefix List

Command	**ipv6 prefix-list** *prefix-list-name* **description** *descripton-text*

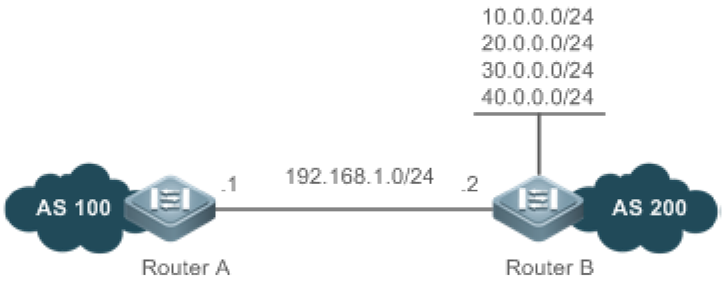
Parameter Description	***prefix-list-name***: Indicates the prefix list name. *descripton-text*: Describes the prefix list.
Command Mode	Global configuration mode
Usage Guide	-

Enabling the Sorting Function for an IPv6 Prefix-List

Command	**ipv6 prefix-list sequence-number**
Parameter Description	**-**
Command Mode	Global configuration mode
Usage Guide	-

Configuration Example

Configuring a Community List

Scenario **Figure 7-4**	 10.0.0.0/24 20.0.0.0/24 30.0.0.0/24 40.0.0.0/24 192.168.1.0/24 .1 .2 AS 100 AS 200 Router A Router B
Configuration Steps	● Define a standard community list to match the community attribute 100: 20. ● Advertise a route with the community attribute on B. ● Associate the community list on A to filter routes received on B.
A	A(config)# ip community-list standard test permit 100:20 A(config)# route-map COM A(config-route-map)# match community test A(config-route-map)# exit
B	B(config)# route-map comm1 B(config-route-map)# set community 100:20 200:20 B(config-route-map)# route-map comm2

	B(config-route-map)# set community 100:20 B(config-route-map)# route-map comm3 B(config-route-map)# set community 200:20 B(config-route-map)# exit
Verification	● Run the **show** command to display the community list. ●

Common Errors

- A filtering list is configured but is not correctly applied in a routing protocol, which causes that the filtering list cannot take effect.

5.5 Monitoring

Displaying

Description	Command
Displays the configurations of a route map.	**show route-map** [*route-map-name*]
Displays the configurations of an ACL.	**show access-lists** [*id* | *name*]
Displays the configurations of an IPv4 prefix-list.	**show ip prefix-list** [*prefix-name*]
Displays the configurations of an IPv6 prefix-list.	**show ipv6 prefix-list** [*prefix-name*]
Displays the configurations of an AS-path list.	**show ip as-path-access-list** [*num*]
Displays the configurations of a community list.	**show ip community-list** [*community-list-number* | *community-list-name*]
Displays the configurations of an extcommunity list.	**show ip extcommunity-list** [*extcommunity-list-num* | *extcommunity-list-name*]