FS.COM

FiberstoreOS

IP Routing Configuration Guide

Contents

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1.1 Overview

Static routing is a concept describing one way of configuring path selection of routers in computer networks. It is the type of routing characterized by the absence of communication between routers regarding the current topology of the network. [1] This is achieved by manually adding routes to the routing table. The opposite of static routing is dynamic routing, sometimes also referred to as adaptive routing.

In these systems, routes through a data network are described by fixed paths (statically). These routes are usually entered into the router by the system administrator. An entire network can be configured using static routes, but this type of configuration is not fault tolerant. When there is a change in the network or a failure occurs between two statically defined nodes, traffic will not be rerouted. This means that anything that wishes to take an affected path will either have to wait for the failure to be repaired or the static route to be updated by the administrator before restarting its journey. Most requests will time out (ultimately failing) before these repairs can be made. There are, however, times when static routes can improve the performance of a network. Some of these include stub networks and default routes.

1.2 Topology

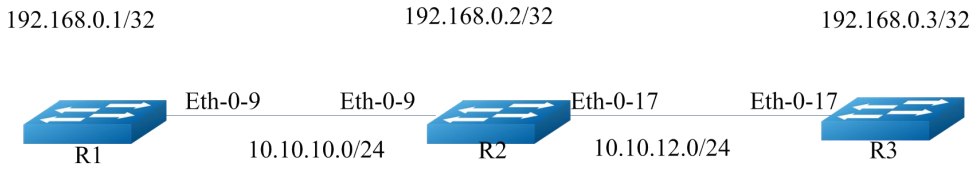

Figure 1-1 Static Routing

1.3 Configuration

R1

Switch# configure terminal	Enter the configure mode
Switch(config)# interface eth-0-9	Specify the interface (eth-0-9) to be configured and enter the Interface mode
Switch(config-if)# no shutdown	Turn up the interface
Switch(config-if)# no switchport	Change this port to Layer3 interface
Switch(config-if)# ip address 10.10.10.1/24	Configure IP address for this interface
Switch(config-if)# exit	Exit the Interface mode and enter the Configure mode
Switch(config)# interface loopback 0	Specify the loopback as the interface you want to configure
Switch(config-if)# ip address 192.168.0.1/32	Configure the IP address on this interface and specify a 32-bit mask, making it a host address.
Switch(config-if)# exit	Exit the Interface mode and return to Configure mode
Switch(config)# ip route 10.10.12.0/24 10.10.10.2 Switch(config)# ip route 192.168.0.2/32 10.10.10.2 Switch(config)# ip route 192.168.0.3/32 10.10.10.2	Specify the destination prefix and mask for the network for which a gateway is required, for example, 10.10.12.0/24. Add a gateway for each of them (in this case 10.10.10.2 for all). Since R2 is the only next hop available, you can configure a default route instead of configuring the same static route for individual addresses, see the configuration of R3

R2

Switch # configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-9	Specify the interface (eth-0-9) to be configured and enter the Interface mode
Switch(config-if)# no shutdown	Turn up the interface
Switch(config-if)# no switchport	Change this port to Layer3 interface
Switch(config-if)# ip address 10.10.10.2/24	Configure IP address for this interface
Switch(config-if)# exit	Exit the Interface mode and enter the Configure mode
Switch(config)# interface eth-0-17	Specify the interface (eth-0-9) to be configured and enter the Interface mode
Switch(config-if)# no shutdown	Turn up the interface
Switch(config-if)# no switchport	Change this port to Layer3 interface
Switch(config-if)# ip address 10.10.12.2/24	Configure IP address for this interface

Switch(config-if)# exit	Exit the Interface mode and enter the Configure mode
Switch(config)# interface loopback 0	Specify loopback as the interface you want to configure
Switch(config-if)# ip address 192.168.0.2/32	Configure the IP address on this interface and specify a 32-bit mask, making it a host address.
Switch(config-if)# exit	Exit the Interface mode and return to Configure mode
Switch(config)# ip route 192.168.0.1/32 10.10.10.1 Switch(config)# ip route 192.168.0.3/32 10.10.12.3	Specify the destination and mask for the network for which gateway is required and add a gateway for each of them.

R3

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-17	Specify the interface (eth-0-9) to be configured and enter the Interface mode
Switch(config-if)# no shutdown	Turn up the interface
Switch(config-if)# no switchport	Change this port to Layer3 interface
Switch(config-if)# ip address 10.10.12.3/24	Configure IP address for this interface
Switch(config-if)# exit	Exit the Interface mode and enter the Configure mode
Switch(config)# interface loopback 0	Specify loopback as the interface you want to configure
Switch(config-if)# ip add 192.168.0.3/32	Configure the IP address on this interface and specify a 32-bit mask, making it a host address.
Switch(config-if)# exit	Exit the Interface mode and return to Configure mode
Switch(config)# ip route 0.0.0.0/0 10.10.12.2	Specify 10.10.12.2 as a default gateway to reach any network. Since 10.10.12.2 is the only route available you can specify it as the default gateway instead of specifying it as the gateway for individual network or host addresses.

1.4 Validation

R 1

R1# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
```

```
    [*] - [AD/Metric]
    * - candidate default

C      10.10.10.0/24 is directly connected, eth-0-9
C      10.10.10.1/32 is in local loopback, eth-0-9
S      10.10.12.0/24 [1/0] via 10.10.10.2, eth-0-9
C      192.168.0.1/32 is directly connected, loopback0
S      192.168.0.2/32 [1/0] via 10.10.10.2, eth-0-9
S      192.168.0.3/32 [1/0] via 10.10.10.2, eth-0-9
```

R 2

R2# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
    [*] - [AD/Metric]
    * - candidate default
C      10.10.10.0/24 is directly connected, eth-0-9
C      10.10.10.2/32 is in local loopback, eth-0-9
C      10.10.12.0/24 is directly connected, eth-0-17
C      10.10.12.2/32 is in local loopback, eth-0-17
S      192.168.0.1/32 [1/0] via 10.10.10.1, eth-0-9
C      192.168.0.2/32 is directly connected, loopback0
S      192.168.0.3/32 [1/0] via 10.10.12.3, eth-0-17
```

R 3

R3# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
    [*] - [AD/Metric]
    * - candidate default
```

Gateway of last resort is 10.10.12.2 to network 0.0.0.0

```
S*     0.0.0.0/0 [1/0] via 10.10.12.2, eth-0-17
C      10.10.12.0/24 is directly connected, eth-0-17
C      10.10.12.3/32 is in local loopback, eth-0-17
C      192.168.0.3/32 is directly connected, loopback0
```

2 Configuring RIP

2.1 Overview

Routing Information Protocol (RIP) is an IP route exchange protocol that uses a distance vector (a number representing distance) to measure the cost of a given route. The cost is a distance vector because the cost is often equivalent to the number of router hops between the source and the destination networks. RIP can receive multiple paths to a destination. The system evaluates the paths, selects the best path, and saves the path in the IP route table as the route to the destination. Typically, the best path is the path with the fewest hops. A hop is another router through which packets must travel to reach the destination. If RIP receives a RIP update from another router that contains a path with fewer hops than the path stored in the route table, the system replaces the older route with the newer one. The system then includes the new path in the updates it sends to other RIP routers. RIP routers also can modify a route's cost, generally by adding to it, to bias the selection of a route for a given destination. In this case, the actual number of router hops may be the same, but the route has an administratively higher cost and is thus less likely to be used than other, lower-cost routes. A RIP route can have a maximum cost of 15. Any destination with a higher cost is considered unreachable. Although limiting to larger networks, the low maximum hop count prevents endless loops in the network.

This chapter contains basic RIP configuration examples. To see details on the commands used in these examples, or to see the outputs of the Validation commands, refer to the RIP Command Reference. To avoid repetition, some Common commands, like configure terminal, have not been listed under the Commands Used section. These Common commands are explained in the NSM Command Reference.

2.2 Enabling RIP

This example shows the minimum configuration required for enabling RIP on an interface. Switch A and B are two routers connecting to network 10.10.11.0/24. Switch A and B are also connected to networks 10.10.10.0/24 and 10.10.12.0/24 respectively. To enable RIP, first define the RIP routing process and then associated a network with the routing process.

2.2.1 Topology

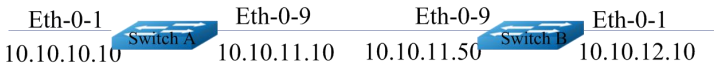

Figure 2-1 RIP Topology

2.2.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-1	Enter the interface mode
Switch(config-if)# no switchport	Change port mode
Switch(config-if)# ip address 10.10.10.10/24	Set ip address on interface
Switch(config-if)# exit	Exit the interface mode
Switch(config)# interface eth-0-9	Enter the interface mode
Switch(config-if)# no switchport	Change port mode
Switch(config-if)# ip address 10.10.11.10/24	Set ip address on interface
Switch(config-if)# exit	Exit the interface mode
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)#network 10.10.10.0/24	Associate networks with the RIP process.
Switch(config-router)#network 10.10.11.0/24	Associate networks with the RIP process.

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-1	Enter the interface mode
Switch(config-if)# no switchport	Change port mode
Switch(config-if)# ip address 10.10.12.10/24	Set ip address on interface
Switch(config-if)# exit	Exit the interface mode
Switch(config)# interface eth-0-9	Enter the interface mode
Switch(config-if)# no switchport	Change port mode
Switch(config-if)# ip address 10.10.11.50/24	Set ip address on interface
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)#network 10.10.11.0/24	Associate networks with the RIP process.
Switch(config-router)#network 10.10.12.0/24	Associate networks with the RIP process.

2.2.3 Validation

Use the commands as follows to validat the configuration:

show ip rip database, show ip protocols rip, show ip rip interface and show ip route

Switch A output

Switch# show ip rip database

```
Codes: R - RIP, Rc - RIP connected, Rs - RIP static, K - Kernel,
    C - Connected, S - Static, O - OSPF, I - IS-IS, B - BGP

  Network         Next Hop      Metric From        If     Time
Rc 10.10.10.0/24                   1               eth-0-1
Rc 10.10.11.0/24                   1               eth-0-9
R  10.10.12.0/24     10.10.11.50       2 10.10.11.50      eth-0-9  00:02:52
```

Switch# show ip protocols rip

```
Routing protocol is "rip"
 Sending updates every 30 seconds with +/-5 seconds, next due in 17 seconds
 Timeout after 180 seconds, Garbage collect after 120 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
 Redistributing:
 Default version control: send version 2, receive version 2
   Interface        Send        Recv   Key-chain
   eth-0-1          2           2
   eth-0-9          2           2
 Routing for Networks:
   10.10.10.0/24
   10.10.11.0/24
 Routing Information Sources:
   Gateway         Distance  Last Update  Bad Packets  Bad Routes
   10.10.11.50          120  00:00:22              0           0
 Number of routes (excluding connected): 3
 Distance: (default is 120)
```

Switch# show ip rip interface

```
eth-0-1 is up, line protocol is up
 Routing Protocol: RIP
   Receive RIP packets
   Send RIP packets
   Passive interface: Disabled
   Split horizon: Enabled with Poisoned Reversed
   IP interface address:
     10.10.10.10/24
eth-0-9 is up, line protocol is up
 Routing Protocol: RIP
   Receive RIP packets
   Send RIP packets
```

```
  Passive interface: Disabled
  Split horizon: Enabled with Poisoned Reversed
  IP interface address:
    10.10.11.10/24
```

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
    [*] - [AD/Metric]
    * - candidate default

C      10.10.10.0/24 is directly connected, eth-0-1
C      10.10.11.0/24 is directly connected, eth-0-9
R      10.10.12.0/24 [120/2] via 10.10.11.50, eth-0-9, 00:25:50
```

2.3 Configuring The RIP Version

Configure a router to receive and send specific versions of packets on an interface In this example, router Switch B is configured to receive and send RIP version 1 and version 2 information on both eth-0-9 and eth-0-20 interfaces.

2.3.1 Topology

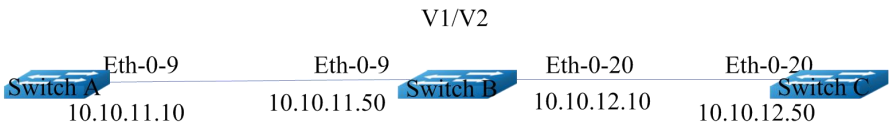

Figure 2-2 RIP Topology II

2.3.2 Configuration

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)# router rip	Enable the RIP routing process.
Switch(config-router)# exit	Exit the configure router mode
Switch(config)# interface eth-0-9	Specify interface eth-0-9 as an interface you want to configure

Switch(config-if)# ip rip send version 1 2	Allow sending RIP version 1 and version 2 packets out of this interface
Switch(config-if)# ip rip receive version 1 2	Allow receiving of RIP version 1 and version 2 packets from the eth-0-9 interface
Switch(config-if)# quit	Quit the Interface mode and return to Configure mode to configure the next interface
Switch(config)# interface eth-0-20	Specify interface eth-0-20 as an interface you want to configure
Switch(config-if)# ip rip send version 1 2	Allow sending RIP version 1 and version 2 packets out of this interface
Switch(config-if)# ip rip receive version 1 2	Allow receiving of RIP version 1 and version 2 packets from the eth-0-20 interface

2.3.3 Validation

Use the commands as follows to validat the configuration:

show ip rip database, Show running-config, show ip protocols rip, show ip rip interface and show ip route

Switch B output

Switch# show ip rip database

```
Codes: R - RIP, Rc - RIP connected, Rs - RIP static, K - Kernel,
    C - Connected, S - Static, O - OSPF, I - IS-IS, B - BGP

  Network         Next Hop      Metric From         If      Time
R  10.0.0.0/8                      1              eth-0-9
Rc 10.10.11.0/24                   1              eth-0-9
Rc 10.10.12.0/24                   1              eth-0-20
```

Switch# show ip protocols rip

```
Routing protocol is "rip"
 Sending updates every 30 seconds with +/-5 seconds, next due in 1 seconds
 Timeout after 180 seconds, Garbage collect after 120 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
 Redistributing:
 Default version control: send version 2, receive version 2
  Interface       Send        Recv   Key-chain
  eth-0-9         1 2         1 2
  eth-0-20        1 2         1 2
 Routing for Networks:
  10.10.11.0/24
  10.10.12.0/24
 Routing Information Sources:
  Gateway         Distance  Last Update  Bad Packets  Bad Routes
  10.10.11.10          120  00:00:22              0           0
```

```
  10.10.12.50          120  00:00:27            0          0
 Number of routes (excluding connected): 3
 Distance: (default is 120)
```

Switch# show ip rip inter

```
eth-0-9 is up, line protocol is up
 Routing Protocol: RIP
   Receive RIPv1 and RIPv2 packets
   Send RIPv1 and RIPv2 packets
   Passive interface: Disabled
   Split horizon: Enabled with Poisoned Reversed
   IP interface address:
     10.10.11.50/24
eth-0-20 is up, line protocol is up
 Routing Protocol: RIP
   Receive RIPv1 and RIPv2 packets
   Send RIPv1 and RIPv2 packets
   Passive interface: Disabled
   Split horizon: Enabled with Poisoned Reversed
   IP interface address:
     10.10.12.10/24
```

Switch# show running-config

```
interface eth-0-9
 no switchport
 ip address 10.10.11.50/24
 ip rip send version 1 2
 ip rip receive version 1 2
!
interface eth-0-20
 no switchport
 ip address 10.10.12.10/24
 ip rip send version 1 2
 ip rip receive version 1 2
!
router rip
 network 10.10.11.0/24
 network 10.10.12.0/24
!
```

Switch A output

Switch# show running-config

```
interface eth-0-9
 no switchport
 ip address 10.10.11.10/24
!
router rip
 network 10.10.11.0/24
!
```

Switch C output

Switch# show run

```
interface eth-0-20
 no switchport
 ip address 10.10.12.50/24
!
router rip
 network 10.10.12.0/24
!
```

2.4 Configuring Metric Parameters

A RIP offset list allows you to add to the metric of specific inbound or outbound routes learned or advertised by RIP. RIP offset lists provide a simple method for adding to the cost of specific routes and therefore biasing the router's route selection away from those routes. An offset list consists of the following parameters:

- An ACL that specifies the routes to which to add the metric.
- The direction:
  - In: applies to routes the router learns from RIP neighbors.
  - Out: applies to routes the router is advertising to its RIP neighbors.
- The offset value that will be added to the routing metric of the routes that match the ACL.
- The interface that the offset list applies (optional).

If a route matches both a global offset list (without specified interface) and an interface-based offset list, the interface-based offset list takes precedence. The interface-based offset list's metric is added to the route in this case.

This example Switch A will advertise route 1.1.1.0 out of int eth-0-13 with metric 3.

2.4.1 Topology

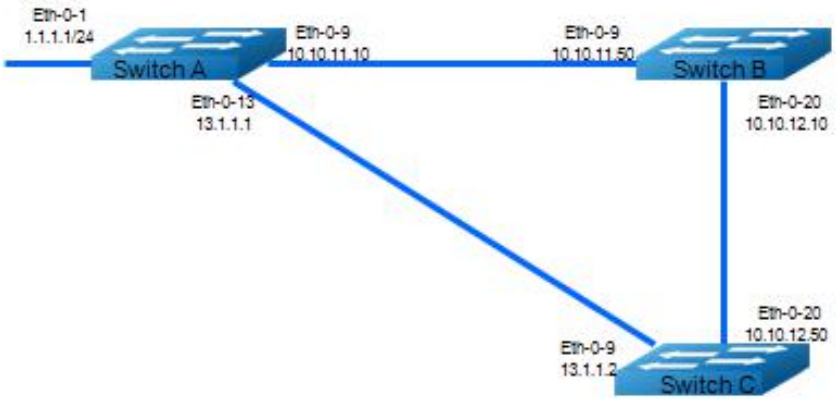

Figure 2-3 RIP Topology III

2.4.2 Configuration

Switch A configuration

```
interface eth-0-1
no switchport
ip address 1.1.1.1/24
!
interface eth-0-9
no switchport
ip address 10.10.11.10/24
!
interface eth-0-13
no switchport
ip address 13.1.1.1/24
!
router rip
network 1.1.1.0/24
network 10.10.11.0/24
network 13.1.1.0/24
!
```

Switch B configuration

```
interface eth-0-9
no switchport
ip address 10.10.11.50/24
!
interface eth-0-20
no switchport
ip address 10.10.12.10/24
!
router rip
```

```
network 10.10.11.0/24
network 10.10.12.0/24
```

Switch C configuration

```
interface eth-0-13
no switchport
ip address 13.1.1.2/24
!
interface eth-0-20
no switchport
ip address 10.10.12.50/24
!
router rip
network 10.10.12.0/24
network 13.1.1.0/24
```

Validation route table on Switch C

Switch# show ip route rip

```
R      1.1.1.0/24 [120/2] via 13.1.1.1, eth-0-13, 00:07:46
R      10.10.11.0/24 [120/2] via 13.1.1.1, eth-0-13, 00:07:39
                [120/2] via 10.10.12.10, eth-0-20, 00:07:39
```

Change router 1.1.1.0/24 via 10.10.12.10.

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)#ip access-list ripoffset	Create IP access list named ripoffset.
Switch(config-ip-acl)#permit any 1.1.1.0 0.0.0.255 any	Configure the access list to match route 1.1.1.0/24.
Switch(config-ip-acl)# router rip	Enter the RIP routing process.
Switch(config-router)# offset-list ripoffset out 3 eth-0-13	RIP updates being sent out from interface eth-0-13 will adds 3 hops to the routes matching the access list ripoffset.

2.4.3 Validation

Switch C output

Switch# show ip route rip

```
R      1.1.1.0/24 [120/3] via 10.10.12.10, eth-0-20, 00:00:02
R      10.10.11.0/24 [120/2] via 13.1.1.1, eth-0-13, 00:11:40
                [120/2] via 10.10.12.10, eth-0-20, 00:11:40
```

2.5 Configuring the Administrative Distance

By default, RIP assigns the default RIP administrative distance (120) to RIP routes. When comparing routes based on administrative distance, the router selects the route with the lower distance. You can change the administrative distance for RIP routes.

This example all Switches have two router protocols, RIP and OSPF, OSPF route has higher priority, Switch C will change route 1.1.1.0 with administrative distance 100.

2.5.1 Topology

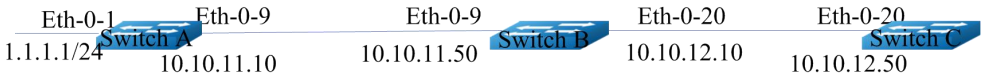

Figure 2-4 RIP Topology III

2.5.2 Configuration

Switch A configuration

```
interface eth-0-1
no switchport
ip address 1.1.1.1/24
!
interface eth-0-9
no switchport
ip address 10.10.11.10/24
!
router ospf
network 1.1.1.0/24 area 0
network 10.10.11.0/24 area 0
!
router rip
network 1.1.1.0/24
network 10.10.11.0/24
```

Switch B configuration

```
interface eth-0-9
no switchport
ip address 10.10.11.50/24
!
interface eth-0-20
no switchport
```

```
ip address 10.10.12.10/24
!
router ospf
network 10.10.11.0/24 area 0
network 10.10.12.0/24 area 0
!
router rip
network 10.10.11.0/24
network 10.10.12.0/24
```

Switch C configuration

```
interface eth-0-20
no switchport
ip address 10.10.12.50/24
!
router ospf
network 10.10.12.0/24 area 0
!
router rip
network 10.10.12.0/24
!
```

Switch C output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default
O      1.1.1.0/24 [110/3] via 10.10.12.10, eth-0-20, 01:05:49
O      10.10.11.0/24 [110/2] via 10.10.12.10, eth-0-20, 01:05:49
C      10.10.12.0/24 is directly connected, eth-0-20
```

To change the administrative distance for RIP routes on switch C, enter a command such as the following:

Switch# configure terminal	Enter the Configure mode
Switch(config)#ip access-list ripdistancelist	Create IP access list named ripoffset.
Switch(config-ip-acl)#permit any 1.1.1.0 0.0.0.255 any	Configure the access list to match all routes 1.1.1.0/24
Switch(config-ip-acl)# router rip	Enter the RIP routing process.
Switch(config-router)# distance 100 0.0.0.0/0 ripdistancelist	The routes which match the criteria will change the administrative distance to 100. The criteria are that the routes match IP access list ripdistancelist and learned from neighbors with source IP address match 0.0.0.0/0.

2.5.3 Validation

Switch C output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

R      1.1.1.0/24 [100/3] via 10.10.12.10, eth-0-20, 00:00:02
O      10.10.11.0/24 [110/2] via 10.10.12.10, eth-0-20, 01:10:42
C      10.10.12.0/24 is directly connected, eth-0-20
```

2.6 Configuring Redistribution

You can configure the router to redistribute static routes, direct connected routes or routes learned through Open Shortest Path First (OSPF) into RIP. When you redistribute a route from one of these other protocols into RIP, the router can use RIP to advertise the route to its RIP neighbors.

Change the default redistribution metric (optional). The router assigns a RIP metric of 1 to each redistributed route by default. You can change the default metric to a value up to 16.

Enable specified routes to redistribute with default or specified metric.

This example the router will set the default metric to 2 for redistributed routes and redistributes static routes and direct connected routes to RIP with default metric 2, redistributes OSPF routes with specified metric 5.

2.6.1 Topology

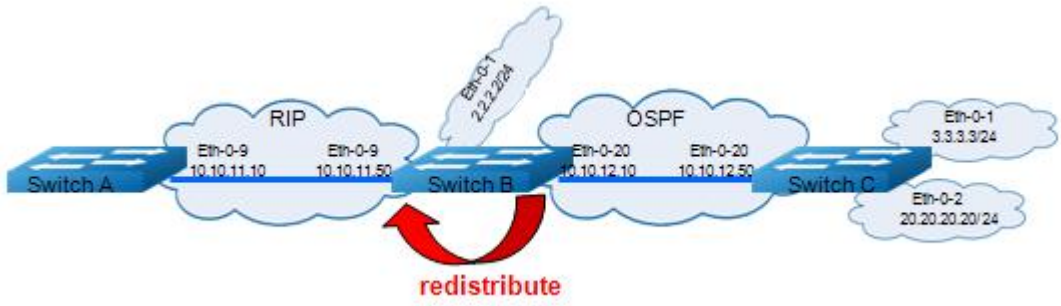

Figure 2-5 RIP Topology III

2.6.2 Configuration

Switch A configuration

```
interface eth-0-9
no switchport
ip address 10.10.11.10/24
!
router rip
network 10.10.11.0/24
!
```

Switch B configuration

```
interface eth-0-1
no switchport
ip address 2.2.2.2/24
!
interface eth-0-9
no switchport
ip address 10.10.11.50/24
!
interface eth-0-20
no switchport
ip address 10.10.12.10/24
!
router ospf
network 10.10.12.0/24 area 0
!
router rip
network 10.10.11.0/24
!
ip route 20.20.20.0/24 10.10.12.50
!
```

Switch C configuration

```
interface eth-0-1
no switchport
ip address 3.3.3.3/24
!
interface eth-0-2
no switchport
ip address 20.20.20.20/24
!
interface eth-0-20
no switchport
ip address 10.10.12.50/24
!
router ospf
network 3.3.3.0/24 area 0
network 10.10.12.0/24 area 0
!
```

Switch A output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

C      10.10.11.0/24 is directly connected, eth-0-9
```

Switch B output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

C      2.2.2.0/24 is directly connected, eth-0-1
O      3.3.3.0/24 [110/2] via 10.10.12.50, eth-0-20, 01:05:41
C      10.10.11.0/24 is directly connected, eth-0-9
C      10.10.12.0/24 is directly connected, eth-0-20
S      20.20.20.0/24 [1/0] via 10.10.12.50, eth-0-20
```

Switch B Configure Redistribute

Switch# configure terminal	Enter the Configure mode

Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)#default-metric 2	Specify the metrics to be assigned to redistributed routes.
Switch(config-router)# redistribute static	Redistribute static routes to RIP with default metric.
Switch(config-router)# redistribute connected	Redistribute connected routes to RIP with default metric.
Switch(config-router)#redistribute ospf metric 5	Redistribute OSPF routes to RIP with metric 5.
Switch(config)# router ospf	Enter the OSPF routing process.
Switch(config-router)# redistribute connected	Redistribute connected routes to RIP with default metric.

2.6.3 Validation

Switch A output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

R      2.2.2.0/24 [120/3] via 10.10.11.50, eth-0-9, 00:02:36
R      3.3.3.0/24 [120/6] via 10.10.11.50, eth-0-9, 00:02:26
C      10.10.11.0/24 is directly connected, eth-0-9
R      10.10.12.0/24 [120/3] via 10.10.11.50, eth-0-9, 00:02:36
R      20.20.20.0/24 [120/3] via 10.10.11.50, eth-0-9, 00:02:41
```

2.7 Configuring Split-horizon Parameters

Normally, routers that are connected to broadcast-type IP networks and that use distance-vector routing protocols employ the split horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router out of any interface from which that information originated. This behavior usually optimizes communications among multiple routers, particularly when links are broken. However, with non-broadcast networks (such as Frame Relay), situations can arise for which this behavior is less than ideal. For these situations, you might want to disable split horizon for RIP.

You can avoid including routes in updates sent to the same gateway from which they were learned. Using the split horizon command omits routes learned from one neighbor, in updates sent to that neighbor. Using the poisoned parameter with this command includes such routes in updates, but sets their metrics to infinity. Thus, advertising these routes means that they are not reachable.

2.7.1 Topology

Figure 2-6 RIP Topology III

2.7.2 Configuration

Switch A Configuration

```
interface eth-0-1
no switchport
ip address 1.1.1.1/24
!
interface eth-0-9
no switchport
ip address 10.10.11.10/24
!
router rip
network 10.10.11.0/24
redistribute connected
```

Switch B Configuration

```
interface eth-0-9
no switchport
ip address 10.10.11.50/24
!
router rip
network 10.10.11.0/24
!
```

Switch B debug Configuration

Switch# debug rip packet send detail

Switch# terminal monitor

Disable Split-horizon on Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-9	Specify interface eth-0-9 as the interface you want to configure
Switch(config-if)# no ip rip split-horizon	Disable split horizon for RIP.

```
Apr  8 06:24:25 Switch RIP4-7: SEND[eth-0-9]: Send to 224.0.0.9:520
Apr  8 06:24:25 Switch RIP4-7: SEND[eth-0-9]: RESPONSE version 2 packet size 44
Apr  8 06:24:25 Switch RIP4-7: 1.1.1.0/24 -> 0.0.0.0 family 2 tag 0 metric 2
Apr  8 06:24:25 Switch RIP4-7: 10.10.11.0/24 -> 0.0.0.0 family 2 tag 0 metric 1
```

Enable Split-horizon on Switch B

Switch(config-if)# ip rip split-horizon	Enable split horizon for RIP without poisoned reverse.
Switch(config-if)# ip rip split-horizon poisoned	Enable split horizon for RIP with poisoned reverse.

```
Apr  8 06:38:35 Switch RIP4-7: SEND[eth-0-9]: Send to 224.0.0.9:520
Apr  8 06:38:35 Switch RIP4-7: SEND[eth-0-9]: RESPONSE version 2 packet size 44
Apr  8 06:38:35 Switch RIP4-7: 1.1.1.0/24 -> 0.0.0.0 family 2 tag 0 metric 16
Apr  8 06:38:35 Switch RIP4-7: 10.10.11.0/24 -> 0.0.0.0 family 2 tag 0 metric 16
```

2.7.3 Validation

show running-config, show ip rip interface

2.8 Configuring Timers

RIP use several timers that determine such variables as the frequency of routing updates, the length of time before a route becomes invalid, and other parameters. You can adjust these timers to tune RIP performance to better suit your internet-work needs. You can make the following timer adjustments:

- The rate (time in seconds between updates) at which routing updates are sent.
- The interval of time (in seconds) after which a route is declared invalid.
- The amount of time (in seconds) that must pass before a route is removed from the routing table.

2.8.1 Configuration

To configure the timers, use the following command:

Switch# configure terminal	Enter the Configure mode
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)# timers basic 10 180 120	Specify the routing table update timer in 10 seconds. Specifies the routing information timeout timer in 180 seconds. Specifies the routing garbage collection timer in 120 seconds.

2.8.2 Validation

Use the commands as follows to validat the configuration:

show running-config and show ip protocols rip

Switch# show ip protocols rip

```
Routing protocol is "rip"
 Sending updates every 10 seconds with +/-5 seconds, next due in 2 seconds
 Timeout after 180 seconds, Garbage collect after 120 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
 Redistributing:
 Default version control: send version 2, receive version 2
  Interface       Send        Recv   Key-chain
  eth-0-9         2           2
 Routing for Networks:
  10.10.11.0/24
 Routing Information Sources:
  Gateway         Distance  Last Update  Bad Packets  Bad Routes
  10.10.11.50          120  00:00:02              0           0
 Number of routes (excluding connected): 5
 Distance: (default is 120)
```

2.9 Configuring RIP Route Distribute Filters

A RIP distribute list allows you to permit or deny learning or advertising of specific routes. A distribute list consists of the following parameters:

An ACL or a prefix list that filter the routes.

The direction:

- In: filter applies to learned routes.
- Out: filter applies to advertised routes
- The interface that the filer applies (optional).

2.9.1 Topology

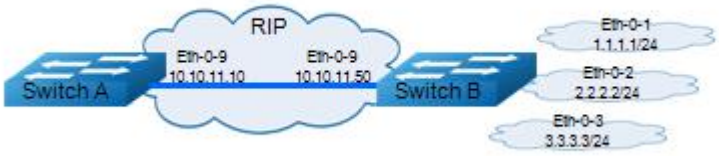

Figure 2-7 RIP Topology III

2.9.2 Configuration

Switch A configuration

```
interface eth-0-9
no switchport
ip address 10.10.11.10/24
!
router rip
network 10.10.11.0/24
!
```

Switch B configuration

```
interface eth-0-1
no switchport
ip address 1.1.1.1/24
!
interface eth-0-2
no switchport
ip address 2.2.2.2/24
!
interface eth-0-3
no switchport
ip address 3.3.3.3/24
!
router rip
network 1.1.1.0/24
network 2.2.2.0/24
network 3.3.3.0/24
network 10.10.11.0/24
!
```

Switch A output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
    [*] - [AD/Metric]
    * - candidate default

R      1.1.1.0/24 [120/2] via 10.10.11.50, eth-0-9, 00:01:50
R      2.2.2.0/24 [120/2] via 10.10.11.50, eth-0-9, 00:01:50
R      3.3.3.0/24 [120/2] via 10.10.11.50, eth-0-9, 00:01:50
C      10.10.11.0/24 is directly connected, eth-0-9
```

To configure the distribute filter on Switch B, use the following command:

Switch# configure terminal	Enter the Configure mode
Switch(config)# ip prefix-list 1 deny 1.1.1.0/24 Switch(config)# ip prefix-list 1 permit any	Build a prefix list
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)# distribute-list prefix 1 out	The prefix list 1 will apply to filter all advertised routes.

2.9.3 Validation

Switch A output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
    [*] - [AD/Metric]
    * - candidate default

R      2.2.2.0/24 [120/2] via 10.10.11.50, eth-0-9, 00:00:08
R      3.3.3.0/24 [120/2] via 10.10.11.50, eth-0-9, 00:00:08
C      10.10.11.0/24 is directly connected, eth-0-9
```

2.10 Configuring RIPv2 authentication (single key)

This RIP implementation provides the choice of configuring authentication for a single key or for multiple keys. This example illustrates authentication of the routing information exchange process for RIP using a single key. Switch A and B are running RIP and exchange routing updates. To configure single key authentication on Switch A, specify an interface and then define a key or password for that interface

Next, specify an authentication mode Any receiving RIP packet on this specified interface should have the same string as password. For an exchange of updates between Switch A and B, define the same password and authentication mode on Switch B.

2.10.1 Topology

Figure 2-8 RIPv2

2.10.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)# network 10.10.11.0/24	Associate network 10.10.11.0/24 with the RIP process.
Switch(config-router)# redistribute connected	Enable redistributing from connected routes.
Switch(config-router)# exit	Quit the Router mode and return to the Configure mode
Switch(config)# interface eth-0-9	Specify the interface (eth-0-9) for authentication.
Switch(config-if)# ip rip authentication string Auth1	Specify the authentication string (Auth1) for this interface
Switch(config-if)# ip rip authentication mode text	Specify the authentication mode to be text.

Switch B

Switch # configure terminal	Enter the Configure mode
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)# network 10.10.11.0/24	Associate network 10.10.11.0/24 with the RIP process.
Switch(config-router)# redistribute connected	Enable redistributing from connected routes.
Switch(config-router)# exit	Quit the Router mode and return to the Configure mode
Switch(config)# interface eth-0-9	Specify the interface (eth-0-9) for authentication.

Switch(config-if)# ip rip authentication string Auth1	Specify the authentication string (Auth1) for this interface
Switch(config-if)# ip rip authentication mode text	Specify the authentication mode to be text.

2.10.3 Validation

Use the commands as follows to validat the configuration:

show running-config, show ip rip database, show ip protocols rip, show ip rip interface and show ip route

2.11 Configuring RIPv2 MD5 authentication (multiple keys)

This example illustrates the md5 authentication of the routing information exchange process for RIP using multiple keys. Switch A and B are running RIP and exchange routing updates. To configure authentication on Switch A, define a key chain, specify keys in the key chain and then define the authentication string or passwords to be used by the keys. Then set the time period during which it is valid to receive or send the authentication key by specifying the accept and send lifetimes.[optional].After defining the key string, specify the key chain (or the set of keys) that will be used for authentication on the interface and the authentication mode to be used. Configure Switch A and B to have the same key ID and key string as Switch A for the time that updates need to be exchanged.

In md5 authentication, both the key ID and key string are matched for authentication. R1 will receive only packets that match both the key ID and the key string in the specified key chain (within the accept lifetime) on that interface In the following example, Switch B has the same key ID and key string as Switch A. For additional security, the accept lifetime and send lifetime are configured such that every fifth day the key ID and key string changes. To maintain continuity, the accept lifetimes should be configured to overlap; however, the send lifetime should not be overlapping.

2.11.1 Topology

Figure 2-9 RIPv2 MD5 authentication

2.11.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)# network 10.10.11.0/24	Associate network 10.10.11.0/24 with the RIP process.
Switch(config-router)# redistribute connected	Enable redistributing from connected routes.
Switch(config-router)# exit	Quit the Router mode and return to the Configure mode
Switch(config)# key chain SUN	Enter the key chain management mode to add keys to the key chain SUN.
Switch(config-keychain)# key 1	Add authentication key ID (1) to the key chain SUN.
Switch(config-keychain-key)# key-string key1	Specify a password (key1) to be used by the specified key.
Switch(config-keychain-key)# accept-lifetime 12:00:00 Mar 2 2012 14:00:00 Mar 7 2012	Specify the time period during which authentication key string key1 can be received. In this case, key string key1 can be received from noon of March 2 to 2 pm March 7, 2012.
Switch(config-keychain-key)# send-lifetime 12:00:00 Mar 2 2012 12:00:00 Mar 7 2012	Specify the time period during which authentication key string key1 can be send. In this case, key string key1 can be sent from noon of March 2 to noon of March 7, 2012.
Switch(config-keychain-key)# exit	Exit the keychain-key mode and return to keychain mode
Switch(config-keychain)# key 2	Add another authentication key (2) to the key chain SUN.
Switch(config-keychain-key)# key-string Earth	Specify a password (Earth) to be used by the specified key.
Switch(config-keychain-key)# accept-lifetime 12:00:00 Mar 7 2012 14:00:00 Mar 12 2012	Specify the time period during which authentication key string Earth can be received. In this case, key string Earth can be received from noon of March 7 to 2 pm March 12, 2012.
Switch(config-keychain-key)# send-lifetime 12:00:00 Mar 7 2012 12:00:00 Mar 12 2012	Specify the time period during which authentication key string Earth can be send. In this case, key string Earth can be sent from noon of March 7 to noon of March 12, 2012.
Switch(config-keychain-key)# end	Enter Privileged Exec mode
Switch # configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-9	Specify the interface (eth-0-9) for authentication.
Switch(config-if)# ip rip authentication key-chain SUN	Enable RIPv2 authentication on eth-0-9 interface and specify the key chain SUN to be used for authentication.

Switch(config-if)# ip rip authentication mode md5	Specify the authentication mode to be MD5.

Switch B

Switch # configure terminal	Enter the Configure mode
Switch(config)# router rip	Enter the RIP routing process.
Switch(config-router)# network 10.10.11.0/24	Associate network 10.10.11.0/24 with the RIP process.
Switch(config-router)# redistribute connected	Enable redistributing from connected routes.
Switch(config-router)# exit	Quit the Router mode and return to the Configure mode
Switch(config)# key chain SUN	Enter the key chain management mode to add keys to the key chain SUN.
Switch(config-keychain)# key 1	Add authentication key ID (1) to the key chain SUN.
Switch(config-keychain-key)# key-string key1	Specify a password (key1) to be used by the specified key.
Switch(config-keychain-key)# accept-lifetime 12:00:00 Mar 2 2012 14:00:00 Mar 7 2012	Specify the time period during which authentication key string key1 can be received. In this case, key string key1 can be received from noon of March 2 to 2 pm March 7, 2012.
Switch(config-keychain-key)# send-lifetime 12:00:00 Mar 2 2012 12:00:00 Mar 7 2012	Specify the time period during which authentication key string key1 can be send. In this case, key string key1 can be sent from noon of March 2 to noon of March 7, 2012.
Switch(config-keychain-key)# exit	Exit the keychain-key mode and return to keychain mode
Switch(config-keychain)# key 2	Add another authentication key (2) to the key chain SUN.
Switch(config-keychain-key)# key-string Earth	Specify a password (Earth) to be used by the specified key.
Switch(config-keychain-key)# accept-lifetime 12:00:00 Mar 7 2012 14:00:00 Mar 12 2012	Specify the time period during which authentication key string Earth can be received. In this case, key string Earth can be received from noon of March 7 to 2 pm March 12, 2012.
Switch(config-keychain-key)# send-lifetime 12:00:00 Mar 7 2012 12:00:00 Mar 12 2012	Specify the time period during which authentication key string Earth can be send. In this case, key string Earth can be sent from noon of March 7 to noon of March 12, 2012.
Switch(config-keychain-key)# end	Enter Privileged Exec mode
Switch # configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-9	Specify the interface (eth-0-9) for authentication.

Switch(config-if)# ip rip authentication key-chain SUN	Enable RIPv2 authentication on eth-0-9 interface and specify the key chain SUN to be used for authentication.
Switch(config-if)# ip rip authentication mode md5	Specify the authentication mode to be MD5.

2.11.3 Validation

Use the commands as follows to validat the configuration:

show running-config, show ip rip, show ip protocols rip, show ip rip interface and show key chain

Validate on Switch A

Switch# show key chain

```
key chain SUN:
  key 1 -- text "key1"
    accept-lifetime <12:00:00 Mar 02 2012> - <14:00:00 Mar 07 2012>
    send-lifetime <12:00:00 Mar 02 2012> - < 12:00:00 Mar 07 2012>
  key 2 -- text "Earth"
    accept-lifetime <12:00:00 Mar 07 2012> - <14:00:00 Mar 12 2012>
    send-lifetime <12:00:00 Mar 07 2012> - < 12:00:00 Mar 12 2012>
Switch#
```

Validate on Switch B

Switch# show key chain

```
key chain SUN:
  key 1 -- text "key1"
    accept-lifetime <12:00:00 Mar 02 2012> - <14:00:00 Mar 07 2012>
    send-lifetime <12:00:00 Mar 02 2012> - < 12:00:00 Mar 07 2012>
  key 2 -- text "Earth"
    accept-lifetime <12:00:00 Mar 07 2012> - <14:00:00 Mar 12 2012>
    send-lifetime <12:00:00 Mar 07 2012> - < 12:00:00 Mar 12 2012>
```

3 Configuring OSPF

3.1 Overview

OSPF is an Interior Gateway Protocol (IGP) designed expressly for IP networks, supporting IP subnet ting and tagging of externally derived routing information. OSPF also allows packet authentication and uses IP multicast when sending and receiving packets.

The implementation conforms to the OSPF Version 2 specifications with these key features:

- **Definition of stub areas is supported**: Routes learned through any IP routing protocol can be redistributed into another IP routing protocol. At the intradomain level, this means that OSPF can import routes learned through RIP. OSPF routes can also be exported into RIP.
- **Plain text and MD5 authentication among neighboring routers within an area is supported**:

  Configurable routing interface parameters include interface output cost, retransmission interval, interface transmit delay, router priority, router dead and hello intervals, and authentication key.
- **Virtual links are not supported**: Not-so-stubby-areas (NSSAs) per RFC 1587 are not supported now.

  OSPF typically requires coordination among many internal routers, area border routers (ABRs) connected to multiple areas, and autonomous system boundary routers (ASBRs). The minimum configuration would use all default parameter values, no authentication, and interfaces assigned to areas. If you customize your environment, you must ensure coordinated configuration of all routers.

3.2 References

The OSPF module is based on the following RFC:

RFC 2328 – OSPF version 2

3.3 Basic OSPF Parameters Configuration

Enabling OSPF requires that you create an OSPF routing process, specify the range of IP addresses to be associated with the routing process, and assign area IDs to be associated with that range. Beginning in privileged EXEC mode, follow these steps to enable OSPF:

Switch# configure terminal	Enter the Configure mode
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define an interface on which OSPF runs and the area ID for that interface You can use the wildcard mask as a single command to define one or more interfaces to be associated with a specific OSPF area. The area ID can be a decimal value or an IP address.
Switch(config-router)# end	Return to privileged EXEC mode
Switch# show ip protocols	Verify your entries.

To end an OSPF routing process, use the “no router ospf process-id” global configuration command.

This example shows how to configure an OSPF routing process and assign it a process number of 109:

Switch(config)# router ospf 109

Switch(config-router)# network 131.108.0.0 255.255.255.0 area 24

3.4 Enabling OSPF on an Interface

This example shows the minimum configuration required for enabling OSPF on an interface Switch A and B are two routers in Area 0 connecting to network 10.10.10.0/24.

Configure one interface so that it belongs to only one area. However, you can configure different interfaces on a router to belong to different areas.

3.4.1 Topology

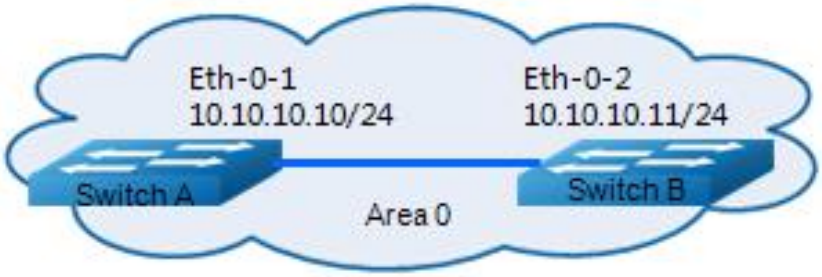

Figure 3-1 OSPF AS

3.4.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)# router ospf 200	Configure the Routing process and specify the Process ID (200). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface

3.4.3 Validation

Use the commands as follows to validate the configuration:

show ip ospf database, show ip ospf interface, show ip ospf neighbor and show ip ospf route

Switch A output

Switch# show ip ospf database

```
        OSPF Router with ID (10.10.10.10) (Process ID 100)
            Router Link States (Area 0)
Link ID         ADV Router      Age  Seq#       CkSum  Link count
10.10.10.10     10.10.10.10     51 0x80000002 0xd012        1
```

Switch# show running-config

```
router ospf 100
 network 10.10.10.0/24 area 0
!
```

Switch B output

Switch# show ip ospf database

```
        OSPF Router with ID (10.10.10.10) (Process ID 200)
            Router Link States (Area 0)
Link ID         ADV Router      Age  Seq#       CkSum  Link count
10.10.10.10     10.10.10.10     267 0x80000002 0xd012 1
```

Switch# show running-config

```
router ospf 200
 network 10.10.10.0/24 area 0
!
```

3.5 Configuring Priority

This example shows the configuration for setting the priority for an interface You can set a high priority for a router to make it the Designated Router (DR). Router Switch C is configured to have a priority of 10, which is higher than the default priority (default priority is 1) of Switch A and B; making it the DR.

3.5.1 Topology

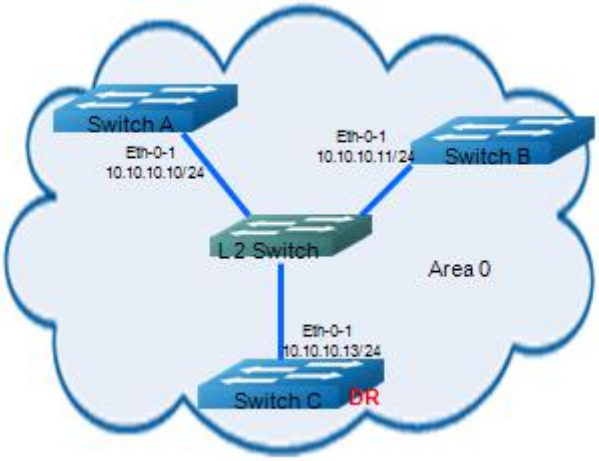

Figure 3-2 OSPF Priority

3.5.2 Configuration

Switch C

Switch(config)# interface eth-0-1	Specify the interface (eth-0-1) to be configured
Switch(config-if)# ip ospf priority 10	Specify the router priority to a higher Switch C the Designated Router (DR)
Switch(config-if)# exit	Exit the Interface mode and return to the Configure mode
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area)

Switch A

Switch(config)# router ospf 200	Configure the Routing process and specify the Process ID (200). The Process ID should be a unique positive integer identifying the routing process
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface

3.5.3 Validation

Use the commands as follows to validate the configuration:

show ip ospf neighbor and show ip ospf interface

Switch C output

Switch# show ip ospf interface

```
eth-0-10 is up, line protocol is up
 Internet Address 10.10.10.13/24, Area 0, MTU 1500
 Process ID 0, Router ID 10.10.10.13, Network Type BROADCAST, Cost: 1
 Transmit Delay is 1 sec, State DR, Priority 10, TE Metric 1
 Designated Router (ID) 10.10.10.13, Interface Address 10.10.10.13
 Backup Designated Router (ID) 10.10.10.11, Interface Address 10.10.10.11
 Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
   Hello due in 00:00:07
 Neighbor Count is 2, Adjacent neighbor count is 2
 Crypt Sequence Number is 1301567281
 Hello received 188 sent 110, DD received 34 sent 23
 LS-Req received 8 sent 6, LS-Upd received 28 sent 26
 LS-Ack received 32 sent 15, Discarded 0
```

3.6 Configuring OSPF Area Parameters

You can optionally configure several OSPF area parameters. These parameters include authentication for password-based protection against unauthorized access to an area and stub areas. Stub areas are areas into which information on external routes is not sent. Instead, the area border router (ABR) generates a default external route into the stub area for destinations outside the autonomous system (AS).

Route summarization is the consolidation of advertised addresses into a single summary route to be advertised by other areas. If network numbers are contiguous, you can use the area range router configuration command to configure the ABR to advertise a summary route that covers all networks in the range.

3.6.1 Topology

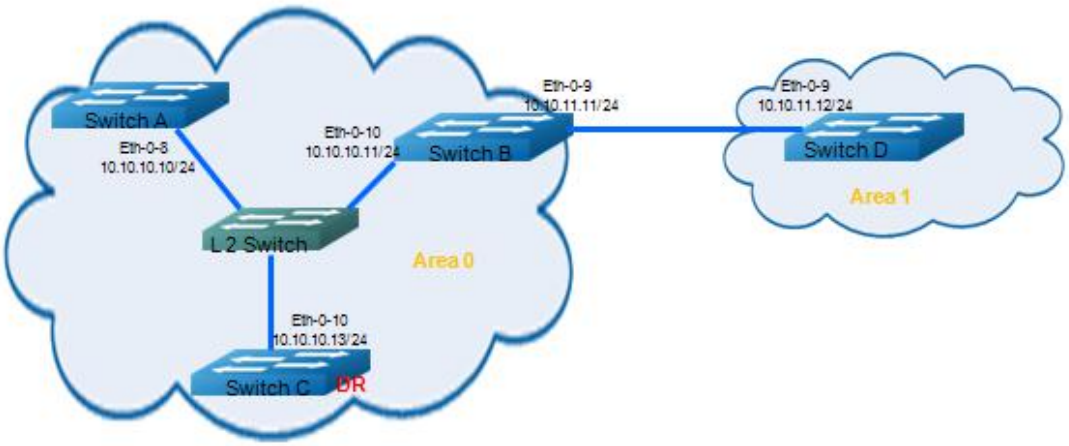

Figure 3-3 OSPF Area

3.6.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-8	Enter interface Eth-0-8
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.10.10/24	Set Eth-0-1 ip address as 10.10.10.10/24
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-10	Enter interface Eth-0-10
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.10.11/24	Set Eth-0-10 ip address as 10.10.10.11/24
Switch(config)#interface eth-0-9	Enter interface Eth-0-9
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.11.11/24	Set Eth-0-9 ip address as 10.10.11.11/24
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).
Switch(config-router)# network 10.10.11.0/24 area 1	Define the interface (10.10.11.0/24) on which OSPF runs and associate the area ID (1) with the interface
Switch(config-router)# area 0 range 10.10.10.0/24	(Optional) Specify an address range for which a single route is advertised. Use this command only with area border routers.
Switch(config-router)# area 1 stub no-summary	(Optional) Define an area as a stub area. The no-summary keyword prevents an ABR from sending summary link advertisements into the stub area.
Switch(config-router)# end	Return to Exec mode
Switch # show ip ospf 100 Switch # show ip ospf 100 database	Display information about the OSPF routing process in general or for a specific process ID to verify configuration. Display lists of information related to the OSPF database for a specific router.

Switch C

Switch # configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-10	Enter interface Eth-0-10
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.10.13/24	Set Eth-0-10 ip address as 10.10.10.11/24
Switch(config-if)# ip ospf priority 10	Set Eth-0-10 priority is 10

Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch D

Switch # configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-9	Enter interface Eth-0-9
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.11.12/24	Set Eth-0-10 ip address as 10.10.11.12/24
Switch(config)# router ospf 200	Configure the Routing process and specify the Process ID (200). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.11.0/24 area 1	Define the interface (10.10.11.0/24) on which OSPF runs and associate the area ID (1) with the interface
Switch(config-router)# area 1 stub no-summary	(Optional) Define an area as a stub area. The no-summary keyword prevents an ABR from sending summary link advertisements into the stub area.

3.6.3 Validation

Use the command **show ip route** to validate the configuration.

Switch A output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

C      10.10.10.0/24 is directly connected, eth-0-8
O IA   10.10.11.0/24 [110/2] via 10.10.10.11, eth-0-8, 00:14:46
```

Switch B output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

C      10.10.10.0/24 is directly connected, eth-0-10
C      10.10.11.0/24 is directly connected, eth-0-9
```

Switch C output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

C      10.10.10.0/24 is directly connected, eth-0-10
O IA   10.10.11.0/24 [110/2] via 10.10.10.11, eth-0-10, 00:20:35
```

Switch D output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

Gateway of last resort is 10.10.11.11 to network 0.0.0.0

O*IA   0.0.0.0/0 [110/2] via 10.10.11.11, eth-0-9, 00:12:46
C      10.10.11.0/24 is directly connected, eth-0-9
```

3.7 Redistributing Routes into OSPF

In this example the configuration causes RIP routes to be imported into the OSPF routing table and advertised as Type 5 External LSAs into Area 0.

3.7.1 Topology

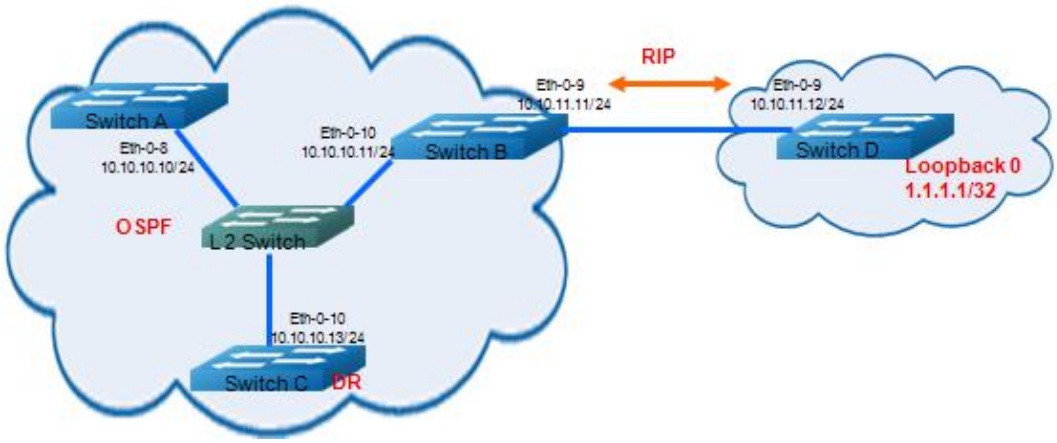

Figure 3-4 OSPF Routes Redistributing

3.7.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-8	Enter interface Eth-0-8
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.10.10/24	Set Eth-0-1 ip address as 10.10.10.10/24
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-10	Enter interface Eth-0-10
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.10.11/24	Set Eth-0-10 ip address as 10.10.10.11/24
Switch(config)#interface eth-0-9	Enter interface Eth-0-9
Switch(config-if)#no switchport	Change port mode to router port

Switch(config-if)#ip address 10.10.11.11/24	Set Eth-0-9 ip address as 10.10.11.11/24
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).
Switch(config-router)# redistribute connected	Redistribute connect route
Switch(config-router)#redistribute rip	Redistribute rip route
Switch(config-router)# exit	Return to Exec mode
Switch(config)# router rip	Config rip route protocol
Switch(config-router)# network 10.10.11.0/24	Define network into rip
Switch(config-router)#redistribute connected	Redistribute connect route

Switch C

Switch # configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-10	Enter interface Eth-0-10
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.10.13/24	Set Eth-0-10 ip address as 10.10.10.11/24
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0	Define the interface (10.10.10.0/24) on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch D

Switch # configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-9	Enter interface Eth-0-9
Switch(config-if)#no switchport	Change port mode to router port
Switch(config-if)#ip address 10.10.11.12/24	Set Eth-0-10 ip address as 10.10.11.12/24
Switch(config)# router rip	Config rip route protocol
Switch(config-router)# network 10.10.11.0/24	Define network into rip
Switch(config-router)# network 1.1.1.1/32	Define network into rip

Switch(config-router)#redistribute connected	Redistribute connect route.

3.7.3 Validation

Use the command to validate the configuration:

show ip ospf database external and show ip route

Switch A output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       [*] - [AD/Metric]
       * - candidate default

O E2    1.1.1.1/32 [110/20] via 10.10.10.11, eth-0-8, 00:21:00
C       10.10.10.0/24 is directly connected, eth-0-8
O E2    10.10.11.0/24 [110/20] via 10.10.10.11, eth-0-8, 00:13:25
```

Switch# show ip ospf database external

```
          OSPF Router with ID (10.10.10.10) (Process ID 100)
                                  AS External Link States
 LS age: 1447
 Options: 0x2 (*|-|-|-|-|-|E|-)
 LS Type: AS-external-LSA
 Link State ID: 1.1.1.1 (External Network Number)
 Advertising Router: 10.10.11.11
 LS Seq Number: 80000002
 Checksum: 0x414e
 Length: 36
 Network Mask: /32
       Metric Type: 2 (Larger than any link state path)
       TOS: 0
       Metric: 20
       Forward Address: 0.0.0.0
       External Route Tag: 0

 LS age: 993
 Options: 0x2 (*|-|-|-|-|-|E|-)
 LS Type: AS-external-LSA
 Link State ID: 10.10.11.0 (External Network Number)
 Advertising Router: 10.10.11.11
 LS Seq Number: 80000001
 Checksum: 0xfc78
 Length: 36
```

```
 Network Mask: /24
      Metric Type: 2 (Larger than any link state path)
      TOS: 0
      Metric: 20
      Forward Address: 0.0.0.0
      External Route Tag: 0
```

Switch B output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
      [*] - [AD/Metric]
      * - candidate default

R      1.1.1.1/32 [120/2] via 10.10.11.12, eth-0-9, 00:24:52
C      10.10.10.0/24 is directly connected, eth-0-10
C      10.10.11.0/24 is directly connected, eth-0-9
```

Switch C output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
      [*] - [AD/Metric]
      * - candidate default

O E2    1.1.1.1/32 [110/20] via 10.10.10.11, eth-0-10, 00:22:38
C      10.10.10.0/24 is directly connected, eth-0-10
O E2    10.10.11.0/24 [110/20] via 10.10.10.11, eth-0-10, 00:15:04
C      100.100.100.0/24 is directly connected, eth-0-7
C      200.200.200.0/24 is directly connected, eth-0-8
```

Switch D output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
      [*] - [AD/Metric]
      * - candidate default

C      1.1.1.1/32 is directly connected, loopback0
R      10.10.10.0/24 [120/2] via 10.10.11.11, eth-0-9, 00:17:36
C      10.10.11.0/24 is directly connected, eth-0-9
```

3.8 OSPF Cost

You can make a route the preferred route by changing its cost. In this example, cost has been configured to make Switch B the next hop for Switch A.

The default cost on each interface is 1(1000M speed). Interface eth2 on Switch B has a cost of 100 and interface eth2 on Switch C has a cost of 150. The total cost to reach(Switch D network 10.10.14.0) through Switch B and Switch C:

Switch B: 1+1+100 = 102

Switch C: 1+1+150 = 152

Therefore, Switch A chooses Switch B as its next hop for destination Switch D

3.8.1 Topology

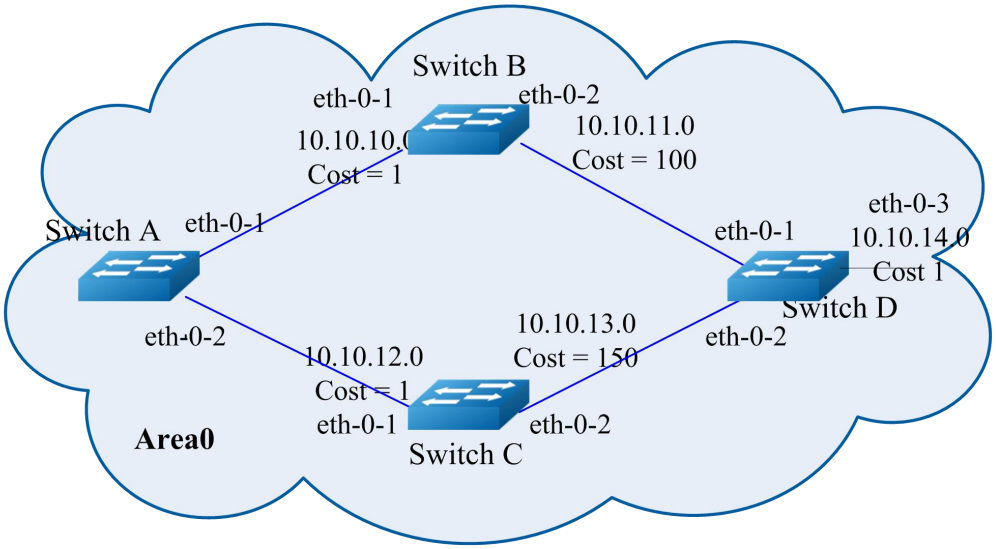

Figure 3-5 OSPF Cost

3.8.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-1	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.10.1/24	Set interface ip address
Switch(config-if)# exit	Exit to configure mode

Switch(config)# interface eth-0-2	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.12.1/24	Set interface ip address
Switch(config-if)# exit	Exit to configure mode
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0 Switch(config-router)# network 10.10.12.0/24 area 0	Define interfaces on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-1	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.10.2/24	Set interface ip address
Switch(config-if)# exit	Exit to configure mode
Switch(config)# interface eth-0-2	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.11.2/24	Set interface ip address
Switch(config-if)# ip ospf cost 100	Change ospf interface cost
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.10.0/24 area 0 Switch(config-router)# network 10.10.11.0/24 area 0	Define interfaces on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch C

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-1	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.12.2/24	Set interface ip address
Switch(config-if)# exit	Exit to configure mode
Switch(config)# interface eth-0-2	Enter the interface mode

Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.13.2/24	Set interface ip address
Switch(config-if)# ip ospf cost 150	Change ospf interface cost
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.12.0/24 area 0 Switch(config-router)# network 10.10.13.0/24 area 0	Define interfaces on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

Switch D

Switch# configure terminal	Enter the Configure mode
Switch(config)# interface eth-0-1	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.11.1/24	Set interface ip address
Switch(config-if)# exit	Exit to configure mode
Switch(config)# interface eth-0-2	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.13.1/24	Set interface ip address
Switch(config)# interface eth-0-3	Enter the interface mode
Switch(config)# no switchport	Set the interface as layer3
Switch(config-if)# ip address 10.10.14.1/24	Set interface ip address
Switch(config)# router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# network 10.10.11.0/24 area 0 Switch(config-router)# network 10.10.13.0/24 area 0 Switch(config-router)# network 10.10.14.0/24 area 0	Define interfaces on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area).

3.8.3 Validation

Use the command **show ip ospf route** to validate the configuration.

Switch A output

Switch# show ip ospf route

```
OSPF process 0:
Codes: C - connected, D - Discard, 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

C  10.10.10.0/24 [1] is directly connected, eth-0-1, Area 0
O  10.10.11.0/24 [101] via 10.10.10.2, eth-0-1, Area 0
C  10.10.12.0/24 [1] is directly connected, eth-0-2, Area 0
O  10.10.13.0/24 [102] via 10.10.10.2, eth-0-1, Area 0
O  10.10.14.0/24 [102] via 10.10.10.2, eth-0-1, Area 0
```

Switch B output

Switch#show ip ospf route

```
OSPF process 100:
Codes: C - connected, D - Discard, 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

C  10.10.10.0/24 [10] is directly connected, eth-0-1, Area 0
C  10.10.11.0/24 [100] is directly connected, eth-0-2, Area 0
O  10.10.12.0/24 [11] via 10.10.10.1, eth-0-1, Area 0
O  10.10.13.0/24 [101] via 10.10.11.1, eth-0-2, Area 0
O  10.10.14.0/24 [101] via 10.10.11.1, eth-0-2, Area 0
```

Switch C output

Switch# show ip ospf route

```
OSPF process 100:
Codes: C - connected, D - Discard, 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

O  10.10.10.0/24 [1] via 10.10.12.1, eth-0-1, Area 0
O  10.10.11.0/24 [101] via 10.10.12.1, eth-0-1, Area 0
C  10.10.12.0/24 [10] is directly connected, eth-0-1, Area 0
O  10.10.13.0/24 [102] via 10.10.12.1, eth-0-1, Area 0
O  10.10.14.0/24 [102] via 10.10.12.1, eth-0-1, Area 0
```

Switch D output

Switch# show ip route

```
Codes: K - kernel, 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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
    [*] - [AD/Metric]
```

```
    * - candidate default

O      10.10.10.0/24 [110/1] via 10.10.11.2, eth-0-1, 00:06:27
C      10.10.11.0/24 is directly connected, eth-0-1
O      10.10.12.0/24 [110/1] via 10.10.13.2, eth-0-2, 00:06:17
C      10.10.13.0/24 is directly connected, eth-0-2
C      10.10.14.0/24 is directly connected, eth-0-3
```

3.9 OSPF Authentication

In our implementation there are three types of OSPF authentications--Null authentication (Type 0), Simple Text (Type 1) authentication and MD5 (Type 2) authentication. With null authentication, routing exchanges over the network are not authenticated. In Simple Text authentication, the authentication type is the same for all routers that communicate using OSPF in a network. For MD5 authentication, you configure a key and a key-id on each router. The router generates a message digest on the basis of the key, key ID and the OSPF packet and adds it to the OSPF packet.

The Authentication type can be configured on a per-interface basis or a per-area basis. Additionally, Interface and Area authentication can be used together. Area authentication is used for an area and interface authentication is used for a specific interface in the area. If the Interface authentication type is different from Area authentication type, Interface authentication type overrides the Area authentication type. If the Authentication type is not specified for an interface, the Authentication type for the area is used. The authentication command descriptions contain details of each type of authentication. Refer to the OSPF Command Reference for OSPF authentication commands.

In the example below, Switch A and B are configured for both the interface and area authentications. The authentication type of interface eth-0-9 on Switch A and interface eth-0-9 on Switch B is null authentication mode The authentication type of interface eth-0-1 on Switch B and interface eth-0-1 on Switch C is simple authentication mode The authentication type of interface eth-0-2 on Switch C and interface eth-0-2 on Switch D is MD5 authentication mode in area1,if you define area 1 authentication type first, you needn’t define interface authentication type, only define authentication key value.

3.9.1 Topology

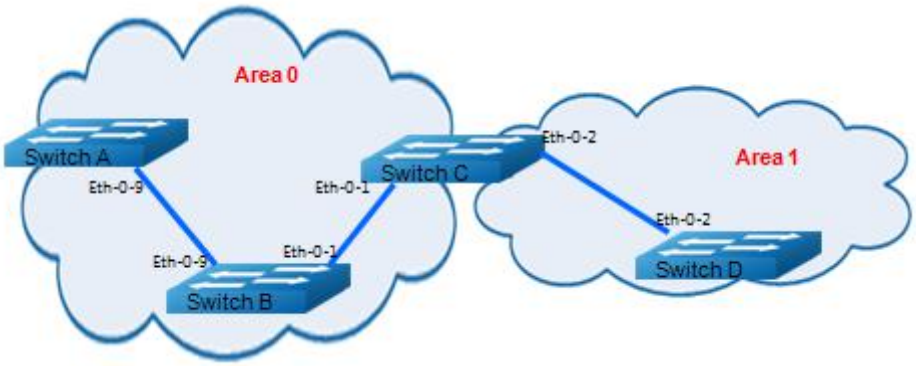

Figure 3-6 OSPF Authentication

3.9.2 Configuration

Switch A

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-9	Enter interface mode
Switch(config-if)#ip address 9.9.9.1/24	Set ip address on interface
Switch(config-if)#ip ospf authentication	Enable interface authentication function
Switch(config-if)#ip ospf authentication null	Specify an OSPF authentication type
Switch(config)# router ospf	Configure the Routing process and specify the Process ID 0. The Process ID should be a unique positive integer identifying the routing process
Switch(config-router)# network 9.9.9.0/24 area 0	Define interfaces on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area)
Switch(config-router)# end	Exit the Router mode and return to Configure mode

Switch B

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-9	Enter interface mode
Switch(config-if)#ip address 9.9.9.2/24	Set ip address on interface
Switch(config-if)#ip ospf authentication	Enable interface authentication function
Switch(config-if)#ip ospf authentication null	Specify an OSPF authentication type

Switch(config)#interface eth-0-1	Enter interface mode
Switch(config-if)#ip address 1.1.1.1/24	Set ip address on interface
Switch(config-if)#ip ospf authentication	Enable interface authentication function
Switch(config-if)# ip ospf authentication-key test	Specify an OSPF authentication type and define key value
Switch(config)# router ospf	Configure the Routing process and specify the Process ID 0. The Process ID should be a unique positive integer identifying the routing process
Switch(config-router)# network 9.9.9.0/24 area 0 Switch(config-router)# network 1.1.1.0/24 area 0	Define interfaces on which OSPF runs and associate the area ID (0) with the interface (area ID 0 specifies the backbone area
Switch(config-router)# end	Exit the Router mode and return to Configure mode

Switch C

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-2	Enter interface mode
Switch(config-if)#ip address 2.2.2.1/24	Set ip address on interface
Switch(config-if)# ip ospf message-digest-key 2 md5 ospf	Specify an OSPF authentication type and MD5 value
Switch(config)#interface eth-0-1	Enter interface mode
Switch(config-if)#ip address 1.1.1.2/24	Set ip address on interface
Switch(config-if)#ip ospf authentication	Enable interface authentication function
Switch(config-if)# ip ospf authentication-key test	Specify an OSPF authentication type and define key value
Switch(config)# router ospf	Configure the Routing process and specify the Process ID 0. The Process ID should be a unique positive integer identifying the routing process
Switch(config-router)# area 1 authentication message-digest Switch(config-router)# network 2.2.2.0/24 area 1 Switch(config-router)# network 1.1.1.0/24 area 0	Define interfaces to different area and specify area 1 authentication type
Switch(config-router)# end	Exit the Router mode and return to Configure mode

Switch D

Switch# configure terminal	Enter the Configure mode
Switch(config)#interface eth-0-2	Enter interface mode
Switch(config-if)#ip address 2.2.2.2/24	Set ip address on interface
Switch(config-if)# ip ospf message-digest-key 2 md5 ospf	Specify an OSPF authentication type and MD5 value
Switch(config)# router ospf	Configure the Routing process and specify the Process ID 0. The Process ID should be a unique positive integer identifying the routing process.
Switch(config-router)# area 1 authentication message-digest Switch(config-router)# network 2.2.2.0/24 area 1	Define interfaces to different area and specify area 1 authentication type
Switch(config-router)# end	Exit the Router mode and return to Configure mode

3.9.3 Validation

Use the command **show ip ospf neighbor** to validate the configuration.

Switch A output

Switch# show ip ospf neighbor

```
OSPF process 0:
Neighbor ID     Pri   State           Dead Time   Address         Interface
9.9.9.2           1   Full/DR         00:00:38    9.9.9.2         eth-0-9
```

Switch B output

Switch# show ip ospf neighbor

```
OSPF process 0:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.1           1   Full/Backup     00:00:35    1.1.1.2         eth-0-1
1.1.1.1           1   Full/Backup     00:00:38    9.9.9.1         eth-0-9
```

Switch C output

Switch# show ip ospf neighbor

```
OSPF process 0:
Neighbor ID     Pri   State           Dead Time   Address         Interface
9.9.9.2           1   Full/DR         00:00:35    1.1.1.1         eth-0-1
2.2.2.2           1   Full/DR         00:00:38    2.2.2.2         eth-0-2
```

Switch# show ip ospf interface

```
eth-0-1 is up, line protocol is up
 Internet Address 1.1.1.2/24, Area 0, MTU 1500
 Process ID 0, Router ID 2.2.2.1, Network Type BROADCAST, Cost: 1
 Transmit Delay is 1 sec, State Backup, Priority 1, TE Metric 1
 Designated Router (ID) 9.9.9.2, Interface Address 1.1.1.1
 Backup Designated Router (ID) 2.2.2.1, Interface Address 1.1.1.2
 Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
   Hello due in 00:00:01
 Neighbor Count is 1, Adjacent neighbor count is 1
 Crypt Sequence Number is 1301244696
 Hello received 385 sent 384, DD received 3 sent 5
 LS-Req received 1 sent 1, LS-Upd received 11 sent 14
 LS-Ack received 12 sent 10, Discarded 1
 Simple password authentication enabled
```

Switch# show ip ospf

```
Routing Process "ospf 0" with ID 2.2.2.1
Process uptime is 1 hour 7 minutes
Process bound to VRF default
Conforms to RFC2328, and RFC1583 Compatibility flag is disabled
Supports only single TOS(TOS0) routes
Supports opaque LSA
This router is an ABR, ABR Type is Alternative Cisco (RFC3509)
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Refresh timer 10 secs
Number of incomming current DD exchange neighbors 0/5
Number of outgoing current DD exchange neighbors 0/5
Number of external LSA 0. Checksum 0x000000
Number of opaque AS LSA 0. Checksum 0x000000
Number of non-default external LSA 0
External LSA database is unlimited.
Number of LSA originated 17
Number of LSA received 57
Number of areas attached to this router: 2
  Area 0 (BACKBONE)
     Number of interfaces in this area is 1(1)
     Number of fully adjacent neighbors in this area is 1
     Area has no authentication
     SPF algorithm last executed 01:06:56.340 ago
     SPF algorithm executed 16 times
     Number of LSA 6. Checksum 0x034b09
  Area 1
     Number of interfaces in this area is 1(1)
     Number of fully adjacent neighbors in this area is 1
     Number of fully adjacent virtual neighbors through this area is 0
     Area has message digest authentication
     SPF algorithm last executed 00:03:29.430 ago
     SPF algorithm executed 17 times
     Number of LSA 5. Checksum 0x0230e3
```

Switch D output

Switch# show ip ospf neighbor

```
OSPF process 0:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.1           1   Full/Backup     00:00:35    2.2.2.1         eth-0-2
```

3.10 Monitoring OSPF

3.10.1 Configuration

You can display specific statistics such as the fiberstore of IP routing tables, caches, and databases.

Switch# show ip ospf 100	Display general information about OSPF routing processes
Switch # show ip ospf 100 database router 10.10.25.21 adv-router 3.3.3.3 Switch # show ip ospf 100 database network self-originate Switch # show ip ospf 100 database summary Switch # show ip ospf 100 database asbr-summary Switch # show ip ospf 100 database external	Display lists of information related to the OSPF database
Switch # show ip ospf border-routes	Display the internal OSPF routing ABR and ASBR table entries
Switch # show ip ospf interface eth-0-1	Display OSPF-related interface information
Switch # show ip ospf neighbor 172.16.12.100	Display OSPF interface neighbor information

4 Configuring Prefix-list

4.1 Overview

Routing Policy is the technology for modifying route information to change traffic route. Prefix list is a kind of route policies that used to control and modify routing information. A prefix list is identified by list name and contains one or more ordered entries which are processed sequentially. Each entry provides a matched range for network prefix and has a unique sequence number in the list. In the matching process， switch will check entries orderly. If a entry matches conditions, this process would finish.

4.2 Basic Configuration

4.2.1 Configuration

Switch# configure terminal	Enter the Configure mode
Switch(config)# ip prefix-list test seq 1 deny 35.0.0.0/8 le 16	Create a prefix-list named test and an entry with sequence number 1
Switch(config)# ip prefix-list test permit any	Configure to add a entry to match everything when the match conditions above are not met. This is used to prevent routes to be denied when not match the match criteria above
Switch(config)# ip prefix-list test description this prefix list is for test	Add description for prefix-list
Switch(config)# ip prefix-list test permit 36.0.0.0/24	Create an entry with default sequence number
Switch(config)# exit	Exit the Configure mode

4.2.2 Validation

Switch# show ip prefix-list detail

```
Prefix-list list number: 1
Prefix-list entry number: 3
Prefix-list with the last deletion/insertion: test
ip prefix-list test:
  Description: this prefix list is fot test
  count: 3, range entries: 0, sequences: 1 - 10
```

```
  seq 1 deny 35.0.0.0/8 le 16 (hit count: 0, refcount: 0)
  seq 5 permit any (hit count: 0, refcount: 0)
  seq 10 permit 36.0.0.0/24 (hit count: 0, refcount: 0)
```

4.3 Used by rip

4.3.1 Configuration

Switch# configure terminal	Enter the Configure mode.
Switch(config)# ip prefix-list aa seq 11 deny 35.0.0.0/8 le 16	Create a prefix-list named aa and a entry
Switch(config)# ip prefix-list aa permit any	Configure to add a entry to match everything when the match conditions above are not met. This is used to prevent routes to be denied when not match the match criteria above.
Switch(config)# router rip	Enter rip router mode.
Switch(config-router)# distribute-list prefix aa out	Configure to apply the prefix-list aa to outbound routes.
Switch(config-router)# end	Exit the rip mode and return to the privileged EXEC mode

4.3.2 Validation Commands

Switch # show ip prefix-list

```
ip prefix-list aa: 2 entries
   seq 11 deny 35.0.0.0/8 le 16
   seq 15 permit any
```

Switch # show running-config

```
Building configuration...
…
ip prefix-list aa seq 11 deny 35.0.0.0/8 le 16
ip prefix-list aa seq 15 permit any
…
router rip
 distribute-list prefix aa out
```

4.4 Used by Route-map

4.4.1 Configuration

Switch# configure terminal	Enter the Configure mode

Switch(config)# ip prefix-list aa seq 11 deny 3.3.3.0/8 le 24	Create a prefix-list named aa and a entry
Switch(config)# ip prefix-list aa permit any	Configure to add a entry to match everything when the match conditions above are not met. This is used to prevent routes to be denied when not match the match criteria above
Switch(config)# route-map abc permit	Create a route-map named abc and enter route-map mode
Switch(config-route-map)# match ip address prefix-list aa	Configure the match criteria
Switch(config-route-map)# set local-preference 200	Configure the set action to be performed
Switch(config-route-map)# exit	Exit route-map mode and return to configure mode
Switch(config)# route-map abc permit 20	Configure to add a route-map with the same tag to match everything when the match conditions above are not met. This is used to prevent routes to be denied when not match the match criteria above
Switch(config-route-map)# exit	Exit route-map mode and return to configure mode
Switch(config)# router bgp 1	Enter BGP router mode
Switch(config-router)# neighbor 1.1.1.2 remote-as 1	Configure the remote peer with neighbor address 1.1.1.2 and remote-as 1
Switch(config-router)# neighbor 1.1.1.2 route-map abc out	Configure to apply the route-map abc to outbound routes
Switch(config-router)# network 2.2.2.2/32	Configure to network the route 2.2.2.2/32
Switch(config-router)# network 3.3.3.3/32	Configure to network the route 3.3.3.3/32
Switch(config-router)# end	Exit the BGP mode and return to the privileged EXEC mode

4.4.2 Validation Commands

Switch# show route-map

```
route-map abc, permit, sequence 10
 Match clauses:
   ip address prefix-list aa
 Set clauses:
   local-preference 200
route-map abc, permit, sequence 20
 Match clauses:
Set clauses:
```

Switch # show running-config

```
Building configuration...
...
ip prefix-list aa seq 11 deny 3.3.3.0/8 le 24
ip prefix-list aa seq 15 permit any
!
!
route-map abc permit 10
 match ip address prefix-list aa
 set local-preference 200
!
route-map abc permit 20
...
router bgp 1
 neighbor 1.1.1.2 remote-as 1
 !
 address-family ipv4
 no synchronization
 network 2.2.2.2 mask 255.255.255.255
 network 3.3.3.3 mask 255.255.255.255
 neighbor 1.1.1.2 activate
 neighbor 1.1.1.2 route-map abc out
 exit-address-family
 !
 address-family vpnv4 unicast
 no synchronization
 exit-address-family
```

5 Configuring Route Map

5.1 Overview

Route-map is used to control and modify routing information. The route-map command allows redistribution of routes. It has a list of match and set commands associated with it. The match commands specify the conditions under which redistribution is allowed, and the set commands specify the particular redistribution actions to be performed if the criteria enforced by match commands are met. Route maps are used for detailed control over route distribution between routing processes.

Route maps also allow policy routing, and might route packets to a different route than the obvious shortest path.

If the permit parameter is specified, and the match criteria are met, the route is redistributed as specified by set actions. If the match criteria are not met, the next route map with the same tag is tested.

If the deny parameter is specified, and the match criteria are met, the route is not redistributed, and any other route maps with the same map tag are not examined.

Routes are checked from line to line looking for a match. If there is no match and the bottom of the route map is reached, then the router denies the route from being redistributed. There is always an implicit deny at the end of a route map.

Specify the sequence parameter to indicate the position a new route map is to have in the list of route maps already configured with the same name.

5.2 Configuring Route-map To OSPF

5.2.1 Configuration

Beginning in privileged EXEC mode, follow these steps to configure the route-map.

DUT# configure terminal	Enter the Configure mode
DUT(config)# route-map abc permit	Create a route-map named abc and enter route-map mode
DUT(config-route-map)# match metric 20	Configure the match criteria.

DUT(config-route-map)# set tag 2	Configure the set action to be performed.
DUT(config-route-map)# exit	Exit route-map mode and return to configure mode
DUT(config)# route-map abc permit 20	Configure to add a route-map with the same tag to match everything when the match conditions above are not met. This is used to prevent routes to be denied when not match the match criteria above.
DUT(config-route-map)# exit	Exit route-map mode and return to configure mode
DUT(config)# router ospf 100	Enter OSPF router mode
DUT(config-router)# redistribute rip route-map abc	Configure to apply the route-map on the redistribute command in OSPF.
DUT(config-router)# end	Exit the OSPF mode and return to the privileged EXEC mode

5.2.2 Validation

To display the route-map configuration, use the show route-map [NAME] in the privileged EXEC command.

DUT# show route-map

```
route-map abc, permit, sequence 10
 Match clauses:
  metric 20
 Set clauses:
  tag 2
route-map abc, permit, sequence 20
 Match clauses:
 Set clauses:
```

5.3 Configuring Route-map And Applying To BGP

5.3.1 Configuration

Beginning in privileged EXEC mode, follow these steps to configure the route-map.

DUT# configure terminal	Enter the Configure mode
DUT(config)# ip access-list acl1	Create an access-list named acl1
DUT(config-ip-acl)# permit any 3.3.3.0 0.0.0.255	Create a rule to permit the route with 3.3.3.0/24
DUT(config-ip-acl)# exit	Exit the access-list configure mode and return to configure mode

DUT(config)# route-map abc permit	Create a route-map named abc and enter route-map mode
DUT(config-route-map)# match ip address acl1	Configure the match criteria
DUT(config-route-map)# set local-preference 200	Configure the set action to be performed
DUT(config-route-map)# exit	Exit route-map mode and return to configure mode
DUT(config)# route-map abc permit 20	Configure to add a route-map with the same tag to match everything when the match conditions above are not met. This is used to prevent routes to be denied when not match the match criteria above
DUT(config-route-map)# exit	Exit route-map mode and return to configure mode
DUT(config)# router bgp 1	Enter BGP router mode
DUT(config-router)# neighbor 1.1.1.2 remote-as 1	Configure the remote peer with neighbor address 1.1.1.2 and remote-as 1
DUT(config-router)# neighbor 1.1.1.2 route-map abc out	Configure to apply the route-map abc to outbound routes
DUT(config-router)# network 2.2.2.2/32	Configure to network the route 2.2.2.2/32
DUT(config-router)# network 3.3.3.3/32	Configure to network the route 3.3.3.3/32
DUT(config-router)# end	Exit the BGP mode and return to the privileged EXEC mode

5.3.2 Validation

To display the route-map configuration, use the show route-map [NAME] in the privileged EXEC command on DUT1.

DUT1# show route-map

```
route-map abc, permit, sequence 10
 Match clauses:
   ip address acl1
 Set clauses:
   local-preference 200
route-map abc, permit, sequence 20
 Match clauses:
 Set clauses:
```

Use the show ip bgp command to show the routes in BGP on DUT2.

DUT2# show ip bgp

```
BGP table version is 6, local router ID is 1.1.1.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i2.2.2.2/32	1.1.1.1	0	100	0	i
*>i3.3.3.3/32	1.1.1.1	0	200	0	i

6 Configure Policy-Based Routing

6.1 Overview

Policy-Based Routing(PBR) provide freedom to implement packet forwarding and routing, according to the defined policies in a way that goes beyond traditional routing protocol concerns. By using policy-based routing, customers can implement policies that selectively cause packets to take different paths.

6.2 Topology

The following figure is a typical topology: You could configure eth-0-1 on DUT1 to Enable PBR, packets from 172.16.6.1 will forward to Lucy, and packets from 172.16.7.1 will do normal routing.

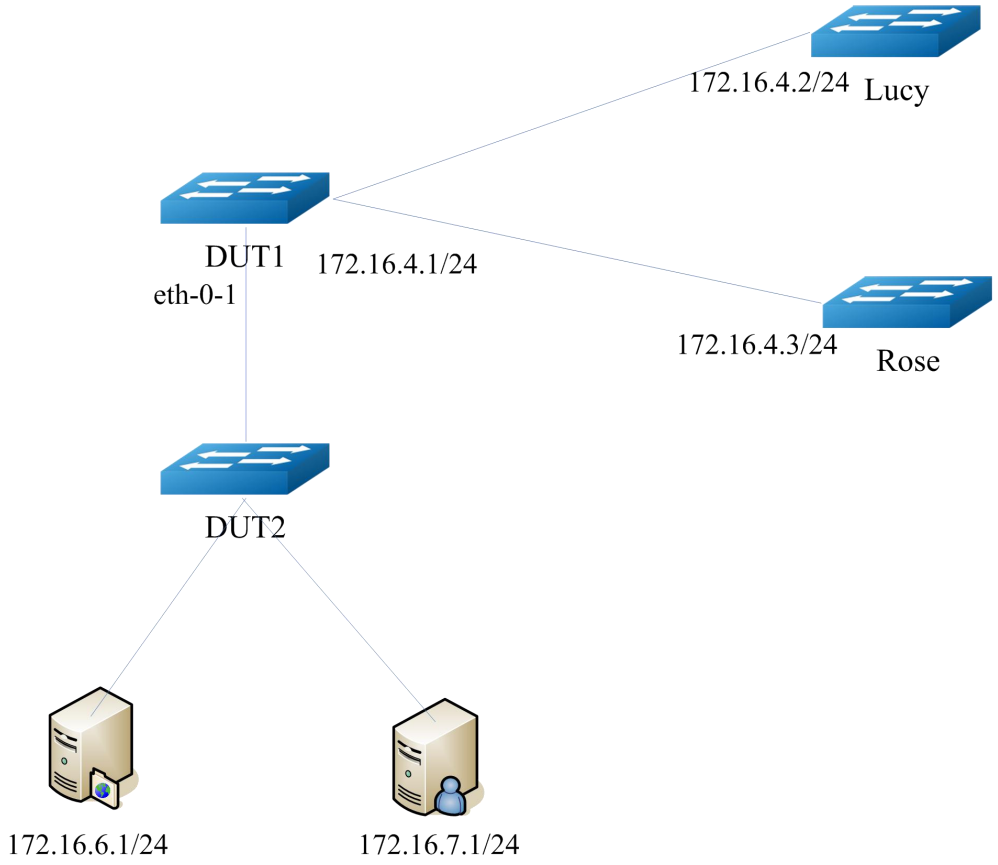

Figure 6-1 Policy-Based Routing Typical Topology

6.3 Configuration

Switch1's configuration is as follow:

Switch# configure terminal	Enter the Configure mode
Switch(config)# ip access-list acl1	Enter the Configure mode.
Switch(config-ip-acl)# 10 permit any 172.16.6.0 0.0.0.255 any	Define a IPV4 ACL and enter ACL configuration mode.
Switch(config-ip-acl)# exit	Exit ACL configuration mode
Switch(config)# route-map richard permit 10	Create a route-map named richard and enter route-map mode
Switch(config-route-map)# match ip address acl1	Configure the match criteria , match an acl named acl1
Switch(config-route-map)# set ip next-hop 172.16.4.2	Configure the set action to be performed, set packets forward address
Switch(config-route-map)# exit	Exit Route-map configuration mode
Switch(config)# interface eth-0-1	Exit Route-map configuration mode
Switch(config-if)# no switchport	Set interface to be a routed port

Switch(config-if)# ip address 172.16.5.2/24	Set interface it's ip address
Switch(config-if)# no shutdown	Set the interface to be up
Switch(config-if)# ip policy route-map richard	Apply route-map to interface
Switch(config-if)# exit	Exit interface configuration mode

6.4 Validation

The result of show ip policy route-map is as follows.

Switch# show ip policy route-map

```
Route-map                interface
richard                  eth-0-1
```