1.2 Lab 2: OSPF Routing

1.2.1 Introduction

1.2.1.1 About This Lab

The Open Shortest Path First (OSPF) protocol is a link-state Interior Gateway Protocol (IGP) developed by the Internet Engineering Task Force (IETF). Currently, OSPF Version 2 (RFC2328) is used for IPv4. As a link-state protocol, OSPF has the following advantages:

- Multicast packet transmission to reduce load on the switches that are not running OSPF
- Classless Inter-Domain Routing (CIDR)
- Load balancing among equal-cost routes
- Packet authentication

With the preceding advantages, OSPF is widely accepted and used as an IGP.

In the lab activity, you will understand basic OSPF configurations and principles by configuring single-area OSPF.

1.2.1.2 Objectives

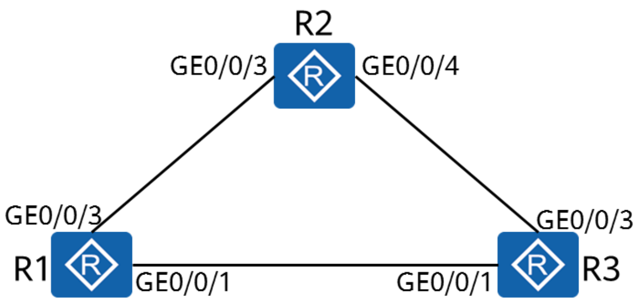
Upon completion of this task, you will be able to:

- Learn the basic commands of OSPF
- Learn how to check the OSPF running status
- Learn how to control OSPF route selection using costs
- Understand the advertisement of default routes in OSPF
- Learn how to configure OSPF authentication

1.2.1.3 Networking Topology

R1, R2, and R3 are gateways of their networks. You need to configure OSPF to enable connectivity between the networks.

Figure 1-1 Lab topology for configuring OSPF



1.2.2 Lab Configuration

1.2.2.1 Configuration Roadmap

1. Create OSPF processes on the devices and enable OSPF on the interfaces.
2. Configure OSPF authentication.
3. Configure OSPF to advertise default routes.
4. Control OSPF route selection using costs.

1.2.2.2 Configuration Procedure

Step 1 Complete basic device configuration.

Follow steps 1, 2, 3, and 4 in lab 1 to name the routers and configure the IP addresses of the physical and loopback interfaces.

Display the routing table on the router (R1 in this example).

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 11       Routes : 11

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.1/32   Direct  0    0           D   127.0.0.1       LoopBack0
     10.0.12.0/24   Direct  0    0           D   10.0.12.1       GigabitEthernet0/0/3
     10.0.12.1/32   Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/3
   10.0.12.255/32   Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/3
     10.0.13.0/24   Direct  0    0           D   10.0.13.1       GigabitEthernet0/0/1
     10.0.13.1/32   Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/1
   10.0.13.255/32   Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/1
      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

At this point, only direct routes exist on the device.

Step 2 Complete the basic OSPF configuration.

Create an OSPF process.

```
[R1]ospf 1
```

You can set OSPF parameters only after creating an OSPF process. OSPF supports multiple independent processes on one device. Route exchange between different OSPF processes is similar to that between different routing protocols. You can specify a process ID when creating an OSPF process. If no process ID is specified, the default process ID 1 is used.

Create an OSPF area and specify the interfaces on which OSPF is to be enabled.

```
[R1-ospf-1]area 0
```

The **area** command creates an OSPF area and displays the OSPF area view.

```
[R1-ospf-1-area-0.0.0.0]network 10.0.12.1 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.13.1 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.1.1 0.0.0.0
```

The **network** *network-address wildcard-mask* command specifies the interfaces on which OSPF is to be enabled. OSPF can run on an interface only when the following two conditions are met:

1. The mask length of the interface's IP address is not shorter than that specified in the **network** command. OSPF uses reverse mask. For example 0.0.0.255 indicates that the mask length is 24 bits.
2. The address of the interface must be within the network range specified in the **network** command.

In this example, OSPF can be enabled on the three interfaces, and they are all added to area 0.

```
[R2]ospf
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.12.2 0.0.0.0
[R2-ospf-1-area-0.0.0.0]network 10.0.23.2 0.0.0.0
[R2-ospf-1-area-0.0.0.0]network 10.0.1.2 0.0.0.0
```

If the wildcard mask in the **network** command is all 0s and the IP address of the interface is the same as the IP address specified in the **network-address** command, the interface also runs OSPF.

```
[R3]ospf
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.0.13.3 0.0.0.0
[R3-ospf-1-area-0.0.0.0]network 10.0.23.3 0.0.0.0
[R3-ospf-1-area-0.0.0.0]network 10.0.1.3 0.0.0.0
```

Step 3 Display the OSPF status.

Displays the OSPF neighbor information.

```
[R1]display ospf peer

     OSPF Process 1 with Router ID 10.0.1.1
          Neighbors

 Area 0.0.0.0 interface 10.0.13.1(GigabitEthernet0/0/1)'s neighbors
 Router ID: 10.0.1.3        Address: 10.0.13.3
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.0.13.3  BDR: 10.0.13.1  MTU: 0
   Dead timer due in 36  sec
   Retrans timer interval: 0
   Neighbor is up for 00:00:30
   Authentication Sequence: [ 0 ]

          Neighbors

 Area 0.0.0.0 interface 10.0.12.1(GigabitEthernet0/0/3)'s neighbors
 Router ID: 10.0.1.2        Address: 10.0.12.2
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.0.12.2  BDR: 10.0.12.1  MTU: 0
   Dead timer due in 39  sec
   Retrans timer interval: 4
   Neighbor is up for 00:00:28
   Authentication Sequence: [ 0 ]
```

The **display ospf peer** command displays information about neighbors in each OSPF area. The information includes the area to which the neighbor belongs, router ID of the neighbor, neighbor status, DR, and BDR.

Display the routes learned from OSPF.

```
[R1]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
       Destinations : 3        Routes : 4

OSPF routing table status : <Active>
       Destinations : 3        Routes : 4
```

```
Destination/Mask            Proto   Pre  Cost      Flags  NextHop         Interface

      10.0.1.2/32   OSPF    10   1          D   10.0.12.2       GigabitEthernet0/0/3
      10.0.1.3/32   OSPF    10   1          D   10.0.13.3       GigabitEthernet0/0/1
     10.0.23.0/24   OSPF    10   2          D   10.0.13.3       GigabitEthernet0/0/1
                    OSPF    10   2          D   10.0.12.2       GigabitEthernet0/0/3

OSPF routing table status : <Inactive>
        Destinations : 0        Routes : 0
```

Step 4 Configure OSPF authentication.

Configure interface authentication on R1.

```
[R1]interface GigabitEthernet0/0/1
[R1- GigabitEthernet0/0/1]ospf authentication-mode md5 1 cipher HCIA-Datacom
[R1]interface GigabitEthernet0/0/3
[R1- GigabitEthernet0/0/3]ospf authentication-mode md5 1 cipher HCIA-Datacom
[R1- GigabitEthernet0/0/3]display this
#
interface GigabitEthernet0/0/3
 ip address 10.0.12.1 255.255.255.0
 ospf authentication-mode md5 1 cipher foCQTYsq-4.A\^38y!DVwQ0#
#
```

The password is displayed in cipher text when you view the configuration because cipher means cipher-text.

Display OSPF neighbors.

```
[R1]display ospf peer brief

 OSPF Process 1 with Router ID 10.0.1.1
   Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                    Neighbor id      State
 ----------------------------------------------------------------------------
Total Peer(s):     0
```

Authentication is not configured on other routers. Therefore, the authentication fails and no neighbor is available.

Configuring interface authentication on R2.

```
[R2]interface GigabitEthernet0/0/3
[R2- GigabitEthernet0/0/3]ospf authentication-mode md5 1 cipher HCIA-Datacom
[R2]interface GigabitEthernet0/0/4
[R2- GigabitEthernet0/0/4]ospf authentication-mode md5 1 cipher HCIA-Datacom
```

Display OSPF neighbors on R2.

```
[R2]display ospf peer brief

 OSPF Process 1 with Router ID 10.0.1.2
   Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                    Neighbor id      State
 0.0.0.0         GigabitEthernet0/0/3              10.0.1.1         Full
 ----------------------------------------------------------------------------
Total Peer(s):     1
```

R2 has established a neighbor relationship with R1.

Configure area authentication on R3.

```
[R3]ospf
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]authentication-mode md5 1 cipher HCIA-Datacom
```

Display OSPF neighbors on R3.

```
[R3]display ospf peer brief

        OSPF Process 1 with Router ID 10.0.1.3
```

```
            Peer Statistic Information
----------------------------------------------------------------------------
 Area Id      Interface            Neighbor id     State
 0.0.0.0      GigabitEthernet0/0/1    10.0.1.1       Full
 0.0.0.0      GigabitEthernet0/0/3    10.0.1.2       Full
----------------------------------------------------------------------------
 Total Peer(s):    2
```

R3 has established a neighbor relationship with R1 and R2. Note: OSPF interface authentication and area authentication implement OSPF packet authentication on OSPF interfaces.

Step 5 Assume that R1 is the egress of all networks. Therefore, R1 advertises the default route to OSPF.

Advertise the default route on R1.

```
[R1]ospf
[R1-ospf-1]default-route-advertise always
```

The **default-route-advertise** command advertises the default route to a common OSPF area. If the **always** argument is not specified, the default route is advertised to other routers only when there are active non-OSPF default routes in the routing table of the local router. In this example, no default route exists in the local routing table. Therefore, the **always** argument needs to be used.

Display the IP routing tables of R2 and R3.

```
 [R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 15      Routes : 16

Destination/Mask   Proto  Pre        Cost       Flags       NextHop      Interface

     0.0.0.0/0      O_ASE  150        1          D          10.0.12.1        GigabitEthernet0/0/3
    10.0.1.1/32     OSPF   10         1          D          10.0.12.1        GigabitEthernet0/0/3
    10.0.1.2/32     Direct  0         0          D          127.0.0.1        LoopBack0
    10.0.1.3/32     OSPF   10         1          D          10.0.23.3        GigabitEthernet0/0/4
   10.0.12.0/24     Direct  0         0          D          10.0.12.2        GigabitEthernet0/0/3
   10.0.12.2/32     Direct  0         0          D          127.0.0.1        GigabitEthernet0/0/3
  10.0.12.255/32           Direct  0             0          D          127.0.0.1        GigabitEthernet0/0/3
   10.0.13.0/24     OSPF   10         2          D          10.0.12.1        GigabitEthernet0/0/3
                    OSPF   10         2          D          10.0.23.3        GigabitEthernet0/0/4
   10.0.23.0/24     Direct  0         0          D          10.0.23.2        GigabitEthernet0/0/4
   10.0.23.2/32     Direct  0         0          D          127.0.0.1        GigabitEthernet0/0/4
  10.0.23.255/32           Direct  0             0          D          127.0.0.1        GigabitEthernet0/0/4
   127.0.0.0/8      Direct  0         0          D          127.0.0.1        InLoopBack0
   127.0.0.1/32     Direct  0         0          D          127.0.0.1        InLoopBack0
127.255.255.255/32         Direct  0             0          D          127.0.0.1        InLoopBack0
255.255.255.255/32         Direct  0             0          D          127.0.0.1        InLoopBack0
```

```
[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 15      Routes : 16

Destination/Mask           Proto  Pre        Cost    Flags  NextHop      Interface

     0.0.0.0/0      O_ASE  150        1       D  10.0.13.1    GigabitEthernet0/0/1
    10.0.1.1/32     OSPF   10         1       D  10.0.13.1    GigabitEthernet0/0/1
    10.0.1.2/32     OSPF   10         1       D  10.0.23.2    GigabitEthernet0/0/3
    10.0.1.3/32     Direct  0         0       D  127.0.0.1    LoopBack0
   10.0.12.0/24     OSPF   10         2       D  10.0.23.2    GigabitEthernet0/0/3
                    OSPF   10         2       D  10.0.13.1    GigabitEthernet0/0/1
   10.0.13.0/24     Direct  0         0       D  10.0.13.3    GigabitEthernet0/0/1
   10.0.13.3/32     Direct  0         0       D  127.0.0.1    GigabitEthernet0/0/1
  10.0.13.255/32           Direct  0             0       D  127.0.0.1    GigabitEthernet0/0/1
```

```
    10.0.23.0/24   Direct  0         0        D  10.0.23.3       GigabitEthernet0/0/3
    10.0.23.3/32   Direct  0         0        D  127.0.0.1       GigabitEthernet0/0/3
  10.0.23.255/32           Direct    0        0          D  127.0.0.1       GigabitEthernet0/0/3
    127.0.0.0/8    Direct  0         0        D  127.0.0.1       InLoopBack0
    127.0.0.1/32   Direct  0         0        D  127.0.0.1       InLoopBack0
127.255.255.255/32         Direct    0        0          D  127.0.0.1       InLoopBack0
255.255.255.255/32         Direct    0        0          D  127.0.0.1       InLoopBack0
```

R2 and R3 have learned the default route.

Step 6 Change the cost values of interfaces on R1 so that LoopBack0 on R1 can reach LoopBack0 on R2 via R3.

\# According to the routing table of R1, the cost of the route from R1 to LoopBack0 of R2 is 1, and the cost of the route from R1 to R2 via R3 is 2. Therefore, you only need to change the cost of the route from R1 to LoopBack0 of R2 to ensure that the value is greater than 2.

```
[R1]interface GigabitEthernet0/0/3
[R1- GigabitEthernet0/0/3]ospf cost 10
```

\# Display the routing table of R1.

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14       Routes : 14

Destination/Mask            Proto   Pre  Cost      Flags  NextHop         Interface

     10.0.1.1/32   Direct  0    0          D   127.0.0.1           LoopBack0
     10.0.1.2/32   OSPF   10   2          D   10.0.13.3           GigabitEthernet0/0/1
     10.0.1.3/32   OSPF   10   1          D   10.0.13.3           GigabitEthernet0/0/1
    10.0.12.0/24   Direct  0    0          D   10.0.12.1           GigabitEthernet0/0/3
    10.0.12.1/32   Direct  0    0          D   127.0.0.1           GigabitEthernet0/0/3
  10.0.12.255/32           Direct  0    0          D   127.0.0.1           GigabitEthernet0/0/3
    10.0.13.0/24   Direct  0    0          D   10.0.13.1           GigabitEthernet0/0/1
    10.0.13.1/32   Direct  0    0          D   127.0.0.1           GigabitEthernet0/0/1
  10.0.13.255/32           Direct  0    0          D   127.0.0.1           GigabitEthernet0/0/1
    10.0.23.0/24   OSPF   10   2          D   10.0.13.3           GigabitEthernet0/0/1
    127.0.0.0/8    Direct  0    0          D   127.0.0.1           InLoopBack0
    127.0.0.1/32   Direct  0    0          D   127.0.0.1           InLoopBack0
127.255.255.255/32         Direct  0    0          D   127.0.0.1           InLoopBack0
255.255.255.255/32         Direct  0    0          D   127.0.0.1           InLoopBack0
```

In this case, the next hop of the route from R1 to LoopBack0 on R2 is GigabitEthernet0/0/1 on R3.

\# Verify the result by issuing Tracert commands.

```
[R1]tracert –a 10.0.1.1 10.0.1.2

 traceroute to  10.0.1.2(10.0.1.2), max hops: 30 ,packet length: 40,press CTRL_C to break

 1 10.0.13.3 40 ms  50 ms  50 ms

 2 10.0.23.2 60 ms  110 ms  70 ms
```

----End

1.2.3 Verification

1. Test the connectivity between interfaces on different devices using Ping.
2. Shut down interfaces to simulate link faults and check the changes in routing tables.

1.2.4 Configuration Reference

Configuration on R1

```
#
```

```
 sysname R1
#
interface GigabitEthernet0/0/1
 ip address 10.0.13.1 255.255.255.0
 ospf authentication-mode md5 1 cipher %^%#`f*R'6q/RMq(+5*g(sP~SB8oQ49;%7WE:07P7X:W%^%#
#
interface GigabitEthernet0/0/3
 ip address 10.0.12.1 255.255.255.0
 ospf cost 10
 ospf authentication-mode md5 1 cipher %^%#]e)pBf~7B0.FM~U;bRAVgE$U>%X;>T\M\tLlYRj2%^%#
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.255
#
ospf 1
 default-route-advertise always
 area 0.0.0.0
  network 10.0.1.1 0.0.0.0
  network 10.0.12.0 0.0.0.255
  network 10.0.13.0 0.0.0.255
#
return
```

Configuration on R2

```
#
 sysname R2
#
interface GigabitEthernet0/0/3
 ip address 10.0.12.2 255.255.255.0
 ospf authentication-mode md5 1 cipher %^%#z+72ZaTk2+v/g7E~AmR"NFYAKC>LZ8~Y`[**Gh=&%^%#
#
 interface GigabitEthernet0/0/4
 ip address 10.0.23.2 255.255.255.0
 ospf authentication-mode md5 1 cipher %^%#=@2jEBu!{&UYoB*(RDVLc5t~<1B_a-PwC$WH%jQ3%^%#
#
interface LoopBack0
 ip address 10.0.1.2 255.255.255.255
#
ospf 1
 area 0.0.0.0
  network 10.0.1.2 0.0.0.0
  network 10.0.12.2 0.0.0.0
  network 10.0.23.2 0.0.0.0
#
return
```

Configuration on R3

```
#
 sysname R3
#
interface GigabitEthernet0/0/1
 ip address 10.0.13.3 255.255.255.0
#
interface GigabitEthernet0/0/3
 ip address 10.0.23.3 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.3 255.255.255.255
#
ospf 1
 area 0.0.0.0
  authentication-mode md5 1 cipher %^%#Rl<:SVln1M>[Gk"v/OeSEW|:0:4*h;b|-d:N"s{>%^%#
  network 10.0.1.3 0.0.0.0
  network 10.0.13.3 0.0.0.0
  network 10.0.23.3 0.0.0.0
#
return
```

1.2.5 Quiz

1. In step 6, what is the path for R2 to return ICMP packets to R1? Try to explain the reason.