配置单区域 OSPF 实现动态路由

难度（最高五星）：★★★ 建议学时：3学时

目录

实验说明

任务描述

企业用户要求不需要花费大量人力去维护网络性能，当网络中出现网络拓扑变动时，可以通过路由更新，计算出新的路由。因此需要使用OSPF动态路由协议保证网络的稳定，实现互连互通。

完成本任务后，学生会对OSPF有一个清晰的了解，可以独立使用OSPF组建和配置一个OSPF单区域的网络。

学习目标

完成本任务的学习后，你应当能：

1. 实现单区域 OSPF 的配置
2. OSPF 区域认证
3. 描述 OSPF 在多路访问网络中邻居关系建立的过程
4. 实现对 OSPF 接口代价值进行修改
5. 掌握 OSPF 中 Silent-interface 的配置方法
6. 实现通过 display 命令查看 OSPF 各种状态
7. OSPF 发布缺省路由

任务准备

网络拓扑

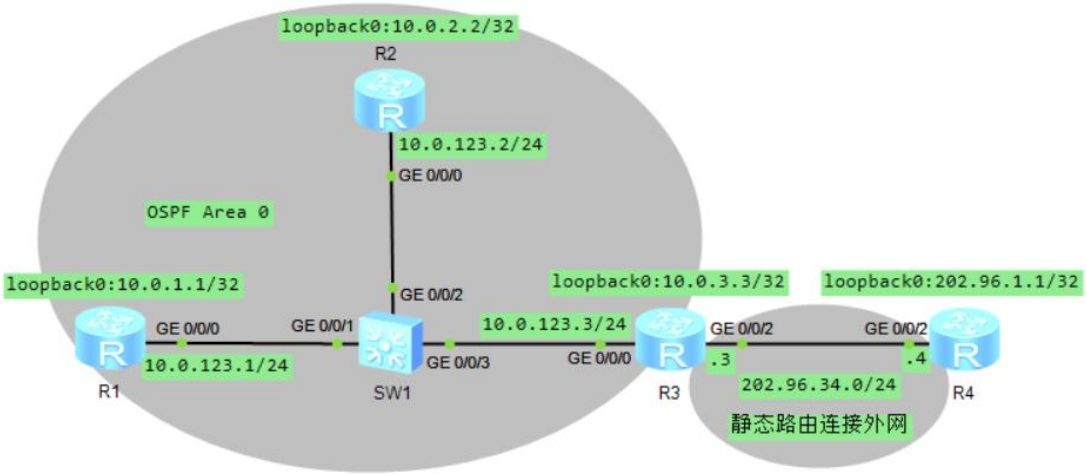

图1 配置单区域OSPF实现网络互通实验拓扑

初始配置

- R1的初始配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]int LoopBack 0
[R1-LoopBack0]ip address 10.0.1.1 32
[R1-LoopBack0]quit
[R1]int g0/0/0
[R1-GigabitEthernet0/0/0]ip address 10.0.123.1 24
[R1-GigabitEthernet0/0/0]quit
[R1]
```

- R2的初始配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]int LoopBack 0
[R2-LoopBack0]ip address 10.0.2.2 32
[R2-LoopBack0]quit
[R2]int g0/0/0
[R2-GigabitEthernet0/0/0]ip address 10.0.123.2 24
[R2-GigabitEthernet0/0/0]quit
[R2]
```

- R3的初始配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]int lo0
[R3-LoopBack0]ip address 10.0.3.3 32
[R3-LoopBack0]quit
[R3]int g0/0/0
[R3-GigabitEthernet0/0/0]ip address 10.0.123.3 24
[R3-GigabitEthernet0/0/0]quit
[R3]int g0/0/2
[R3-GigabitEthernet0/0/2]ip address 202.96.34.3 24
```

```
[R3-GigabitEthernet0/0/2]quit
[R3]
```

- R4的初始配置，注意：R4上有一条指向OSPF的静态路由。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R4
[R4]int LoopBack 0
[R4-LoopBack0]ip address 202.96.1.1 32
[R4-LoopBack0]quit
[R4]int g0/0/2
[R4-GigabitEthernet0/0/2]ip address 202.96.34.4 24
[R4-GigabitEthernet0/0/2]quit
[R4]
[R4]ip route-static 10.0.0.0 255.255.0.0 202.96.34.3
[R4]
```

任务实施

1 查看基础配置

在R1、R2、R3和R4上执行display ip interface brief命令，检查接口配置情况。

```
<R1>display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
The number of interface that is UP in Physical is 3
The number of interface that is DOWN in Physical is 2
The number of interface that is UP in Protocol is 3
The number of interface that is DOWN in Protocol is 2

Interface                         IP Address/Mask      Physical   Protocol
GigabitEthernet0/0/0              10.0.123.1/24        up         up
GigabitEthernet0/0/1              unassigned           down       down
GigabitEthernet0/0/2              unassigned           down       down
LoopBack0                         10.0.1.1/32          up         up(s)
NULL0                             unassigned           up         up(s)
<R1>
```

```
<R2>display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
The number of interface that is UP in Physical is 3
The number of interface that is DOWN in Physical is 2
The number of interface that is UP in Protocol is 3
The number of interface that is DOWN in Protocol is 2

Interface                         IP Address/Mask      Physical   Protocol
GigabitEthernet0/0/0              10.0.123.2/24        up         up
GigabitEthernet0/0/1              unassigned           down       down
GigabitEthernet0/0/2              unassigned           down       down
LoopBack0                         10.0.2.2/32          up         up(s)
NULL0                             unassigned           up         up(s)
<R2>

[R3]display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
The number of interface that is UP in Physical is 4
The number of interface that is DOWN in Physical is 1
The number of interface that is UP in Protocol is 4
The number of interface that is DOWN in Protocol is 1

Interface                         IP Address/Mask      Physical   Protocol
GigabitEthernet0/0/0              10.0.123.3/24        up         up
GigabitEthernet0/0/1              unassigned           down       down
GigabitEthernet0/0/2              202.96.34.3/24       up         up
LoopBack0                         10.0.3.3/32          up         up(s)
NULL0                             unassigned           up         up(s)

[R4]display ip interface brief
*down: administratively down
^down: standby
```

```
(l): loopback
(s): spoofing
The number of interface that is UP in Physical is 3
The number of interface that is DOWN in Physical is 2
The number of interface that is UP in Protocol is 3
The number of interface that is DOWN in Protocol is 2

Interface                         IP Address/Mask      Physical   Protocol
GigabitEthernet0/0/0              unassigned           down       down
GigabitEthernet0/0/1              unassigned           down       down
GigabitEthernet0/0/2              202.96.34.4/24       up         up
LoopBack0                         202.96.1.1/32        up         up(s)
NULL0                             unassigned           up         up(s)
[R4]
```

[R3]执行ping命令，检测R3与其它设备间的连通性。

```
[R3]ping 10.0.123.1
  PING 10.0.123.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.1: bytes=56 Sequence=1 ttl=255 time=60 ms
    Reply from 10.0.123.1: bytes=56 Sequence=2 ttl=255 time=40 ms
    Reply from 10.0.123.1: bytes=56 Sequence=3 ttl=255 time=50 ms
    Reply from 10.0.123.1: bytes=56 Sequence=4 ttl=255 time=60 ms
    Reply from 10.0.123.1: bytes=56 Sequence=5 ttl=255 time=40 ms

  --- 10.0.123.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 40/50/60 ms

[R3]ping 10.0.123.2
  PING 10.0.123.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.2: bytes=56 Sequence=1 ttl=255 time=110 ms
    Reply from 10.0.123.2: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 10.0.123.2: bytes=56 Sequence=3 ttl=255 time=50 ms
    Reply from 10.0.123.2: bytes=56 Sequence=4 ttl=255 time=50 ms
    Reply from 10.0.123.2: bytes=56 Sequence=5 ttl=255 time=60 ms
```

```
  --- 10.0.123.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 30/60/110 ms

[R3]ping 202.96.34.4
  PING 202.96.34.4: 56  data bytes, press CTRL_C to break
    Reply from 202.96.34.4: bytes=56 Sequence=1 ttl=255 time=30 ms
    Reply from 202.96.34.4: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 202.96.34.4: bytes=56 Sequence=3 ttl=255 time=20 ms
    Reply from 202.96.34.4: bytes=56 Sequence=4 ttl=255 time=20 ms
    Reply from 202.96.34.4: bytes=56 Sequence=5 ttl=255 time=20 ms

  --- 202.96.34.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 20/24/30 ms

[R3]
```

执行ping命令，检测R2与其它设备间的连通性。

```
<R2>ping 10.0.123.3
  PING 10.0.123.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.3: bytes=56 Sequence=1 ttl=255 time=40 ms
    Reply from 10.0.123.3: bytes=56 Sequence=2 ttl=255 time=60 ms
    Reply from 10.0.123.3: bytes=56 Sequence=3 ttl=255 time=50 ms
    Reply from 10.0.123.3: bytes=56 Sequence=4 ttl=255 time=40 ms
    Reply from 10.0.123.3: bytes=56 Sequence=5 ttl=255 time=60 ms

  --- 10.0.123.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 40/50/60 ms

<R2>
```

执行display ip routing-table命令，检测R4上配置的静态路由。

```
[R4]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 9        Routes : 9

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.0.0.0/16  Static  60   0           RD   202.96.34.3 GigabitEthernet 0/0/2
       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
     202.96.1.1/32   Direct  0    0           D    127.0.0.1       LoopBack0
    202.96.34.0/24   Direct  0    0           D    202.96.34.4  GigabitEthernet 0/0/2
    202.96.34.4/32   Direct  0    0           D    127.0.0.1    GigabitEthernet 0/0/2
  202.96.34.255/32   Direct  0    0           D    127.0.0.1    GigabitEthernet 0/0/2
255.255.255.255/32   Direct  0    0           D    127.0.0.1       InLoopBack0

[R4]
```

2 配置单区域 OSPF

配置R1、R2、R3的OSPF Router ID为Loopback0接口地址，OSPF进程号为1

```
[R1]ospf 1 router-id 10.0.1.1

[R2]ospf 1 router-id 10.0.2.2

[R3]ospf 1 router-id 10.0.3.3
```

在R1、R2、R3的互联接口、Loopback0接口激活OSPF

```
[R1]ospf 1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0] network 10.0.123.1 0.0.0.0
[R1-ospf-1-area-0.0.0.0] network 10.0.1.1 0.0.0.0

[R2]ospf 1
```

```
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0] network 10.0.123.2 0.0.0.0
[R2-ospf-1-area-0.0.0.0] network 10.0.2.2 0.0.0.0

[R3]ospf 1
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0] network 10.0.123.3 0.0.0.0
[R3-ospf-1-area-0.0.0.0] network 10.0.3.3 0.0.0.0
```

3 设置接口在选举 DR 时的优先级

ospf dr-priority命令用来设置接口在选举DR时的优先级。priority值越大，优先级越高，取值范围是0～255。默认为1。配置R1为OSPF的DR。

```
[R1]int g0/0/0
[R1-GigabitEthernet0/0/0]ospf dr-priority 10
```

4 OSPF 区域认证

为保证安全性，配置OSPF的区域认证，使用明文方式，密码配置为“huawei”

```
[R1]ospf 1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0] authentication-mode simple plain huawei

[R2]ospf 1
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0] authentication-mode simple plain huawei

[R3]ospf 1
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0] authentication-mode simple plain huawei
```

5 检查 OSPF 邻居关系

检查R1、R2、R3上的OSPF邻居信息

```
[R1]display ospf peer

        OSPF Process 1 with Router ID 10.0.1.1
          Neighbors
```

```
Area 0.0.0.0 interface 10.0.123.1(GigabitEthernet0/0/0)'s neighbors
Router ID: 10.0.2.2          Address: 10.0.123.2
  State: Full  Mode:Nbr is  Master  Priority: 1
  DR: 10.0.123.1  BDR: 10.0.123.3  MTU: 0
  Dead timer due in 33  sec
  Retrans timer interval: 5
  Neighbor is up for 00:02:18
  Authentication Sequence: [ 0 ]

Router ID: 10.0.3.3          Address: 10.0.123.3
  State: Full  Mode:Nbr is  Master  Priority: 1
  DR: 10.0.123.1  BDR: 10.0.123.3  MTU: 0
  Dead timer due in 40  sec
  Retrans timer interval: 5
  Neighbor is up for 00:03:16
  Authentication Sequence: [ 0 ]

[R1]
```

从输出结果可知R1和R2、R3之间已经成功建立OSPF邻居关系。

```
[R2]display ospf peer

        OSPF Process 1 with Router ID 10.0.2.2
          Neighbors

Area 0.0.0.0 interface 10.0.123.2(GigabitEthernet0/0/0)'s neighbors
Router ID: 10.0.1.1          Address: 10.0.123.1
  State: Full  Mode:Nbr is  Slave  Priority: 1
  DR: 10.0.123.1  BDR: 10.0.123.3  MTU: 0
  Dead timer due in 35  sec
  Retrans timer interval: 0
  Neighbor is up for 00:02:52
  Authentication Sequence: [ 0 ]

Router ID: 10.0.3.3          Address: 10.0.123.3
  State: Full  Mode:Nbr is  Master  Priority: 1
  DR: 10.0.123.1  BDR: 10.0.123.3  MTU: 0
  Dead timer due in 29  sec
  Retrans timer interval: 5
```

```
  Neighbor is up for 00:02:52
  Authentication Sequence: [ 0 ]

[R2]
```

从输出结果可知R2和R1、R3之间已经成功建立OSPF邻居关系。

```
[R3]display ospf peer

        OSPF Process 1 with Router ID 10.0.3.3
          Neighbors

 Area 0.0.0.0 interface 10.0.123.3(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.0.1.1          Address: 10.0.123.1
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.0.123.1  BDR: 10.0.123.3  MTU: 0
   Dead timer due in 38  sec
   Retrans timer interval: 0
   Neighbor is up for 00:04:33
   Authentication Sequence: [ 0 ]

 Router ID: 10.0.2.2          Address: 10.0.123.2
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.0.123.1  BDR: 10.0.123.3  MTU: 0
   Dead timer due in 36  sec
   Retrans timer interval: 5
   Neighbor is up for 00:03:35
   Authentication Sequence: [ 0 ]

[R3]
```

从输出结果可知R3和R1、R2之间已经成功建立OSPF邻居关系。

6 检查 OSPF 路由表

检查R1、R2、R3上的OSPF邻居路由表

```
[R1]display ospf routing

        OSPF Process 1 with Router ID 10.0.1.1
           Routing Tables

 Routing for Network
```

```
Destination        Cost   Type       NextHop         AdvRouter       Area
10.0.1.1/32        0      Stub       10.0.1.1        10.0.1.1        0.0.0.0
10.0.123.0/24      1      Transit    10.0.123.1      10.0.1.1        0.0.0.0
10.0.2.2/32        1      Stub       10.0.123.2      10.0.2.2        0.0.0.0
10.0.3.3/32        1      Stub       10.0.123.3      10.0.3.3        0.0.0.0

Total Nets: 4
Intra Area: 4  Inter Area: 0  ASE: 0  NSSA: 0
[R1]
```

从输出结果可知R1已经成功学习到R2、R3的Loopback0接口路由。

```
[R2]display ospf routing

        OSPF Process 1 with Router ID 10.0.2.2
           Routing Tables

 Routing for Network
 Destination        Cost   Type       NextHop         AdvRouter       Area
 10.0.2.2/32        0      Stub       10.0.2.2        10.0.2.2        0.0.0.0
 10.0.123.0/24      1      Transit    10.0.123.2      10.0.2.2        0.0.0.0
 10.0.1.1/32        1      Stub       10.0.123.1      10.0.1.1        0.0.0.0
 10.0.3.3/32        1      Stub       10.0.123.3      10.0.3.3        0.0.0.0

 Total Nets: 4
 Intra Area: 4  Inter Area: 0  ASE: 0  NSSA: 0

[R2]
```

从输出结果可知R2已经成功学习到R1、R3的Loopback0接口路由。

```
[R3]display ospf routing

        OSPF Process 1 with Router ID 10.0.3.3
           Routing Tables

 Routing for Network
 Destination        Cost   Type       NextHop         AdvRouter       Area
 10.0.3.3/32        0      Stub       10.0.3.3        10.0.3.3        0.0.0.0
 10.0.123.0/24      1      Transit    10.0.123.3      10.0.3.3        0.0.0.0
 10.0.1.1/32        1      Stub       10.0.123.1      10.0.1.1        0.0.0.0
 10.0.2.2/32        1      Stub       10.0.123.2      10.0.2.2        0.0.0.0
```

```
 Total Nets: 4
 Intra Area: 4  Inter Area: 0  ASE: 0  NSSA: 0

[R3]
```

从输出结果可知R3已经成功学习到R1、R2的Loopback0接口路由。

7 检查环回口之间的连通性

R1上以Loopback0接口地址为源测试与R2、R3的Loopback0接口之间的连通性。

```
[R1]ping -c 2 -a 10.0.1.1 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=255 time=80 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=255 time=40 ms

  --- 10.0.2.2 ping statistics ---
    2 packet(s) transmitted
    2 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 40/60/80 ms

[R1]ping -c 2 -a 10.0.1.1 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=255 time=60 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=255 time=50 ms

  --- 10.0.3.3 ping statistics ---
    2 packet(s) transmitted
    2 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 50/55/60 ms

[R1]
```

8 在 R1 上查看 OSPF LSDB

```
[R1]display ospf lsdb

         OSPF Process 1 with Router ID 10.0.1.1
           Link State Database
```

```
                Area: 0.0.0.0
Type       LinkState ID     AdvRouter          Age  Len   Sequence   Metric
Router     10.0.3.3         10.0.3.3           685  48    80000006       0
Router     10.0.2.2         10.0.2.2           684  48    80000005       0
Router     10.0.1.1         10.0.1.1           684  48    80000008       0
Network    10.0.123.1       10.0.1.1           684  36    80000004       0

[R1]
```

在这里一共可以看到4条LSA，前3条为Type-1 LSA，分别由R1、R2和R3产生，可以通过AdvRouter判断该LSA是由哪台路由器生成的。第四条为Type-2 LSA，是由一个网段的DR产生的。在这里，R1是10.0.123.0/24这个网段的DR，所以该Type-2 LSA的AdvRouter为10.0.1.1。

9 查看 R1 产生的 Type-1 LSA

```
[R1]display ospf lsdb router self-originate

       OSPF Process 1 with Router ID 10.0.1.1
                Area: 0.0.0.0
         Link State Database

 Type      : Router
 Ls id     : 10.0.1.1
 Adv rtr   : 10.0.1.1
 Ls age    : 794
 Len       : 48
 Options   :  E
 seq#      : 80000008
 chksum    : 0x8f7b
 Link count: 2
  * Link ID: 10.0.1.1
    Data   : 255.255.255.255
    Link Type: StubNet
    Metric : 0
    Priority : Medium
  * Link ID: 10.0.123.1
    Data   : 10.0.123.1
    Link Type: TransNet
    Metric : 1
```

```
[R1]
```

从输出中可以看到这条LSA一共描述了2个Link，第一个Link描述了Loopback接口所在网段，Link Type为StubNet，Link ID和Data分别是该Stub网段的IP地址和掩码。第二个Link描述了三台路由器的互联网段，Link Type为TransNet，可以看到Link ID为DR的接口地址：10.0.123.1，Data为该网段上本地接口的IP地址：10.0.123.1。

10 查看 R1 产生的 Type-2 LSA

```
[R1]display ospf lsdb network self-originate

        OSPF Process 1 with Router ID 10.0.1.1
                  Area: 0.0.0.0
          Link State Database

  Type      : Network
  Ls id     : 10.0.123.1
  Adv rtr   : 10.0.1.1
  Ls age    : 897
  Len       : 36
  Options   :  E
  seq#      : 80000004
  chksum    : 0x3f57
  Net mask  : 255.255.255.0
  Priority  : Low
     Attached Router    10.0.1.1
     Attached Router    10.0.2.2
     Attached Router    10.0.3.3

[R1]
```

从输出信息可以看到Type-2 LSA中的Attached Router描述了DR所在网段的邻居信息。

11 观察 OSPF 邻居关系建立过程

之前查看OSPF邻居信息时可以看到DR为10.0.123.1，这与根据DR选举原则进行预测的结果并不一致。在OSPF中，DR的选举为非抢占，即网络中存在DR或BDR时，新进入网络的路由器不能抢占DR或BDR的角色。当在配置OSPF时对设备的配置顺序存在前后差距，就

可能导致选举出的DR为先启动的设备。

为此可以关闭R1、R2、R3的互联接口，并使用**debugging ospf 1 event**观察OSPF邻居关系建立的具体过程，之后尽量同时重新打开R1、R2、R3的接口，通过debug输出信息查看DR、BDR的选举过程。

关闭R1、R2、R3的互联接口

```
[R1]interface GigabitEthernet0/0/0
[R1-GigabitEthernet0/0/3] shutdown

[R2] interface GigabitEthernet0/0/0
[R2-GigabitEthernet0/0/4] shutdown

[R3] interface GigabitEthernet0/0/0
[R3-GigabitEthernet0/0/4] shutdown
```

打开R1、R2、R3的debug功能以及开启debug ospf event

```
[R1]quit
<R1>terminal debugging
Info: Current terminal debugging is on.
<R1>
<R1>terminal monitor
Info: Current terminal monitor is on.
<R1>
<R1>debugging ospf 1 event
<R1>

[R2]quit
<R2>terminal debugging
Info: Current terminal debugging is on.
<R2>
<R2>terminal monitor
Info: Current terminal monitor is on.
<R2>
<R2>debugging ospf 1 event
<R2>

[R3]quit
<R3>terminal debugging
```

```
Info: Current terminal debugging is on.
<R3>
<R3>terminal monitor
Info: Current terminal monitor is on.
<R3>
<R3>debugging ospf 1 event
<R3>
```

重新打开R1、R2、R3的互联接口

```
[R1] interface GigabitEthernet0/0/0
[R1-GigabitEthernet0/0/0] undo shutdown

[R2] interface GigabitEthernet0/0/0
[R2-GigabitEthernet0/0/0] undo shutdown

[R3] interface GigabitEthernet0/0/0
[R3-GigabitEthernet0/0/0] undo shutdown
```

在R3上观察debug输出信息

```
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:14-08:00 R3 %%01IFPDT/4/IF_STATE(l)[6]:Interface GigabitEthern
et0/0/0 has turned into UP state.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:14-08:00 R3 %%01IFNET/4/LINK_STATE(l)[7]:The line protocol IP
on the interface GigabitEthernet0/0/0 has entered the UP state.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:14.202.4-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802c Line: 1295 Level: 0x20

  OSPF 1: Intf 10.0.123.3 Rcv InterfaceUp State Down -> Waiting.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:14.202.5-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802c Line: 1409 Level: 0x20

  OSPF 1 Send Hello Interface Up on 10.0.123.3
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:47-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[8]:Neighbor changes eve
nt: neighbor status changed. (ProcessId=256, NeighborAddress=2.123.0.10, Neighbo
```

```
rEvent=HelloReceived, NeighborPreviousState=Down, NeighborCurrentState=Init)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:47.602.2-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1136 Level: 0x20

  OSPF 1: Nbr 10.0.123.2 Rcv HelloReceived State Down -> Init.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:50-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[9]:Neighbor changes eve
nt: neighbor status changed. (ProcessId=256, NeighborAddress=1.123.0.10, Neighbo
rEvent=HelloReceived, NeighborPreviousState=Down, NeighborCurrentState=Init)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:50.552.2-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1136 Level: 0x20

  OSPF 1: Nbr 10.0.123.1 Rcv HelloReceived State Down -> Init.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:51-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[10]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=1.123.0.10, Neighb
orEvent=2WayReceived, NeighborPreviousState=Init, NeighborCurrentState=2Way)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:51-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[11]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=2.123.0.10, Neighb
orEvent=2WayReceived, NeighborPreviousState=Init, NeighborCurrentState=2Way)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:51.462.3-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1732 Level: 0x20

  OSPF 1: Nbr 10.0.123.1 Rcv 2WayReceived State Init -> 2Way.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:51.462.4-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1732 Level: 0x20

  OSPF 1: Nbr 10.0.123.2 Rcv 2WayReceived State Init -> 2Way.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:56-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[12]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=1.123.0.10, Neighb
orEvent=AdjOk?, NeighborPreviousState=2Way, NeighborCurrentState=ExStart)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:56-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[13]:Neighbor changes ev
```

```
ent: neighbor status changed. (ProcessId=256, NeighborAddress=2.123.0.10, Neighb
orEvent=AdjOk?, NeighborPreviousState=2Way, NeighborCurrentState=ExStart)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[14]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=1.123.0.10, Neighb
orEvent=NegotiationDone, NeighborPreviousState=ExStart, NeighborCurrentState=Exc
hange)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[15]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=2.123.0.10, Neighb
orEvent=NegotiationDone, NeighborPreviousState=ExStart, NeighborCurrentState=Exc
hange)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[16]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=1.123.0.10, Neighb
orEvent=ExchangeDone, NeighborPreviousState=Exchange, NeighborCurrentState=Loadi
ng)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[17]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=1.123.0.10, Neighb
orEvent=LoadingDone, NeighborPreviousState=Loading, NeighborCurrentState=Full)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[18]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=2.123.0.10, Neighb
orEvent=ExchangeDone, NeighborPreviousState=Exchange, NeighborCurrentState=Loadi
ng)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57-08:00 R3 %%01OSPF/4/NBR_CHANGE_E(l)[19]:Neighbor changes ev
ent: neighbor status changed. (ProcessId=256, NeighborAddress=2.123.0.10, Neighb
orEvent=LoadingDone, NeighborPreviousState=Loading, NeighborCurrentState=Full)
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:56.982.1-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1732 Level: 0x20

  OSPF 1: Nbr 10.0.123.1 Rcv AdjOk? State 2Way -> ExStart.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:56.982.2-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1732 Level: 0x20
```

```
  OSPF 1: Nbr 10.0.123.2 Rcv AdjOk? State 2Way -> ExStart.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:56.982.3-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802c Line: 2096 Level: 0x20

  OSPF 1 Send Hello Interface State Changed on 10.0.123.3
Apr  3 2025 21:23:56.982.4-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802c Line: 2107 Level: 0x20

  OSPF 1: Intf 10.0.123.3 Rcv WaitTimer State Waiting -> DROther.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57.22.1-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1845 Level: 0x20

  OSPF 1: Nbr 10.0.123.1 Rcv NegotiationDone State ExStart -> Exchange.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57.42.1-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1845 Level: 0x20

  OSPF 1: Nbr 10.0.123.2 Rcv NegotiationDone State ExStart -> Exchange.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57.72.1-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1957 Level: 0x20

  OSPF 1: Nbr 10.0.123.1 Rcv ExchangeDone State Exchange -> Loading.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57.72.2-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 2356 Level: 0x20

  OSPF 1: Nbr 10.0.123.1 Rcv LoadingDone State Loading -> Full.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57.92.1-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 1957 Level: 0x20

  OSPF 1: Nbr 10.0.123.2 Rcv ExchangeDone State Exchange -> Loading.
[R3-GigabitEthernet0/0/0]
Apr  3 2025 21:23:57.92.2-08:00 R3 RM/6/RMDEBUG:
 FileID: 0xd017802d Line: 2356 Level: 0x20
```

```
 OSPF 1: Nbr 10.0.123.2 Rcv LoadingDone State Loading -> Full.
[R3-GigabitEthernet0/0/0]
```

从上面的信息，可以清晰的看到OSPF建立邻接的过程。

12 配置 OSPF 接口的网络类型

在R1上查看OSPF路由表中的R2、R3的Loopback0接口路由

```
<R1>display ospf routing 10.0.2.2

        OSPF Process 1 with Router ID 10.0.1.1

 Destination : 10.0.2.2/32
 AdverRouter : 10.0.2.2                Area      : 0.0.0.0
 Cost        : 1                       Type      : Stub
 NextHop     : 10.0.123.2              Interface : GigabitEthernet0/0/0
 Priority    : Medium                  Age       : 00h09m25s
<R1>

<R1>display ospf routing 10.0.3.3

        OSPF Process 1 with Router ID 10.0.1.1

 Destination : 10.0.3.3/32
 AdverRouter : 10.0.3.3                Area      : 0.0.0.0
 Cost        : 1                       Type      : Stub
 NextHop     : 10.0.123.3              Interface : GigabitEthernet0/0/0
 Priority    : Medium                  Age       : 00h10m06s
<R1>
```

以R2为例查看OSPF的Type-1 LSA

```
<R2>display ospf lsdb router 10.0.2.2

        OSPF Process 1 with Router ID 10.0.2.2
                  Area: 0.0.0.0
          Link State Database


  Type      : Router
  Ls id     : 10.0.2.2
  Adv rtr   : 10.0.2.2
```

```
  Ls age     : 654
  Len        : 48
  Options    :  E
  seq#       : 8000000b
  chksum     : 0x946c
  Link count: 2
   * Link ID: 10.0.2.2
     Data    : 255.255.255.255
     Link Type: StubNet
     Metric : 0
     Priority : Medium
   * Link ID: 10.0.123.1
     Data    : 10.0.123.2
     Link Type: TransNet
     Metric : 1
<R2>
```

可以看到R2上关于Loopback0接口的LSA里已经将掩码设为32位，OSPF将Loopback接口视为一个末梢网络，且该网络中只连接着一个节点，因此无论该接口实际配置的网络掩码是多少位，OSPF在Type-1 LSA中描述这个接口时，都以主机（32位网络掩码）的形式进行通告。

13 修改 OSPF 接口的 Cost 值

在R1上查看OSPF路由表中的R3 Loopback0接口路由。

```
<R1>display ospf routing 10.0.3.3

        OSPF Process 1 with Router ID 10.0.1.1

 Destination : 10.0.3.3/32
 AdverRouter : 10.0.3.3                Area      : 0.0.0.0
 Cost        : 1                       Type      : Stub
 NextHop     : 10.0.123.3              Interface : GigabitEthernet0/0/0
 Priority    : Medium                  Age       : 00h10m06s
<R1>display ospf routing 10.0.3.3

        OSPF Process 1 with Router ID 10.0.1.1

 Destination : 10.0.3.3/32
```

```
 AdverRouter : 10.0.3.3                Area      : 0.0.0.0
 Cost        : 1                       Type      : Stub
 NextHop     : 10.0.123.3              Interface : GigabitEthernet0/0/0
 Priority    : Medium                  Age       : 00h13m52s
<R1>
<R1>
```

从输出信息可以看到其Cost值为1。

修改R1的GE0/0/0接口OSPF Cost值为20，修改R3的GE0/0/0接口OSPF Cost值为10

```
[R1]interface GigabitEthernet0/0/0
[R1-GigabitEthernet0/0/0] ospf cost 20

[R3]interface GigabitEthernet0/0/0
[R3-GigabitEthernet0/0/0] ospf cost 10
```

在R1上重新查看OSPF路由表中的R2 Loopback0接口路由

```
[R1]display ospf routing 10.0.2.2

        OSPF Process 1 with Router ID 10.0.1.1

 Destination : 10.0.2.2/32
 AdverRouter : 10.0.2.2                Area      : 0.0.0.0
 Cost        : 20                      Type      : Stub
 NextHop     : 10.0.123.2              Interface : GigabitEthernet0/0/0
 Priority    : Medium                  Age       : 00h00m57s
[R1]
```

从输出信息可以看到其Cost值为20。

在R3上查看OSPF路由表中的R1 Loopback0接口路由

```
[R3]display ospf routing 10.0.1.1

        OSPF Process 1 with Router ID 10.0.3.3

 Destination : 10.0.1.1/32
 AdverRouter : 10.0.1.1                Area      : 0.0.0.0
 Cost        : 10                      Type      : Stub
 NextHop     : 10.0.123.1              Interface : GigabitEthernet0/0/0
 Priority    : Medium                  Age       : 00h01m38s
[R3]
```

从输出信息可以看到其Cost值为10。

14 配置 OSPF 的 Silent-Interface

将R1的GE0/0/0接口配置为Silent-Iinterface

```
[R1]ospf 1
[R1-ospf-1] silent-interface GigabitEthernet 0/0/0
```

查看R1的OSPF邻居表

```
<R1>display ospf peer


OSPF Process 1 with Router ID 10.0.1.1
```

配置互联接口为Silent-Interface之后，不再从该接口发送、接收hello报文，已经建立关系的邻居消失。

查看R1的OSPF接口 GE0/0/0的信息

```
[R1-ospf-1]display ospf interface GigabitEthernet 0/0/0

        OSPF Process 1 with Router ID 10.0.1.1
          Interfaces


 Interface: 10.0.123.1 (GigabitEthernet0/0/0)
 Cost: 20      State: DR        Type: Broadcast    MTU: 1500
 Priority: 1
 Designated Router: 10.0.123.1
 Backup Designated Router: 0.0.0.0
 Timers: Hello 10 , Dead 40 , Poll  120 , Retransmit 5 , Transmit Delay 1
 Silent interface, No hellos
[R1-ospf-1]
```

从输出信息可以看到该接口被设置为Silent-Interface，不再存在hello报文。

删除R1上Silent-Interface配置

```
[R1-ospf-1]
[R1-ospf-1]undo silent-interface GigabitEthernet 0/0/0
[R1-ospf-1]
```

将R2、R3的Loopback0配置为Silent-Interface

```
[R2]ospf 1
[R2-ospf-1] silent-interface LoopBack 0
```

```
[R3]ospf 1
[R3-ospf-1] silent-interface LoopBack 0
```

在R1上查看OSPF路由表

```
[R1]display ospf routing

        OSPF Process 1 with Router ID 10.0.1.1
           Routing Tables

 Routing for Network
 Destination        Cost  Type       NextHop         AdvRouter       Area
 10.0.1.1/32        0     Stub       10.0.1.1        10.0.1.1        0.0.0.0
 10.0.123.0/24      20    Transit    10.0.123.1      10.0.1.1        0.0.0.0
 10.0.2.2/32        20    Stub       10.0.123.2      10.0.2.2        0.0.0.0
 10.0.3.3/32        20    Stub       10.0.123.3      10.0.3.3        0.0.0.0

 Total Nets: 4
 Intra Area: 4  Inter Area: 0  ASE: 0  NSSA: 0

[R1]
```

可以看到R2、R3 Loopback0接口路由依旧存在。

15 发布缺省路由

在R3上配置缺省路由，访问外网（以R4的loopback接口为例）

```
[R3]ip route-static 0.0.0.0 0.0.0.0 202.96.34.4
[R3]ping 202.96.1.1
  PING 202.96.1.1: 56  data bytes, press CTRL_C to break
    Reply from 202.96.1.1: bytes=56 Sequence=1 ttl=255 time=40 ms
    Reply from 202.96.1.1: bytes=56 Sequence=2 ttl=255 time=20 ms
    Reply from 202.96.1.1: bytes=56 Sequence=3 ttl=255 time=30 ms
    Reply from 202.96.1.1: bytes=56 Sequence=4 ttl=255 time=10 ms
    Reply from 202.96.1.1: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 202.96.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 10/26/40 ms
```

```
[R3]
```

R3可以ping通R4的loopback接口，但R1和R2因为没有路由，无法ping通R4的loopback接口。

```
<R1>ping 202.96.1.1
  PING 202.96.1.1: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 202.96.1.1 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss

<R1>

<R2>ping 202.96.1.1
  PING 202.96.1.1: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 202.96.1.1 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss

<R2>
```

在R3的ospf中分布缺省路由。

```
[R3]ospf 1
[R3-ospf-1]default-route-advertise always cost 10
```

在R1和R2上查看，OSPF有了一条缺省路由。

```
<R1>display ospf routing
```

```
        OSPF Process 1 with Router ID 10.0.1.1
            Routing Tables

 Routing for Network
 Destination        Cost  Type       NextHop         AdvRouter       Area
 10.0.1.1/32        0     Stub       10.0.1.1        10.0.1.1        0.0.0.0
 10.0.123.0/24      20    Transit    10.0.123.1      10.0.1.1        0.0.0.0
 10.0.2.2/32        20    Stub       10.0.123.2      10.0.2.2        0.0.0.0
 10.0.3.3/32        20    Stub       10.0.123.3      10.0.3.3        0.0.0.0

 Routing for ASEs
 Destination        Cost      Type       Tag         NextHop         AdvRouter
 0.0.0.0/0          10        Type2      1           10.0.123.3      10.0.3.3

 Total Nets: 5
 Intra Area: 4  Inter Area: 0  ASE: 1  NSSA: 0

<R1>

<R2>display ospf routing

        OSPF Process 1 with Router ID 10.0.2.2
            Routing Tables

 Routing for Network
 Destination        Cost  Type       NextHop         AdvRouter       Area
 10.0.2.2/32        0     Stub       10.0.2.2        10.0.2.2        0.0.0.0
 10.0.123.0/24      1     Transit    10.0.123.2      10.0.2.2        0.0.0.0
 10.0.1.1/32        1     Stub       10.0.123.1      10.0.1.1        0.0.0.0
 10.0.3.3/32        1     Stub       10.0.123.3      10.0.3.3        0.0.0.0

 Routing for ASEs
 Destination        Cost      Type       Tag         NextHop         AdvRouter
 0.0.0.0/0          10        Type2      1           10.0.123.3      10.0.3.3

 Total Nets: 5
 Intra Area: 4  Inter Area: 0  ASE: 1  NSSA: 0
```

```
<R2>
```

在R1和R2上ping R4的loopback接口IP地址202.96.1.1，可以ping通了

```
<R1>ping 202.96.1.1
  PING 202.96.1.1: 56  data bytes, press CTRL_C to break
    Reply from 202.96.1.1: bytes=56 Sequence=1 ttl=254 time=50 ms
    Reply from 202.96.1.1: bytes=56 Sequence=2 ttl=254 time=70 ms
    Reply from 202.96.1.1: bytes=56 Sequence=3 ttl=254 time=40 ms
    Reply from 202.96.1.1: bytes=56 Sequence=4 ttl=254 time=60 ms
    Reply from 202.96.1.1: bytes=56 Sequence=5 ttl=254 time=50 ms

  --- 202.96.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 40/54/70 ms

<R1>

<R2>ping 202.96.1.1
  PING 202.96.1.1: 56  data bytes, press CTRL_C to break
    Reply from 202.96.1.1: bytes=56 Sequence=1 ttl=254 time=60 ms
    Reply from 202.96.1.1: bytes=56 Sequence=2 ttl=254 time=50 ms
    Reply from 202.96.1.1: bytes=56 Sequence=3 ttl=254 time=60 ms
    Reply from 202.96.1.1: bytes=56 Sequence=4 ttl=254 time=50 ms
    Reply from 202.96.1.1: bytes=56 Sequence=5 ttl=254 time=60 ms

  --- 202.96.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 50/56/60 ms

<R2>
```

结果验证

实验过程中已验证。