配置多区域 OSPF 实现动态路由

难度（最高五星）：★★★ 建议学时：3学时

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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组建和配置中大型网络。

学习目标

完成本任务的学习后，你应当能：

1. 实现多区域 OSPF 的配置
2. 区域间路由汇总
3. 将外部路由引入 OSPF 区域
4. 配置 stub 和 Total stub 区域
5. 配置 NSSA 区域

任务准备

网络拓扑

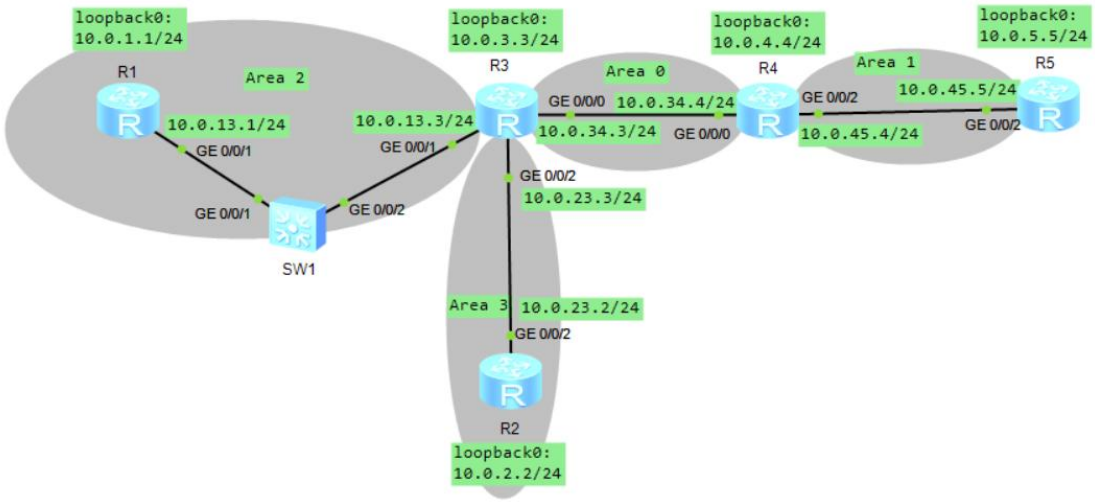

图1 配置单区域OSPF实现网络互通实验拓扑

设备互联方式及IP地址规划如图所示，OSPF区域规划如下：

1. R1 与 R3 的互联接口、R1 的 Loopback0 接口属于 OSPF 区域 2。

2. R3 与 R4 的互联接口以及它们的 Loopback0 接口属于 OSPF 区域 0。
3. R4 与 R5 的互联接口属于 OSPF 区域 1，R5 的 Loopback0 接口不属于任何区域。
4. R2 与 R3 的互联接口属于 OSPF 区域 3，R2 的 Loopback0 接口不属于任何区域。

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 24
[R1-LoopBack0]quit
[R1]int g0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/1]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 lo0
[R2-LoopBack0]ip address 10.0.2.2 24
[R2-LoopBack0]int g0/0/2
[R2-GigabitEthernet0/0/2]ip address 10.0.23.2 24
[R2-GigabitEthernet0/0/2]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 LoopBack 0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]int g0/0/1
[R3-GigabitEthernet0/0/1]ip address 10.0.13.3 24
[R3-GigabitEthernet0/0/0]int g0/0/0
```

```
[R3-GigabitEthernet0/0/0]ip address 10.0.34.3 24
[R3-GigabitEthernet0/0/0]int g0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.23.3 24
[R3-GigabitEthernet0/0/2]quit
[R3]
```

- R4的初始配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R4
[R4]int LoopBack 0
[R4-LoopBack0]ip address 10.0.4.4 24
[R4-LoopBack0]int g0/0/0
[R4-GigabitEthernet0/0/0]ip address 10.0.34.4 24
[R4-GigabitEthernet0/0/0]int g0/0/2
[R4-GigabitEthernet0/0/2]ip address 10.0.45.4 24
[R4-GigabitEthernet0/0/2]quit
[R4]
```

- R5的初始配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R5
[R5]int LoopBack 0
[R5-LoopBack0]ip address 10.0.5.5 24
[R5-LoopBack0]int g0/0/2
[R5-GigabitEthernet0/0/2]ip address 10.0.45.5 24
[R5-GigabitEthernet0/0/2]quit
[R5]
```

任务实施

1 查看基础配置

在R1、R2、R3、R4和R5上执行display ip interface brief命令，检查接口配置情况。

```
<R1>display ip int 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              10.0.13.1/24         up         up
GigabitEthernet0/0/2              unassigned           down       down
LoopBack0                         10.0.1.1/24          up         up(s)
NULL0                             unassigned           up         up(s)
<R1>

[R2]display ip int 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              10.0.23.2/24         up         up
LoopBack0                         10.0.2.2/24          up         up(s)
NULL0                             unassigned           up         up(s)
[R2]

[R3]display ip int brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
The number of interface that is UP in Physical is 5
```

```
The number of interface that is DOWN in Physical is 0
The number of interface that is UP in Protocol is 5
The number of interface that is DOWN in Protocol is 0

Interface                         IP Address/Mask      Physical   Protocol
GigabitEthernet0/0/0              10.0.34.3/24         up         up
GigabitEthernet0/0/1              10.0.13.3/24         up         up
GigabitEthernet0/0/2              10.0.23.3/24         up         up
LoopBack0                         10.0.3.3/24          up         up(s)
NULL0                             unassigned           up         up(s)
[R3]

<R4>display ip int 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              10.0.34.4/24         up         up
GigabitEthernet0/0/1              unassigned           down       down
GigabitEthernet0/0/2              10.0.45.4/24         up         up
LoopBack0                         10.0.4.4/24          up         up(s)
NULL0                             unassigned           up         up(s)
<R4>

<R5>display ip int 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              10.0.45.5/24         up         up
LoopBack0                         10.0.5.5/24          up         up(s)
NULL0                             unassigned           up         up(s)
<R5>
```

R3和R5执行ping命令，检测设备间的连通性。

```
[R3]ping 10.0.13.1
  PING 10.0.13.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.13.1: bytes=56 Sequence=1 ttl=255 time=130 ms
    Reply from 10.0.13.1: bytes=56 Sequence=2 ttl=255 time=40 ms
    Reply from 10.0.13.1: bytes=56 Sequence=3 ttl=255 time=60 ms
    Reply from 10.0.13.1: bytes=56 Sequence=4 ttl=255 time=40 ms
    Reply from 10.0.13.1: bytes=56 Sequence=5 ttl=255 time=50 ms

  --- 10.0.13.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 40/64/130 ms

[R3]ping 10.0.23.2
  PING 10.0.23.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.2: bytes=56 Sequence=1 ttl=255 time=80 ms
    Reply from 10.0.23.2: bytes=56 Sequence=2 ttl=255 time=20 ms
    Reply from 10.0.23.2: bytes=56 Sequence=3 ttl=255 time=20 ms
    Reply from 10.0.23.2: bytes=56 Sequence=4 ttl=255 time=20 ms
    Reply from 10.0.23.2: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.23.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 20/34/80 ms

[R3]ping 10.0.34.4
```

```
  PING 10.0.34.4: 56  data bytes, press CTRL_C to break
    Reply from 10.0.34.4: bytes=56 Sequence=1 ttl=255 time=50 ms
    Reply from 10.0.34.4: bytes=56 Sequence=2 ttl=255 time=20 ms
    Reply from 10.0.34.4: bytes=56 Sequence=3 ttl=255 time=40 ms
    Reply from 10.0.34.4: bytes=56 Sequence=4 ttl=255 time=30 ms
    Reply from 10.0.34.4: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.34.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 20/34/50 ms

[R3]

[R5]ping 10.0.45.4
  PING 10.0.45.4: 56  data bytes, press CTRL_C to break
    Reply from 10.0.45.4: bytes=56 Sequence=1 ttl=255 time=90 ms
    Reply from 10.0.45.4: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 10.0.45.4: bytes=56 Sequence=3 ttl=255 time=20 ms
    Reply from 10.0.45.4: bytes=56 Sequence=4 ttl=255 time=20 ms
    Reply from 10.0.45.4: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.45.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 20/38/90 ms

[R5]
```

2 配置多区域 OSPF

按照规划配置OSPF，手动指定Loopback0接口地址为OSPF Router ID，修改Loopback0接口的网络类型为Broadcast。

- 配置R1

```
[R1] ospf 1 router-id 10.0.1.1
[R1-ospf-1] area 0.0.0.2
```

```
[R1-ospf-1-area-0.0.0.2] network 10.0.1.1 0.0.0.0
[R1-ospf-1-area-0.0.0.2] network 10.0.13.1 0.0.0.0
[R1-ospf-1-area-0.0.0.2] quit
[R1-ospf-1] quit
[R1] interface LoopBack0
[R1-LoopBack0] ospf network-type broadcast
```

- 配置R2

```
[R2] ospf 1 router-id 10.0.2.2
[R2-ospf-1] area 0.0.0.3
[R2-ospf-1-area-0.0.0.3] network 10.0.23.2 0.0.0.0
[R2-ospf-1-area-0.0.0.3] quit
[R2-ospf-1] quit
[R2] interface LoopBack0
[R2-LoopBack0] ospf network-type broadcast
```

- 配置R3

```
[R3] ospf 1 router-id 10.0.3.3
[R3-ospf-1] area 0.0.0.0
[R3-ospf-1-area-0.0.0.0] network 10.0.3.3 0.0.0.0
[R3-ospf-1-area-0.0.0.0] network 10.0.34.3 0.0.0.0
[R3-ospf-1-area-0.0.0.0] area 0.0.0.2
[R3-ospf-1-area-0.0.0.2] network 10.0.13.3 0.0.0.0
[R3-ospf-1-area-0.0.0.2] area 0.0.0.3
[R3-ospf-1-area-0.0.0.3] network 10.0.23.3 0.0.0.0
[R3-ospf-1-area-0.0.0.3] quit
[R3-ospf-1] quit
[R3] interface LoopBack0
[R3-LoopBack0] ospf network-type broadcast
```

- 配置R4

```
[R4] ospf 1 router-id 10.0.4.4
[R4-ospf-1] area 0.0.0.0
[R4-ospf-1-area-0.0.0.0] network 10.0.4.4 0.0.0.0
[R4-ospf-1-area-0.0.0.0] network 10.0.34.4 0.0.0.0
[R4-ospf-1-area-0.0.0.0] area 0.0.0.1
[R4-ospf-1-area-0.0.0.1] network 10.0.45.4 0.0.0.0
[R4-ospf-1-area-0.0.0.1] quit
[R4-ospf-1] quit
[R4] interface LoopBack0
[R4-LoopBack0] ospf network-type broadcast
```

- 配置R5

```
[R5] ospf 1 router-id 10.0.5.5
[R5-ospf-1] area 1
[R5-ospf-1-area-0.0.0.1] network 10.0.45.5 0.0.0.0
[R5-ospf-1-area-0.0.0.1] quit
[R5-ospf-1] quit
[R5] interface LoopBack0
[R5-LoopBack0] ospf network-type broadcast
```

3 检查 OSPF 多区域配置

- 在R3上检查OSPF邻居的概要信息

```
<R3>display ospf peer brief

        OSPF Process 1 with Router ID 10.0.3.3
            Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                       Neighbor id      State
 0.0.0.0          GigabitEthernet0/0/0            10.0.4.4         Full
 0.0.0.2          GigabitEthernet0/0/1            10.0.1.1         Full
 0.0.0.3          GigabitEthernet0/0/2            10.0.2.2         Full
 ----------------------------------------------------------------------------
<R3>
```

- 在R5上检查OSPF邻居的概要信息

```
<R5>display ospf peer brief

        OSPF Process 1 with Router ID 10.0.5.5
            Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                       Neighbor id      State
 0.0.0.1          GigabitEthernet0/0/2            10.0.4.4         Full
 ----------------------------------------------------------------------------
<R5>
```

从输出信息可以判断出所有设备之间的OSPF邻居关系状态正常。

- 在R3上查看OSPF路由表

```
<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
 10.0.3.0/24        0     Stub       10.0.3.3        10.0.3.3        0.0.0.0
 10.0.13.0/24       1     Transit    10.0.13.3       10.0.3.3        0.0.0.2
 10.0.23.0/24       1     Transit    10.0.23.3       10.0.3.3        0.0.0.3
 10.0.34.0/24       1     Transit    10.0.34.3       10.0.3.3        0.0.0.0
 10.0.1.0/24        1     Stub       10.0.13.1       10.0.1.1        0.0.0.2
 10.0.4.0/24        1     Stub       10.0.34.4       10.0.4.4        0.0.0.0
 10.0.45.0/24       2     Inter-area 10.0.34.4       10.0.4.4        0.0.0.0

 Total Nets: 7
 Intra Area: 6  Inter Area: 1  ASE: 0  NSSA: 0

<R3>
```

除未激活OSPF的R2 Loopback0接口、R5 Loopback0接口，R3已经学习到其余接口路由。

4 配置将外部路由引入到 OSPF 中

- 将R5的Loopback0接口路由引入到OSPF中

```
[R5]ospf 1
[R5-ospf-1]import-route direct
[R5-ospf-1]
```

- R2上配置缺省路由

在R2上配置缺省路由，且指定出接口为 Loopback0接口，并将该缺省路由引入到OSPF中，外部路由类型设置为1，Cost值设置为20，不携带always参数。

```
[R2] ip route-static 0.0.0.0 0.0.0.0 LoopBack 0
[R2]ospf 1
[R2-ospf-1]default-route-advertise type 1 cost 20
[R2-ospf-1]
```

- 在R3上查看引入的外部路由，并测试其连通性

```
<R3>display ospf routing 0.0.0.0

        OSPF Process 1 with Router ID 10.0.3.3

 Destination : 0.0.0.0/0
```

```
 AdverRouter : 10.0.2.2                Tag       : 1
 Cost        : 21                      Type      : Type1
 NextHop     : 10.0.23.2               Interface : GigabitEthernet0/0/2
 Priority    : Low                     Age       : 00h01m21s
<R3>

<R3>display ospf routing 10.0.5.5

        OSPF Process 1 with Router ID 10.0.3.3

 Destination : 10.0.5.0/24
 AdverRouter : 10.0.5.5                Tag       : 1
 Cost        : 1                       Type      : Type2
 NextHop     : 10.0.34.4               Interface : GigabitEthernet0/0/0
 Priority    : Low                     Age       : 00h03m36s
<R3>

<R3>ping -c 2 10.0.5.5
  PING 10.0.5.5: 56  data bytes, press CTRL_C to break
    Reply from 10.0.5.5: bytes=56 Sequence=1 ttl=254 time=50 ms
    Reply from 10.0.5.5: bytes=56 Sequence=2 ttl=254 time=40 ms

  --- 10.0.5.5 ping statistics ---
    2 packet(s) transmitted
    2 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 40/45/50 ms

<R3>ping -c 2 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=40 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=255 time=30 ms

  --- 10.0.2.2 ping statistics ---
    2 packet(s) transmitted
    2 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 30/35/40 ms
```

```
<R3>
```

结果验证

实验过程中已验证。