3 BGP 路由协议

3.1 项目背景

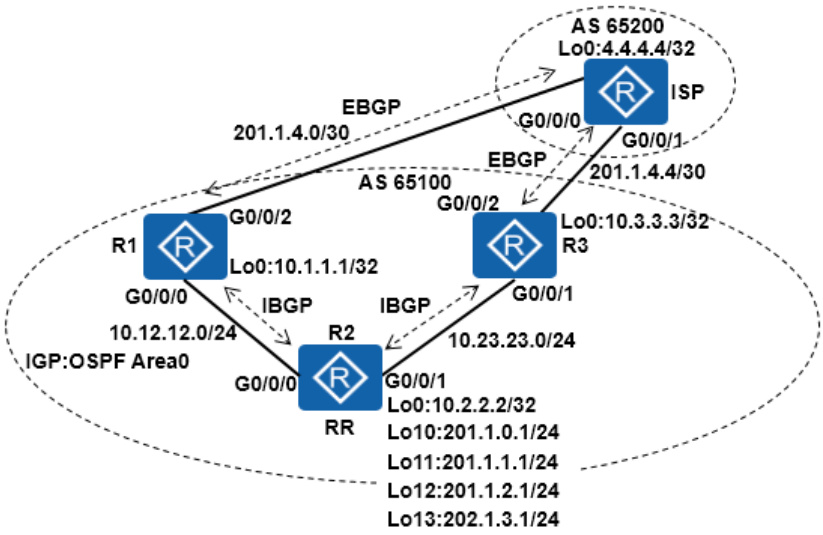
近年来，A 公司网络规模不断扩大，新的业务对互联网接入的速度和稳定性提出了更高的要求，公司计划升级网络为用户提供更好的服务品质和体验，为此向运营商 B 租用两条线路接入其网络，目的是优化公司网络资源利用率和增强网络安全性、稳定性和可靠性。李同学正在该公司实习，为了提高实际工作的准确性和工作效率，做好技术储备，项目经理安排他在实验室环境下模拟企业边界设备接入运营商网络测试，为项目实施和网络运行奠定坚实的基础。李同学用 1 台路由器模拟运营商的网络，企业通过两台边界路由器接入运营商 B 的网络，企业内部网络运行 OSPF 路由协议实现网络互联。

3.2 项目目的

通过本项目可以掌握如下知识点和技能点，同时积累项目经验。

- 启动 BGP 路由进程及通告网络的方法。
- IBGP 邻居和 EBGP 邻居配置的方法。
- BGP 路由更新源和 next-hop-local 配置的方法。
- BGP 路由反射器配置的方法。
- BGP 路由聚合和 BGP 团体属性配置的方法。
- BGP 验证和 Dampening 配置的方法。
- 查看和调试 BGP 路由协议相关信息。

3.3 项目拓扑



3.4 项目规划

本项目的核心任务是完成 BGP 部署，为保持项目的完整性，需完成前期准备工作。注意：本项目涉及前缀列表和路由策略的知识请参见第四章。

3.4.1 项目前期准备工作

步骤 1　配置 IP 地址：公司内部网络设备之间及其环回接口使用私有地址，公司业务网段和与 ISP 设备互联的网络使用公网地址，业务网段在路由器 R2 和 ISP 上分别用与环回接口模拟。配置路由器接口的 IP 地址并测试所有直连链路的连通性。

步骤 2　配置 OSPF：内部网络路由器 R1、R2 和 R3 上配置 OSPF 路由协议，以便建立 IBGP 邻居时提供发送 BGP 报文源地址的连通性。

3.4.2 项目核心任务

步骤 1　配置 BGP 基本功能：启动 BGP 进程,配置 BGP 路由器 ID,创建 IBGP 和 EBGP 对等体,指定 BGP 报文发送源地址，配置 IBGP 的 next-hop-local 和通告网络等。

步骤 2　配置 BGP 验证：为了提高网络安全性，在 R1 到 ISP 的链路上，配置 BGP MD5 验证。在 R3 到 ISP 的链路上，配置 BGP Keychain 验证。

步骤 3　配置路由反射器：IBGP 对等体之间不需要建立全连接关系，将路由器 R2 配置为 BGP 路由反射器，R1 和 R3 作为客户机。

步骤 4　配置 BGP 路由聚合：在边界路由器 R1 和 R3 上分别配置 BGP 路由聚合,减少路由器 ISP 路由表大小。

步骤 5　配置 BGP 团体属性：在边界路由器 R1 和 R3 上分别配置 BGP 团体属性，实现聚合路由发布给 ISP 路由器时携带团体属性。

步骤 6　配置 BGP Damping：在路由器 R1 上对 4.4.4.4 路由配置 Damping 功能，抑制不稳定的路由。

设备接口连接规划表和设备接口 IP 地址规划表如下。

表3-1 设备接口连接规划表

设备	接口	接口所在网段	对端设备及接口
R1	G0/0/0	10.12.12.0/24	R2 G0/0/0
	G0/0/2	201.1.4.0/30	ISP G0/0/0
R2	G0/0/0	10.12.12.0/24	R1 G0/0/0
	G0/0/1	10.23.23.0/24	R3 G0/0/1
R3	G0/0/1	10.23.23.0/24	R2 G0/0/1
	G0/0/2	201.1.4.4/30	ISP G0/0/1
ISP	G0/0/0	201.1.4.0/30	R1 G0/0/2
	G0/0/1	201.1.4.4/30	R3 G0/0/2

表3-2 设备接口 IP 地址规划表

设备	接口	IP 地址	备注
R1	G0/0/0	10.12.12.1/24	
	G0/0/2	201.1.4.1/30	
	LoopBack0	10.1.1.1/32	建立 IBGP 邻居更新源地址
R2	G0/0/0	10.12.12.2/24	
	G0/0/1	10.23.23.2/24	
	LoopBack0	10.2.2.2/32	建立 IBGP 邻居更新源地址
	LoopBack10	201.1.0.1/24	模拟公司内部网络主机
	LoopBack11	201.1.1.1/24	模拟公司内部网络主机
	LoopBack12	201.1.2.1/24	模拟公司内部网络主机
	LoopBack13	201.1.3.1/24	模拟公司内部网络主机
R3	G0/0/1	10.23.23.3/24	
	G0/0/1	201.1.4.5/30	
	LoopBack0	10.3.3.3/32	建立 IBGP 邻居更新源地址
ISP	G0/0/0	201.1.4.2/30	
	G0/0/1	201.1.4.6/30	
	LoopBack0	4.4.4.4/24	模拟 ISP 主机

3.5 项目实施

3.5.1 项目准备工作

步骤 1　配置 IP 地址

公司内部网络设备之间及其环回接口使用私有地址，公司业务网段和与 ISP 设备互联的网络使用公网地址，业务网段在路由器 R2 和 ISP 上分别用与环回接口模拟。配置路由器接口的 IP 地址并测试所有直连链路的连通性。

- 配置路由器 R1

```
[R1]interface GigabitEthernet0/0/0
[R1-GigabitEthernet0/0/0]ip address 10.12.12.1 255.255.255.0
[R1-GigabitEthernet0/0/0]quit
[R1]interface GigabitEthernet0/0/2
[R1-GigabitEthernet0/0/2]ip address 201.1.4.1 255.255.255.252
[R1-GigabitEthernet0/0/2]quit
[R1]interface LoopBack0
[R1-LoopBack0]ip address 10.1.1.1 255.255.255.255
[R1-LoopBack0]quit
```

- 配置路由器 R2

```
[R2]interface GigabitEthernet0/0/0
[R2-GigabitEthernet0/0/0]ip address 10.12.12.2 255.255.255.0
[R2-GigabitEthernet0/0/0]quit
[R2]interface GigabitEthernet0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.23.23.2 255.255.255.0
[R2-GigabitEthernet0/0/1]quit
[R2]interface LoopBack0
[R2-LoopBack0]ip address 10.2.2.2 255.255.255.255
[R2-LoopBack0]quit
[R2]interface LoopBack10
[R2-LoopBack10]ip address 201.1.0.1 255.255.255.0
[R2-LoopBack10]quit
[R2]interface LoopBack11
[R2-LoopBack11]ip address 201.1.1.1 255.255.255.0
[R2-LoopBack11]quit
[R2]interface LoopBack12
[R2-LoopBack12]ip address 201.1.2.1 255.255.255.0
[R2-LoopBack12]quit
[R2]interface LoopBack13
[R2-LoopBack13]ip address 201.1.3.1 255.255.255.0
[R2-LoopBack13]quit
```

- 配置路由器 R3

```
[R3]interface GigabitEthernet0/0/1
[R3-GigabitEthernet0/0/1]ip address 10.23.23.3 255.255.255.0
[R3-GigabitEthernet0/0/1]quit
[R3]interface GigabitEthernet0/0/2
[R3-GigabitEthernet0/0/2]ip address 201.1.4.5 255.255.255.252
[R3-GigabitEthernet0/0/2]quit
[R3]interface LoopBack0
[R3-LoopBack0]ip address 10.3.3.3 255.255.255.0
[R3-LoopBack0]quit
```

- 配置路由器 ISP

```
[ISP]interface GigabitEthernet0/0/0
[ISP-GigabitEthernet0/0/0]ip address 201.1.4.2 255.255.255.252
[ISP-GigabitEthernet0/0/0]quit
[ISP]interface GigabitEthernet0/0/1
[ISP-GigabitEthernet0/0/1]ip address 201.1.4.6 255.255.255.252
[ISP-GigabitEthernet0/0/1]quit
[ISP]interface LoopBack0
```

```
[ISP-LoopBack0]ip address 4.4.4.4 255.255.255.255
[ISP-LoopBack0]quit
```

验证以上配置任务。

```
[R1]display ip interface brief | exclude unassigned
*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              10.12.12.1/24        up         up
GigabitEthernet0/0/2              201.1.4.1/30         up         up
LoopBack0                         10.1.1.1/32          up         up

[R2]display ip interface brief | exclude unassigned
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
The number of interface that is UP in Physical is 8
The number of interface that is DOWN in Physical is 1
The number of interface that is UP in Protocol is 8
The number of interface that is DOWN in Protocol is 1

Interface                         IP Address/Mask      Physical   Protocol
GigabitEthernet0/0/0              10.12.12.2/24        up         up
GigabitEthernet0/0/1              10.23.23.2/24        up         up
LoopBack0                         10.2.2.2/32          up         up(s)
LoopBack10                        201.1.0.1/24         up         up(s)
LoopBack11                        201.1.1.1/24         up         up(s)
LoopBack12                        201.1.2.1/24         up         up(s)
LoopBack13                        201.1.3.1/24         up         up(s)

[R3]display ip interface brief | exclude unassigned
*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
GigabitEthernet0/0/1              10.23.23.3/24        up         up
GigabitEthernet0/0/2              201.1.4.5/30         up         up
LoopBack0                         10.3.3.3/24          up         up(s)

[ISP]display ip interface brief | exclude unassigned
*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              201.1.4.2/30         up         up
GigabitEthernet0/0/1              201.1.4.6/30         up         up
LoopBack0                         4.4.4.4/32           up         up(s)
```

步骤 2　配置 OSPF

内部网络路由器 R1、R2 和 R3 上配置 OSPF 路由协议，以便建立 IBGP 邻居时提供发送 BGP 报文源地址的连通性。

- 配置路由器 R1

```
[R1]ospf 1 router-id 1.1.1.1
[R1-ospf-1]bandwidth-reference 1000
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.1.1.1 0.0.0.0
[R1-ospf-1-area-0.0.0.0]network 10.12.12.1 0.0.0.0
```

- 配置路由器 R2

```
[R2]ospf 1 router-id 2.2.2.2
[R2-ospf-1]bandwidth-reference 1000
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.2.2.2 0.0.0.0
[R2-ospf-1-area-0.0.0.0]network 10.12.12.2 0.0.0.0
[R2-ospf-1-area-0.0.0.0]network 10.23.23.2 0.0.0.0
```

- 配置路由器 R3

```
[R3]ospf 1 router-id 3.3.3.3
[R3-ospf-1]bandwidth-reference 1000
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.3.3.3 0.0.0.0
[R3-ospf-1-area-0.0.0.0]network 10.23.23.3 0.0.0.0
```

验证以上配置任务。

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

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

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.2.2.2/32 OSPF    10   1             D  10.12.12.2     GigabitEthernet0/0/0
        10.3.3.3/32 OSPF    10   2             D  10.12.12.2     GigabitEthernet0/0/0
       10.23.23.0/24 OSPF   10   2             D  10.12.12.2     GigabitEthernet0/0/0

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

```
[R2]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
         Destinations : 2        Routes : 2

OSPF routing table status : <Active>
         Destinations : 2        Routes : 2

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.1.1.1/32  OSPF    10   1           D   10.12.12.1      GigabitEthernet0/0/0
        10.3.3.3/32  OSPF    10   1           D   10.23.23.3      GigabitEthernet0/0/1

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

[R3]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
         Destinations : 3        Routes : 3

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

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.1.1.1/32  OSPF    10   2           D   10.23.23.2      GigabitEthernet0/0/1
        10.2.2.2/32  OSPF    10   1           D   10.23.23.2      GigabitEthernet0/0/1
       10.12.12.0/24 OSPF    10   2           D   10.23.23.2      GigabitEthernet0/0/1

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

3.5.2 项目核心任务

步骤 1　配置 BGP 基本功能

项目核心任务是完成 BGP 部署。配置 BGP 基本功能包括在 4 台路由器启动 BGP 进程,配置 BGP 路由器 ID,创建 IBGP 和 EBGP 对等体,指定 BGP 报文发送源地址，配置 IBGP 的 next-hop-local，修改 keepalive 计时器和通告网络等。

- 配置路由器 R1

```
[R1]bgp 65100
[R1-bgp]router-id 1.1.1.1
[R1-bgp]peer 10.2.2.2 as-number 65100
[R1-bgp]peer 10.2.2.2 connect-interface LoopBack0
[R1-bgp]peer 10.2.2.2 enable
[R1-bgp]peer 10.2.2.2 next-hop-local
[R1-bgp]peer 201.1.4.2 as-number 65200
[R1-bgp]peer 201.1.4.2 enable
[R1-bgp]timer keepalive 60 hold 180
```

- 配置路由器 R2

```
[R2]bgp 65100
[R2-bgp]router-id 2.2.2.2
```

```
[R2-bgp]peer 10.1.1.1 as-number 65100
[R2-bgp]peer 10.1.1.1 connect-interface LoopBack0
[R2-bgp]peer 10.1.1.1 enable
[R2-bgp]peer 10.3.3.3 as-number 65100
[R2-bgp]peer 10.3.3.3 connect-interface LoopBack0
[R2-bgp]peer 10.3.3.3 enable
[R2-bgp]network 201.1.0.0 24
[R2-bgp]network 201.1.1.0 24
[R2-bgp]network 201.1.2.0 24
[R2-bgp]network 201.1.3.0 24
```

- 配置路由器 R3

```
[R3]bgp 65100
[R3-bgp]router-id 3.3.3.3
[R3-bgp]peer 10.2.2.2 as-number 65100
[R3-bgp]peer 10.2.2.2 connect-interface LoopBack0
[R3-bgp]peer 10.2.2.2 enable
[R3-bgp]peer 10.2.2.2 next-hop-local
[R3-bgp]peer 201.1.4.6 as-number 65200
[R3-bgp]peer 201.1.4.6 enable
```

- 配置路由器 ISP

```
[ISP]bgp 65200
[ISP-bgp]router-id 4.4.4.4
[ISP-bgp]peer 201.1.4.1 as-number 65100
[ISP-bgp]peer 201.1.4.1 enable
[ISP-bgp]peer 201.1.4.5 as-number 65100
[ISP-bgp]peer 201.1.4.5 enable
[ISP-bgp]network 4.4.4.4 255.255.255.255
```

步骤 2　配置 BGP 验证

为了提高网络安全性，在 R1 到 ISP 的链路上，配置 BGP MD5 验证。在 R3 到 ISP 的链路上，配置 BGP Keychain 验证。

- 在 R1 到 ISP 的链路上，配置 BGP MD5 验证。

```
[R1]bgp 65100
[R1-bgp]peer 201.1.4.2 password cipher huawei123

[ISP]bgp 65200
[ISP-bgp]peer 201.1.4.1 password cipher hauwei123
```

- 在 R3 到 ISP 的链路上，配置 BGP Keychain 验证。

```
[R3]keychain toISP mode periodic daily
[R3-keychain]key-id 1
[R3-keychain-keyid-1]algorithm md5
[R3-keychain-keyid-1]key-string cipher huawei123
[R3-keychain-keyid-1]send-time daily 00:00 to 23:59
[R3-keychain-keyid-1]receive-time daily 00:00 to 23:59
[R3]bgp 65100
[R3-bgp]peer 201.1.4.6 keychain toISP

[ISP]keychain toR3 mode periodic daily
[ISP-keychain]key-id 1
[ISP-keychain-keyid-1]algorithm md5
[ISP-keychain-keyid-1]key-string cipher huawei123
[ISP-keychain-keyid-1]send-time daily 00:00 to 23:59
```

```
[ISP-keychain-keyid-1]receive-time daily 00:00 to 23:59
[ISP]bgp 65200
[ISP-bgp]peer 201.1.4.5 keychain toR3
```

步骤 3　配置路由反射器

IBGP 对等体之间不需要建立全连接关系，将路由器 R2 配置为 BGP 路由反射器，R1 和 R3 作为客户机。

```
[R2]bgp 65100
[R2-bgp]undo reflect between-clients
[R2-bgp]reflector cluster-id 123
[R2-bgp]peer 10.1.1.1 reflect-client
[R2-bgp]peer 10.3.3.3 reflect-client
```

步骤 4　配置 BGP 路由聚合

在边界路由器 R1 和 R3 上分别配置 BGP 路由聚合,减少路由器 ISP 路由表大小。

```
[R1]bgp 65100
[R1-bgp]aggregate 201.1.0.0 255.255.252.0 as-set detail-suppressed

[R3]bgp 65100
[R3-bgp]aggregate 201.1.0.0 255.255.252.0 as-set detail-suppressed
```

步骤 5　配置 BGP 团体属性

在边界路由器 R1 和 R3 上分别配置 BGP 团体属性，实现聚合路由发布给 ISP 路由器时携带团体属性。

- 配置路由器 R1

```
[R1]ip ip-prefix R1 index 10 permit 201.1.0.0 22
[R1]route-policy R1 permit node 10
[R1-route-policy]if-match ip-prefix R1
[R1-route-policy]apply community 65100:123
[R1]route-policy R1 permit node 20
[R1]bgp 65100
[R1-bgp]peer 201.1.4.2 route-policy R1 export
[R1-bgp]peer 201.1.4.2 advertise-community
```

- 配置路由器 R3

```
[R3]bgp 65100
[R3-ospf-1]ip ip-prefix 3 index 10 permit 201.1.0.0 22
[R3]route-policy R3 permit node 10
[R3-route-policy]if-match ip-prefix R3
[R3-route-policy]apply community 65100:123
[R3]route-policy R3 permit node 20
[R3-bgp]peer 201.1.4.6 route-policy R3 export
[R3-bgp]peer 201.1.4.6 advertise-community
```

步骤 6　配置 BGP Damping

在路由器 R1 上对 4.4.4.4 路由配置 Damping 功能，抑制不稳定的路由。

```
[R1]ip ip-prefix 4 index 10 permit 4.4.4.4 32
[R1]route-policy fromISP permit node 10
[R1-route-policy]if-match ip-prefix 4
[R1-route-policy]apply dampening 15 750 2000 3000
[R1]route-policy fromISP permit node 20
```

```
[R1]bgp 65100
[R1-bgp]dampening route-policy fromISP
```

3.6 项目验证

3.6.1 查看 TCP 连接状态信息

```
[ISP]display tcp status | include 179
TCPCB       Tid/Soid Local Add:port      Foreign Add:port      VPNID   State
b4b06aa8 164/1       0.0.0.0:179         201.1.4.1:0           0       Listening *
b4b06d30 164/4       0.0.0.0:179         201.1.4.5:0           0       Listening
b4b06bec 164/3       201.1.4.2:49258     201.1.4.1:179         0       Established *
b4b06e74 164/6       201.1.4.6:49872     201.1.4.5:179         0       Established

[R2]display tcp status | include 179
TCPCB       Tid/Soid Local Add:port      Foreign Add:port      VPNID   State
b4b76ef8 164/1       0.0.0.0:179         10.1.1.1:0            0       Listening
b4b77690 164/4       0.0.0.0:179         10.3.3.3:0            0       Listening
b4b7703c 164/3       10.2.2.2:50650      10.1.1.1:179          0       Established
b4b777d4 164/6       10.2.2.2:50650      10.3.3.3:179          0       Established
```

3.6.2 查看 BGP 对等体信息

- 查看路由器 R1 BGP 对等体信息

```
[R1]display bgp peer

 BGP local router ID : 1.1.1.1
 Local AS number : 65100
 Total number of peers : 2           Peers in established state : 2

  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv

  10.2.2.2        4       65100     1335     1333     0 22:09:43 Established     4
  201.1.4.2       4       65200     1336     1335     0 22:10:19 Established     1
```

- 查看路由器 R2 BGP 对等体信息

```
[R2]display bgp peer

 BGP local router ID : 2.2.2.2
 Local AS number : 65100
 Total number of peers : 2           Peers in established state : 2

  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv

  10.1.1.1        4       65100     1332     1335     0 22:09:32 Established     2
  10.3.3.3        4       65100     1332     1335     0 22:09:32 Established     2
```

- 查看路由器 R3 BGP 对等体信息

```
[R3]display bgp peer

 BGP local router ID : 3.3.3.3
 Local AS number : 65100
 Total number of peers : 2           Peers in established state : 2
```

```
 Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv

 10.2.2.2        4       65100     1335     1333     0 22:09:49 Established     4
 201.1.4.6       4       65200     1336     1335     0 22:10:24 Established     1
```

- 查看路由器 ISP BGP 对等体信息

```
[ISP]display bgp peer

 BGP local router ID : 4.4.4.4
 Local AS number : 65200
 Total number of peers : 2            Peers in established state : 2

 Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv

 201.1.4.1       4       65100     1334     1336     0 22:10:34 Established     1
 201.1.4.5       4       65100     1334     1336     0 22:10:33 Established     1
```

3.6.3 查看 BGP 对等体详细信息

```
[R3]display bgp peer 201.1.4.6 verbose

          BGP Peer is 201.1.4.6,    remote AS 65200
   Type: EBGP link
   BGP version 4, Remote router ID 4.4.4.4
   Update-group ID: 2
   BGP current state: Established, Up for 22h49m40s
   BGP current event: KATimerExpired
   BGP last state: OpenConfirm
   BGP Peer Up count: 1
   Received total routes: 1
   Received active routes total: 1
   Advertised total routes: 1
   Port:    Local - 179       Remote - 49872
   Configured: Connect-retry Time: 32 sec
   Configured: Active Hold Time: 180 sec  Keepalive Time:60 sec
   Received    : Active Hold Time: 180 sec
   Negotiated: Active Hold Time: 180 sec  Keepalive Time:60 sec
   Peer optional capabilities:
   Peer supports bgp multi-protocol extension
   Peer supports bgp route refresh capability
   Peer supports bgp 4-byte-as capability
   Address family IPv4 Unicast: advertised and received
 Received: Total 1378 messages
           Update messages              7
           Open messages                1
           KeepAlive messages           1370
           Notification messages        0
           Refresh messages             0
 Sent: Total 1378 messages
           Update messages              6
           Open messages                2
           KeepAlive messages           1370
           Notification messages        0
           Refresh messages             0
 Authentication type configured: Keychain(toISP)
 Last keepalive received: 2020/04/25 17:25:38 UTC-08:00
 Last keepalive sent        : 2020/04/25 17:25:39 UTC-08:00
 Last update        received: 2020/04/25 17:21:16 UTC-08:00
```

```
Last update       sent       : 2020/04/25 17:20:49 UTC-08:00
Minimum route advertisement interval is 30 seconds
Optional capabilities:
Route refresh capability has been enabled
4-byte-as capability has been enabled
Send community has been configured
Peer Preferred Value: 0
Routing policy configured:
No import update filter list
No export update filter list
No import prefix list
No export prefix list
No import route policy
Export route policy is: R3
No import distribute policy
No export distribute policy
```

3.6.4 查看 BGP 初始化默认配置

```
[R2]display default-parameter bgp
 BGP version                     : 4
 EBGP preference                 : 255
 IBGP preference                 : 255
 Local preference                : 255
 BGP connect-retry               : 32s
 BGP holdtime                    : 180s
 BGP keepAlive                   : 60s
 EBGP route-update-interval: 30s
 IBGP route-update-interval: 15s
 Default local-preference    : 100
 Default MED                     : 0
 IPv4-family unicast             : enable
 EBGP-interface-sensitive    : enable
 Reflect between-clients     : enable
 Check-first-as                  : enable
 Synchronization                 : disable
 Nexthop-resolved rules      :
      IPv4-family                : unicast(ip)
                                   label-route(ip)
                                   multicast(ip)
                                   vpn-instance(tunnel)
                                   vpnv4(ip)
      IPv6-family                : unicast(ip)
                                   vpn-instance(tunnel)
```

3.6.5 查看 BGP 路由信息

- 查看路由器 R1 BGP 路由信息

```
[R1]display bgp routing-table

 BGP Local router ID is 1.1.1.1
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete


 Total Number of Routes: 5
```

```
      Network            NextHop        MED        LocPrf     PrefVal  Path/Ogn

*>    4.4.4.4/32         201.1.4.2      0                     0        65200i
*>    201.1.0.0/22       127.0.0.1                            0        i
s>i   201.1.0.0          10.2.2.2       0          100        0        i
s>i   201.1.1.0          10.2.2.2       0          100        0        i
s>i   201.1.2.0          10.2.2.2       0          100        0        i
s>i   201.1.3.0          10.2.2.2       0          100        0        i
```

- 查看路由器 R2 BGP 路由信息

```
[R2]display bgp routing-table

 BGP Local router ID is 2.2.2.2
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete


 Total Number of Routes: 6
      Network            NextHop        MED        LocPrf     PrefVal  Path/Ogn

*>i   4.4.4.4/32         10.1.1.1       0          100        0        65200i
* i                      10.3.3.3       0          100        0        65200i
*>i   201.1.0.0/22       10.1.1.1                  100        0        i
* i                      10.3.3.3                  100        0        i
*>    201.1.0.0          0.0.0.0        0                     0        i
*>    201.1.1.0          0.0.0.0        0                     0        i
*>    201.1.2.0          0.0.0.0        0                     0        i
*>    201.1.3.0          0.0.0.0        0                     0        i
```

- 查看路由器 R3 BGP 路由信息

```
[R3]display bgp routing-table

 BGP Local router ID is 3.3.3.3
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete


 Total Number of Routes: 5
      Network            NextHop        MED        LocPrf     PrefVal  Path/Ogn

*>    4.4.4.4/32         201.1.4.6      0                     0        65200i
*>    201.1.0.0/22       127.0.0.1                            0        i
s>i   201.1.0.0          10.2.2.2       0          100        0        i
s>i   201.1.1.0          10.2.2.2       0          100        0        i
s>i   201.1.2.0          10.2.2.2       0          100        0        i
s>i   201.1.3.0          10.2.2.2       0          100        0        i
```

- 查看路由器 ISP BGP 路由信息

```
[ISP]display bgp routing-table

 BGP Local router ID is 4.4.4.4
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete
```

```
Total Number of Routes: 3
      Network              NextHop          MED          LocPrf      PrefVal Path/Ogn

*>    4.4.4.4/32           0.0.0.0           0                        0       i
*>    201.1.0.0/22         201.1.4.1                                  0       65100i
*                          201.1.4.5                                  0       65100i
```

3.6.6 查看 BGP 路由详细信息

```
[R2]display bgp routing-table 4.4.4.4 32

 BGP local router ID : 2.2.2.2
 Local AS number : 65100
 Paths:    2 available, 1 best, 1 select
 BGP routing table entry information of 4.4.4.4/32:
 RR-client route.
 From: 10.1.1.1 (1.1.1.1)
 Route Duration: 22h28m47s
 Relay IP Nexthop: 10.12.12.1
 Relay IP Out-Interface: GigabitEthernet0/0/0
 Original nexthop: 10.1.1.1
 Qos information : 0x0
 AS-path 65200, origin igp, MED 0, localpref 100, pref-val 0, valid, internal, b
est, select, active, pre 255, IGP cost 1
 Not advertised to any peer yet

 BGP routing table entry information of 4.4.4.4/32:
 RR-client route.
 From: 10.3.3.3 (3.3.3.3)
 Route Duration: 22h28m47s
 Relay IP Nexthop: 10.23.23.3
 Relay IP Out-Interface: GigabitEthernet0/0/1
 Original nexthop: 10.3.3.3
 Qos information : 0x0
 AS-path 65200, origin igp, MED 0, localpref 100, pref-val 0, valid, internal, p
re 255, IGP cost 1, not preferred for router ID
 Not advertised to any peer yet
```

3.6.7 查看 BGP 路由表中携带团体属性的路由

```
[ISP]display bgp routing-table community

 BGP Local router ID is 4.4.4.4
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete

 Total Number of Routes: 2
      Network              NextHop          MED          LocPrf      PrefVal Community

 *>   201.1.0.0/22         201.1.4.1                                  0       <65100:123 >
 *                         201.1.4.5                                  0       <65100:123>
```

3.6.8 调试 BGP 路由衰减

在路由器 ISP 上将环回接口 0 的 IP 地址删除，再配置，重复几次后，在路由器 R1 查看 BGP 路由衰减的信息。

- 如若最后执行的是配置 IP 地址，说明 R1 路由器最后收到的是 Update 报文，该路由被打上 d 标志，如下所示。

```
[R1]display bgp routing-table | include d
BGP Local router ID is 1.1.1.1
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete

 Total Number of Routes: 6
      Network            NextHop        MED        LocPrf    PrefVal Path/Ogn

  d   4.4.4.4/32         201.1.4.2      0                    0       65200i
```

- 如若最后执行的是删除 IP 地址，说明 R1 路由器最后收到的是撤销报文，该路由被打上 h 标志，如下所示。

```
[R1]display bgp routing-table | include h
BGP Local router ID is 1.1.1.1
 Status codes: * - valid, > - best, d - damped,
               h - history,  i - internal, s - suppressed, S - Stale
               Origin : i - IGP, e - EGP, ? - incomplete

 Total Number of Routes: 6
      Network            NextHop        MED        LocPrf    PrefVal  Path/Ogn

  h   4.4.4.4/32         201.1.4.2      0                    0        65200i
```

3.6.9 查看 IP 路由表

- 查看路由器 R1 IP 路由表中 BGP 路由信息

```
[R1]display ip routing-table protocol bgp
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : BGP
         Destinations : 5        Routes : 5

BGP routing table status : <Active>
         Destinations : 5        Routes : 5

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        201.1.0.0/22  IBGP   255  0           D   127.0.0.1       NULL0
        201.1.0.0/24  IBGP   255  0           RD  10.2.2.2        GigabitEthernet0/0/0
        201.1.1.0/24  IBGP   255  0           RD  10.2.2.2        GigabitEthernet0/0/0
        201.1.2.0/24  IBGP   255  0           RD  10.2.2.2        GigabitEthernet0/0/0
        201.1.3.0/24  IBGP   255  0           RD  10.2.2.2        GigabitEthernet0/0/0

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

- 查看路由器 R2 IP 路由表中 BGP 路由信息

```
[R2]display ip routing-table protocol bgp
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : BGP
         Destinations : 2        Routes : 2

BGP routing table status : <Active>
         Destinations : 2        Routes : 2

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        4.4.4.4/32  IBGP    255  0           RD  10.3.3.3        GigabitEthernet0/0/1
      201.1.0.0/22  IBGP    255  0           RD  10.1.1.1        GigabitEthernet0/0/0

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

- 查看路由器 R3 IP 路由表中 BGP 路由信息

```
[R3]display ip routing-table protocol bgp
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : BGP
         Destinations : 6        Routes : 6

BGP routing table status : <Active>
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        4.4.4.4/32  EBGP    255  0           D   201.1.4.6       GigabitEthernet0/0/2
      201.1.0.0/22  IBGP    255  0           D   127.0.0.1       NULL0
      201.1.0.0/24  IBGP    255  0           RD  10.2.2.2        GigabitEthernet0/0/1
      201.1.1.0/24  IBGP    255  0           RD  10.2.2.2        GigabitEthernet0/0/1
      201.1.2.0/24  IBGP    255  0           RD  10.2.2.2        GigabitEthernet0/0/1
      201.1.3.0/24  IBGP    255  0           RD  10.2.2.2        GigabitEthernet0/0/1

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

- 查看路由器 ISP IP 路由表中 BGP 路由信息

```
[ISP]display ip routing-table protocol bgp
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : BGP
         Destinations : 1        Routes : 1

BGP routing table status : <Active>
         Destinations : 1        Routes : 1

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      201.1.0.0/22  EBGP    255  0           D   201.1.4.1       GigabitEthernet0/0/0

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

3.6.10 测试连通性

- 从 R2 LoopBack0 为源地址测试到达 ISP LoopBack0 的网络连通性

```
<R2>ping -a 201.1.0.1 4.4.4.4
  PING 4.4.4.4: 56  data bytes, press CTRL_C to break
    Reply from 4.4.4.4: bytes=56 Sequence=1 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=2 ttl=254 time=20 ms
    Reply from 4.4.4.4: bytes=56 Sequence=3 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=4 ttl=254 time=20 ms
    Reply from 4.4.4.4: bytes=56 Sequence=5 ttl=254 time=20 ms

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

- 从 R2 LoopBack1 为源地址测试到达 ISP LoopBack0 的网络连通性

```
<R2>ping -a 201.1.1.1 4.4.4.4
  PING 4.4.4.4: 56  data bytes, press CTRL_C to break
    Reply from 4.4.4.4: bytes=56 Sequence=1 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=2 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=3 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=4 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=5 ttl=254 time=10 ms

  --- 4.4.4.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 10/26/30 ms
```

- 从 R2 LoopBack2 为源地址测试到达 ISP LoopBack0 的网络连通性

```
<R2>ping -a 201.1.2.1 4.4.4.4
  PING 4.4.4.4: 56  data bytes, press CTRL_C to break
    Reply from 4.4.4.4: bytes=56 Sequence=1 ttl=254 time=20 ms
    Reply from 4.4.4.4: bytes=56 Sequence=2 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=3 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=4 ttl=254 time=20 ms
    Reply from 4.4.4.4: bytes=56 Sequence=5 ttl=254 time=20 ms

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

- 从 R2 LoopBack3 为源地址测试到达 ISP LoopBack0 的网络连通性

```
<R2>ping -a 201.1.3.1 4.4.4.4
  PING 4.4.4.4: 56  data bytes, press CTRL_C to break
    Reply from 4.4.4.4: bytes=56 Sequence=1 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=2 ttl=254 time=40 ms
    Reply from 4.4.4.4: bytes=56 Sequence=3 ttl=254 time=20 ms
    Reply from 4.4.4.4: bytes=56 Sequence=4 ttl=254 time=30 ms
    Reply from 4.4.4.4: bytes=56 Sequence=5 ttl=254 time=20 ms
```

```
--- 4.4.4.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 20/28/40 ms
```