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  - http://support.huawei.com/learning/NavigationAction!createNavi?navId=_31&lang=en
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HCIP-Routing & Switching-IENP

Improving Enterprise Network Performance

Lab Guide

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Huawei Certification

Improving Enterprise Network Performance

Lab Guide

Edition 2.5

Huawei Certification System

Relying on its strong technical and professional training and certification system and in accordance with customers of different ICT technology levels, Huawei certification is committed to providing customers with authentic, professional certification, and addresses the need for the development of quality engineers that are capable of supporting Enterprise networks in the face of an eer changing ICT industry. The Huawei certification portfolio for routing and switching (R&S) is comprised of three levels to support and validate the growth and value of customer skills and knowledge in routing and switching technologies.

The Huawei Certified Network Associate (HCIA) certification level validates the skills and knowledge of IP network engineers to implement and support small to medium-sized enterprise networks. The HCIA certification provides a rich foundation of skills and knowledge for the establishment of such enterprise networks, along with the capability to implement services and features within existing enterprise networks, to effectively support true industry operations.

HCIA certification covers fundamentals skills for TCP/IP, routing, switching and related IP network technologies, together with Huawei data communications products, and skills for versatile routing platform (VRP) operation and management.

The Huawei Certified Network Professional (HCIP-R&S) certification is aimed at enterprise network engineers involved in design and maintenance, as well as professionals who wish to develop an in depth knowledge of routing, switching, network efficiency and optimization technologies. HCIP-R&S consists of three units including Implementing Enterprise Routing and Switching Network (IERS), Improving Enterprise Network Performance (IENP), and Implementing Enterprise Network Engineering Project (IEEP), which includes advanced IPv4 routing and switching technology principles, network security, high availability and QoS, as well as application of the covered technologies in Huawei products.

The Huawei Certified Internet Expert (HCIE-R&S) certification is designed to imbue engineers with a variety of IP network technologies and proficiency in maintenance, for the diagnosis and troubleshooting of Huawei products, to equip engineers with in-depth competency in the planning, design and optimization of large-scale IP networks.

About This Document

Overview

This document is HCIP-Improving Enterprise Network Performance (HCIP-IENP) certification training material. It is intended for those who are preparing for the HCIP-IENP exam and those who want to improve enterprise network performance and Huawei Versatile Routing Platform (VRP) implementation.

Chapter 1 introduces principles and configurations of MPLS and MPLS VPN, and helps readers master methods to improve enterprise network service bearer capabilities.

Chapters 2, 3, 4, 5, and 6 illustrate principles and configurations of DHCP, QoS, network security basics, VRRP, and BFD, and help readers to comprehensively master corresponding theories and practices to improve enterprise network service quality and enhance enterprise network security and reliability.

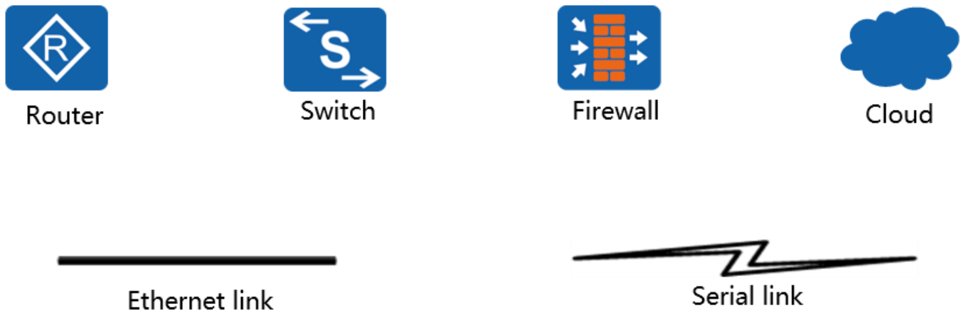
This course helps readers gradually understand routing technologies and how these technologies are implemented on Huawei products.

Background Knowledge Required

To fully understand this document, readers should:

- Have participated in HCIA training.
- Have passed HCIA exams.
- Familiarize with the TCP/IP protocol stack and IP addressing.

Icons



CONTENTS

Chapter 1 MPLS VPN Configuration

Lab 1-1 MPLS LDP Configuration

Learning Objectives

The objectives of this lab are to learn and understand:

- How to enable and disable MPLS
- How to enable and disable MPLS LDP
- How to configure LSPs using MPLS LDP
- How to configure the LDP LSP trigger policy on an MPLS router

Topology

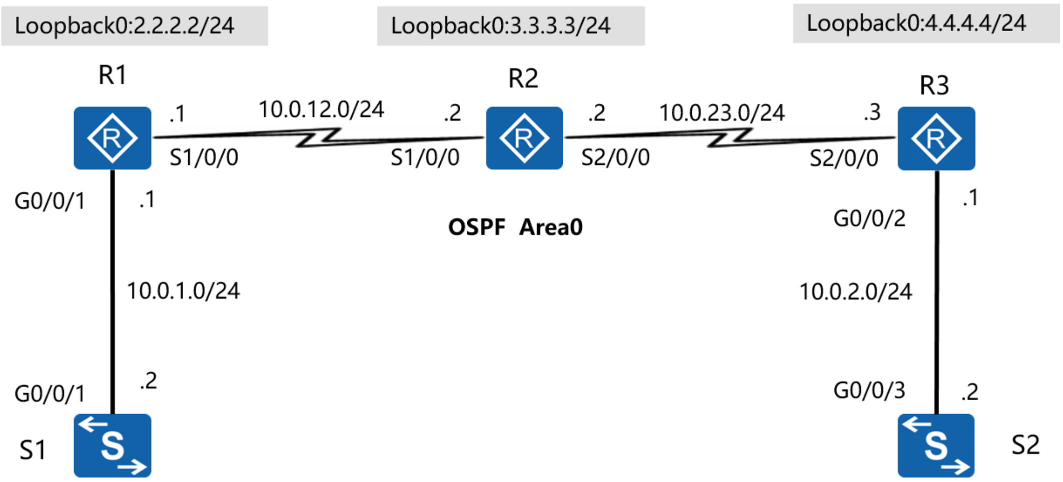


Figure 1-1 MPLS LDP topology

Scenario

Assume that you are a network administrator of an enterprise. Your enterprise uses an IP network with poor forwarding performance. You need to use MPLS to improve the forwarding rate of routers. Static LSPs are configured manually, while LDP is a protocol developed for label distribution. To perform flexible configuration, use LDP to set up MPLS LSPs.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses and masks for all routers.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname S1
[S1]interface Vlanif 1
[S1-Vlanif1]ip address 10.0.1.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.1.1 24
[R1-GigabitEthernet0/0/1]quit
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]quit
[R1]interface loopback 0
[R1-LoopBack0]ip address 2.2.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]quit
[R2]interface Serial 2/0/0
```

```
[R2-Serial2/0/0]ip address 10.0.23.2 24

[R2-Serial2/0/0]quit

[R2]interface loopback 0

[R2-LoopBack0]ip address 3.3.3.3 24
```

```
<Huawei>system-view

Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R3

[R3]interface GigabitEthernet 0/0/2

[R3-GigabitEthernet0/0/2]ip address 10.0.2.1 24

[R3-GigabitEthernet0/0/2]quit

[R3]interface Serial 2/0/0

[R3-Serial2/0/0]ip address 10.0.23.3 24

[R3-Serial2/0/0]quit

[R3]interface loopback 0

[R3-LoopBack0]ip address 4.4.4.4 24
```

```
<Huawei>system-view

Enter system view, return user view with Ctrl+Z.

[Huawei]sysname S2

[S2]interface Vlanif 1

[S2-Vlanif1]ip address 10.0.2.2 24
```

After the configurations are complete, test the connectivity of direct links.

Step 2 **Configure a single OSPF area.**

Add 10.0.12.0/24, 10.0.23.0/24, 10.0.1.0/24, and 10.0.2.0/24 to OSPF area 0.

```
[S1]ospf 1 router-id 1.1.1.1

[S1-ospf-1]area 0

[S1-ospf-1-area-0.0.0.0]network 10.0.1.0 0.0.0.255
```

```
[R1]ospf 1 router-id 2.2.2.2
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.1.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 2.2.2.0 0.0.0.255

[R2]ospf 1 router-id 3.3.3.3
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 10.0.23.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 3.3.3.0 0.0.0.255

[R3]ospf 1 router-id 4.4.4.4
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.0.23.0 0.0.0.255
[R3-ospf-1-area-0.0.0.0]network 10.0.2.0 0.0.0.255
[R3-ospf-1-area-0.0.0.0]network 4.4.4.0 0.0.0.255

[S2]ospf 1 router-id 5.5.5.5
[S2-ospf-1]area 0
[S2-ospf-1-area-0.0.0.0]network 10.0.2.0 0.0.0.255
```

Check the routing table and test connectivity on the entire network.

```
[R2]ping 10.0.1.2
  PING 10.0.1.2: 56   data bytes, press CTRL_C to break
    Reply from 10.0.1.2: bytes=56 Sequence=1 ttl=253 time=36 ms
    Reply from 10.0.1.2: bytes=56 Sequence=2 ttl=253 time=31 ms
    Reply from 10.0.1.2: bytes=56 Sequence=3 ttl=253 time=31 ms
    Reply from 10.0.1.2: bytes=56 Sequence=4 ttl=253 time=31 ms
    Reply from 10.0.1.2: bytes=56 Sequence=5 ttl=253 time=31 ms

  --- 10.0.1.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 31/32/36 ms

[R2]ping 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=253 time=38 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=253 time=33 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=253 time=33 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=253 time=33 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=253 time=33 ms

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 33/34/38 ms
```

Run the **display ip routing-table** command to check the OSPF routing table.

```
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
```

```
Routing Tables: Public
         Destinations : 19        Routes : 19

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        2.2.2.2/32  OSPF    10   1562        D   10.0.12.1       Serial1/0/0
        3.3.3.0/24  Direct  0    0           D   3.3.3.3         LoopBack0
        3.3.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      3.3.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
        4.4.4.4/32  OSPF    10   1562        D   10.0.23.3       Serial2/0/0
       10.0.1.0/24  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
       10.0.2.0/24  OSPF    10   1563        D   10.0.23.3       Serial2/0/0
      10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
      10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
      10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.0/24  Direct  0    0           D   10.0.23.2       Serial2/0/0
      10.0.23.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.3/32  Direct  0    0           D   10.0.23.3       Serial2/0/0
    10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      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
```

Step 3 **Configure MPLS LDP.**

Configure MPLS and LDP globally on MPLS routers.

```
[R1]mpls lsr-id 2.2.2.2
```

```
[R1]mpls

Info: Mpls starting, please wait... OK!

[R1-mpls]mpls ldp


[R2]mpls lsr-id 3.3.3.3

[R2]mpls

Info: Mpls starting, please wait... OK!

[R2-mpls]mpls ldp


[R3]mpls lsr-id 4.4.4.4

[R3]mpls

Info: Mpls starting, please wait... OK!

[R3-mpls]mpls ldp
```

Configure MPLS and LDP on interfaces of MPLS routers.

```
[R1]interface Serial 1/0/0

[R1-Serial1/0/0]mpls

[R1-Serial1/0/0]mpls ldp


[R2]interface Serial 1/0/0

[R2-Serial1/0/0]mpls

[R2-Serial1/0/0]mpls ldp

[R2-Serial1/0/0]quit

[R2]interface Serial 2/0/0

[R2-Serial2/0/0]mpls

[R2-Serial2/0/0]mpls ldp


[R3]interface Serial 2/0/0

[R3-Serial2/0/0]mpls
```

```
[R3-Serial2/0/0]mpls ldp
```

After the configurations are complete, run the **display mpls ldp session** command on Routers. You can see that the status of local LDP sessions between R1 and R2 and between R1 and R3 are **Operational**.

```
[R1]display mpls ldp session
 LDP Session(s) in Public Network
 Codes: LAM(Label Advertisement Mode), SsnAge Unit(DDDD:HH:MM)
 A '*' before a session means the session is being deleted.
 ------------------------------------------------------------------------------
 PeerID              Status        LAM   SsnRole   SsnAge        KASent/Rcv
 ------------------------------------------------------------------------------
 3.3.3.3:0          Operational DU     Passive   0000:00:10   41/41
 ------------------------------------------------------------------------------ TOTAL: 1 session(s) Found.

[R2]display mpls ldp session
 LDP Session(s) in Public Network
 Codes: LAM(Label Advertisement Mode), SsnAge Unit(DDDD:HH:MM)
 A '*' before a session means the session is being deleted.
 ------------------------------------------------------------------------------
 PeerID              Status        LAM   SsnRole   SsnAge        KASent/Rcv
 ------------------------------------------------------------------------------
 2.2.2.2:0          Operational DU     Active     0000:00:11   46/46
 4.4.4.4:0          Operational DU     Passive   0000:00:10   43/43
 ------------------------------------------------------------------------------
 TOTAL: 2 session(s) Found.

[R3]display mpls ldp session
```

```
 LDP Session(s) in Public Network

 Codes: LAM(Label Advertisement Mode), SsnAge Unit(DDDD:HH:MM)

 A '*' before a session means the session is being deleted.

 ------------------------------------------------------------------------

 PeerID                 Status        LAM   SsnRole   SsnAge        KASent/Rcv

 ------------------------------------------------------------------------

 3.3.3.3:0             Operational DU     Active     0000:00:11    46/46

 ------------------------------------------------------------------------

 TOTAL: 1 session(s) Found.
```

Step 4 **Establish LDP LSPs.**

All LSRs are triggered to establish LDP LSPs based on the host route, which is the default trigger policy.

Run the **display mpls ldp lsp** command on LSRs. All host routes are triggered to establish LDP LSPs.

```
[R1]display mpls ldp lsp

  LDP LSP Information

 ------------------------------------------------------------------------

 DestAddress/Mask    In/OutLabel     UpstreamPeer     NextHop           OutInterface

 ------------------------------------------------------------------------

 2.2.2.2/32            3/NULL               3.3.3.3            127.0.0.1         InLoop0

*2.2.2.2/32            Liberal/1024                             DS/3.3.3.3

 3.3.3.3/32            NULL/3               -                  10.0.12.2         S1/0/0

 3.3.3.3/32            1024/3              3.3.3.3             10.0.12.2         S1/0/0

 4.4.4.4/32            NULL/1025           -                   10.0.12.2         S1/0/0

 4.4.4.4/32            1025/1025          3.3.3.3             10.0.12.2         S1/0/0

 ------------------------------------------------------------------------
 TOTAL: 5 Normal LSP(s) Found.
 TOTAL: 1 Liberal LSP(s) Found.
 TOTAL: 0 Frr LSP(s) Found.
 A '*' before an LSP means the LSP is not established
 A '*' before a Label means the USCB or DSCB is stale
 A '*' before a UpstreamPeer means the session is in GR state
 A '*' before a DS means the session is in GR state
 A '*' before a NextHop means the LSP is FRR LSP

[R2]display mpls ldp lsp
 LDP LSP Information
 -------------------------------------------------------------------------------
 DestAddress/Mask   In/OutLabel    UpstreamPeer    NextHop         OutInterface
 -------------------------------------------------------------------------------
 2.2.2.2/32         NULL/3          -                10.0.12.1       S1/0/0
 2.2.2.2/32         1024/3         2.2.2.2         10.0.12.1       S1/0/0
 2.2.2.2/32         1024/3         4.4.4.4         10.0.12.1       S1/0/0
*2.2.2.2/32         Liberal/1024                   DS/4.4.4.4
 3.3.3.3/32         3/NULL          2.2.2.2         127.0.0.1       InLoop0
 3.3.3.3/32         3/NULL          4.4.4.4         127.0.0.1       InLoop0
*3.3.3.3/32         Liberal/1024                   DS/2.2.2.2
*3.3.3.3/32         Liberal/1025                   DS/4.4.4.4
 4.4.4.4/32         NULL/3          -                10.0.23.3       S2/0/0
 4.4.4.4/32         1025/3         2.2.2.2         10.0.23.3       S2/0/0
 4.4.4.4/32         1025/3         4.4.4.4         10.0.23.3       S2/0/0
*4.4.4.4/32         Liberal/1025                   DS/2.2.2.2
 -------------------------------------------------------------------------------
 TOTAL: 8 Normal LSP(s) Found.
 TOTAL: 4 Liberal LSP(s) Found.
 TOTAL: 0 Frr LSP(s) Found.
 A '*' before an LSP means the LSP is not established
 A '*' before a Label means the USCB or DSCB is stale
 A '*' before a UpstreamPeer means the session is in GR state
 A '*' before a DS means the session is in GR state
 A '*' before a NextHop means the LSP is FRR LSP

[R3]display mpls ldp lsp
  LDP LSP Information
 -------------------------------------------------------------------------------
 DestAddress/Mask    In/OutLabel    UpstreamPeer    NextHop         OutInterface
 -------------------------------------------------------------------------------
 2.2.2.2/32          NULL/1024       -               10.0.23.2       S2/0/0
 2.2.2.2/32          1024/1024      3.3.3.3         10.0.23.2       S2/0/0
 3.3.3.3/32          NULL/3          -               10.0.23.2       S2/0/0
 3.3.3.3/32          1025/3         3.3.3.3         10.0.23.2       S2/0/0
 4.4.4.4/32          3/NULL         3.3.3.3         127.0.0.1       InLoop0
*4.4.4.4/32          Liberal/1025                   DS/3.3.3.3
 -------------------------------------------------------------------------------
 TOTAL: 5 Normal LSP(s) Found.
 TOTAL: 1 Liberal LSP(s) Found.
 TOTAL: 0 Frr LSP(s) Found.
 A '*' before an LSP means the LSP is not established
 A '*' before a Label means the USCB or DSCB is stale
 A '*' before a UpstreamPeer means the session is in GR state
 A '*' before a DS means the session is in GR state
 A '*' before a NextHop means the LSP is FRR LSP
```

In most cases, the default trigger policy is used. The establishment of an LDP LSP is triggered in Host mode.

Change the trigger policy to All on LSRs so that all static routes and IGP entries can trigger the establishment of the LDP LSPs.

```
[R1]mpls
[R1-mpls]lsp-trigger all


[R2]mpls
[R2-mpls]lsp-trigger all


[R3]mpls
[R3-mpls]lsp-trigger all
```

After the configuration is complete, run the **display mpls ldp lsp** command on each node to view the established LDP LSPs.

```
[R1]display mpls ldp lsp
 LDP LSP Information
 -------------------------------------------------------------------------------
 DestAddress/Mask   In/OutLabel    UpstreamPeer    NextHop         OutInterface
 -------------------------------------------------------------------------------
 2.2.2.0/24         3/NULL         3.3.3.3         2.2.2.2         Loop0
 2.2.2.2/32         3/NULL         3.3.3.3         127.0.0.1       InLoop0
*2.2.2.2/32         Liberal/1024                   DS/3.3.3.3
*3.3.3.0/24         Liberal/3                      DS/3.3.3.3
 3.3.3.3/32         NULL/3         -               10.0.12.2       S1/0/0
 3.3.3.3/32         1024/3         3.3.3.3         10.0.12.2       S1/0/0
 4.4.4.4/32         NULL/1025      -               10.0.12.2       S1/0/0
 4.4.4.4/32         1025/1025      3.3.3.3         10.0.12.2       S1/0/0
 10.0.1.0/24        3/NULL          3.3.3.3        10.0.1.1       GE0/0/1
*10.0.1.0/24        Liberal/1026                   DS/3.3.3.3
 10.0.2.0/24        NULL/1027        -             10.0.12.2      S1/0/0
 10.0.2.0/24        1027/1027       3.3.3.3        10.0.12.2      S1/0/0
 10.0.12.0/24       3/NULL          3.3.3.3        10.0.12.1      S1/0/0
*10.0.12.0/24       Liberal/3                      DS/3.3.3.3
 10.0.23.0/24       NULL/3           -             10.0.12.2      S1/0/0
 10.0.23.0/24       1026/3          3.3.3.3        10.0.12.2      S1/0/0
 -------------------------------------------------------------------------------
 TOTAL: 12 Normal LSP(s) Found.
 TOTAL: 4 Liberal LSP(s) Found.
 TOTAL: 0 Frr LSP(s) Found.
 A '*' before an LSP means the LSP is not established
 A '*' before a Label means the USCB or DSCB is stale
 A '*' before a UpstreamPeer means the session is in GR state
 A '*' before a DS means the session is in GR state
 A '*' before a NextHop means the LSP is FRR LSP

[R2]display mpls ldp lsp
  LDP LSP Information
 -------------------------------------------------------------------------------
 DestAddress/Mask   In/OutLabel    UpstreamPeer    NextHop        OutInterface
 -------------------------------------------------------------------------------
*2.2.2.0/24         Liberal/3                      DS/2.2.2.2
 2.2.2.2/32         NULL/3           -             10.0.12.1      S1/0/0
 2.2.2.2/32         1024/3          2.2.2.2        10.0.12.1      S1/0/0
 2.2.2.2/32         1024/3          4.4.4.4        10.0.12.1      S1/0/0
*2.2.2.2/32         Liberal/1024                   DS/4.4.4.4
 3.3.3.0/24         3/NULL          2.2.2.2        3.3.3.3        Loop0
 3.3.3.0/24        3/NULL         4.4.4.4        3.3.3.3          Loop0
 3.3.3.3/32        3/NULL         2.2.2.2        127.0.0.1        InLoop0
 3.3.3.3/32        3/NULL         4.4.4.4        127.0.0.1        InLoop0
*3.3.3.3/32        Liberal/1024                  DS/2.2.2.2
*3.3.3.3/32        Liberal/1025                  DS/4.4.4.4
*4.4.4.0/24        Liberal/3                     DS/4.4.4.4
 4.4.4.4/32        NULL/3         -              10.0.23.3        S2/0/0
 4.4.4.4/32        1025/3         2.2.2.2        10.0.23.3        S2/0/0
 4.4.4.4/32        1025/3         4.4.4.4        10.0.23.3        S2/0/0
*4.4.4.4/32        Liberal/1025                  DS/2.2.2.2
 10.0.1.0/24       NULL/3         -              10.0.12.1        S1/0/0
 10.0.1.0/24       1026/3         2.2.2.2        10.0.12.1        S1/0/0
 10.0.1.0/24       1026/3         4.4.4.4        10.0.12.1        S1/0/0
*10.0.1.0/24       Liberal/1026                  DS/4.4.4.4
 10.0.2.0/24       NULL/3         -              10.0.23.3        S2/0/0
 10.0.2.0/24       1027/3         2.2.2.2        10.0.23.3        S2/0/0
 10.0.2.0/24       1027/3         4.4.4.4        10.0.23.3        S2/0/0
*10.0.2.0/24       Liberal/1027                  DS/2.2.2.2
 10.0.12.0/24      3/NULL         2.2.2.2        10.0.12.2        S1/0/0
 10.0.12.0/24      3/NULL         4.4.4.4        10.0.12.2        S1/0/0
*10.0.12.0/24      Liberal/3                     DS/2.2.2.2
*10.0.12.0/24      Liberal/1027                  DS/4.4.4.4
 10.0.23.0/24      3/NULL         2.2.2.2        10.0.23.2        S2/0/0
 10.0.23.0/24      3/NULL         4.4.4.4        10.0.23.2        S2/0/0
*10.0.23.0/24      Liberal/1026                  DS/2.2.2.2
*10.0.23.0/24      Liberal/3                     DS/4.4.4.4
 -------------------------------------------------------------------------------
 TOTAL: 20 Normal LSP(s) Found.
 TOTAL: 12 Liberal LSP(s) Found.
 TOTAL: 0 Frr LSP(s) Found.
 A '*' before an LSP means the LSP is not established
 A '*' before a Label means the USCB or DSCB is stale
 A '*' before a UpstreamPeer means the session is in GR state
 A '*' before a DS means the session is in GR state
 A '*' before a NextHop means the LSP is FRR LSP

[R3]display mpls ldp lsp
  LDP LSP Information
 -------------------------------------------------------------------------------
 DestAddress/Mask    In/OutLabel    UpstreamPeer    NextHop        OutInterface
 -------------------------------------------------------------------------------
 2.2.2.2/32          NULL/1024       -               10.0.23.2      S2/0/0
 2.2.2.2/32          1024/1024      3.3.3.3         10.0.23.2      S2/0/0
*3.3.3.0/24          Liberal/3                      DS/3.3.3.3
 3.3.3.3/32          NULL/3         -               10.0.23.2      S2/0/0
 3.3.3.3/32          1025/3         3.3.3.3         10.0.23.2      S2/0/0
 4.4.4.0/24          3/NULL         3.3.3.3         4.4.4.4        Loop0
 4.4.4.4/32          3/NULL         3.3.3.3         127.0.0.1      InLoop0
*4.4.4.4/32          Liberal/1025                   DS/3.3.3.3
 10.0.1.0/24         NULL/1026       -               10.0.23.2      S2/0/0
 10.0.1.0/24         1026/1026      3.3.3.3         10.0.23.2      S2/0/0
 10.0.2.0/24         3/NULL         3.3.3.3         10.0.2.1       GE0/0/2
*10.0.2.0/24         Liberal/1027                   DS/3.3.3.3
 10.0.12.0/24        NULL/3          -               10.0.23.2      S2/0/0
 10.0.12.0/24        1027/3         3.3.3.3         10.0.23.2      S2/0/0
 10.0.23.0/24        3/NULL         3.3.3.3         10.0.23.3      S2/0/0
*10.0.23.0/24        Liberal/3                      DS/3.3.3.3
 -------------------------------------------------------------------------------
```

```
TOTAL: 12 Normal LSP(s) Found.

TOTAL: 4 Liberal LSP(s) Found.

TOTAL: 0 Frr LSP(s) Found.

A '*' before an LSP means the LSP is not established

A '*' before a Label means the USCB or DSCB is stale

A '*' before a UpstreamPeer means the session is in GR state

A '*' before a DS means the session is in GR state

A '*' before a NextHop means the LSP is FRR LSP
```

Step 5 **Configure the LDP inbound policy.**

If labels received on R1 are not controlled, R1 will establish a large number of LSPs, consuming large memory.

After an inbound LDP policy is configured, R1 receives label mapping messages only from R2 and establishes LSPs to R2, saving resources.

Run the **display mpls lsp** command on R1. Information about established LSPs is displayed.

```
[R1]display mpls lsp

-------------------------------------------------------------------------------

                    LSP Information: LDP LSP

-------------------------------------------------------------------------------

FEC                 In/Out Label   In/Out IF                        Vrf Name

3.3.3.3/32          NULL/3          -/S1/0/0

3.3.3.3/32          1024/3         -/S1/0/0

2.2.2.2/32          3/NULL          -/-

4.4.4.4/32          NULL/1025       -/S1/0/0

4.4.4.4/32          1025/1025      -/S1/0/0

10.0.12.0/24         3/NULL          -/-

10.0.1.0/24         3/NULL          -/-

2.2.2.0/24          3/NULL          -/-

10.0.23.0/24         NULL/3          -/S1/0/0
```

```
10.0.23.0/24          1026/3           -/S1/0/0
10.0.2.0/24          NULL/1027        -/S1/0/0
10.0.2.0/24          1027/1027        -/S1/0/0
```

You can see that LSPs to R2 and R3 are established on R1. Configure the inbound policy on R1 to allow only the routes to R2.

```
[R1]ip ip-prefix prefix1 permit 10.0.12.0 24
[R1]mpls ldp
[R1-mpls-ldp]inbound peer 3.3.3.3 fec ip-prefix prefix1
[R1-mpls-ldp]quit
[R1]display mpls lsp
-------------------------------------------------------------------------------
                   LSP Information: LDP LSP
-------------------------------------------------------------------------------
FEC                  In/Out Label   In/Out IF                        Vrf Name
2.2.2.2/32           3/NULL          -/-
10.0.12.0/24          3/NULL          -/-
10.0.1.0/24          3/NULL          -/-
2.2.2.0/24           3/NULL          -/-
```

----End

Additional Exercise: Analysis and Verification

How can you configure R1 to receive Label Mapping messages from R1 to R3?

Device Configuration

```
<S1>display current-configuration
!Software Version V200R008C00SPC500
#
```

```
sysname S1
#
interface Vlanif1
 ip address 10.0.1.2 255.255.255.0
#
ospf 1 router-id 1.1.1.1
 area 0.0.0.0
  network 10.0.1.0 0.0.0.255
#
return

<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
mpls lsr-id 2.2.2.2
 mpls
  lsp-trigger all
#
mpls ldp
 inbound peer 3.3.3.3 fec ip-prefix prefix1
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.1 255.255.255.0
 mpls
 mpls ldp
#
```

```
interface GigabitEthernet0/0/1
 ip address 10.0.1.1 255.255.255.0
#
interface LoopBack0
 ip address 2.2.2.2 255.255.255.0
#
ospf 1 router-id 2.2.2.2
 area 0.0.0.0
  network 10.0.1.0 0.0.0.255
  network 10.0.12.0 0.0.0.255
  network 2.2.2.0 0.0.0.255
#
 ip ip-prefix prefix1 index 10 permit 10.0.12.0 24
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
mpls lsr-id 3.3.3.3
 mpls
  lsp-trigger all
#
mpls ldp
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.2 255.255.255.0

 mpls

 mpls ldp

#

interface Serial2/0/0

 link-protocol ppp

 ip address 10.0.23.2 255.255.255.0

 mpls

 mpls ldp

#

interface LoopBack0

 ip address 3.3.3.3 255.255.255.0

#

ospf 1 router-id 3.3.3.3

 area 0.0.0.0

  network 10.0.12.0 0.0.0.255

  network 10.0.23.0 0.0.0.255

  network 3.3.3.0 0.0.0.255

#

return


<R3>display current-configuration

[V200R007C00SPC600]

#

 sysname R3

#

mpls lsr-id 4.4.4.4

 mpls

  lsp-trigger all
```

```
#
mpls ldp
#
interface Serial2/0/0
 link-protocol ppp
 ip address 10.0.23.3 255.255.255.0
 mpls
 mpls ldp
#
interface GigabitEthernet0/0/2
 ip address 10.0.2.1 255.255.255.0
#
interface LoopBack0
 ip address 4.4.4.4 255.255.255.0
#
ospf 1 router-id 4.4.4.4
 area 0.0.0.0
  network 10.0.2.0 0.0.0.255
  network 10.0.23.0 0.0.0.255
  network 4.4.4.0 0.0.0.255
#
return

<S2>display current-configuration
!Software Version V200R008C00SPC500
#
sysname S2
#
interface Vlanif1
```

```
 ip address 10.0.2.2 255.255.255.0
#
ospf 1 router-id 5.5.5.5
 area 0.0.0.0
  network 10.0.2.0 0.0.0.255
#
return
```

Lab 1-2 MPLS VPN Configuration

Learning Objectives

The objectives of this lab are to learn and understand:

- How to configure MPLS VPN instances
- How to configure MP-BGP
- How to configure MPLS LDP
- MPLS VPN route transmission and data forwarding processes

Topology

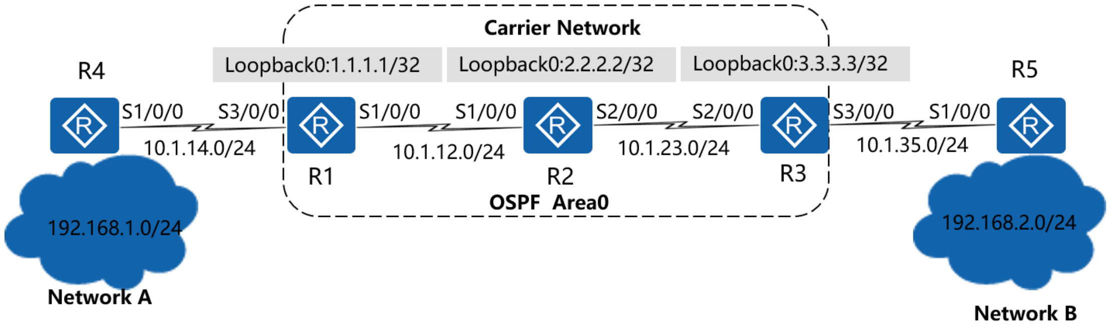


Figure 1-2 MPLS VPN topology

Scenario

An enterprise has networks A and B. Employees on the two networks are required to communicate through VPN routes. The edge device needs to use the Border

Gateway Protocol (BGP) to advertise VPN routes to the carrier network. The carrier uses MP-BGP to transmit VPN routes on the public network, and ensures security and privacy of customer network information through MPLS VPN.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses and masks for all routers.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.1.12.1 24
[R1-Serial1/0/0]quit
[R1]interface Serial 3/0/0
[R1-Serial3/0/0]ip address 10.1.14.1 24
[R1-Serial3/0/0]quit
[R1]interface LoopBack 0
[R1-LoopBack0]ip address 1.1.1.1 32
```

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]ip address 10.1.12.2 24
[R2-Serial1/0/0]quit
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]ip address 10.1.23.2 24
[R1-Serial2/0/0]quit
[R2]interface LoopBack 0
```

```
[R2-LoopBack0]ip address 2.2.2.2 32

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ip address 10.1.23.3 24
[R3-Serial2/0/0]quit
[R3]interface Serial 3/0/0
[R3-Serial3/0/0]ip address 10.1.35.3 24
[R3-Serial3/0/0]quit
[R3]interface LoopBack 0
[R3-LoopBack0]ip address 3.3.3.3 32

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R4
[R4]interface Serial 1/0/0
[R4-Serial1/0/0]ip address 10.1.14.4 24
[R4-Serial1/0/0]quit
[R4]interface LoopBack 0
[R4-LoopBack0]ip address 192.168.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R5
[R5]interface Serial 1/0/0
[R5-Serial1/0/0]ip address 10.1.35.5 24
[R5-Serial1/0/0]quit
```

```
[R5]interface LoopBack 0

[R5-LoopBack0]ip address 192.168.2.1 24
```

Test link connectivity after the configurations are complete.

Step 2 **Configure a single OSPF area on the carrier network.**

Add 10.1.12.0/24, 10.1.23.0/24, and addresses of Loopback0 interfaces on the carrier network to OSPF area 0.

```
[R1]router id 1.1.1.1

[R1]ospf 1

[R1-ospf-1]area 0

[R1-ospf-1-area-0.0.0.0]network 10.1.12.0 0.0.0.255

[R1-ospf-1-area-0.0.0.0]network 1.1.1.1 0.0.0.0


[R2]router id 2.2.2.2

[R2]ospf 1

[R2-ospf-1]area 0

[R2-ospf-1-area-0.0.0.0]network 10.1.12.0 0.0.0.255

[R2-ospf-1-area-0.0.0.0]network 10.1.23.0 0.0.0.255

[R2-ospf-1-area-0.0.0.0]network 2.2.2.2 0.0.0.0


[R3]router id 3.3.3.3

[R3]ospf 1

[R3-ospf-1]area 0

[R3-ospf-1-area-0.0.0.0]network 10.1.23.0 0.0.0.255

[R3-ospf-1-area-0.0.0.0]network 3.3.3.3 0.0.0.0
```

Check the OSPF neighbor relationship on R1, R2, and R3 after the configurations are complete.

```
[R1]display ospf peer brief

         OSPF Process 1 with Router ID 1.1.1.1
                  Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id           Interface                          Neighbor id      State
 0.0.0.0           Serial1/0/0                        2.2.2.2          Full
 ----------------------------------------------------------------------------
 Total Peer(s):       1

[R2]display ospf peer brief

         OSPF Process 1 with Router ID 2.2.2.2
                  Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id           Interface                          Neighbor id      State
 0.0.0.0           Serial1/0/0                        1.1.1.1          Full
 0.0.0.0           Serial2/0/0                        3.3.3.3          Full
 ----------------------------------------------------------------------------
 Total Peer(s):       2

[R3]display ospf peer brief

         OSPF Process 1 with Router ID 3.3.3.3
                  Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id           Interface                          Neighbor id      State
 0.0.0.0           Serial2/0/0                        2.2.2.2          Full
 ----------------------------------------------------------------------------
```

```
Total Peer(s):        1
```

Step 3 **Configure VPN instances on edge devices of the carrier network.**

Configure VPN instances for network A and network B on R1 and R3 respectively. Set the VPN instance to **VPN1**, router distinguisher (RD) to 1:1, and route target to 1:2 for network A. Set the VPN instance to **VPN2**, RD to 2:2, and route target to 1:2 for network B.

```
[R1]ip vpn-instance VPN1
[R1-vpn-instance-VPN1]route-distinguisher 1:1
[R1-vpn-instance-VPN1-af-ipv4]vpn-target 1:2 both
[R1-vpn-instance-VPN1-af-ipv4]quit
[R1-vpn-instance-VPN1]quit
[R1]interface Serial 3/0/0
[R1-Serial3/0/0]ip binding vpn-instance VPN1
Info: All IPv4 related configurations on this interface are removed!
Info: All IPv6 related configurations on this interface are removed!
[R1-Serial3/0/0] ip address 10.1.14.1 24

[R3]ip vpn-instance VPN2
[R3-vpn-instance-VPN2]route-distinguisher 2:2
[R3-vpn-instance-VPN2-af-ipv4]vpn-target 1:2 both
[R3-vpn-instance-VPN2-af-ipv4]quit
[R3-vpn-instance-VPN2]quit
[R3]interface Serial 3/0/0
[R3-Serial3/0/0]ip binding vpn-instance VPN2
Info: All IPv4 related configurations on this interface are removed!
Info: All IPv6 related configurations on this interface are removed!
```

```
[R3-Serial3/0/0]ip address 10.1.35.3 24
```

Check VPN instances on R1 and R3 after the configurations are complete.

```
[R1]display ip vpn-instance verbose
 Total VPN-Instances configured        : 1
 Total IPv4 VPN-Instances configured : 1
 Total IPv6 VPN-Instances configured : 0

 VPN-Instance Name and ID : VPN1, 1
  Interfaces : Serial3/0/0
 Address family ipv4
  Create date : 2016/09/20 14:51:08
  Up time : 0 days, 00 hours, 09 minutes and 34 seconds
  Route Distinguisher : 1:1
  Export VPN Targets :   1:2
  Import VPN Targets :   1:2
  Label Policy : label per route
  Log Interval : 5

[R3]display ip vpn-instance verbose
 Total VPN-Instances configured        : 1
 Total IPv4 VPN-Instances configured : 1
 Total IPv6 VPN-Instances configured : 0

 VPN-Instance Name and ID : VPN2, 1
  Interfaces : Serial3/0/0
 Address family ipv4
  Create date : 2016/09/20 15:02:52
  Up time : 0 days, 00 hours, 05 minutes and 32 seconds

  Route Distinguisher : 2:2

  Export VPN Targets :   1:2

  Import VPN Targets :   1:2

  Label Policy : label per route

  Log Interval : 5
```

Step 4 **Configure BGP to transmit routes on edge devices of the customer networks(CE) and carrier network(PE).**

Set AS numbers of network A, carrier network, and network B to 14, 123, and 35 respectively. Establish BGP neighbor relationships between CE and PE to advertise customer VPN routes to PE using BGP.

```
[R1]bgp 123

[R1-bgp]ipv4-family vpn-instance VPN1

[R1-bgp-VPN1]peer 10.1.14.4 as-number 14


[R3]bgp 123

[R3-bgp]ipv4-family vpn-instance VPN2

[R3-bgp-VPN2]peer 10.1.35.5 as-number 35


[R4]bgp 14

[R4-bgp]peer 10.1.14.1 as-number 123

[R4-bgp]network 192.168.1.0 24


[R5]bgp 35

[R5-bgp]peer 10.1.35.3 as-number 123

[R5-bgp]network 192.168.2.0 24
```

Check the OSPF neighbor relationship between R1 and R4 and between R3 and R5 after the configurations are complete.

```
[R1]display bgp vpnv4 vpn-instance VPN1 peer

 BGP local router ID : 1.1.1.1

 Local AS number : 123

 VPN-Instance VPN1, Router ID 1.1.1.1:

 Total number of peers : 1                 Peers in established state : 1


  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv


  10.1.14.4       4          14        7        8     0 00:05:21 Established       0


[R4]display bgp peer

 BGP local router ID : 10.1.14.4

 Local AS number : 14

 Total number of peers : 1                 Peers in established state : 1


  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv


  10.1.14.1       4         123        4        6     0 00:02:56 Established       0


[R3]display bgp vpnv4 vpn-instance VPN2 peer

 BGP local router ID : 3.3.3.3

 Local AS number : 123

 VPN-Instance VPN2, Router ID 3.3.3.3:

 Total number of peers : 1                 Peers in established state : 1


  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv
  10.1.35.5         4           35          7          8      0 00:05:16 Established         0


[R5]display bgp peer

 BGP local router ID : 192.168.1.1

 Local AS number : 35

 Total number of peers : 1                  Peers in established state : 1


  Peer              V            AS   MsgRcvd   MsgSent   OutQ   Up/Down         State PrefRcv


  10.1.35.3         4          123          8         10      0 00:06:04 Established         0
```

Check VPN routes learned from customer networks in VPN routing table on R1 and R3.

```
[R1]display ip routing-table vpn-instance VPN1

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Tables: VPN1

         Destinations : 6            Routes : 6


Destination/Mask      Proto     Pre   Cost        Flags NextHop            Interface


      10.1.14.0/24   Direct   0      0              D     10.1.14.1         Serial3/0/0

      10.1.14.1/32   Direct   0      0              D     127.0.0.1         Serial3/0/0

      10.1.14.4/32   Direct   0      0              D     10.1.14.4         Serial3/0/0

    10.1.14.255/32   Direct   0      0              D     127.0.0.1         Serial3/0/0

    192.168.1.0/24   EBGP    255   0              D     10.1.14.4         Serial3/0/0

255.255.255.255/32   Direct   0      0              D     127.0.0.1         InLoopBack0
```

```
[R3]display ip routing-table vpn-instance VPN2

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Tables: VPN2

         Destinations : 6          Routes : 6


Destination/Mask    Proto   Pre  Cost        Flags NextHop         Interface


      10.1.35.0/24   Direct   0     0           D     10.1.35.3        Serial3/0/0

      10.1.35.3/32   Direct   0     0           D     127.0.0.1        Serial3/0/0

      10.1.35.5/32   Direct   0     0           D     10.1.35.5        Serial3/0/0

    10.1.35.255/32   Direct   0     0           D     127.0.0.1        Serial3/0/0

    192.168.2.0/24   EBGP    255   0           D     10.1.35.5        Serial3/0/0

255.255.255.255/32   Direct   0     0           D     127.0.0.1        InLoopBack0
```

Step 5 **Configure devices on the carrier network to transmit customer VPN routes using MP-BGP.**

Establish the IBGP neighbor relationship between R1 and R3, and transmit customer VPN routes to the remote PE using MP-BGP.

```
[R1]bgp 123

[R1-bgp]peer 3.3.3.3 as-number 123

[R1-bgp]peer 3.3.3.3 connect-interface LoopBack 0

[R1-bgp]ipv4-family vpnv4 unicast

[R1-bgp-af-vpnv4]peer 3.3.3.3 enable


[R3]bgp 123

[R3-bgp]peer 1.1.1.1 as-number 123

[R3-bgp]peer 1.1.1.1 connect-interface LoopBack 0
```

```
[R3-bgp]ipv4-family vpnv4 unicast

[R3-bgp-af-vpnv4]peer 1.1.1.1 enable
```

Check the MP-BGP neighbor relationship on R1 and R3 after the configurations are complete.

```
[R1]display bgp vpnv4 all peer

 BGP local router ID : 1.1.1.1

 Local AS number : 123

 Total number of peers : 2                 Peers in established state : 2


  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv


  3.3.3.3         4         123        4        7     0 00:02:10 Established       0


[R3]display bgp vpnv4 all peer

 BGP local router ID : 3.3.3.3

 Local AS number : 123

 Total number of peers : 2                 Peers in established state : 2


  Peer            V          AS  MsgRcvd  MsgSent  OutQ  Up/Down       State PrefRcv


  1.1.1.1              4          123        5        6     0 00:03:22 Established       0
```

Step 6 **Configure devices on the carrier network to forward customer VPN data using MPLS LDP.**

Enable MPLS LDP on each device of the carrier network, and use labels to forward customer VPN data to isolate customer data from other network data.

```
[R1]mpls lsr-id 1.1.1.1
[R1]mpls
[R1-mpls]mpls ldp
[R1-mpls-ldp]quit
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]mpls
[R1-Serial1/0/0]mpls ldp

[R2]mpls lsr-id 2.2.2.2
[R2]mpls
[R2-mpls]mpls ldp
[R2-mpls-ldp]quit
[R2]interface s1/0/0
[R2-Serial1/0/0]mpls
[R2-Serial1/0/0]mpls ldp
[R2-Serial1/0/0]quit
[R2]interface s2/0/0
[R2-Serial2/0/0]mpls
[R2-Serial2/0/0]mpls ldp

[R3]mpls lsr-id 3.3.3.3
[R3]mpls
[R3-mpls]mpls ldp
[R3-mpls-ldp]quit
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]mpls
[R3-Serial2/0/0]mpls ldp
```

Check the MPLS LDP neighbor relationship on R1, R2, and R3 after the configurations are complete.

```
[R1]display mpls ldp peer

 LDP Peer Information in Public network

 A '*' before a peer means the peer is being deleted.

 -------------------------------------------------------------------------

 PeerID                  TransportAddress    DiscoverySource

 -------------------------------------------------------------------------

 2.2.2.2:0               2.2.2.2             Serial1/0/0

 -------------------------------------------------------------------------

 TOTAL: 1 Peer(s) Found.


[R2]display mpls ldp peer

 LDP Peer Information in Public network

 A '*' before a peer means the peer is being deleted.

 -------------------------------------------------------------------------

 PeerID                  TransportAddress    DiscoverySource

 -------------------------------------------------------------------------

 1.1.1.1:0               1.1.1.1             Serial1/0/0

 3.3.3.3:0               3.3.3.3             Serial2/0/0

 -------------------------------------------------------------------------

 TOTAL: 2 Peer(s) Found.


[R3]display mpls ldp peer

 LDP Peer Information in Public network

 A '*' before a peer means the peer is being deleted.

 -------------------------------------------------------------------------

 PeerID                  TransportAddress    DiscoverySource

 -------------------------------------------------------------------------
 2.2.2.2:0                   2.2.2.2              Serial2/0/0
 ------------------------------------------------------------------------------
 TOTAL: 1 Peer(s) Found.
```

Step 7 **Test the connectivity between network A and network B on CEs.**

Use Loopback0 to simulate the user network on R4 and R5 respectively, and run the **ping** command to test connectivity between network A and network B.

```
<R4>ping -a 192.168.1.1 192.168.2.1
  PING 192.168.2.1: 56  data bytes, press CTRL_C to break
    Reply from 192.168.2.1: bytes=56 Sequence=1 ttl=252 time=106 ms
    Reply from 192.168.2.1: bytes=56 Sequence=2 ttl=252 time=107 ms
    Reply from 192.168.2.1: bytes=56 Sequence=3 ttl=252 time=106 ms
    Reply from 192.168.2.1: bytes=56 Sequence=4 ttl=252 time=105 ms
    Reply from 192.168.2.1: bytes=56 Sequence=5 ttl=252 time=106 ms

  --- 192.168.2.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 105/106/107 ms

<R5>ping -a 192.168.2.1 192.168.1.1
  PING 192.168.1.1: 56  data bytes, press CTRL_C to break
    Reply from 192.168.1.1: bytes=56 Sequence=1 ttl=252 time=107 ms
    Reply from 192.168.1.1: bytes=56 Sequence=2 ttl=252 time=105 ms
    Reply from 192.168.1.1: bytes=56 Sequence=3 ttl=252 time=106 ms
    Reply from 192.168.1.1: bytes=56 Sequence=4 ttl=252 time=106 ms
    Reply from 192.168.1.1: bytes=56 Sequence=5 ttl=252 time=106 ms


  --- 192.168.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 105/106/107 ms
```

Check routes learned from remote networks on R4 and R5.

```
<R4>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------Routing Tables: Public
         Destinations : 12        Routes : 12
Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface
      10.1.14.0/24  Direct  0    0           D   10.1.14.4       Serial1/0/0
      10.1.14.1/32  Direct  0    0           D   10.1.14.1       Serial1/0/0
      10.1.14.4/32  Direct  0    0           D   127.0.0.1       Serial1/0/0
    10.1.14.255/32  Direct  0    0           D   127.0.0.1       Serial1/0/0
      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
    192.168.1.0/24  Direct  0    0           D   192.168.1.1     LoopBack0
    192.168.1.1/32  Direct  0    0           D   127.0.0.1       LoopBack0
  192.168.1.255/32  Direct  0    0           D   127.0.0.1       LoopBack0
    192.168.2.0/24  EBGP    255  0           D   10.1.14.1       Serial1/0/0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
<R5>display ip routing-table
Route Flags: R - relay, D - download to fib
```

```
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 12         Routes : 12
Destination/Mask     Proto    Pre   Cost        Flags NextHop           Interface
      10.1.35.0/24   Direct   0      0           D     10.1.35.5         Serial1/0/0
      10.1.35.3/32   Direct   0      0           D     10.1.35.3         Serial1/0/0
      10.1.35.5/32   Direct   0      0           D     127.0.0.1         Serial1/0/0
    10.1.35.255/32   Direct   0      0           D     127.0.0.1         Serial1/0/0
      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
    192.168.1.0/24   EBGP     255    0           D     10.1.35.3         Serial1/0/0
    192.168.2.0/24   Direct   0      0           D     192.168.2.1       LoopBack0
    192.168.2.1/32   Direct   0      0           D     127.0.0.1         LoopBack0
  192.168.2.255/32   Direct   0      0           D     127.0.0.1         LoopBack0
255.255.255.255/32   Direct   0      0           D     127.0.0.1         InLoopBack0
```

----End

Additional Exercise: Analysis and Verification

When another MPLS VPN is added on R1, how R1 is configured to enable communication between the two VPNs?

Device Configuration

<R1>display current-configuration

```
[V200R007C00SPC600]
#
 sysname R1
```

```
#
router id 1.1.1.1
#
ip vpn-instance VPN1
 ipv4-family
  route-distinguisher 1:1
  vpn-target 1:2 export-extcommunity
  vpn-target 1:2 import-extcommunity
#
mpls lsr-id 1.1.1.1
mpls
#
mpls ldp
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.1.12.1 255.255.255.0
 mpls
 mpls ldp
#
interface Serial3/0/0
 link-protocol ppp
 ip binding vpn-instance VPN1
 ip address 10.1.14.1 255.255.255.0
#
interface LoopBack0
 ip address 1.1.1.1 255.255.255.255
#
bgp 123
```

```
 peer 3.3.3.3 as-number 123
 peer 3.3.3.3 connect-interface LoopBack0
 #
 ipv4-family unicast
  undo synchronization
  peer 3.3.3.3 enable
 #
 ipv4-family vpnv4
  policy vpn-target
  peer 3.3.3.3 enable
 #
 ipv4-family vpn-instance VPN1
  peer 10.1.14.4 as-number 14
#
ospf 1
 area 0.0.0.0
  network 1.1.1.1 0.0.0.0
  network 10.1.12.0 0.0.0.255
#
return
```

<R2>display current-configuration

```
[V200R007C00SPC600]
#
 sysname R2
#
router id 2.2.2.2
#
```

```
mpls lsr-id 2.2.2.2
mpls
#
mpls ldp
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.1.12.2 255.255.255.0
 mpls
 mpls ldp
#
interface Serial2/0/0
 link-protocol ppp
 ip address 10.1.23.2 255.255.255.0
 mpls
 mpls ldp
#
interface LoopBack0
 ip address 2.2.2.2 255.255.255.255
#
ospf 1
 area 0.0.0.0
  network 2.2.2.2 0.0.0.0
  network 10.1.12.0 0.0.0.255
  network 10.1.23.0 0.0.0.255
#
return
```

```
<R3>display current-configuration
[V200R007C00SPC600]
#
 sysname R3
#
router id 3.3.3.3
#
ip vpn-instance VPN2
 ipv4-family
  route-distinguisher 2:2
  vpn-target 1:2 export-extcommunity
  vpn-target 1:2 import-extcommunity
#
mpls lsr-id 3.3.3.3
mpls
#
mpls ldp
#
interface Serial2/0/0
 link-protocol ppp
 ip address 10.1.23.3 255.255.255.0
 mpls
 mpls ldp
#
interface Serial3/0/0
 link-protocol ppp
 ip binding vpn-instance VPN2
 ip address 10.1.35.3 255.255.255.0
#
```

```
interface LoopBack0
 ip address 3.3.3.3 255.255.255.255
#
bgp 123
 peer 1.1.1.1 as-number 123
 peer 1.1.1.1 connect-interface LoopBack0
 #
 ipv4-family unicast
  undo synchronization
  peer 1.1.1.1 enable
 #
 ipv4-family vpnv4
  policy vpn-target
  peer 1.1.1.1 enable
 #
 ipv4-family vpn-instance VPN2
  peer 10.1.35.5 as-number 35
#
ospf 1
 area 0.0.0.0
  network 3.3.3.3 0.0.0.0
  network 10.1.23.0 0.0.0.255
#
return
```

```
<R4>display current-configuration
```

```
[V200R007C00SPC600]
#
```

```
 sysname R4
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.1.14.4 255.255.255.0
#
interface LoopBack0
 ip address 192.168.1.1 255.255.255.0
#
bgp 14
 peer 10.1.14.1 as-number 123
 #
 ipv4-family unicast
  undo synchronization
  network 192.168.1.0
  peer 10.1.14.1 enable
#
return
```

```
<R5>display current-configuration
```

```
[V200R007C00SPC600]
#
 sysname R5
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.1.35.5 255.255.255.0
#
interface LoopBack0
```

```
 ip address 192.168.2.1 255.255.255.0
#
bgp 35
 peer 10.1.35.3 as-number 123
 #
 ipv4-family unicast
  undo synchronization
  network 192.168.2.0
  peer 10.1.35.3 enable
#
return
```

Chapter 2 DHCP Configuration

Lab 2-1 DHCP Configuration

Learning Objectives

The objectives of this lab are to learn and understand:

- How to configure an IP address pool
- How to configure the DHCP server
- How to configure the DHCP client
- How to configure the DHCP relay
- How to configure basic functions of DHCP snooping

Topology

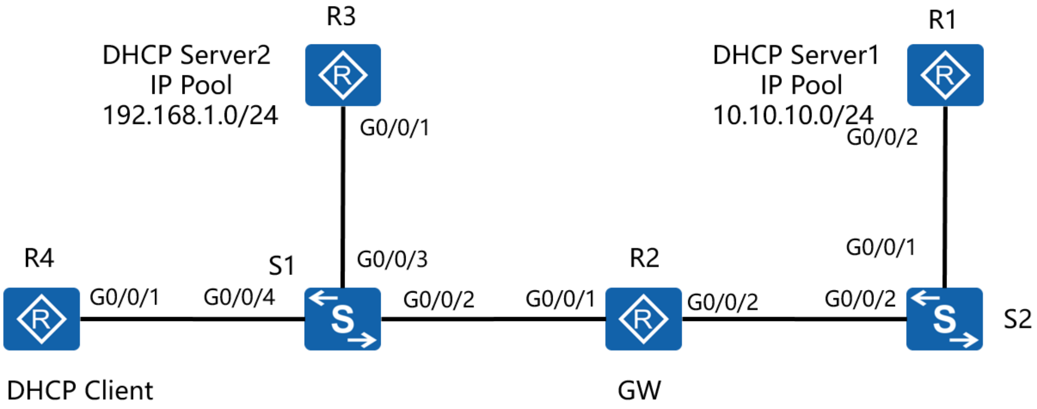


Figure 2-1 DHCP configuration

Scenario

Assume that you are a network administrator of an enterprise. A DHCP server needs to be configured on the network because it is difficult to manage many hosts with static addresses.

R1 functions as the DHCP server, R4 as the DHCP client, and R2 as the gateway for devices on S1. DHCP Discover packets are broadcast packets and cannot pass through routers, so a DHCP relay agent is deployed to send DHCP Request packets from R2 to R1. S2 does not require any configuration, and only transparently transmit packets.

To improve network security and prevent DHCP clients from obtaining incorrect IP addresses from other DHCP servers, deploy DHCP snooping on S1 so that R4 obtains the IP address of R1 (DHCP server 1) but not the IP address of R3 (DHCP server 2). To further enhance security, enable some features of DHCP snooping to prevent DHCP exhaustion and DHCP man-in-the-middle attacks.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses and masks for all routers.

```
<Huawei>system-view

Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R1

[R1]interface GigabitEthernet 0/0/2

[R1-GigabitEthernet0/0/2]ip address 10.0.12.1 24

[R1-GigabitEthernet0/0/2]quit

[R1]interface loopback 0

[R1-LoopBack0]ip address 1.1.1.1 32


<Huawei>system-view

Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R2

[R2]interface GigabitEthernet 0/0/2

[R2-GigabitEthernet0/0/2]ip address 10.0.12.2 24

[R2]interface GigabitEthernet 0/0/1

[R2-GigabitEthernet0/0/1]ip address 10.10.10.1 24
```

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]ip address 192.168.1.1 24
```

To enable an interface of R4 to obtain IP addresses using DHCP, enable the DHCP client function on the interface.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R4
[R4]dhcp enable
[R4]interface GigabitEthernet 0/0/1
[R4-GigabitEthernet0/0/1] ip address dhcp-alloc
```

Configure the switch name and disable unnecessary interfaces.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname S1
[S1]interface GigabitEthernet 0/0/9
[S1-GigabitEthernet0/0/9]shutdown
[S1-GigabitEthernet0/0/9]quit
[S1]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]shutdown
[S1-GigabitEthernet0/0/10]quit
[S1]interface GigabitEthernet 0/0/13
[S1-GigabitEthernet0/0/13]shutdown
[S1-GigabitEthernet0/0/13]quit
[S1]interface GigabitEthernet 0/0/14
```

```
[S1-GigabitEthernet0/0/14]shutdown


<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname S2
[S2]interface GigabitEthernet 0/0/6
[S2-GigabitEthernet0/0/6]shutdown
[S2-GigabitEthernet0/0/6]quit
[S2]interface GigabitEthernet 0/0/7
[S2-GigabitEthernet0/0/7]shutdown
```

Test the connectivity between R2 and R1.

```
[R1]ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.12.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Step 2 **Configure a route between R1 and R2.**

R1 advertises the route of its loopback interface to R2, and R2 advertises the route of the interface connected to S1 to R1 so that the LAN gateway and external network can communicate.

```
[R1]ospf 1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 1.1.1.1 0.0.0.0
[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255

[R2]ospf 1
[R2-ospf-1]silent-interface GigabitEthernet 0/0/1
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.10.10.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
```

Configure the interface connected to R2 as a silent interface to ensure route advertisement of the network segment. However, no neighbor relationship is established on this interface. Test the connectivity between the two networks.

```
[R2]ping –a 10.10.10.1 1.1.1.1
  PING 1.1.1.1: 56   data bytes, press CTRL_C to break
    Reply from 1.1.1.1: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 1.1.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
```

```
round-trip min/avg/max = 1/1/1 ms
```

Step 3 **Configure IP address pools.**

Create IP address pools on R1 and R3 respectively. The IP address pool on R1 ranges from 10.10.10.0 to 10.10.10.24, the IP address of G0/0/0 on R2 is 10.10.10.1, and the DNS server address is 1.1.1.1. To prevent some static addresses on this network from being allocated, reserve 10.10.10.2 to 10.10.10.10 from being dynamically allocated through DHCP. The IP address pool on R3 ranges from 192.168.1.0 to 192.168.1.24, the IP address of G0/0/0 on R3 is 192.168.1.1, and the DNS server address is 192.168.1.1. To reserve IP addresses 192.168.1.2 to 192.168.1.10 from being dynamically allocated through DHCP, set the leases of two servers to 3 days.

```
[R1]ip pool DHCP
[R1-ip-pool-DHCP]gateway-list 10.10.10.1
[R1-ip-pool-DHCP]network 10.10.10.0 mask 255.255.255.0
[R1-ip-pool-DHCP]excluded-ip-address 10.10.10.2 10.10.10.10
[R1-ip-pool-DHCP]dns-list 1.1.1.1
[R1-ip-pool-DHCP]lease day 3

[R3]ip pool DHCP
[R3-ip-pool-DHCP]gateway-list 192.168.1.1
[R3-ip-pool-DHCP]network 192.168.1.0 mask 255.255.255.0
[R3-ip-pool-DHCP]excluded-ip-address 192.168.1.2 192.168.1.10
[R3-ip-pool-DHCP]dns-list 192.168.1.1
[R1-ip-pool-DHCP]lease day 3
```

Verify the IP address pool configuration.

```
<R1>display ip pool
  -----------------------------------------------------------------------------
  Pool-name        : DHCP
  Pool-No          : 0
  Lease            : 3 Days 0 Hours 0 Minutes
  Position         : Local           Status           : Unlocked
  Gateway-0        : 10.10.10.1
  Network          : 10.10.10.0
  Mask             : 255.255.255.0
  VPN instance     : --
  Address Statistic: Total       :253        Used        :0
                     Idle        :244        Expired     :0
                     Conflict    :0          Disable     :9


  IP address Statistic
    Total       :253
    Used        :0          Idle        :244
    Expired     :0          Conflict    :0          Disable    :9


<R3>display ip pool
 -----------------------------------------------------------------------
  Pool-name        : DHCP
  Pool-No          : 0
  Lease            : 3 Days 0 Hours 0 Minutes
  Position         : Local           Status           : Unlocked
  Gateway-0        : 192.168.1.1
  Network          : 192.168.1.0
  Mask             : 255.255.255.0
  VPN instance     : --
  Address Statistic: Total        :253        Used         :0
                     Idle         :244        Expired      :0
                     Conflict     :0          Disable      :9


  IP address Statistic
    Total       :253
    Used        :0          Idle        :244
    Expired     :0          Conflict    :0          Disable    :9
```

Step 4 **Configure a DHCP server based on the global address pool.**

DHCP address pool parameters have been configured, but cannot be used by clients. DHCP needs to be enabled globally and on the interface.

```
[R3]dhcp enable
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]dhcp select global
```

After DHCP is configured on R3, R4 can obtain the IP address normally.

```
<R4>display ip interface GigabitEthernet 0/0/1
GigabitEthernet0/0/1 current state : UP
Line protocol current state : UP
The Maximum Transmit Unit : 1500 bytes
input packets : 0, bytes : 0, multicasts : 0
output packets : 17, bytes : 5605, multicasts : 0
Directed-broadcast packets:
 received packets:             0, sent packets:             17
 forwarded packets:            0, dropped packets:            0
```

```
ARP packet input number:           0
  Request packet:                  0
  Reply packet:                    0
  Unknown packet:                  0
Internet Address is allocated by DHCP, 192.168.1.254/24
Broadcast address : 192.168.1.255
TTL being 1 packet number:         0
TTL invalid packet number:         0
ICMP packet input number:          0
  Echo reply:                      0
  Unreachable:                     0
  Source quench:                   0
  Routing redirect:                0
  Echo request:                    0
  Router advert:                   0
  Router solicit:                  0
  Time exceed:                     0
  IP header bad:                   0
  Timestamp request:               0
  Timestamp reply:                 0
  Information request:             0
  Information reply:               0
  Netmask request:                 0
  Netmask reply:                   0
  Unknown type:                    0
```

The IP address of this interface is 192.168.1.254, which is obtained through DHCP.

Step 5 **Configure the DHCP relay.**

The configuration of R3 as a temporary DHCP server is complete. The actual DHCP server is R1. Because DHCP Discover packets cannot be directly sent from DHCP clients to R1. In this case, configure R2 as the DHCP relay agent and specify R2 as the gateway of the LAN connected to S1. Then R2 can transmit DHCP Request packets of DHCP clients.

Enable DHCP on R1.

```
[R1]dhcp enable

[R1]interface GigabitEthernet 0/0/2

[R1-GigabitEthernet0/0/2]dhcp select global
```

On R2, specify the IP address of the DHCP server as 10.0.12.1 and configure the DHCP relay on the interface.

```
[R2]dhcp enable

[R2]dhcp server group DHCP

[R2-dhcp-server-group-DHCP]dhcp-server 10.0.12.1

[R2-dhcp-server-group-DHCP]quit

[R2]interface GigabitEthernet 0/0/1

[R2-GigabitEthernet0/0/1]dhcp select relay

[R2-GigabitEthernet0/0/1]dhcp relay server-select DHCP
```

Verify the DHCP relay configuration on R2.

```
[R2]display dhcp server group

  Group-name             : DHCP

    (0)   Server-IP      : 10.0.12.1

    Gateway              : --

    VPN instance         : --

  1 DHCP server group(s) in total


[R2]display dhcp relay all
```

```
 DHCP relay agent running information of interface GigabitEthernet0/0/1 :
 Server group name          : DHCP
 Gateway address in use : 10.10.10.1
```

The DHCP server group is configured on R2 and the IP address of the DHCP server in the DHCP server group is 10.0.12.1. The DHCP relay function is enabled on G0/0/1 of R2, and the DHCP relay agent sends DHCP Request packets to the DHCP server.

To further verify whether the DHCP relay is deployed successfully, disable the interface on R3 (to prevent R2 from obtaining an IP address from R3), disable the interface on R4, and then enable the interfaces again. Normally, R4 can obtain the subnet address of 10.10.10.0/24.

```
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]shutdown

[R4]interface GigabitEthernet 0/0/1
[R4-GigabitEthernet0/0/1]shutdown
[R4-GigabitEthernet0/0/1]undo shutdown

[R4]display ip interface GigabitEthernet 0/0/1
GigabitEthernet0/0/1 current state : UP
Line protocol current state : UP
The Maximum Transmit Unit : 1500 bytes
input packets : 0, bytes : 0, multicasts : 0
output packets : 36, bytes : 11866, multicasts : 0
Directed-broadcast packets:
 received packets:                  0, sent packets:               36
 forwarded packets:                 0, dropped packets:               0
ARP packet input number:                0
   Request packet:                      0
```

```
  Reply packet:                  0
  Unknown packet:                  0
Internet Address is allocated by DHCP, 10.10.10.254/24
Broadcast address : 10.10.10.255
TTL being 1 packet number:            0
TTL invalid packet number:            0
ICMP packet input number:              0
  Echo reply:                    0
  Unreachable:                     0
  Source quench:                   0
  Routing redirect:              0
  Echo request:                    0
  Router advert:                   0
  Router solicit:                0
  Time exceed:                     0
  IP header bad:                   0
  Timestamp request:                 0
  Timestamp reply:                   0
  Information request:             0
  Information reply:             0
  Netmask request:                   0
  Netmask reply:                     0
  Unknown type:                        0
```

R4 successfully obtains the IP address 10.10.10.254. Check statistics on R2 and the IP address pool status on R1.

```
<R2>display dhcp relay statistics
 The statistics of DHCP RELAY:
  DHCP packets received from clients       : 2
      DHCP DISCOVER packets received      : 1
      DHCP REQUEST packets received       : 1
      DHCP RELEASE packets received       : 0
      DHCP INFORM packets received        : 0
      DHCP DECLINE packets received       : 0
  DHCP packets sent to clients             : 2
      Unicast packets sent to clients     : 2
      Broadcast packets sent to clients : 0
  DHCP packets received from servers       : 2
      DHCP OFFER packets received         : 1
      DHCP ACK packets received           : 1
      DHCP NAK packets received           : 0
  DHCP packets sent to servers             : 2
  DHCP Bad packets received                : 0

<R1>display ip pool
 -----------------------------------------------------------------------
  Pool-name            : DHCP
  Pool-No              : 0
  Lease                : 3 Days 0 Hours 0 Minutes
  Position             : Local              Status               : Unlocked
  Gateway-0            : 10.10.10.1
  Network              : 10.10.10.0
  Mask                 : 255.255.255.0
  VPN instance         : --
  Address Statistic: Total       :253        Used          :1
                     Idle        :243        Expired       :0
                     Conflict    :0          Disable       :9
  IP address Statistic
  Total       :253
  Used        :1          Idle        :243
  Expired     :0          Conflict    :0          Disable    :9
```

Check the route of R4, and test the connectivity from R4 to the loopback interface of R1.

```
<R4>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 8        Routes : 8

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        0.0.0.0/0   Unr     60   0           D   10.10.10.1      GigabitEthernet0/0/0
     10.10.10.0/24  Direct  0    0           D   10.10.10.254    GigabitEthernet0/0/0
   10.10.10.254/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/0
   10.10.10.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/0
      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

<R4>ping 1.1.1.1
  PING 1.1.1.1: 56  data bytes, press CTRL_C to break
  Reply from 1.1.1.1: bytes=56 Sequence=1 ttl=254 time=1 ms
  Reply from 1.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
  Reply from 1.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
  Reply from 1.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
  Reply from 1.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- 1.1.1.1 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 1/1/1 ms
```

Step 6 **Configure DHCP snooping and attack defense features.**

In the preceding step, the interface on R3 is disabled temporarily. In this case, R4 obtains the IP address only from R1 through R2. Which configuration is required when the interface on R3 needs to be enabled and R4 does not obtain an IP address from R3? In particular, DHCP is enabled on SOHO-level routers by default. If they are connected to the network, there are serious security risks. You are advised to enable DHCP snooping on S1 to prevent unauthorized DHCP servers from interfering with hosts on the LAN.

On S1, defense against DHCP exhaustion attacks and DHCP man-in-the-middle attacks can be enabled to further protect the network where devices obtain IP addresses through DHCP.

Configure DHCP snooping to prevent unauthorized DHCP servers from providing IP addresses.

```
[S1]dhcp enable
[S1]dhcp snooping enable
[S1]interface GigabitEthernet 0/0/3
```

```
[S1-GigabitEthernet0/0/3]dhcp snooping enable

[S1-GigabitEthernet0/0/3]quit

[S1]interface GigabitEthernet 0/0/2

[S1-GigabitEthernet0/0/2]dhcp snooping enable
```

By default, the interface where DHCP snooping is enabled is an untrusted interface.

```
[S1]display dhcp snooping

 DHCP snooping global running information :

 DHCP snooping                                    : Enable

 Static user max number                         : 1024

 Current static user number                   : 0

 Dhcp user max number                            : 1024        (default)

 Current dhcp user number                      : 0

 Arp dhcp-snooping detect                      : Disable    (default)

 Alarm threshold                                 : 100          (default)

 Check dhcp-rate                                  : Disable    (default)

 Dhcp-rate limit(pps)                          : 100          (default)

 Alarm dhcp-rate                                  : Disable    (default)

 Alarm dhcp-rate threshold                     : 100          (default)

 Discarded dhcp packets for rate limit       : 0

 Bind-table autosave                             : Disable    (default)

 Offline remove mac-address                    : Disable    (default)

 Client position transfer allowed              : Enable     (default)


 DHCP snooping running information for interface GigabitEthernet0/0/2 :

 DHCP snooping                                    : Enable

 Trusted interface                              : No

 Dhcp user max number                            : 1024        (default)

 Current dhcp user number                      : 0
```

```
Check dhcp-giaddr                          : Disable   (default)
Check dhcp-chaddr                           : Disable   (default)
Alarm dhcp-chaddr                           : Disable   (default)
Check dhcp-request                         : Disable   (default)
Alarm dhcp-request                         : Disable   (default)
Check dhcp-rate                           : Disable   (default)
Alarm dhcp-rate                           : Disable   (default)
Alarm dhcp-rate threshold                 : 100
Discarded dhcp packets for rate limit   : 0
Alarm dhcp-reply                          : Disable   (default)

DHCP snooping running information for interface GigabitEthernet0/0/3 :
DHCP snooping                               : Enable
Trusted interface                        : No
Dhcp user max number                        : 1024       (default)
Current dhcp user number                   : 0
Check dhcp-giaddr                          : Disable   (default)
Check dhcp-chaddr                           : Disable   (default)
Alarm dhcp-chaddr                           : Disable   (default)
Check dhcp-request                         : Disable   (default)
Alarm dhcp-request                         : Disable   (default)
Check dhcp-rate                           : Disable   (default)
Alarm dhcp-rate                           : Disable   (default)
Alarm dhcp-rate threshold                 : 100
Discarded dhcp packets for rate limit   : 0
Alarm dhcp-reply                          : Disable   (default)
```

Enable the interface on R4 again. In this case, R4 cannot obtain an IP address from any DHCP server because the interfaces connected to the two servers are untrusted interfaces.

```
[R4]interface GigabitEthernet 0/0/1
[R4-GigabitEthernet0/0/1]shutdown
[R4-GigabitEthernet0/0/1]undo shutdown


[r4]display ip interface GigabitEthernet 0/0/1
GigabitEthernet0/0/1 current state : UP
Line protocol current state : DOWN
The Maximum Transmit Unit : 1500 bytes
input packets : 0, bytes : 0, multicasts : 0
output packets : 8, bytes : 2624, multicasts : 0
Directed-broadcast packets:
 received packets:            0, sent packets:             8
 forwarded packets:           0, dropped packets:          0
ARP packet input number:          0
  Request packet:                 0
  Reply packet:                   0
  Unknown packet:                 0
Internet protocol processing : disabled
Broadcast address : 0.0.0.0
TTL being 1 packet number:        0
TTL invalid packet number:        0
ICMP packet input number:         0
  Echo reply:                     0
  Unreachable:                    0
  Source quench:                  0
  Routing redirect:               0
  Echo request:                   0
  Router advert:                0
  Router solicit:             0
  Time exceed:                   0
  IP header bad:               0
  Timestamp request:             0
  Timestamp reply:               0
  Information request:          0
  Information reply:           0
  Netmask request:               0
  Netmask reply:                 0
  Unknown type:                    0
```

Because R1 is the authorized DHCP server, the interface on the switch connected to R2 can be configured as the trusted interface.

```
[S1]interface GigabitEthernet 0/0/2
[S1-GigabitEthernet0/0/2]dhcp snooping trusted
```

Check DHCP snooping on this interface.

```
[S1]display dhcp snooping interface GigabitEthernet 0/0/2
 DHCP snooping running information for interface GigabitEthernet0/0/2 :
 DHCP snooping                                   : Enable
 Trusted interface                             : Yes
 Dhcp user max number                            : 1024      (default)
 Current dhcp user number                      : 0
 Check dhcp-giaddr                             : Disable    (default)
 Check dhcp-chaddr                              : Disable    (default)
 Alarm dhcp-chaddr                              : Disable    (default)
 Check dhcp-request                            : Disable    (default)
 Alarm dhcp-request                         : Disable    (default)
 Check dhcp-rate                            : Disable    (default)
 Alarm dhcp-rate                            : Disable    (default)
 Alarm dhcp-rate threshold                  : 100
 Discarded dhcp packets for rate limit      : 0
 Alarm dhcp-reply                           : Disable    (default)
```

R4 can obtain an IP address again.

```
[R4]display ip interface GigabitEthernet 0/0/0
GigabitEthernet0/0/0 current state : UP
Line protocol current state : UP
The Maximum Transmit Unit : 1500 bytes
input packets : 0, bytes : 0, multicasts : 0
output packets : 94, bytes : 30832, multicasts : 0
Directed-broadcast packets:
 received packets:              0, sent packets:             94
 forwarded packets:             0, dropped packets:           0
ARP packet input number:          0
  Request packet:                 0
  Reply packet:                   0
  Unknown packet:                 0
Internet Address is allocated by DHCP, 10.10.10.254/24
Broadcast address : 10.10.10.255
TTL being 1 packet number:        0
TTL invalid packet number:        0
ICMP packet input number:         0
  Echo reply:                     0
  Unreachable:                    0
  Source quench:              0
  Routing redirect:           0
  Echo request:               0
  Router advert:              0
  Router solicit:             0
  Time exceed:                0
  IP header bad:              0
  Timestamp request:          0
  Timestamp reply:            0
  Information request:        0
  Information reply:          0
  Netmask request:            0
  Netmask reply:              0
  Unknown type:               0
```

The preceding configurations are complete. Assume that R4 is an untrusted host that may send many DHCP Request packets to exhaust available IP addresses. Defense against DHCP exhaustion attacks is enabled on the interface of S1 connected to R4.

```
[S1]interface GigabitEthernet 0/0/4
[S1-GigabitEthernet0/0/4]dhcp snooping check dhcp-chaddr enable
```

Check whether the value of **Check dhcp-chaddr** is **Enable**. If the value of **Check dhcp-chaddr** is **Enable**, the switch checks the CHADDR field in the received DHCP Request packet and determines whether the value of the CHADDR field is consistent with the hardware address of the host. If the value of the CHADDR field is inconsistent with the hardware address of the host, the interface does not forward the DHCP Request packet.

```
[S1]display dhcp snooping interface GigabitEthernet 0/0/4
```

```
 DHCP snooping running information for interface GigabitEthernet0/0/4 :
 DHCP snooping                                : Disable    (default)
 Trusted interface                            : No
 Dhcp user max number                         : 1024       (default)
 Current dhcp user number                     : 0
 Check dhcp-giaddr                            : Disable    (default)
 Check dhcp-chaddr                            : Enable
 Alarm dhcp-chaddr                            : Disable    (default)
 Check dhcp-request                           : Disable    (default)
 Alarm dhcp-request                           : Disable    (default)
 Check dhcp-rate                              : Disable    (default)
 Alarm dhcp-rate                              : Disable    (default)
 Alarm dhcp-rate threshold                    : 100
 Discarded dhcp packets for rate limit        : 0
 Alarm dhcp-reply                             : Disable    (default)
```

Enable defense against DHCP man-in-the-middle attacks.

```
[S1]arp dhcp-snooping-detect enable
```

Check global DHCP snooping.

```
[S1]display dhcp snooping
 DHCP snooping global running information :
 DHCP snooping                                : Enable
 Static user max number                       : 1024
 Current static user number                   : 0
 Dhcp user max number                         : 1024       (default)
 Current dhcp user number                     : 0
 Arp dhcp-snooping detect                     : Enable
 Alarm threshold                           : 100       (default)
 Check dhcp-rate                           : Disable   (default)
 Dhcp-rate limit(pps)                      : 100       (default)
 Alarm dhcp-rate                           : Disable   (default)
 Alarm dhcp-rate threshold                 : 100       (default)
 Discarded dhcp packets for rate limit     : 0
 Bind-table autosave                       : Disable   (default)
 Offline remove mac-address                : Disable   (default)
 Client position transfer allowed          : Enable    (default)
```

Association between ARP and DHCP snooping is enabled. By default, association between ARP and DHCP snooping is disabled. The DHCP security defense configurations are complete.

----End

Configuration Reference

```
<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
dhcp enable
#
ip pool DHCP
 gateway-list 10.10.10.1
 network 10.10.10.0 mask 255.255.255.0
 excluded-ip-address 10.10.10.2 10.10.10.10
 lease day 3 hour 0 minute 0
 dns-list 1.1.1.1
```

```
interface GigabitEthernet0/0/2
 ip address 10.0.12.1 255.255.255.0
 dhcp select global
#
interface LoopBack0
 ip address 1.1.1.1 255.255.255.255
#
ospf 1
 area 0.0.0.0
  network 1.1.1.1 0.0.0.0
  network 10.0.12.0 0.0.0.255
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
dhcp enable
#
dhcp server group DHCP
 dhcp-server 10.0.12.1 0
#
interface GigabitEthernet0/0/1
 ip address 10.10.10.1 255.255.255.0
 dhcp select relay
 dhcp relay server-select DHCP
```

```
#
interface GigabitEthernet0/0/2
 ip address 10.0.12.2 255.255.255.0
#
ospf 1
 silent-interface GigabitEthernet0/0/1
 area 0.0.0.0
  network 10.0.12.0 0.0.0.255
  network 10.10.10.0 0.0.0.255
#
return

<R3>display current-configuration
[V200R007C00SPC600]
#
 sysname R3
#
dhcp enable
#
ip pool DHCP
 gateway-list 192.168.1.1
 network 192.168.1.0 mask 255.255.255.0
 excluded-ip-address 192.168.1.2 192.168.1.10
 lease day 3 hour 0 minute 0
 dns-list 192.168.1.1
#
interface GigabitEthernet0/0/1
 ip address 192.168.1.1 255.255.255.0
 dhcp select global
```

```
#
return

<R4>display current-configuration
[V200R007C00SPC600]
#
 sysname R4
#
dhcp enable
#
interface GigabitEthernet0/0/1
 ip address dhcp-alloc
#
return

<SW1>display current-configuration
!Software Version V200R008C00SPC500
#
sysname S1
#
dhcp enable
#
dhcp snooping enable
arp dhcp-snooping-detect enable
#
#
interface GigabitEthernet0/0/2
 dhcp snooping enable
 dhcp snooping trusted
```

```
#
interface GigabitEthernet0/0/3
 dhcp snooping enable
#
interface GigabitEthernet0/0/4
 dhcp snooping check dhcp-chaddr enable
#
interface GigabitEthernet0/0/9
 shutdown
#
interface GigabitEthernet0/0/10
 shutdown
#
interface GigabitEthernet0/0/13
 shutdown
#
interface GigabitEthernet0/0/14
 shutdown
#
return

<SW2>display current-configuration
!Software Version V200R008C00SPC500
#
sysname SW2
#
interface GigabitEthernet0/0/6
 shutdown
#
```

```
interface GigabitEthernet0/0/7
 shutdown
#
return
```

Chapter 3 Service Quality and Traffic Control

Lab 3-1 QoS Basics

Learning Objectives

The objectives of this lab are to learn and understand:

- How to analyze the SLA using NQA
- How to implement priority mapping and traffic policing
- How to configure traffic shaping
- How to implement congestion management based on queues and traffic classifiers
- How to configure congestion avoidance based on WRED

Topology

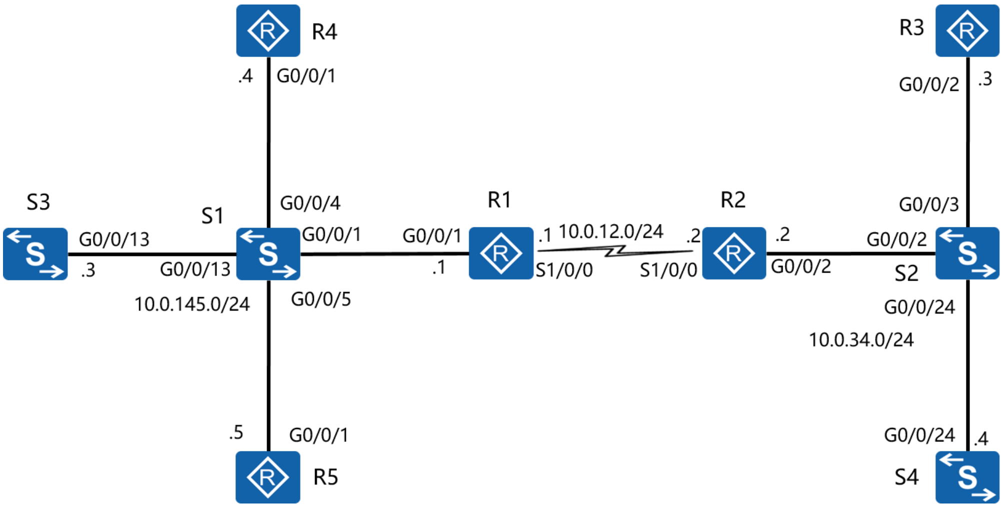


Figure 3-1 QoS

Scenario

Assume that you are a network administrator of an enterprise. R1 and S1 are located in the enterprise headquarters, and R2 and S2 are located in the enterprise branch. The headquarters and branch are connected through a leased line.

The intranet bandwidth increases gradually, but the bandwidth of the leased line does not increase. In this case, important services are delayed or some services are unavailable.

You can use differentiated services of QoS and adjust QoS parameters to ensure that important service data is first sent to the destination.

In the lab, S3 and S4 use NQA to exchange a large number of data flows. R3, R4, and R5 simulate the clients and server to check whether important applications are available.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses and masks for all the routers and switches S3 and S4.

Set the baud rate of S1/0/0 on R1 to 72000, and simulate congestion on the WAN link because of insufficient bandwidth.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 255.255.255.0
[R1-Serial1/0/0]baudrate 72000
[R1-Serial1/0/0]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.145.1 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 255.255.255.0
```

```
[R2-Serial1/0/0]interface GigabitEthernet 0/0/2
[R2-GigabitEthernet0/0/2]ip address 10.0.34.2 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.34.3 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R4
[R4]interface GigabitEthernet 0/0/1
[R4-GigabitEthernet0/0/1]ip address 10.0.145.4 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R5
[R5]interface GigabitEthernet 0/0/1
[R5-GigabitEthernet0/0/1]ip address 10.0.145.5 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname S3
[S3]interface Vlanif 1
[S3-Vlanif1]ip address 10.0.145.3 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
```

```
[Huawei]sysname S4

[S4]interface Vlanif 1

[S4-Vlanif1]ip address 10.0.34.4 255.255.255.0
```

After the configurations are complete, test the connectivity of direct links.

```
[R1]ping -c 1 10.0.12.2
  PING 10.0.12.2: 56   data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=36 ms

  --- 10.0.12.2 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 36/36/36 ms

[R1]ping -c 1 10.0.145.3
  PING 10.0.145.3: 56   data bytes, press CTRL_C to break
    Reply from 10.0.145.3: bytes=56 Sequence=1 ttl=255 time=35 ms

  --- 10.0.145.3 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 35/35/35 ms

[R1]ping -c 1 10.0.145.4
  PING 10.0.145.4: 56   data bytes, press CTRL_C to break
    Reply from 10.0.145.4: bytes=56 Sequence=1 ttl=255 time=6 ms
  --- 10.0.145.4 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 6/6/6 ms

[R1]ping -c 1 10.0.145.5
  PING 10.0.145.5: 56   data bytes, press CTRL_C to break
    Reply from 10.0.145.5: bytes=56 Sequence=1 ttl=255 time=6 ms

  --- 10.0.145.5 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 6/6/6 ms

[R2]ping -c 1 10.0.34.3
  PING 10.0.34.3: 56   data bytes, press CTRL_C to break
    Reply from 10.0.34.3: bytes=56 Sequence=1 ttl=255 time=5 ms

  --- 10.0.34.3 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 5/5/5 ms

[R2]ping -c 1 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=36 ms


  --- 10.0.34.4 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 36/36/36 ms
```

Step 2 **Configure static routes and NQA.**

Configure static routes for all the routers and switches S3 and S4.

```
[R1]ip route-static 10.0.34.0 255.255.255.0 10.0.12.2


[R2]ip route-static 10.0.145.0 255.255.255.0 10.0.12.1


[R3]ip route-static 0.0.0.0 0.0.0.0 10.0.34.2


[R4]ip route-static 0.0.0.0 0.0.0.0 10.0.145.1


[R5]ip route-static 0.0.0.0 0.0.0.0 10.0.145.1


[S3]ip route-static 0.0.0.0 0.0.0.0 10.0.145.1


[S4]ip route-static 0.0.0.0 0.0.0.0 10.0.34.2
```

After the configurations are complete, test the network connectivity.

```
[S3]ping -c 1 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=252 time=40 ms

  --- 10.0.34.4 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 40/40/40 ms

[R4]ping -c 1 10.0.34.3
  PING 10.0.145.4: 56   data bytes, press CTRL_C to break
    Reply from 10.0.145.4: bytes=56 Sequence=1 ttl=255 time=3 ms

  --- 10.0.145.4 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 3/3/3 ms

[R5]ping -c 1 10.0.34.3
  PING 10.0.34.3: 56   data bytes, press CTRL_C to break
    Reply from 10.0.34.3: bytes=56 Sequence=1 ttl=253 time=44 ms

  --- 10.0.34.3 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 44/44/44 ms
```

The links between S3 and S4, between R4 and R3, and between R5 and R3 are reachable, indicating that network communication is normal.

Congestion easily occurs on the 72 kbit/s serial link between the headquarters and branch.

Use NQA to generate traffic. S4 functions as the NQA server and S3 functions as the NQA client.

Create NQA UDP and jitter test instances to simulate data and voice traffic respectively.

Set parameters in NQA test instances to simulate the environment where congestion does not occur if there is only data or voice traffic and congestion occurs if there is data and voice traffic.

Configure S4 as the NQA server, and set the IP address of the interface used for monitoring UDP services to 10.0.34.4 and port number to 6000.

```
[S4]nqa-server udpecho 10.0.34.4 6000
```

On S3, configure an NQA UDP test instance to simulate data traffic, and set the ToS to 28, packet size to 5800 bytes, interval at which packets are sent to 1s, interval for the NQA test to 3s, and timeout interval for the NQA test to 1s, and start the NQA UDP test instance.

```
[S3]nqa test-instance admin udp

[S3-nqa-admin-udp]test-type udp

[S3-nqa-admin-udp]destination-address ipv4 10.0.34.4

[S3-nqa-admin-udp]destination-port 6000

[S3-nqa-admin-udp]tos 28

[S3-nqa-admin-udp]datasize 5800

[S3-nqa-admin-udp]interval seconds 1

[S3-nqa-admin-udp]frequency 3

[S3-nqa-admin-udp]timeout 1
```

```
[S3-nqa-admin-udp]start now
```

Check the NQA UDP test instance.

```
[S3]display nqa results test-instance admin udp
1 . Test 2 result     The test is finished
    Send operation times: 3                Receive response times: 3
    Completion:success                     RTD OverThresholds number: 0
    Attempts number:1                      Drop operation number:0
    Disconnect operation number:0          Operation timeout number:0
    System busy operation number:0         Connection fail number:0
    Operation sequence errors number:0     RTT Stats errors number:0
    Destination ip address:10.0.34.4
    Min/Max/Average Completion Time: 930/950/943
    Sum/Square-Sum    Completion Time: 2830/2669900
    Last Good Probe Time: 2010-10-10 18:10:02.4
    Lost packet ratio: 0 %
```

No packet is discarded and congestion does not occur. Shut down the NQA UDP test instance.

```
[S3]nqa test-instance admin udp
[S3-nqa-admin-udp]stop
```

On S3, configure an NQA jitter test instance to simulate voice traffic, and set the ToS to 46, packet size to 90 bytes, interval at which packets are sent to 20 ms, interval for the NQA test to 3s, and timeout interval for the NQA test to 1s, and start the NQA jitter test instance.

```
[S3]nqa test-instance admin jitter
[S3-nqa-admin-jitter]test-type jitter
```

```
[S3-nqa-admin-jitter]destination-address ipv4 10.0.34.4

[S3-nqa-admin-jitter]destination-port 6000

[S3-nqa-admin-jitter]tos 46

[S3-nqa-admin-jitter]datasize 90

[S3-nqa-admin-jitter]interval milliseconds 20

[S3-nqa-admin-jitter]frequency 3

[S3-nqa-admin-jitter]timeout 1

[S3-nqa-admin-jitter]start now
```

Check the NQA jitter test instance.

```
[S3]display nqa results test-instance admin jitter


 NQA entry(admin, jitter) :testflag is active ,testtype is jitter

  1 . Test 1 result     The test is finished

   SendProbe:60                            ResponseProbe:60

   Completion:success                      RTD OverThresholds number:0

   Min/Max/Avg/Sum RTT:40/70/54/3260          RTT    Square Sum:179800

   NumOfRTT:60                                Drop operation number:0

   Operation sequence errors number:0     RTT Stats errors number:0

   System busy operation number:0          Operation timeout number:0

   Min Positive SD:10                      Min Positive DS:10

   Max Positive SD:10                      Max Positive DS:10

   Positive SD Number:5                    Positive DS Number:11

   Positive SD Sum:50                      Positive DS Sum:110

   Positive SD Square Sum:500              Positive DS Square Sum:1100

   Min Negative SD:10                      Min Negative DS:10

   Max Negative SD:10                      Max Negative DS:20

   Negative SD Number:4                       Negative DS Number:10
```

```
    Negative SD Sum:40                      Negative DS Sum:110
    Negative SD Square Sum:400              Negative DS Square Sum:1300
    Min Delay SD:20                         Min Delay DS:19
    Avg Delay SD:27                         Avg Delay DS:26
    Max Delay SD:35                         Max Delay DS:34
    Packet Loss SD:0                        Packet Loss DS:0
    Packet Loss Unknown:0                   jitter out value:0.0937500
    jitter in value:0.2291667               NumberOfOWD:60
    OWD SD Sum:1630                              OWD DS Sum:1570
    TimeStamp unit: ms
```

No packet is discarded and congestion does not occur. Shut down the NQA jitter test instance.

```
[S3]nqa test-instance admin jitter
[S3-nqa-admin-jitter]stop
```

Step 3 **Configure priority mapping.**

Run the **ping** command to simulate traffic of less important services, and map DSCP priorities of traffic to BE without QoS guarantee.

Configure G0/0/1 and S1/0/0 on R1 to trust DSCP priorities of packets.

```
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]trust dscp override
[R1-GigabitEthernet0/0/1]interface Serial 1/0/0
[R1-Serial1/0/0]trust dscp
```

Specify **override** in the **trust** command on G0/0/1 so that DSCP priorities are changed to mapped values after priority mapping is configured on R1.

Run the **ping** command on R4 to simulate the traffic destined for R3 and set the ToS to 26.

```
[R4]ping –tos 26 10.0.34.3
```

Configure priority mapping on R1 and map DSCP priority 26 to 0.

```
[R1]qos map-table dscp-dscp
[R1-maptbl-dscp-dscp]input 26 output 0
```

Check the priority mapping configuration on R1.

```
[R1]display qos map-table dscp-dscp
Input DSCP        DSCP
-------------------
  0               0
  1               1
  2               2
  3               3
  4               4
  5               5
  6               6
  7               7
  8               8
  9               9
 10              10
 11              11
 12              12
 13              13
 14              14
 15              15
```

```
16              16
17              17
18              18
19              19
20              20
21              21
22              22
23              23
24              24
25              25
26              0
27              27
28              28
29              29
30              30
```

The preceding information shows that DSCP priority 26 is mapped to 0 and other DSCP priorities use default values.

Step 4 **Configure traffic shaping and traffic policing.**

Start NQA UDP and jitter test instances on S3 to simulate congestion on the 72 kbit/s link between the headquarters and branch.

```
[S3]nqa test-instance admin udp
[S3-nqa-admin-udp]start now
[S3-nqa-admin-udp]quit
[S3]nqa test-instance admin jitter
[S3-nqa-admin-jitter]start now
```

On R4, run the **ping** command with the packet size of 700 bytes and packet count of 10 to simulate the traffic destined for R3.

```
[R4]ping -s 700 -c 10 10.0.34.3
  PING 10.0.34.3: 700   data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
    Reply from 10.0.34.3: bytes=700 Sequence=9 ttl=253 time=1944 ms
    Request time out

  --- 10.0.34.3 ping statistics ---
    10 packet(s) transmitted
    1 packet(s) received
    90.00% packet loss
round-trip min/avg/max = 1944/1944/1944 ms
```

Severe congestion occurs on the link between the headquarters and branch, causing serious packet loss. There is a long delay for forwarded data packets. In this case, R4 cannot communicate with R3.

The following describes how to configure traffic policing and traffic shaping to eliminate congestion on the link so that R4 in headquarters can communicate with R3 on the branch.

Configure traffic policing to eliminate congestion. On S1, configure traffic policing on G0/0/13 and set the CIR to 64 kbit/s.

```
[S1]interface GigabitEthernet 0/0/13
[S1-GigabitEthernet0/0/13]qos lr inbound cir 64
```

Check the traffic policing configuration on S1.

```
[S1]display qos lr inbound interface GigabitEthernet 0/0/13
GigabitEthernet0/0/13 lr inbound:
  cir: 64 Kbps, cbs: 8000 Byte
```

On R4, run the **ping** command with the packet size of 700 bytes and packet count of 10 to simulate the traffic destined for R3.

```
[R4]ping -s 700 -c 10 10.0.34.3
  PING 10.0.34.3: 700   data bytes, press CTRL_C to break
    Reply from 10.0.34.3: bytes=700 Sequence=1 ttl=253 time=1412 ms
    Reply from 10.0.34.3: bytes=700 Sequence=2 ttl=253 time=255 ms
    Reply from 10.0.34.3: bytes=700 Sequence=3 ttl=253 time=736 ms
    Reply from 10.0.34.3: bytes=700 Sequence=4 ttl=253 time=1746 ms
    Reply from 10.0.34.3: bytes=700 Sequence=5 ttl=253 time=246 ms
    Reply from 10.0.34.3: bytes=700 Sequence=6 ttl=253 time=746 ms
    Reply from 10.0.34.3: bytes=700 Sequence=7 ttl=253 time=1736 ms
    Reply from 10.0.34.3: bytes=700 Sequence=8 ttl=253 time=258 ms
    Reply from 10.0.34.3: bytes=700 Sequence=9 ttl=253 time=766 ms
    Reply from 10.0.34.3: bytes=700 Sequence=10 ttl=253 time=1736 ms

  --- 10.0.34.3 ping statistics ---
    10 packet(s) transmitted
    10 packet(s) received
    0.00% packet loss
```

```
round-trip min/avg/max = 246/963/1746 ms
```

No packets are discarded and R4 can communicate with R3 normally, indicating that traffic policing takes effect.

Delete the traffic policing configuration from S1.

```
[S1]interface GigabitEthernet 0/0/13
[S1-GigabitEthernet0/0/13]undo qos lr inbound
```

The following uses traffic shaping to eliminate congestion. On S3, configure traffic shaping on GE0/0/13 and set the CIR to 64 kbit/s.

```
[S3]interface GigabitEthernet0/0/13
[S3-GigebitEthernet0/0/13]qos lr outbound cir 64
```

On R4, run the **ping** command with the packet size of 700 bytes and packet count of 10 to simulate the traffic destined for R3.

```
[R4]ping -s 700 -c 10 10.0.34.3
  PING 10.0.34.3: 700   data bytes, press CTRL_C to break
    Reply from 10.0.34.3: bytes=700 Sequence=1 ttl=253 time=240 ms
    Reply from 10.0.34.3: bytes=700 Sequence=2 ttl=253 time=284 ms
    Reply from 10.0.34.3: bytes=700 Sequence=3 ttl=253 time=334 ms
    Reply from 10.0.34.3: bytes=700 Sequence=4 ttl=253 time=224 ms
    Reply from 10.0.34.3: bytes=700 Sequence=5 ttl=253 time=344 ms
    Reply from 10.0.34.3: bytes=700 Sequence=6 ttl=253 time=275 ms
    Reply from 10.0.34.3: bytes=700 Sequence=7 ttl=253 time=534 ms
    Reply from 10.0.34.3: bytes=700 Sequence=8 ttl=253 time=184 ms
    Reply from 10.0.34.3: bytes=700 Sequence=9 ttl=253 time=204 ms
    Reply from 10.0.34.3: bytes=700 Sequence=10 ttl=253 time=314 ms
  --- 10.0.34.3 ping statistics ---
    10 packet(s) transmitted
    10 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 184/293/534 ms
```

No packets are discarded and R4 can communicate with R3 normally, indicating that traffic shaping takes effect.

Delete the traffic shaping configuration from S3.

```
[S3]interface GigebitEthernet0/0/13
[S3-GigebitEthernet0/0/13]undo qos lr outbound
```

On R4, run the **ping** command with the packet size of 700 bytes and packet count of 10 to simulate the traffic destined for R3.

```
[R4]ping -s 700 -c 10 10.0.34.3
  PING 10.0.34.3: 700   data bytes, press CTRL_C to break
    Reply from 10.0.34.3: bytes=700 Sequence=1 ttl=253 time=1918 ms
    Request time out
    Reply from 10.0.34.3: bytes=700 Sequence=3 ttl=253 time=1762 ms
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
```

```
--- 10.0.34.3 ping statistics ---
  10 packet(s) transmitted
  2 packet(s) received
  80.00% packet loss
  round-trip min/avg/max = 1762/1840/1918 ms
```

After the configuration is deleted, many packets are discarded and forwarded data packets are delayed. R4 cannot communicate with R3.

Step 5 **Configure queue-based congestion management and congestion avoidance.**

To prevent network congestion on the link between the headquarters and branch, configure queue-based congestion management and congestion avoidance.

On R1, create a WRED drop profile named **data** based on DSCP priorities and set the upper drop threshold to 90, lower drop threshold to 50, and maximum drop probability to 30.

```
[R1]drop-profile data
[R1-drop-profile-data]wred dscp
[R1-drop-profile-data]dscp af32 low-limit 50 high-limit 90 discard-percentage 30
```

Create a queue profile named **queue-profile1** on R1, put data traffic into WFQ queues, bind the queue profile to the WRED drop profile **data**, and put high-priority and delay-sensitive voice traffic to PQ queues.

```
[R1]qos queue-profile queue-profile1
[R1-qos-queue-profile-queue-profile1]schedule wfq 3 pq 5
[R1-qos-queue-profile-queue-profile1]queue 3 drop-profile data
```

Apply the queue profile to S1/0/0 of R1.

```
[R1]interface Serial 1/0/0

[R1-Serial1/0/0]qos queue-profile queue-profile1
```

Check the queue profile configuration.

```
[R1]display qos queue-profile queue-profile1

Queue-profile: queue-profile1

Queue   Schedule   Weight   Length(Bytes/Packets) Gts(CIR/CBS)

-----------------------------------------------------------------

3        WFQ        10                   0/0                 -/-

5        PQ         -                    0/0                 -/-
```

Data traffic and voice traffic enter WFQ and PQ queues respectively.

Check the drop profile configuration.

```
[R1]display drop-profile data

Drop-profile[1]: data

DSCP              Low-limit    High-limit   Discard-percentage

-----------------------------------------------------------------

default             30          100          10

1                   30          100          10

2                   30          100          10

3                   30          100          10

4                   30          100          10

5                   30          100          10

6                   30          100          10

7                   30          100          10

cs1                 30          100          10

9                   30          100          10
```

```
af11          30       100      10

11            30       100      10

af12          30       100      10

13            30       100      10

af13          30       100      10

15            30       100      10

cs2           30       100      10

17            30       100      10

af21          30       100      10

19            30       100      10

af22          30       100      10

21            30       100      10

af23          30       100      10

23            30       100      10

cs3           30       100      10

25            30       100      10

af31          30       100      10

27            30       100      10

af32          50       90       30

29            30       100      10

af33          30       100      10

31            30       100      10

cs4           30       100      10

33            30       100      10

af41          30       100      10
```

Parameters in the WRED drop profile **data** take effect, and other parameters use default values.

Step 6 **Configure flow-based congestion management and congestion avoidance.**

To prevent network congestion on the link between the headquarters and branch, configure flow-based congestion management and congestion avoidance.

Define the traffic exchanged between R4 in the headquarters and R3 on the branch as important traffic and perform QoS guarantee for the traffic so that R4 can communicate with R3.

Delete the queue profile from S1/0/0 on R1.

```
[R1]interface GigabitEthernet 0/0/1

[R1-GigabitEthernet0/0/1]undo qos queue-profile
```

On R4, run the **ping** command with the source address of 10.0.145.4, packet size of 700 bytes, and packet count of 10 to test the connectivity between R4 and R3.

```
[R4]ping -a 10.0.145.4 -s 700 -c 10 10.0.34.3

  PING 10.0.34.3: 700   data bytes, press CTRL_C to break

    Reply from 10.0.34.3: bytes=700 Sequence=1 ttl=253 time=1279 ms

    Request time out

    Reply from 10.0.34.3: bytes=700 Sequence=3 ttl=253 time=1587 ms

    Reply from 10.0.34.3: bytes=700 Sequence=4 ttl=253 time=1827 ms

    Request time out

    Reply from 10.0.34.3: bytes=700 Sequence=6 ttl=253 time=1717 ms

    Request time out

    Request time out

    Request time out

    Request time out


  --- 10.0.34.3 ping statistics ---

    10 packet(s) transmitted
    4 packet(s) received
    60.00% packet loss
    round-trip min/avg/max = 1279/1602/1827 ms
```

Congestion has occurred on the link between the headquarters and branch, a large number of packets are discarded, and R4 cannot communicate with R3.

Create ACL 3001 on R1 to match the traffic sent from 10.0.145.4 to 10.0.34.3.

```
[R1]acl number 3001
[R1-acl-adv-3001]rule 0 per ip source 10.0.145.4 0.0.0.0 destination 10.0.34.3 0.0.0.0
```

Create a traffic classifier **class-ef**, reference ACL 3001 in the traffic classifier, create a traffic behavior **behavior-ef**, set the queue scheduling mode to EF, and set the bandwidth to 10 kbit/s.

```
[R1]traffic classifier class-ef
[R1-classifier-class-ef]if-match acl 3001
[R1-classifier-class-ef]quit
[R1]traffic behavior behavior-ef
[R1-behavior-behavior-ef]queue ef bandwidth 10
```

Create a traffic classifier **class-af32** to match data traffic with the DSCP priority of AF32, create a traffic behavior **behavior-af32**, set the queue scheduling mode to AF, set the bandwidth to 30 kbit/s, and bind the traffic behavior to the drop profile **data**.

```
[R1]traffic classifier class-af32
[R1-classifier-class-af32]if-match dscp af32
[R1-classifier-class-af32]quit
[R1]traffic behavior behavior-af32
[R1-behavior-behavior-af32]queue af bandwidth 30
```

```
[R1-behavior-behavior-af32]drop-profile data
```

Create a traffic policy **policy-1**, associate the traffic policy with the traffic classifier **class-ef** and traffic behavior **behavior-ef**, and the traffic classifier **class-af32** and traffic behavior **behavior-af32**, and apply the traffic policy to S1/0/0 on R1.

```
[R1]traffic policy policy-1
[R1-trafficpolicy-policy-1]classifier class-ef behavior behavior-ef
[R1-trafficpolicy-policy-1]classifier class-af32 behavior behavior-af32
[R1-trafficpolicy-policy-1]quit
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]traffic-policy policy-1 outbound
```

On R4, run the **ping** command with the source address of 10.0.145.4, packet size of 700 bytes, and packet count of 10 to test the connectivity between R4 and R3.

```
[R4]ping -a 10.0.145.4 -s 700 -c 10 10.0.34.3
  PING 10.0.34.3: 700   data bytes, press CTRL_C to break
    Reply from 10.0.34.3: bytes=700 Sequence=1 ttl=253 time=694 ms
    Reply from 10.0.34.3: bytes=700 Sequence=2 ttl=253 time=391 ms
    Reply from 10.0.34.3: bytes=700 Sequence=3 ttl=253 time=361 ms
    Reply from 10.0.34.3: bytes=700 Sequence=4 ttl=253 time=671 ms
    Reply from 10.0.34.3: bytes=700 Sequence=5 ttl=253 time=211 ms
    Reply from 10.0.34.3: bytes=700 Sequence=6 ttl=253 time=611 ms
    Reply from 10.0.34.3: bytes=700 Sequence=7 ttl=253 time=688 ms
    Reply from 10.0.34.3: bytes=700 Sequence=8 ttl=253 time=391 ms
    Reply from 10.0.34.3: bytes=700 Sequence=9 ttl=253 time=301 ms
    Reply from 10.0.34.3: bytes=700 Sequence=10 ttl=253 time=651 ms

  --- 10.0.34.3 ping statistics ---
```

```
    10 packet(s) transmitted
    10 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 211/497/694 ms
```

Configure traffic from R4 to R3 to enter EF queues. Then R4 can communicate with R3.

----End

Additional Exercise: Analysis and Verification

QoS uses differentiated services to ensure bandwidth and shorten the delay for various services. Does increased bandwidth solve service quality problems so that QoS is not required?

After the lab, recollect and summarize the QoS process.

Device Configuration

```
<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
acl number 3001
 rule 0 permit ip source 10.0.145.4 0 destination 10.0.34.3 0
#
drop-profile data
wred dscp
  dscp af32 low-limit 50 high-limit 90 discard-percentage 30
#
```

```
qos queue-profile queue-profile1
  queue 3 drop-profile data
  schedule wfq 3 pq 5
#
qos map-table dscp-dscp
  input 26 output 0
#
traffic classifier class-ef operator or
 if-match acl 3001
traffic classifier class-af32 operator or
 if-match dscp af32
#
traffic behavior behavior-ef
 queue ef bandwidth 10 cbs 250
traffic behavior behavior-af32
 queue af bandwidth 30
 drop-profile data
traffic behavior behavir-af32
 queue af bandwidth 30
#
traffic policy policy-1
 classifier class-ef behavior behavior-ef
 classifier class-af32 behavior behavior-af32
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.1 255.255.255.0
 trust dscp
 traffic-policy policy-1 outbound
 baudrate 72000
#
interface GigabitEthernet0/0/1
 ip address 10.0.145.1 255.255.255.0
 trust dscp override
#
 ip route-static 10.0.34.0 255.255.255.0 10.0.12.2
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.2 255.255.255.0
#
interface GigabitEthernet0/0/2
 ip address 10.0.34.2 255.255.255.0
#
 ip route-static 10.0.145.0 255.255.255.0 10.0.12.1
#
return

<R3>display current-configuration
[V200R007C00SPC600]
#
```

```
 sysname R3
#
interface GigabitEthernet0/0/2
 ip address 10.0.34.3 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.34.2
#
return

<R4>display current-configuration
[V200R007C00SPC600]
#
 sysname R4
#
interface GigabitEthernet0/0/1
 ip address 10.0.145.4 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.145.1
#
return

<R5>display current-configuration
[V200R007C00SPC600]
#
 sysname R5
#
interface GigabitEthernet0/0/1
 ip address 10.0.145.5 255.255.255.0
#
```

```
 ip route-static 0.0.0.0 0.0.0.0 10.0.145.1
#
return

<S3>display current-configuration
#
!Software Version V200R008C00SPC500
 sysname S3
#
interface Vlanif1
 ip address 10.0.145.3 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.145.1
#
nqa test-instance admin udp
 test-type udp
 destination-address ipv4 10.0.34.4
 destination-port 6000
 tos 28
 frequency 3
 interval seconds 1
 timeout 1
 datasize 5800
 start now
nqa test-instance admin jitter
 test-type jitter
 destination-address ipv4 10.0.34.4
 destination-port 6000
 tos 46
 frequency 3
 interval milliseconds 20
 timeout 1
 datasize 90
 start now
#
return

<S4>display current-configuration
#
!Software Version V200R008C00SPC500
 sysname S4
#
interface Vlanif1
 ip address 10.0.34.4 255.255.255.0
#
 nqa-server udpecho 10.0.34.4 6000
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.34.2
#
return
```

Chapter 4 Firewall Configuration

Lab 4-1 Firewall Zone and Security Policy Configuration

Learning Objectives

The objectives of this lab are to learn and understand:

- How to configure firewall zones
- How to configure security policies

Topology

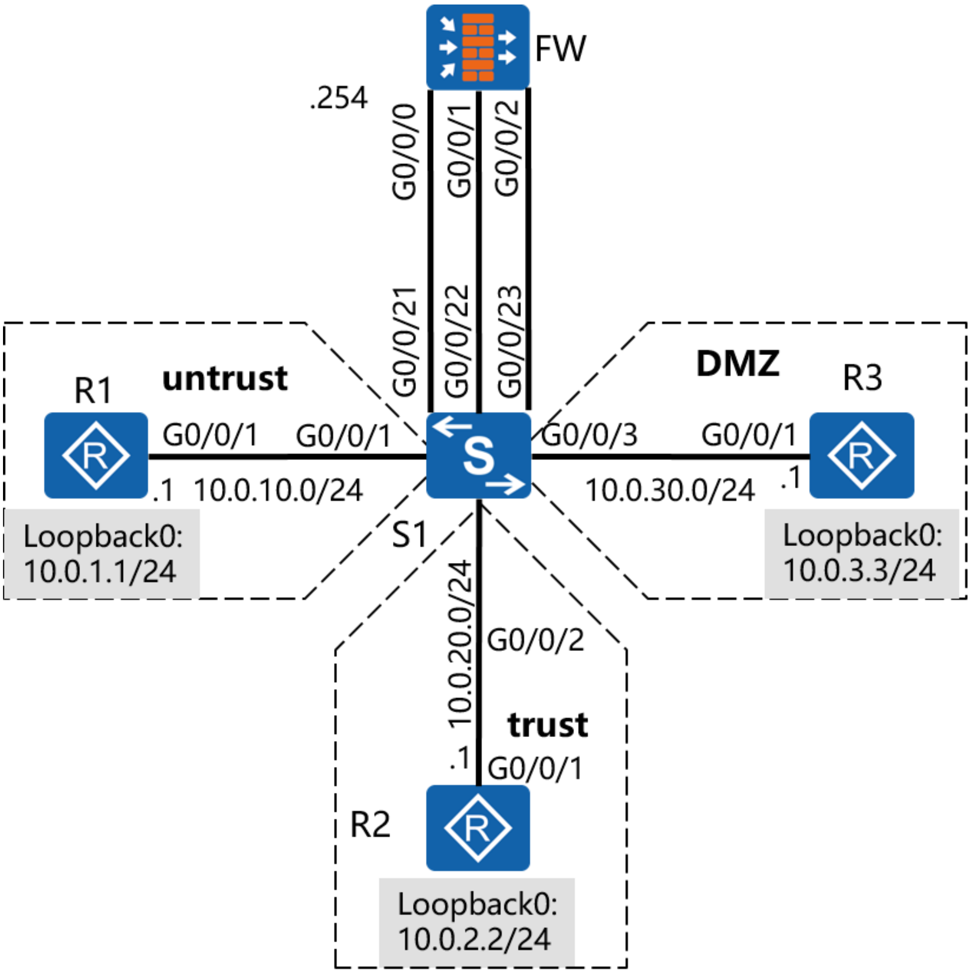


Figure 4-1 Firewall zone configuration

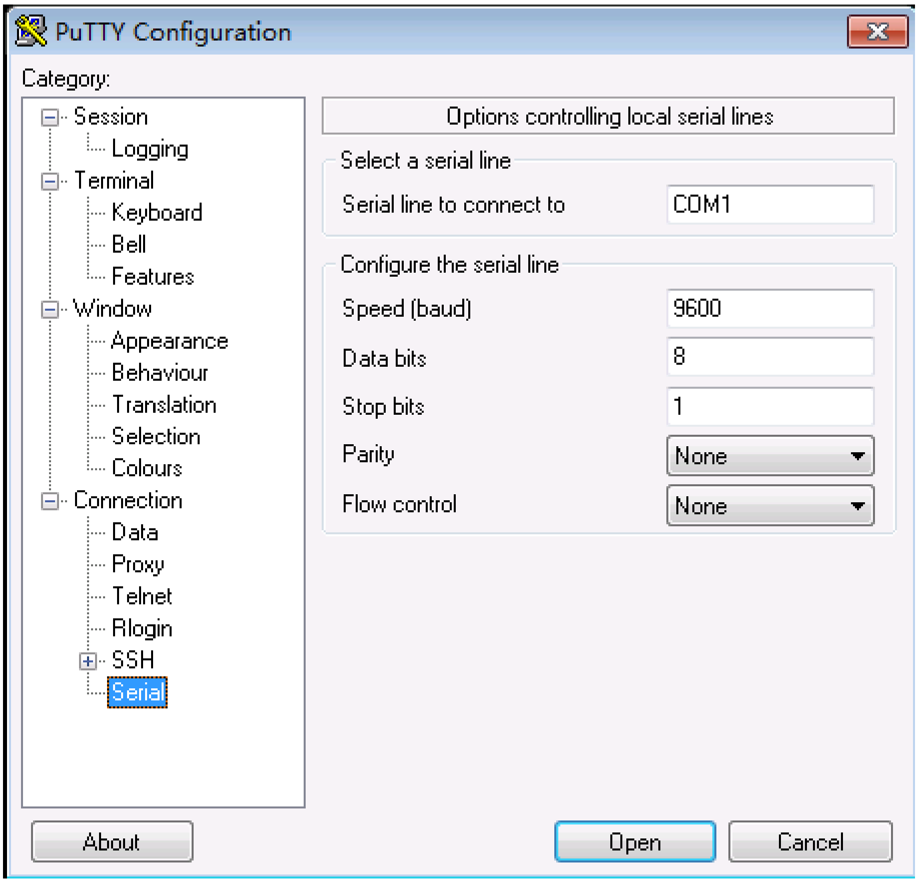
Scenario

Assume that you are a network administrator of an enterprise. The headquarters network is divided into three zones: trust, untrust, and DMZ. The firewall is used to control data, ensure internal network security, and provide services for external networks through the DMZ.

Tasks

Step 1 **Log in to the device using the console port.**

1. Connect cables of configuration ports.
   - Disable the firewall and configure a power supply for the terminal.
   - Connect the RS-232 serial port of the terminal to the console port of the firewall through the configuration cable.
   - Power on the device after checking the installation.
2. Configure HyperTerminal software. (You can obtain free HyperTerminal software such as PuTTY from the Internet.)
   - Download the PuTTY software to the local PC and double-click it to run the software.
   - Select Session and set Connection type to Serial.
   - Set parameters for connecting the serial port to the device. Figure 1-2 shows parameter settings.



Options controlling local serial lines

Select a serial line

Serial line to connect to: COM1

Configure the serial line

Speed (baud): 9600

Data bits: 8

Stop bits: 1

Parity: None

Flow control: None

Figure 4-2 Setting PuTTY parameters for connecting the serial port to the firewall

- Click **Open**.

3. Press **Enter**, and enter the default administrator account **admin** and password **Admin@123**.
4. Modify the password of the default administrator account, and enter the CLI.

To ensure security, the password must meet the minimum complexity requirement. That is, the password must contain at least three combinations of uppercase letters (A to Z), lowercase letters (a to z), digits (0 to 9), and special characters (such as !, @, #, $, and %).

Remember the new password for future logins.

Step 2 **Perform basic configurations and configure IP addresses.**

Configure IP addresses and static routes for routers and the firewall, and configure

VLANs on the switch.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.10.1 24
[R1-GigabitEthernet0/0/1]quit
[R1]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24
```

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.20.1 24
[R2-GigabitEthernet0/0/1]quit
[R2]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24
```

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]ip address 10.0.30.1 24
[R3-GigabitEthernet0/0/1]quit
[R3]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
```

By default, the firewall has configured the IP address of GigabitEthernet0/0/0. You can delete it to prevent address conflicts.

```
<USG6300>system-view

Enter system view, return user view with Ctrl+Z.

[USG6300]sysname FW

[FW]int GigabitEthernet 0/0/0

[FW-GigabitEthernet0/0/0]undo ip address

[FW-GigabitEthernet0/0/0]quit

[FW]interface GigabitEthernet 1/0/0

[FW-GigabitEthernet1/0/0]ip address 10.0.10.254 24

[FW-GigabitEthernet1/0/0]quit

[FW]interface GigabitEthernet 1/0/1

[FW-GigabitEthernet1/0/1]ip address 10.0.20.254 24

[FW-GigabitEthernet1/0/1]quit

[FW]interface GigabitEthernet 1/0/2

[FW-GigabitEthernet1/0/2]ip address 10.0.30.254 24

[FW-GigabitEthernet1/0/2]quit
```

Configure VLANs on the switch as required.

```
[Quidway]sysname S1

[S1]vlan batch 11 to 13

[S1]interface GigabitEthernet 0/0/1

[S1-GigabitEthernet0/0/1]port link-type access

[S1-GigabitEthernet0/0/1]port default vlan 11

[S1-GigabitEthernet0/0/1]quit

[S1]interface GigabitEthernet 0/0/2

[S1-GigabitEthernet0/0/2]port link-type access

[S1-GigabitEthernet0/0/2]port default vlan 12
```

```
[S1-GigabitEthernet0/0/2]quit

[S1]interface GigabitEthernet 0/0/3

[S1-GigabitEthernet0/0/3]port link-type access

[S1-GigabitEthernet0/0/3]port default vlan 13

[S1-GigabitEthernet0/0/3]quit

[S1]interface GigabitEthernet 0/0/21

[S1-GigabitEthernet0/0/21]port link-type access

[S1-GigabitEthernet0/0/21]port default vlan 11

[S1-GigabitEthernet0/0/21]quit

[S1]interface GigabitEthernet 0/0/22

[S1-GigabitEthernet0/0/22]port link-type access

[S1-GigabitEthernet0/0/22]port default vlan 12

[S1-GigabitEthernet0/0/22]quit

[S1]interface GigabitEthernet 0/0/23

[S1-GigabitEthernet0/0/23]port link-type access

[S1-GigabitEthernet0/0/23]port default vlan 13
```

Configure default routes on R1, R2, and R3 and specific static routes on the firewall to implement connectivity of three network segments that are connected by three Loopback0 interfaces.

```
[R1]ip route-static 0.0.0.0 0 10.0.10.254


[R2]ip route-static 0.0.0.0 0 10.0.20.254


[R3]ip route-static 0.0.0.0 0 10.0.30.254


[FW]ip route-static 10.0.1.0 24 10.0.10.1

[FW]ip route-static 10.0.2.0 24 10.0.20.1
```

```
[FW]ip route-static 10.0.3.0 24 10.0.30.1
```

After the configuration is complete, check routing information on the firewall.

```
[FW]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

      10.0.1.0/24   Static   60   0          RD   10.0.10.1       GigabitEthernet1/0/0
      10.0.2.0/24   Static   60   0          RD   10.0.20.1       GigabitEthernet1/0/1
     10.0.3.0/24    Static   60   0          RD   10.0.30.1       GigabitEthernet1/0/2
     10.0.10.0/24   Direct   0    0           D   10.0.10.254     GigabitEthernet1/0/0
   10.0.10.254/32   Direct   0    0           D   127.0.0.1       InLoopBack0
     10.0.20.0/24   Direct   0    0           D   10.0.20.254     GigabitEthernet1/0/1
   10.0.20.254/32   Direct   0    0           D   127.0.0.1       InLoopBack0
     10.0.30.0/24   Direct   0    0           D   10.0.30.254     GigabitEthernet1/0/2
   10.0.30.254/32   Direct   0    0           D   127.0.0.1       InLoopBack0
     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
```

Step 3 **Configure firewall zones.**

The firewall has four zones by default: local zone, trust zone, untrust zone, and DMZ. Here, the trust zone, untrust zone, and DMZ are used. Add interfaces to zones. To prevent address conflicts, delete GE0/0/0 because GE0/0/0 is added to the trust zone by default.

```
[FW]firewall zone dmz
[FW-zone-dmz]add interface GigabitEthernet 1/0/2
[FW-zone-dmz]quit
[FW]firewall zone trust
[FW-zone-trust]add interface GigabitEthernet 1/0/1
[FW-zone-trust]undo add interface GigabitEthernet 0/0/0
[FW-zone-trust]quit
[FW]firewall zone untrust
[FW-zone-untrust]add interface GigabitEthernet 1/0/0
[FW-zone-untrust]quit
```

Check zones where interfaces belong.

```
[FW]display zone interface

local
#
trust
  interface of the zone is (1):
      GigabitEthernet1/0/1
#
untrust
  interface of the zone is (1):
      GigabitEthernet1/0/0
#
dmz
  interface of the zone is (1):
    GigabitEthernet1/0/2
#
```

Check the priority of each zone.

```
[FW]display zone

local
 priority is 100
#
trust
 priority is 85
 interface of the zone is (1):
    GigabitEthernet1/0/1
#
untrust
 priority is 5
 interface of the zone is (1):
    GigabitEthernet1/0/0
#
dmz
 priority is 50
 interface of the zone is (1):
    GigabitEthernet1/0/2
#
```

You can see that three interfaces have been added to corresponding zones. By default, interfaces in different zones cannot communicate with each other. Traffic between routers cannot pass through zones, so inter-zone security policies are required to allow traffic to pass.

Step 4 **Configure a security policy.**

If no inter-zone security policy is configured on the firewall or no security policy is matched, the default packet filtering policy is used by default. That is, all traffic is denied.

Configure a security policy to enable devices in the trust zone to access devices in other zones and prevent access between other zones.

```
[FW]security-policy
[FW-policy-security]rule name policy_sec_1
[FW-policy-security-rule-policy_sec_1]source-zone trust
[FW-policy-security-rule-policy_sec_1]destination-zone untrust
[FW-policy-security-rule-policy_sec_1]action permit
[FW-policy-security-rule-policy_sec_1]quit
[FW-policy-security]rule name policy_sec_2
[FW-policy-security-rule-policy_sec_2]source-zone trust
[FW-policy-security-rule-policy_sec_2]destination-zone dmz
[FW-policy-security-rule-policy_sec_2]action permit
[FW-policy-security-rule-policy_sec_2]quit
[FW-policy-security]quit
```

Verify the configuration.

```
[FW]display security-policy all

Total:3
RULE ID RULE NAME                     STATE      ACTION          HITTED
------------------------------------------------------------------------
```

```
0          default                              enable       deny                  0
1          policy_sec_1                        enable       permit               0
2          policy_sec_2                        enable       permit               0
-------------------------------------------------------------------------


[FW]display security-policy rule policy_sec_1


  (0 times matched)
 rule name policy_sec_1
  source-zone trust
  destination-zone untrust
  action permit


[FW]display security-policy rule policy_sec_2


  (0 times matched)
 rule name policy_sec_2
  source-zone trust
  destination-zone dmz
  action permit
```

Check the connectivity from the trust zone to the untrust zone and DMZ.

```
[R2]ping -a 10.0.2.2 10.0.1.1
  PING 10.0.1.1: 56   data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[R2]ping -a 10.0.2.2 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=254 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=1 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 1/1/1 ms
```

Check the connectivity from the untrust zone to the trust zone and DMZ.

```
[R1]ping -a 10.0.1.1 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

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

[R1]ping -a 10.0.1.1 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

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

Check the connectivity from the DMZ to the untrust zone and trust zone.

```
[R3]ping -a 10.0.3.3 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
```

```
      Request time out

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

[R3]ping -a 10.0.3.3 10.0.2.2
   PING 10.0.2.2: 56   data bytes, press CTRL_C to break
      Request time out
      Request time out
      Request time out
      Request time out
      Request time out

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

Through verification, devices in the trust zone can access the untrust zone and the DMZ, but devices in other zones cannot access each other.

Configure an inter-zone packet filtering policy to allow devices in the untrust zone to access the specified server in the DMZ.

The Telnet service is enabled for the untrust zone on the server at 10.0.3.3 in the DMZ. Enable ICMP ping to test network connectivity.

```
[FW]security-policy
[FW-policy-security]rule name policy_sec_3
```

```
[FW-policy-security-rule-policy_sec_3]source-zone untrust

[FW-policy-security-rule-policy_sec_3]destination-zone dmz

[FW-policy-security-rule-policy_sec_3]destination-address 10.0.3.3 mask 255.255.255.255

[FW-policy-security-rule-policy_sec_3]service icmp

[FW-policy-security-rule-policy_sec_3]service telnet

[FW-policy-security-rule-policy_sec_3]action permit
```

Enable the Telnet function on R3 to perform the Telnet test.

```
[R3]telnet server enable

[R3]aaa

[R3-aaa]local-user test password irreversible-cipher Admin@123

[R3-aaa]local-user test service-type telnet

[R3-aaa]quit

[R3]user-interface vty 0 4

[R3-ui-vty0-4]authentication-mode aaa

[R3-ui-vty0-4]protocol inbound telnet
```

Perform ping and Telnet operations from R1 (untrust zone) to R3 (DMZ).

```
<R1>ping 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=254 time=1 ms

    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=1 ms

    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=1 ms

    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=1 ms

    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=1 ms


  --- 10.0.3.3 ping statistics ---

    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

<R1>ping 10.0.30.1
  PING 10.0.30.1: 56   data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

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

<R1>telnet 10.0.3.3
  Press CTRL_] to quit telnet mode
  Trying 10.0.3.3 ...
  Connected to 10.0.3.3 ...

Login authentication


Username:test
Password:
  -------------------------------------------------------------------------
  User last login information:
```

```
  ------------------------------------------------------------------------------
  Access Type: Telnet
  IP-Address : 10.0.10.1
  Time        : 2016-09-25 03:29:23+00:00
  ------------------------------------------------------------------------------
<R3>quit

  Info:Configuration console exit, please retry to log on

  The connection was closed by the remote host

<R1>telnet 10.0.30.1
  Press CTRL_] to quit telnet mode
  Trying 10.0.30.1 ...
  Error: Can't connect to the remote host
<R1>
```

Through verification, only ICMP and Telnet packets with the specified IP address can pass, and other traffic are denied.

Device Configuration

```
<S1>display current-configuration
!Software Version V200R008C00SPC500
#
sysname S1
#
vlan batch 11 to 13
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 11
#
interface GigabitEthernet0/0/2
 port link-type access
 port default vlan 12
#
interface GigabitEthernet0/0/3
 port link-type access
 port default vlan 13
#
interface GigabitEthernet0/0/21
 port link-type access
 port default vlan 11
#
interface GigabitEthernet0/0/22
 port link-type access
 port default vlan 12
#
interface GigabitEthernet0/0/23
 port link-type access
 port default vlan 13
#
return

<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
```

```
interface GigabitEthernet0/0/1
 ip address 10.0.10.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
ip route-static 0.0.0.0 0.0.0.0 10.0.10.254
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
interface GigabitEthernet0/0/1
 ip address 10.0.20.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ip route-static 0.0.0.0 0.0.0.0 10.0.20.254
#
return

<R3>display current-configuration
[V200R007C00SPC600]
#
 sysname R3
```

```
#
aaa
 local-user test password irreversible-cipher Admin@123
 local-user test privilege level 0
 local-user test service-type telnet
#
interface GigabitEthernet0/0/1
 ip address 10.0.30.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
 telnet server enable
#
ip route-static 0.0.0.0 0.0.0.0 10.0.30.254
#
user-interface vty 0 4
 authentication-mode aaa
 protocol inbound telnet
#
return

<FW>display current-configuration
#
 sysname FW
#
interface GigabitEthernet1/0/0
 ip address 10.0.10.254 255.255.255.0
#
```

```
interface GigabitEthernet1/0/1
 ip address 10.0.20.254 255.255.255.0
#
interface GigabitEthernet1/0/2
 ip address 10.0.30.254 255.255.255.0
#
firewall zone local
 set priority 100
#
firewall zone trust
 set priority 85
 add interface GigabitEthernet1/0/1
#
firewall zone untrust
 set priority 5
 add interface GigabitEthernet1/0/0
#
firewall zone dmz
 set priority 50
 add interface GigabitEthernet1/0/2
#
 ip route-static 10.0.1.0 255.255.255.0 10.0.10.1
 ip route-static 10.0.2.0 255.255.255.0 10.0.20.1
 ip route-static 10.0.3.0 255.255.255.0 10.0.30.1
#
security-policy
 rule name policy_sec_1
  source-zone trust
  destination-zone untrust
  action permit
 rule name policy_sec_2
  source-zone trust
  destination-zone dmz
  action permit
 rule name policy_sec_3
  source-zone untrust
  destination-zone dmz
  destination-address 10.0.3.3 mask 255.255.255.255
  service icmp
  service telnet
  action permit
#
return
```

Lab 4-2 Firewall NAT Configuration

Learning Objectives

The objectives of this lab are to learn and understand:

- How to configure Network Address and Port Translation (NAPT) based on the address pool on the firewall
- How to configure the NAT server on the firewall

Topology

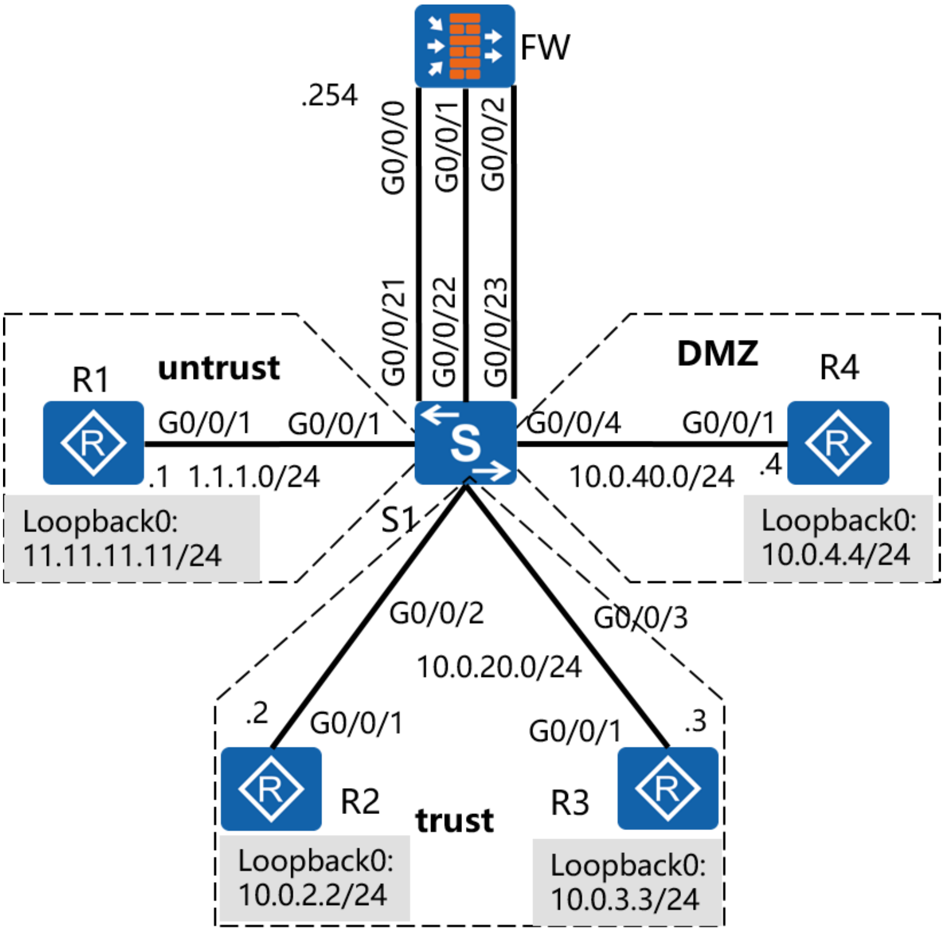


Figure 4-2 NAT configuration on the firewall

Scenario

Assume that you are a network administrator of an enterprise. The enterprise network is isolated into three zones by the firewall. Users in the trust zone are required to access the untrust zone, You need to deliver Telnet and FTP services provided by the server at 10.0.4.4 in the DMZ, and set the public IP address to 1.1.1.254/24.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses and static routes for routers and the firewall, and configure

VLANs on the switch.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 1.1.1.1 24
[R1-GigabitEthernet0/0/1]quit
[R1]interface loopback 0
[R1-LoopBack0]ip address 11.11.11.11 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.20.2 24
[R2-GigabitEthernet0/0/1]quit
[R2]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet0/0/1
[R3-GigabitEthernet0/0/1]ip address 10.0.20.3 24
[R3-GigabitEthernet0/0/1]quit
[R3]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24

<Huawei>system-view
```

```
Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R4

[R4]interface GigabitEthernet 0/0/1

[R4-GigabitEthernet0/0/1]ip address 10.0.40.4 24

[R4-GigabitEthernet0/0/1]quit

[R4]interface loopback 0

[R4-LoopBack0]ip address 10.0.4.4 24
```

By default, the firewall has configured the IP address of GigabitEthernet0/0/0. You can delete it to prevent address conflicts.

```
<USG6300>system-view

Enter system view, return user view with Ctrl+Z.

[USG6300]sysname FW

[FW]interface GigabitEthernet 0/0/0

[FW-GigabitEthernet0/0/0]undo ip address

[FW-GigabitEthernet0/0/0]quit

[FW]interface GigabitEthernet 1/0/0

[FW-GigabitEthernet1/0/0]ip address 10.0.10.254 24

[FW-GigabitEthernet1/0/0]ip address 1.1.1.254 24 sub

[FW-GigabitEthernet1/0/0]quit

[FW]interface GigabitEthernet 1/0/1

[FW-GigabitEthernet1/0/1]ip address 10.0.20.254 24

[FW-GigabitEthernet1/0/1]quit

[FW]interface GigabitEthernet 1/0/2

[FW-GigabitEthernet1/0/2]ip address 10.0.40.254 24

[FW-GigabitEthernet1/0/2]quit
```

Configure VLANs on the switch as required.

```
[Quidway]sysname S1

[S1]vlan batch 11 to 13

[S1]interface GigabitEthernet 0/0/1

[S1-GigabitEthernet0/0/1]port link-type access

[S1-GigabitEthernet0/0/1]port default vlan 11

[S1-GigabitEthernet0/0/1]quit

[S1]interface GigabitEthernet 0/0/2

[S1-GigabitEthernet0/0/2]port link-type access

[S1-GigabitEthernet0/0/2]port default vlan 12

[S1-GigabitEthernet0/0/2]quit

[S1]interface GigabitEthernet 0/0/3

[S1-GigabitEthernet0/0/3]port link-type access

[S1-GigabitEthernet0/0/3]port default vlan 12

[S1-GigabitEthernet0/0/2]quit

[S1]interface GigabitEthernet 0/0/4

[S1-GigabitEthernet0/0/3]port link-type access

[S1-GigabitEthernet0/0/3]port default vlan 13

[S1-GigabitEthernet0/0/3]quit

[S1]interface GigabitEthernet 0/0/21

[S1-GigabitEthernet0/0/21]port link-type access

[S1-GigabitEthernet0/0/21]port default vlan 11

[S1-GigabitEthernet0/0/21]quit

[S1]interface GigabitEthernet 0/0/22

[S1-GigabitEthernet0/0/22]port link-type access

[S1-GigabitEthernet0/0/22]port default vlan 12

[S1-GigabitEthernet0/0/22]quit

[S1]interface GigabitEthernet 0/0/23

[S1-GigabitEthernet0/0/23]port link-type access

[S1-GigabitEthernet0/0/23]port default vlan 13
```

Configure default routes on R2, R3, and R4 and specific static routes on the firewall to implement connectivity of network segments that are connected four Loopback0 interfaces. The default route does not need to be defined on R1 used as an Internet device because R1 does not need to know any private network information about the trust zone and DMZ.

```
[R2]ip route-static 0.0.0.0 0 10.0.20.254


[R3]ip route-static 0.0.0.0 0 10.0.20.254


[R4]ip route-static 0.0.0.0 0 10.0.40.254


[FW]ip route-static 10.0.2.0 24 10.0.20.2
[FW]ip route-static 10.0.3.0 24 10.0.20.3
[FW]ip route-static 10.0.4.0 24 10.0.40.4
[FW]ip route-static 0.0.0.0 0 1.1.1.1
```

After the configuration is complete, check routing information on the firewall.

```
[FW]display ip routing-table
06:44:57  2016/09/25
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 12         Routes : 12

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

         0.0.0.0/0   Static   60   0          RD   1.1.1.1         GigabitEthernet1/0/0
```

```
        1.1.1.0/24   Direct   0     0          D   1.1.1.254        GigabitEthernet1/0/0
      1.1.1.254/32   Direct   0     0          D   127.0.0.1        InLoopBack0
        10.0.2.0/24  Static   60    0          RD  10.0.20.2        GigabitEthernet1/0/1
        10.0.3.0/24  Static   60    0          RD  10.0.20.3        GigabitEthernet1/0/1
        10.0.4.0/24  Static   60    0          RD  10.0.40.4        GigabitEthernet1/0/2
      10.0.20.0/24   Direct   0     0          D   10.0.20.254      GigabitEthernet1/0/1
    10.0.20.254/32   Direct   0     0          D   127.0.0.1        InLoopBack0
      10.0.40.0/24   Direct   0     0          D   10.0.40.254      GigabitEthernet1/0/2
    10.0.40.254/32   Direct   0     0          D   127.0.0.1        InLoopBack0
      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
```

Step 2 **Add interfaces to zones.**

The firewall has four zones by default: local zone, trust zone, untrust zone, and DMZ. Here, the trust zone, untrust zone, and DMZ are used. Add interfaces to zones. To prevent address conflicts, delete GE0/0/0 because GE0/0/0 is added to the trust zone by default.

```
[FW]firewall zone dmz
[FW-zone-dmz]add interface GigabitEthernet 1/0/2
[FW-zone-dmz]quit
[FW]firewall zone trust
[FW-zone-trust]add interface GigabitEthernet 1/0/1
[FW-zone-trust]undo add interface GigabitEthernet 0/0/0
[FW-zone-trust]quit
[FW]firewall zone untrust
[FW-zone-untrust]add interface GigabitEthernet 1/0/0
[FW-zone-untrust]quit
```

Check zones where interfaces belong.

```
[FW]display zone interface


local

#

trust

  interface of the zone is (1):

        GigabitEthernet1/0/1

#

untrust

  interface of the zone is (1):

        GigabitEthernet1/0/0

#

dmz

  interface of the zone is (1):

        GigabitEthernet1/0/2

#
```

Check the priority of each zone.

```
[FW]display zone


local

  priority is 100

#

trust

         priority is 85

  interface of the zone is (1):

        GigabitEthernet1/0/1

#
```

```
untrust
    priority is 5
 interface of the zone is (1):
    GigabitEthernet1/0/0
#
dmz
    priority is 50
 interface of the zone is (1):
    GigabitEthernet1/0/2
#
```

You can see that three interfaces have been added to corresponding zones. By default, interfaces in different zones cannot communicate with each other. Traffic between routers cannot pass through zones, so inter-zone security policies are required to allow traffic to pass.

Step 3 **Configure a security policy.**

If no inter-zone security policy is configured on the firewall or no security policy is matched, the default packet filtering policy is used by default. That is, all traffic is denied.

Configure the firewall to permit data packets sent from network segments 10.0.2.0 and 10.0.3.0 in the trust zone to the untrust zone, and allow Telnet and FTP requests sent from the untrust zone to the destination server at 10.0.4.4 in the DMZ.

```
[FW]security-policy
[FW-policy-security]rule name policy_sec_1
[FW-policy-security-rule-policy_sec_1]source-zone trust
[FW-policy-security-rule-policy_sec_1]destination-zone untrust
[FW-policy-security-rule-policy_sec_1]source-address 10.0.2.0 mask 255.255.255.0
```

```
[FW-policy-security-rule-policy_sec_1]source-address 10.0.3.0 mask 255.255.255.0
[FW-policy-security-rule-policy_sec_1]action permit
[FW-policy-security-rule-policy_sec_1]quit
[FW-policy-security]rule name policy_sec_2
[FW-policy-security-rule-policy_sec_2]source-zone untrust
[FW-policy-security-rule-policy_sec_2]destination-zone dmz
[FW-policy-security-rule-policy_sec_2]destination-address 10.0.4.4 mask 255.255.255.255
[FW-policy-security-rule-policy_sec_2]service ftp
[FW-policy-security-rule-policy_sec_2]service telnet
[FW-policy-security-rule-policy_sec_2]action permit
```

Step 4 **Configure NAT based on source IP addresses.**

Use the public IP address 1.1.1.254 to translate the source IP address.

```
[FW]nat address-group group1
[FW-nat-address-group-group1]section 1.1.1.254 1.1.1.254
```

After the configuration is complete, check the address pool status.

```
[FW]display nat address-group

NAT address-group information:
 ID             : 0                         name           : group1
 sectionID      : 0                         sectionName    : ---
 startaddr      : 1.1.1.254                 endaddr        : 1.1.1.254
 excludeIP      : 0                         excludePort    : 0
 reference      : 0                         vrrp           : ---
 vpninstance    : root                      natMode        : pat
 description    : ---
```

```
  Total     1 address-groups
```

Configure a NAT policy.

```
[FW]nat-policy
[FW-policy-nat]rule name policy_nat_1
[FW-policy-nat-rule-policy_nat_1]source-zone trust
[FW-policy-nat-rule-policy_nat_1]destination-zone untrust
[FW-policy-nat-rule-policy_nat_1]source-address 10.0.2.2 24
[FW-policy-nat-rule-policy_nat_1]source-address 10.0.3.3 24
[FW-policy-nat-rule-policy_nat_1]action nat address-group group1
```

Test the connectivity.

```
[R2]ping 11.11.11.11
  PING 11.11.11.11: 56   data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

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

[R2]ping -a 10.0.2.2 1.1.1.1
  PING 1.1.1.1: 56   data bytes, press CTRL_C to break
```

```
    Reply from 1.1.1.1: bytes=56 Sequence=1 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

  --- 1.1.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[R3]ping 11.11.11.11
  PING 11.11.11.11: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

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

[R3]ping -a 10.0.3.3 11.11.11.11
  PING 11.11.11.11: 56  data bytes, press CTRL_C to break
    Reply from 11.11.11.11: bytes=56 Sequence=1 ttl=254 time=1 ms
    Reply from 11.11.11.11: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 11.11.11.11: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 11.11.11.11: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 11.11.11.11: bytes=56 Sequence=5 ttl=254 time=1 ms

  --- 11.11.11.11 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

When you directly test the connectivity between R2 and 11.11.11.11 and between R3 and 11.11.11.11, the connectivity cannot be implemented. Perform the ping operation with the source IP address specified. The connectivity is implemented.

The cause is that R2 directly sends data packets with the source IP address of 10.0.20.2 to the firewall and this IP address is not within the NAT address range, so does R3.

```
[FW]display nat-policy all

Total:2
RULE ID RULE NAME                          STATE       ACTION              HITTED
-------------------------------------------------------------------------
0         default                        enable      no-nat              0
1         policy_nat_1                   enable      nat                 2
-------------------------------------------------------------------------

[FW]display nat-policy rule policy_nat_1

  (2 times matched)
```

```
 rule name policy_nat_1
  source-zone trust
  destination-zone untrust
  source-address 10.0.2.0 mask 255.255.255.0
  source-address 10.0.3.0 mask 255.255.255.0
  action nat address-group group1
```

Step 5 **Configure the NAT server and NAT based on source IP addresses to deliver services provided by the server.**

Set the public IP address of the NAT server to 1.1.1.254, Telnet port number to 2323, and FTP port number to 2121.

```
[FW]nat server policy_natserver_1 protocol tcp global 1.1.1.254 2323 inside 10.0.4.4 telnet no-reverse
[FW]nat server policy_natserver_2 protocol tcp global 1.1.1.254 2121 inside 10.0.4.4 ftp no-reverse


[FW]display nat server


Server in private network information:
 name                    : policy_natserver_1
 zone                    : ---
 interface               : ---
 global-start-addr : 1.1.1.254              global-end-addr    : ---
 inside-start-addr : 10.0.4.4               inside-end-addr    : ---
 global-start-port : 2323                   global-end-port    : ---
 insideport              : 23(teln)
 globalvpn               : public           insidevpn          : public
 protocol                : tcp              vrrp               : ---
 no-reverse              : yes
```

```
name                   : policy_natserver_2
zone                   : ---
interface              : ---
global-start-addr : 1.1.1.254          global-end-addr     : ---
inside-start-addr : 10.0.4.4           inside-end-addr     : ---
global-start-port : 2121               global-end-port     : ---
insideport             : 21(ftp)
globalvpn              : public        insidevpn           : public
protocol               : tcp           vrrp                : ---
no-reverse             : yes

  Total     2 NAT servers
```

Enable Telnet and FTP services on R4.

```
[R4]telnet server enable
[R4]ftp server enable
[R4]user-interface vty 0 4
[R4-ui-vty0-4]authentication-mode aaa
[R4-ui-vty0-4]protocol inbound telnet
[R4-ui-vty0-4]quit
[R4]aaa
[R4-aaa]local-user test password irreversible-cipher Admin@123
[R4-aaa]local-user test service telnet ftp
[R4-aaa]local-user test ftp-directory flash:/
[R4-aaa]local-user test privilege level 3
[R4-aaa]quit
```

You need to configure NAT Application Level Gateway (NAT ALG) during address translation because FTP is a multi-channel protocol.

Configure NAT ALG in the DMZ and the untrust zone to so that the NAT server can provide FTP services for external users.

```
[FW]firewall interzone dmz untrust

[FW-interzone-dmz-untrust]detect ftp
```

Test the configuration results on R1.

```
<R1>telnet 1.1.1.254 2323

  Press CTRL_] to quit telnet mode

  Trying 1.1.1.254 ...

  Connected to 1.1.1.254 ...


Login authentication



Username:test

Password:

  ------------------------------------------------------------------------

  User last login information:

  ------------------------------------------------------------------------

  Access Type: Telnet

  IP-Address : 1.1.1.1

  Time       : 2016-09-25 07:45:45+00:00

  ------------------------------------------------------------------------

<R4>quit


<R1>ftp 1.1.1.254 2121

Trying 1.1.1.254 ...
```

```
Press CTRL+K to abort
Connected to 1.1.1.254.
220 FTP service ready.
User(1.1.1.254:(none)):test
331 Password required for test.
Enter password:
230 User logged in.

[R1-ftp]
```

The untrust zone can access Telnet and FTP services provided by the DMZ.

Device Configuration

```
 <S1>display current-configuration
!Software Version V200R008C00SPC500
#
sysname S1
#
vlan batch 11 to 13
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 11
#
interface GigabitEthernet0/0/2
 port link-type access
 port default vlan 12
#
interface GigabitEthernet0/0/3
```

```
 port link-type access
 port default vlan 12
#
interface GigabitEthernet0/0/4
 port link-type access
 port default vlan 13
#
interface GigabitEthernet0/0/21
 port link-type access
 port default vlan 11
#
interface GigabitEthernet0/0/22
 port link-type access
 port default vlan 12
#
interface GigabitEthernet0/0/23
 port link-type access
 port default vlan 13
#
return

<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
interface GigabitEthernet0/0/1
 ip address 1.1.1.1 255.255.255.0
#
```

```
interface LoopBack0
 ip address 11.11.11.11 255.255.255.0
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
interface GigabitEthernet0/0/1
 ip address 10.0.20.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ip route-static 0.0.0.0 0.0.0.0 10.0.20.254
#
return

<R3>display current-configuration
[V200R007C00SPC600]
#
 sysname R3
#
interface GigabitEthernet0/0/1
 ip address 10.0.20.3 255.255.255.0
#
interface LoopBack0
```

```
 ip address 10.0.3.3 255.255.255.0
#
ip route-static 0.0.0.0 0.0.0.0 10.0.20.254
#
return


<R4>display current-configuration
[V200R007C00SPC600]
#
 sysname R4
#
aaa
 local-user test password irreversible-cipher Admin@123
 local-user test privilege level 3
 local-user test ftp-directory flash:/
 local-user test service-type telnet ftp
#
interface GigabitEthernet0/0/1
 ip address 10.0.40.4 255.255.255.0
#
interface LoopBack0
 ip address 10.0.4.4 255.255.255.0
#
 ftp server enable
#
 telnet server enable
#
ip route-static 0.0.0.0 0.0.0.0 10.0.40.254
#
```

```
user-interface vty 0 4
 authentication-mode aaa
 protocol inbound telnet
#
return

<FW>display current-configuration
#
 nat server policy_natserver_1 protocol tcp global 1.1.1.254 2323 inside 10.0.4.4 telnet no-reverse
 nat server policy_natserver_2 protocol tcp global 1.1.1.254 2121 inside 10.0.4.4 ftp no-reverse
#
 sysname FW
#
interface GigabitEthernet1/0/0
    ip address 10.0.10.254 255.255.255.0
 ip address 1.1.1.254 255.255.255.0 sub
#
interface GigabitEthernet1/0/1
 ip address 10.0.20.254 255.255.255.0
#
interface GigabitEthernet1/0/2
 ip address 10.0.40.254 255.255.255.0
#
firewall zone local
 set priority 100
#
firewall zone trust
 set priority 85
 add interface GigabitEthernet1/0/1
#
firewall zone untrust
 set priority 5
 add interface GigabitEthernet1/0/0
#
firewall zone dmz
 set priority 50
 add interface GigabitEthernet1/0/2
#
firewall interzone dmz untrust
 detect ftp
#
 ip route-static 0.0.0.0 0.0.0.0 1.1.1.1
 ip route-static 10.0.2.0 255.255.255.0 10.0.20.2
 ip route-static 10.0.3.0 255.255.255.0 10.0.20.3
 ip route-static 10.0.4.0 255.255.255.0 10.0.40.4
#
 nat address-group group1
 section 0 1.1.1.254 1.1.1.254
#
security-policy
 rule name policy_sec_1
  source-zone trust
  destination-zone untrust
  source-address 10.0.2.0 mask 255.255.255.0
  source-address 10.0.3.0 mask 255.255.255.0
  action permit
 rule name policy_sec_2
```

```
  source-zone untrust
  destination-zone dmz
  destination-address 10.0.4.4 mask 255.255.255.255
  service ftp
  service telnet
  action permit
#
nat-policy
 rule name policy_nat_1
  source-zone trust
  destination-zone untrust
  source-address 10.0.2.0 mask 255.255.255.0
  source-address 10.0.3.0 mask 255.255.255.0
  action nat address-group group1
#
return
```

Chapter 5 VRRP Configuration

Lab 5-1 VRRP Configuration

Learning Objectives

The objectives of this lab are to learn and understand:

- How to configure a Virtual Router Redundancy Protocol (VRRP) group and the virtual IP address
- How to configure the VRRP priority
- How to check the VRRP configuration
- How to configure VRRP to monitor the uplink
- How to configure load balancing for multiple VRRP groups

Topology

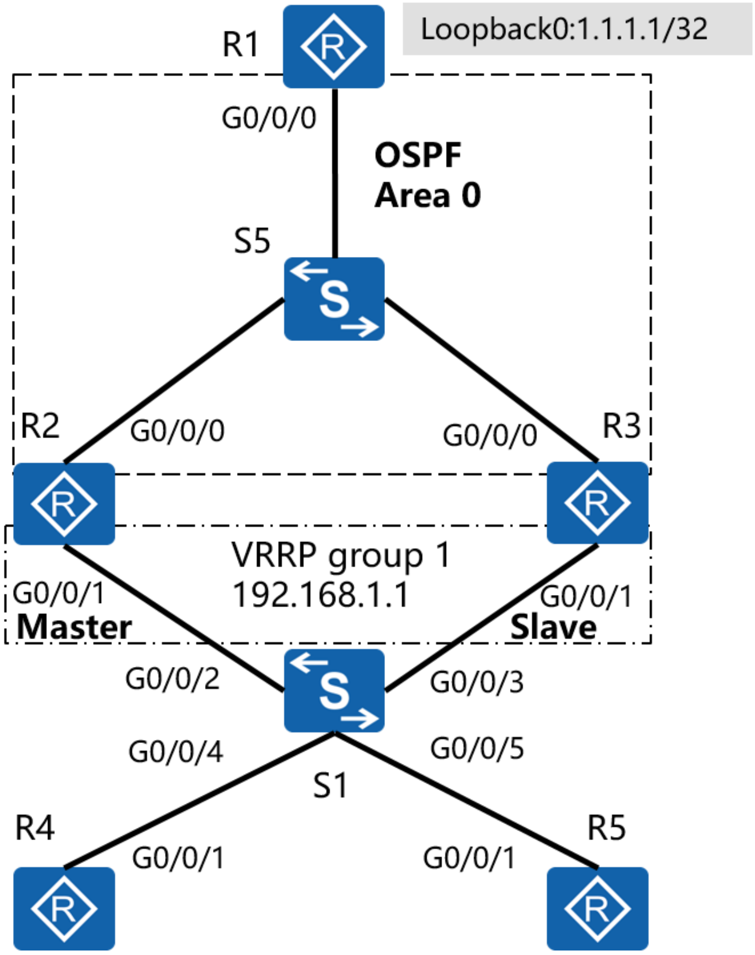


Figure 5-1 VRRP topology

Scenario

R1 functions as the gateway for a LAN and an external network. R1 connects to R2 and R3 through S5, and R2, R3, R4, and R5 connect to a LAN through S1. VRRPv2 needs to be enabled on interfaces of R2 and R3 connecting to S1 to implement first-hop redundancy. R2 is the master router and R3 is the backup router. No extra configurations are required for switches. The switches only transparently forward packets.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses for all routers.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface loopback 0
[R1-LoopBack0]ip address 1.1.1.1 32
[R1-LoopBack0]quit
[R1]interface GigabitEthernet 0/0/0
[R1-GigabitEthernet0/0/0]ip address 10.0.123.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet 0/0/0
[R2-GigabitEthernet0/0/0]ip address 10.0.123.2 24
[R2-GigabitEthernet0/0/0]quit
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]ip address 192.168.1.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ip address 10.0.123.3 24
[R3-GigabitEthernet0/0/0]quit
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]ip address 192.168.1.3 24

<Huawei>system-view
```

```
Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R4

[R4]interface GigabitEthernet 0/0/1

[R4-GigabitEthernet0/0/1]ip address 192.168.1.4 24


<Huawei>system-view

Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R5

[R5]interface GigabitEthernet 0/0/1

[R5-GigabitEthernet0/0/1]ip address 192.168.1.5 24
```

After the configuration is complete, test the connectivity between R1 and R2 and between R1 and R3.

```
[R1]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=1 ms

    Reply from 10.0.123.2: bytes=56 Sequence=2 ttl=255 time=1 ms

    Reply from 10.0.123.2: bytes=56 Sequence=3 ttl=255 time=1 ms

    Reply from 10.0.123.2: bytes=56 Sequence=4 ttl=255 time=1 ms

    Reply from 10.0.123.2: bytes=56 Sequence=5 ttl=255 time=1 ms


  --- 10.0.123.2 ping statistics ---

    5 packet(s) transmitted

    5 packet(s) received

    0.00% packet loss

    round-trip min/avg/max = 1/1/1 ms


[R1]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=1 ms
    Reply from 10.0.123.3: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.123.3: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.123.3: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.123.3: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.123.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Test the connectivity between R2, R3, R4, and R5. R2 is used as an example.

```
[R2]ping 192.168.1.3
  PING 192.168.1.3: 56  data bytes, press CTRL_C to break
    Reply from 192.168.1.3: bytes=56 Sequence=1 ttl=255 time=27 ms
    Reply from 192.168.1.3: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 192.168.1.3: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 192.168.1.3: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 192.168.1.3: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 192.168.1.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/6/27 ms
```

```
[R2]ping 192.168.1.4
  PING 192.168.1.4: 56  data bytes, press CTRL_C to break
    Reply from 192.168.1.4: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 192.168.1.4: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 192.168.1.4: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 192.168.1.4: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 192.168.1.4: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 192.168.1.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[R2]ping 192.168.1.5
  PING 192.168.1.5: 56  data bytes, press CTRL_C to break
    Reply from 192.168.1.5: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 192.168.1.5: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 192.168.1.5: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 192.168.1.5: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 192.168.1.5: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 192.168.1.5 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Step 2 **Configure OSPF and static routes.**

The loopback interface on R1 and connected interfaces on R1, R2, and R3 run in OSPF area 0. Routes of interfaces on R2 and R3 connecting to S1 are advertised to OSPF, but no OSPF neighbor relationships. The silent mode is therefore used.

To simulate PCs, R4 and R5 use default static routes pointing to 192.168.1.1 (VRRP virtual IP address).

Enable R1 to learn routes to 192.168.1.0, and enable R2 and R3 to learn routes to 1.1.1.1.

```
[R1]ospf 1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.123.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 1.1.1.1 0.0.0.0

[R2]ospf 1
[R2-ospf-1]silent-interface GigabitEthernet 0/0/1
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.123.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 192.168.1.0 0.0.0.255

[R3]ospf 1
[R3-ospf-1]silent-interface GigabitEthernet 0/0/1
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.0.123.0 0.0.0.255
[R3-ospf-1-area-0.0.0.0]network 192.168.1.0 0.0.0.255

[R4]ip route-static 0.0.0.0 0.0.0.0 192.168.1.1
[R5]ip route-static 0.0.0.0 0.0.0.0 192.168.1.1
```

After the configuration is complete, check the routing table ofR1, R2, and R4.

```
[R1]display ip routing-table

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Tables: Public

         Destinations : 9          Routes : 10


Destination/Mask    Proto   Pre  Cost       Flags NextHop         Interface


        1.1.1.1/32  Direct  0    0           D    127.0.0.1       LoopBack0

     10.0.123.0/24  Direct  0    0           D    10.0.123.1      GigabitEthernet0/0/0

     10.0.123.1/32  Direct  0    0           D    127.0.0.1       GigabitEthernet0/0/0

   10.0.123.255/32  Direct  0    0           D    127.0.0.1       GigabitEthernet0/0/0

      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

    192.168.1.0/24  OSPF    10   2           D    10.0.123.3      GigabitEthernet0/0/0

                    OSPF    10   2           D    10.0.123.2      GigabitEthernet0/0/0

255.255.255.255/32  Direct  0    0           D    127.0.0.1       InLoopBack0


[R2]display ip routing-table

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Tables: Public

         Destinations : 12         Routes : 12


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

```
          1.1.1.1/32   OSPF     10    1             D    10.0.123.1        GigabitEthernet0/0/0
          10.0.0.2/32   Direct   0     0             D    127.0.0.1         LoopBack0
        10.0.123.0/24   Direct   0     0             D    10.0.123.2        GigabitEthernet0/0/0
        10.0.123.2/32   Direct   0     0             D    127.0.0.1         GigabitEthernet0/0/0
      10.0.123.255/32   Direct   0     0             D    127.0.0.1         GigabitEthernet0/0/0
         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
       192.168.1.0/24   Direct   0     0             D    192.168.1.2       GigabitEthernet0/0/1
       192.168.1.2/32   Direct   0     0             D    127.0.0.1         GigabitEthernet0/0/1
     192.168.1.255/32   Direct   0     0             D    127.0.0.1         GigabitEthernet0/0/1
  255.255.255.255/32   Direct   0     0             D    127.0.0.1         InLoopBack0

[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

          0.0.0.0/0   Static   60    0           RD   192.168.1.1       GigabitEthernet0/0/1
          10.0.0.4/32   Direct   0     0             D    127.0.0.1         LoopBack0
         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
       192.168.1.0/24   Direct   0     0             D    192.168.1.4       GigabitEthernet0/0/1
       192.168.1.4/32   Direct   0     0             D    127.0.0.1         GigabitEthernet0/0/1
     192.168.1.255/32   Direct   0     0             D    127.0.0.1         GigabitEthernet0/0/1
```

```
255.255.255.255/32   Direct   0     0              D     127.0.0.1          InLoopBack0
```

The preceding output shows that R1 can learn routes to 192.168.1.0/24, R2 can learn routes to 1.1.1.1/32, and R4 has a default static route to 192.168.1.1.

Step 3 **Configure a VRRP group and the virtual IP address.**

Enable VRRP on interfaces of R2 and R3, and configure the VRID and virtual IP address.

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]vrrp vrid 1 virtual-ip 192.168.1.1
```

R2 is configured first and becomes the master router if there is no other member in the VRRP group after a period of time.

```
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]vrrp vrid 1 virtual-ip 192.168.1.1
```

After the configuration is complete, check the VRRP status on R2 and R3.

```
[R2]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 100
    PriorityConfig : 100
    MasterPriority : 100
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-22 18:00:03
Last change time : 2016-07-22 18:00:07

[R3]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Backup
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 100
    PriorityConfig : 100
    MasterPriority : 100
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-22 18:03:16
    Last change time : 2016-07-22 18:03:16
```

R2 is selected as the master router and R3 as the backup router. The priorities of master and slave routers are both 100. When R3 is started first, it becomes the master router, which is not expected.

Configure the VRRP priority and verify the active/standby switchover.

Configure VRRP priorities on R2 and R3. A greater priority value indicates a higher priority. Set VRRP priorities of R2 and R3 to 120 and 110, respectively.

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]vrrp vrid 1 priority 120


[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]vrrp vrid 1 priority 110
```

Check the configuration after priorities are changed.

```
[R2]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 120
    PriorityConfig : 120
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-22 18:00:03
    Last change time : 2016-07-22 18:00:07

[R3]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Backup
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 110
    PriorityConfig : 110
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-22 18:03:16
    Last change time : 2016-07-22 18:03:16
```

The preceding output shows that priorities of R2 and R3 have been changed successfully. By default, VRRP preemption is enabled. When the priority of R3 is changed to be higher, an active/standby switchover will be triggered.

Test the connectivity between R4 and R1.

```
[R4]ping 1.1.1.1
  PING 1.1.1.1: 56  data bytes, press CTRL_C to break
    Reply from 1.1.1.1: bytes=56 Sequence=1 ttl=254 time=57 ms
    Reply from 1.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

  --- 1.1.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/12/57 ms
```

The preceding output shows that the virtual gateway works properly and can forward data of the LAN where R4 is located to R1. Normally, the master router forwards data, so traffic passes through R2. To verify the switching status, perform the ping operation from R4 to R1 for a long time and shut down the interface of R2 connected to S1.

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]shutdown
```

R4 discards two data packets during the switchover, and subsequent data is forwarded normally.

```
[R4]ping -c 1000 1.1.1.1
  PING 1.1.1.1: 56  data bytes, press CTRL_C to break
    Reply from 1.1.1.1: bytes=56 Sequence=1 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=6 ttl=254 time=1 ms
    Request time out
    Request time out
    Reply from 1.1.1.1: bytes=56 Sequence=9 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=10 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=11 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=12 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=13 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=14 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=15 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=16 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=17 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=18 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=19 ttl=254 time=1 ms
    Reply from 1.1.1.1: bytes=56 Sequence=20 ttl=254 time=1 ms

  --- 1.1.1.1 ping statistics ---
    20 packet(s) transmitted
    18 packet(s) received
    10.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

R3 becomes the master router after the switchover.

```
[R3]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
```

```
Virtual IP : 192.168.1.1
Master IP : 192.168.1.3
PriorityRun : 110
PriorityConfig : 110
MasterPriority : 110
Preempt : YES     Delay Time : 0 s
TimerRun : 1 s
TimerConfig : 1 s
Auth type : NONE
Virtual MAC : 0000-5e00-0101
Check TTL : YES
Config type : normal-vrrp
Backup-forward : disabled
Create time : 2016-07-22 18:03:16
Last change time : 2016-07-22 18:29:41
```

Configure VRRP to monitor the uplink.

The VRRP active/standby switchover is implemented by listening to Advertisement packets. If the backup router cannot listen to messages of the master router or has a higher priority, the backup router preempts to be the master router (no preemption delay by default).

If the fault occurs on the uplink link, the active/standby switchover is not performed. In this case, all Internet access traffic cannot be forwarded after reaching R2. VRRP is enabled to monitor the uplink. When the uplink fails, R2 automatically reduces its priority. R3 preempts to be the master router, and traffic is switched to the backup router and backup uplink.

Before configuring VRRP to monitor the uplink, restore the link that is shut down.

Configure VRRP to monitor the uplink interface and set the value by which the priority decreases to 30. That is, when the link fails, the priority of R2 becomes 90, which is lower than the priority of R3 (110).

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]undo shutdown
[R2-GigabitEthernet0/0/1]vrrp vrid 1 track interface GigabitEthernet 0/0/0 reduced 30
```

Check the configuration.

```
[R2]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 120
    PriorityConfig : 120
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Track IF : GigabitEthernet0/0/0     Priority reduced : 30
    IF state : UP
    Create time : 2016-07-25 17:14:56 UTC-08:00
    Last change time : 2016-07-25 17:32:27 UTC-08:00
```

Perform the ping operation on R4 for a long time and shut down the uplink interface on R2.

```
[R2]interface GigabitEthernet 0/0/0
[R2-GigabitEthernet0/0/0]shutdown
```

```
[R2]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Backup
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.3
    PriorityRun : 90
    PriorityConfig : 120
    MasterPriority : 110
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Track IF : GigabitEthernet0/0/0     Priority reduced : 30
    IF state : DOWN
    Create time : 2016-07-25 17:14:56 UTC-08:00
    Last change time : 2016-07-25 19:57:46 UTC-08:00
```

```
[R3]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.3
    PriorityRun : 110
    PriorityConfig : 110
    MasterPriority : 110
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-25 17:20:00 UTC-08:00
    Last change time : 2016-07-25 19:56:24 UTC-08:00
```

R3 becomes the master router and traffic is successfully switched to R3.

Restore the uplink and priority of R2. R2 preempts to be the master router again. During preemption, few packets are discarded on R4. This is because OSPF routes are not converged rapidly. For details about route convergence acceleration, see the OSPF experiment.

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


[R2]display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
```

```
Master IP : 192.168.1.2
PriorityRun : 120
PriorityConfig : 120
MasterPriority : 120
Preempt : YES     Delay Time : 0 s
TimerRun : 1 s
TimerConfig : 1 s
Auth type : NONE
Virtual MAC : 0000-5e00-0101
Check TTL : YES
Config type : normal-vrrp
Backup-forward : disabled
Track IF : GigabitEthernet0/0/0     Priority reduced : 30
IF state : UP
Create time : 2016-07-25 17:14:56 UTC-08:00
Last change time : 2016-07-25 20:04:40 UTC-08:00
```

When the interface goes Up, the OSPF neighbor relationship needs to be reestablished on the uplink interface of R2. If OSPF fast convergence is not configured, data cannot be forwarded for several seconds. You are advised to set the preemption delay to be longer than the OSPF convergence time during the switchback.

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]vrrp vrid 1 preempt-mode timer delay 10
```

Check the VRRP configurations again. You can see that the preemption delay has been configured successfully.

```
[R2]display vrrp
```

```
GigabitEthernet0/0/1 | Virtual Router 1
  State : Master
  Virtual IP : 192.168.1.1
  Master IP : 192.168.1.2
  PriorityRun : 120
  PriorityConfig : 120
  MasterPriority : 120
  Preempt : YES     Delay Time : 10 s
  TimerRun : 1 s
  TimerConfig : 1 s
  Auth type : NONE
  Virtual MAC : 0000-5e00-0101
  Check TTL : YES
  Config type : normal-vrrp
  Backup-forward : disabled
  Track IF : GigabitEthernet0/0/0     Priority reduced : 30
  IF state : UP
  Create time : 2016-07-25 17:14:56 UTC-08:00
  Last change time : 2016-07-25 20:04:40 UTC-08:00
```

Step 4 **Configure load balancing of multiple VRRP groups.**

Normally, the master device forwards all traffic, and the backup device is idle.

To implement dual-gateway load balancing, configure multiple VRRP groups. Configure VRRP group 1 on R2 and R3, set the virtual IP address to 192.168.1.1, and configure R2 as the master device. Configure VRRP group 2, set the virtual address to 192.168.1.254, and configure R3 as the master device. Configure the default gateway address pointing to 192.168.1.1 for R4 and the default gateway address pointing to 192.168.1.254 for R5. Internet access traffic can be load balanced to two gateways.

The configuration is as follows.

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]vrrp vrid 2 virtual-ip 192.168.1.254
[R2-GigabitEthernet0/0/1]vrrp vrid 2 priority 110

[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]vrrp vrid 2 virtual-ip 192.168.1.254
[R3-GigabitEthernet0/0/1]vrrp vrid 2 priority 120
[R3-GigabitEthernet0/0/1]vrrp vrid 2 track interface GigabitEthernet0/0/0 reduced 30

[R5]undo ip route-static 0.0.0.0 0.0.0.0 192.168.1.1
[R5]ip route-static 0.0.0.0 0.0.0.0 192.168.1.254
```

Check load balancing of two VRRP groups on R2 and R3.

```
<R2>display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 120
    PriorityConfig : 120
    MasterPriority : 120
    Preempt : YES     Delay Time : 10 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Track IF : GigabitEthernet0/0/0     Priority reduced : 30
    IF state : UP
    Create time : 2016-07-25 17:14:56 UTC-08:00
    Last change time : 2016-07-25 20:04:40 UTC-08:00

  GigabitEthernet0/0/1 | Virtual Router 2
    State : Backup
    Virtual IP : 192.168.1.254
    Master IP : 192.168.1.3
    PriorityRun : 110
    PriorityConfig : 110
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0102
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-25 17:15:54 UTC-08:00
    Last change time : 2016-07-25 17:20:30 UTC-08:00

<R3>display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Backup
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.2
    PriorityRun : 110
    PriorityConfig : 110
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-25 17:20:00 UTC-08:00
    Last change time : 2016-07-25 20:03:15 UTC-08:00

  GigabitEthernet0/0/1 | Virtual Router 2
    State : Master
    Virtual IP : 192.168.1.254
    Master IP : 192.168.1.3
    PriorityRun : 120
    PriorityConfig : 120
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0102
    Check TTL : YES
    Config type : normal-vrrp

    Backup-forward : disabled

    Track IF : GigabitEthernet0/0/0     Priority reduced : 30

    IF state : UP

    Create time : 2016-07-25 17:20:14 UTC-08:00

    Last change time : 2016-07-25 17:20:23 UTC-08:00
```

Perform the tracert operation to check the gateways that process data destined for the two default routes. You can see that data sent by R4 is forwarded by the master device in VRRP group 1 and data sent by R5 is forwarded by the master device in VRRP group 2.

# Enable R1 to send ICMP Port Unreachable packets.

```
[R1]icmp port-unreachable send


<R4>tracert 1.1.1.1


 traceroute to   1.1.1.1(1.1.1.1), max hops: 30 ,packet length: 40,press CTRL_C t
o break


 1 192.168.1.2 80 ms   40 ms   40 ms


 2 10.0.123.1 100 ms   70 ms   70 ms


<R5>tracert 1.1.1.1


 traceroute to   1.1.1.1(1.1.1.1), max hops: 30 ,packet length: 40,press CTRL_C t
o break
```

```
 1 192.168.1.3 50 ms   30 ms   50 ms

 2 10.0.123.1 60 ms   90 ms   60 ms
```

Check the switchover when the uplink fails.

```
[R2]interface GigabitEthernet 0/0/0
[R2-GigabitEthernet0/0/0]shutdown

<R4>tracert 1.1.1.1

 traceroute to   1.1.1.1(1.1.1.1), max hops: 30 ,packet length: 40,press CTRL_C t
o break

 1 192.168.1.3 50 ms   40 ms   50 ms

 2 10.0.123.1 70 ms   80 ms   50 ms

<R5>tracert 1.1.1.1

 traceroute to   1.1.1.1(1.1.1.1), max hops: 30 ,packet length: 40,press CTRL_C t
o break

 1 192.168.1.3 40 ms   50 ms   40 ms

 2 10.0.123.1 70 ms   100 ms   90 ms
```

Check the status of the two VRRP groups.

```
<R2>display vrrp
```

```
GigabitEthernet0/0/1 | Virtual Router 1
  State : Backup
  Virtual IP : 192.168.1.1
  Master IP : 192.168.1.3
  PriorityRun : 90
  PriorityConfig : 120
  MasterPriority : 110
  Preempt : YES     Delay Time : 10 s
  TimerRun : 1 s
  TimerConfig : 1 s
  Auth type : NONE
  Virtual MAC : 0000-5e00-0101
  Check TTL : YES
  Config type : normal-vrrp
  Backup-forward : disabled
  Track IF : GigabitEthernet0/0/0     Priority reduced : 30
  IF state : DOWN
  Create time : 2016-07-25 17:14:56 UTC-08:00
  Last change time : 2016-07-25 20:48:28 UTC-08:00

GigabitEthernet0/0/1 | Virtual Router 2
  State : Backup
  Virtual IP : 192.168.1.254
  Master IP : 192.168.1.3
  PriorityRun : 110
  PriorityConfig : 110
  MasterPriority : 120
  Preempt : YES     Delay Time : 0 s
  TimerRun : 1 s
```

```
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0102
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-25 17:15:54 UTC-08:00
    Last change time : 2016-07-25 17:20:30 UTC-08:00

<R3>display vrrp
  GigabitEthernet0/0/1 | Virtual Router 1
    State : Master
    Virtual IP : 192.168.1.1
    Master IP : 192.168.1.3
    PriorityRun : 110
    PriorityConfig : 110
    MasterPriority : 110
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-07-25 17:20:00 UTC-08:00
    Last change time : 2016-07-25 20:46:42 UTC-08:00

  GigabitEthernet0/0/1 | Virtual Router 2
```

```
    State : Master
    Virtual IP : 192.168.1.254
    Master IP : 192.168.1.3
    PriorityRun : 120
    PriorityConfig : 120
    MasterPriority : 120
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-0102
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Track IF : GigabitEthernet0/0/0     Priority reduced : 30
    IF state : UP
    Create time : 2016-07-25 17:20:14 UTC-08:00
Last change time : 2016-07-25 17:20:23 UTC-08:00
```

Normally, R2 and R3 load balance traffic. When R2 is faulty, R3 takes over all traffic on R2. In this case, load balancing of two VRRP groups is configured.

Device Configuration

```
<R1>display current-configuration
    #
     sysname R1
    #
    interface GigabitEthernet0/0/0
     ip address 10.0.123.1 255.255.255.0
    #
    interface LoopBack0
     ip address 1.1.1.1 255.255.255.255
    #
    ospf 1
     area 0.0.0.0
      network 1.1.1.1 0.0.0.0
      network 10.0.123.0 0.0.0.255
    #
    return

<R2>display current-configuration

    #
     sysname R2
    #
    interface GigabitEthernet0/0/0
     shutdown
     ip address 10.0.123.2 255.255.255.0
    #
    interface GigabitEthernet0/0/1
     ip address 192.168.1.2 255.255.255.0
     vrrp vrid 1 virtual-ip 192.168.1.1
     vrrp vrid 1 priority 120
     vrrp vrid 1 preempt-mode timer delay 10
     vrrp vrid 1 track interface GigabitEthernet0/0/0 reduced 30
     vrrp vrid 2 virtual-ip 192.168.1.254
     vrrp vrid 2 priority 110
    #
    ospf 1
     silent-interface GigabitEthernet0/0/1
     area 0.0.0.0
      network 10.0.123.0 0.0.0.255
      network 192.168.1.0 0.0.0.255
    #
    return
```

```
<R3>display current-configuration
    #
     sysname R3
    #
    interface GigabitEthernet0/0/0
     ip address 10.0.123.3 255.255.255.0
    #
    interface GigabitEthernet0/0/1
     ip address 192.168.1.3 255.255.255.0
     vrrp vrid 1 virtual-ip 192.168.1.1
     vrrp vrid 1 priority 110
     vrrp vrid 2 virtual-ip 192.168.1.254
     vrrp vrid 2 priority 120
     vrrp vrid 2 track interface GigabitEthernet0/0/0 reduced 30
    #
    ospf 1
     silent-interface GigabitEthernet0/0/1
     area 0.0.0.0
```

```
   network 10.0.123.0 0.0.0.255
   network 192.168.1.0 0.0.0.255
#
return
```

```
<R4>display current-configuration
      #
       sysname R4
      #
      interface GigabitEthernet0/0/1
       ip address 192.168.1.4 255.255.255.0
      #
      ip route-static 0.0.0.0 0.0.0.0 192.168.1.1
      #
      return
```

```
<R5>display current-configuration
      #
       sysname R5
      #
      interface GigabitEthernet0/0/1
       ip address 192.168.1.5 255.255.255.0
      #
      ip route-static 0.0.0.0 0.0.0.0 192.168.1.254
      #
return
```

Chapter 6 BFD Configuration

Lab 6-1 Association Between BFD and Static Routes

Learning Objectives

The objectives of this lab are to learn and understand:

- How to associate Bidirectional Forwarding Detection (BFD) with static routes to implement floating routes

Topology

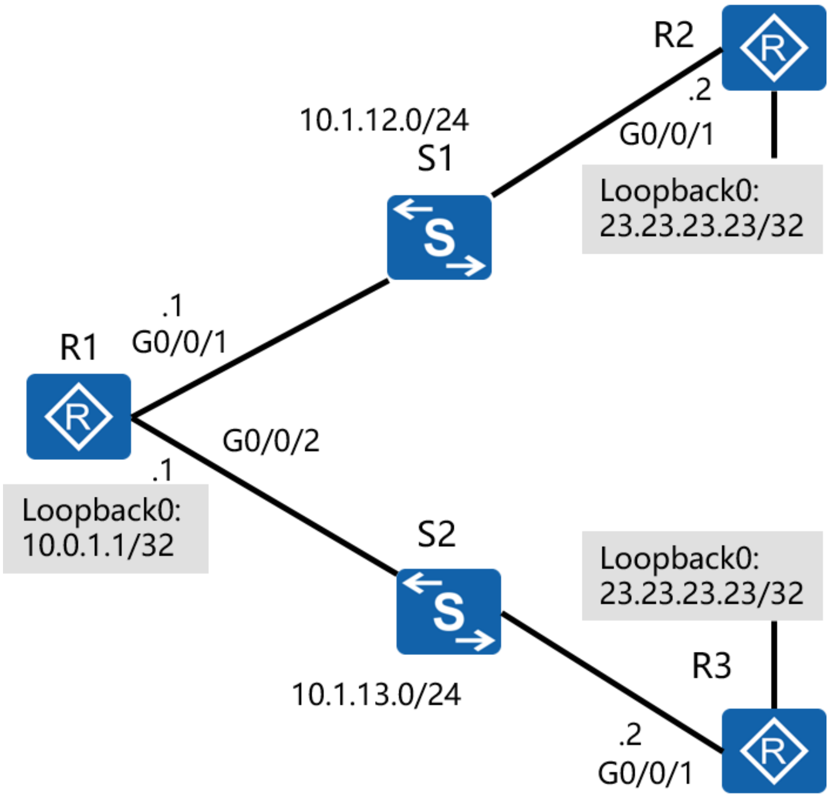


Figure 6-1 Networking of association between BFD and static routes

Scenario

R1 is connected to R2 and R3 through S1 and S2. Devices are connected through static routes, and packets can reach the target network 23.23.23.23/32 through R2 or

R3. R2 is the active next hop, and R3 is the standby next hop. The link is not the direct one, so the interface status does not affect reachability of the static routes. BFD is used to detect reachability of the static routes. When detection fails, the backup static route is used to forward data.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses for all routers and check the addresses.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.12.1 24
[R1-GigabitEthernet0/0/1]quit
[R1]interface GigabitEthernet 0/0/2
[R1-GigabitEthernet0/0/2]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/2]quit
[R1]interface LoopBack 0
[R1-LoopBack0]ip address 10.0.1.1 32


[R1]display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 9
The number of interface that is DOWN in Physical is 3
The number of interface that is UP in Protocol is 6
The number of interface that is DOWN in Protocol is 6

Interface                   IP Address/Mask     Physical   Protocol
Cellular0/0/0               unassigned          down        down
Cellular0/0/1               unassigned          down        down
GigabitEthernet0/0/0        unassigned          up         down
GigabitEthernet0/0/1        10.0.12.1/24         up         up
GigabitEthernet0/0/2        10.0.13.1/24         up         up
GigabitEthernet0/0/3        unassigned           up         down
LoopBack0                   10.0.1.1/32          up         up(s)
NULL0                       unassigned          up         up(s)
Serial1/0/0                 unassigned          up         up
Serial2/0/0                 unassigned          up         down
Serial3/0/0                 unassigned          up         up
Serial4/0/0                 unassigned          down        down
```

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.12.2 24
[R2-GigabitEthernet0/0/1]quit
[R2]interface LoopBack 0
[R2-LoopBack0]ip address 23.23.23.23 32
[R2-LoopBack0]quit

[R2]display ip interface brief
```

```
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 9
The number of interface that is DOWN in Physical is 4
The number of interface that is UP in Protocol is 5
The number of interface that is DOWN in Protocol is 8

Interface                    IP Address/Mask     Physical   Protocol
Cellular0/0/0                unassigned          down       down
Cellular0/0/1                unassigned          down       down
Ethernet4/0/0                unassigned          down       down
Ethernet4/0/1                unassigned          down       down
GigabitEthernet0/0/0         unassigned          up         down
GigabitEthernet0/0/1         10.0.12.2/24        up         up
GigabitEthernet0/0/2         unassigned          up         down
GigabitEthernet0/0/3         unassigned          up         down
LoopBack0                    23.23.23.23/32      up         up(s)
NULL0                        unassigned          up         up(s)
Serial1/0/0                  unassigned          up         up
Serial2/0/0                  unassigned          up         up
Serial3/0/0                  unassigned          up         down


<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
```

```
[R3]interface GigabitEthernet 0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.13.2 24
[R3-GigabitEthernet0/0/2]quit
[R3]interface LoopBack 0
[R3-LoopBack0]ip address 23.23.23.23 32
[R3-LoopBack0]quit

[R3]display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 9
The number of interface that is DOWN in Physical is 4
The number of interface that is UP in Protocol is 5
The number of interface that is DOWN in Protocol is 8

Interface                         IP Address/Mask       Physical   Protocol
Cellular0/0/0                     unassigned            down       down
Cellular0/0/1                     unassigned            down       down
Ethernet4/0/0                     unassigned            down       down
Ethernet4/0/1                     unassigned            down       down
GigabitEthernet0/0/0              unassigned            up         down
GigabitEthernet0/0/1              unassigned            up         down
GigabitEthernet0/0/2              10.0.13.2/24          up         up
GigabitEthernet0/0/3              unassigned            up         down
LoopBack0                         23.23.23.23/32        up         up(s)
```

```
NULL0                          unassigned          up           up(s)
Serial1/0/0                    unassigned          up           down
Serial2/0/0                    unassigned          up           up
Serial3/0/0                    unassigned          up           up
```

Check the connectivity between R1 and R2 and between R1 and R3.

```
[R1]ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.12.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[R1]ping 10.0.13.2
  PING 10.0.13.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.13.2: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=5 ttl=255 time=1 ms
  --- 10.0.13.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Step 2 **Configure BFD.**

Enable BFD on the active path and check the interface on R1 connected to R2.

```
[R1]bfd
[R1-bfd]quit
[R1]bfd 1 bind peer-ip 10.0.12.2 source-ip 10.0.12.1 auto
[R1-bfd-session-1]commit
[R1-bfd-session-1]quit

[R2]bfd
[R2-bfd]quit
[R2]bfd 1 bind peer-ip 10.0.12.1 source-ip 10.0.12.2 auto
[R2-bfd-session-1]commit
[R2-bfd-session-1]quit
```

Check BFD session information.

```
[R1]display bfd session all
--------------------------------------------------------------------------------
Local Remote     PeerIpAddr      State     Type           InterfaceName
--------------------------------------------------------------------------------
8192   8192       10.0.12.2      Up        S_AUTO_PEER          -
--------------------------------------------------------------------------------
```

```
     Total UP/DOWN Session Number : 1/0


[R2]display bfd session all
--------------------------------------------------------------------------------
Local Remote      PeerIpAddr      State     Type          InterfaceName
--------------------------------------------------------------------------------
8192   8192         10.0.12.1       Up       S_AUTO_PEER         -
--------------------------------------------------------------------------------
     Total UP/DOWN Session Number : 1/0
```

Step 3 **Configure association between BFD and static routes.**

On R2 and R3, configure static routes to the loopback interface on R1.

```
[R2]ip route-static 10.0.0.0 8 10.0.12.1
[R2]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

       10.0.0.0/8    Static   60     0          RD     10.0.12.1        GigabitEthernet0/0/1
      10.0.12.0/24   Direct   0      0           D     10.0.12.2        GigabitEthernet0/0/1
      10.0.12.2/32   Direct   0      0           D     127.0.0.1        GigabitEthernet0/0/1
    10.0.12.255/32   Direct   0      0           D     127.0.0.1        GigabitEthernet0/0/1
    23.23.23.23/32   Direct   0      0           D     127.0.0.1        LoopBack0
      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]ip route-static 10.0.0.0 8 10.0.13.1
[R3]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

      10.0.0.0/8     Static   60    0            RD     10.0.13.1         GigabitEthernet0/0/2
      10.0.13.0/24   Direct   0     0             D     10.0.13.2         GigabitEthernet0/0/2
      10.0.13.2/32   Direct   0     0             D     127.0.0.1         GigabitEthernet0/0/2
    10.0.13.255/32   Direct   0     0             D     127.0.0.1         GigabitEthernet0/0/2
    23.23.23.23/32   Direct   0     0             D     127.0.0.1         LoopBack0
      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
```

Configure two static routes on R1 and associate them with BFD.

```
[R1]ip route-static 0.0.0.0 0.0.0.0 10.0.12.2 track bfd-session 1
[R1]ip route-static 0.0.0.0 0.0.0.0 10.0.13.2 preference 100
```

The route to R3 has the priority of 100 and is lower than the route to R2 (60). The routing table is as follows.

```
[R1]display ip routing-table

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Tables: Public

         Destinations : 12        Routes : 12


Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface


       0.0.0.0/0   Static  60   0          RD   10.0.12.2       GigabitEthernet0/0/1

       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       GigabitEthernet0/0/1

      10.0.12.1/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/1

    10.0.12.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/1

      10.0.13.0/24  Direct  0    0           D   10.0.13.1       GigabitEthernet0/0/2

      10.0.13.1/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/2

    10.0.13.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/2

      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

255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0


[R1]display ip routing-table 0.0.0.0 0.0.0.0 verbose

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Table : Public

Summary Count : 2


Destination: 0.0.0.0/0

     Protocol: Static           Process ID: 0
     Preference: 60                    Cost: 0
         NextHop: 10.0.12.2         Neighbour: 0.0.0.0
           State: Active Adv Relied        Age: 00h01m19s
             Tag: 0                   Priority: medium
           Label: NULL                  QoSInfo: 0x0
     IndirectID: 0x80000001
  RelayNextHop: 0.0.0.0             Interface: GigabitEthernet0/0/1
       TunnelID: 0x0                      Flags: RD

Destination: 0.0.0.0/0
       Protocol: Static               Process ID: 0
     Preference: 100                   Cost: 0
         NextHop: 10.0.13.2         Neighbour: 0.0.0.0
           State: Inactive Adv Relied      Age: 00h01m03s
             Tag: 0                   Priority: medium
           Label: NULL                  QoSInfo: 0x0
     IndirectID: 0x80000002
  RelayNextHop: 0.0.0.0             Interface: GigabitEthernet0/0/2
       TunnelID: 0x0                      Flags: R
```

Check the connectivity in the normal situation.

```
[R1]ping -a 10.0.1.1 23.23.23.23
  PING 23.23.23.23: 56  data bytes, press CTRL_C to break
    Reply from 23.23.23.23: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=5 ttl=255 time=1 ms
  --- 23.23.23.23 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 1/1/1 ms
```

Perform the ping operation on R1 for a long time and shut down the interface on R2.

```
[R1]ping -c 100 23.23.23.23
```

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]shutdown
```

Check the configuration on R1.

```
[R1]ping -c 100 23.23.23.23
  PING 23.23.23.23: 56   data bytes, press CTRL_C to break
    Reply from 23.23.23.23: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=5 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=6 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=7 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=8 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=9 ttl=255 time=1 ms
    Request time out
    Request time out
    Reply from 23.23.23.23: bytes=56 Sequence=12 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=13 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=14 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=15 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=16 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=17 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=18 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=19 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=20 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=21 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=22 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=23 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=24 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=25 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=26 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=27 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=28 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=29 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=30 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=31 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=32 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=33 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=34 ttl=255 time=1 ms
    Reply from 23.23.23.23: bytes=56 Sequence=35 ttl=255 time=1 ms

  --- 23.23.23.23 ping statistics ---
    35 packet(s) transmitted
    33 packet(s) received
    5.71% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Check the BFD session.

```
[R1]display bfd session all
--------------------------------------------------------------------------------
Local Remote      PeerIpAddr      State     Type           InterfaceName
--------------------------------------------------------------------------------
8192   0          10.0.12.2       Down      S_AUTO_PEER          -
--------------------------------------------------------------------------------
     Total UP/DOWN Session Number : 0/1
```

Check routing information on R1.

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 12        Routes : 12

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        0.0.0.0/0   Static  100  0          RD   10.0.13.2       GigabitEthernet0/0/2
        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       GigabitEthernet0/0/1
       10.0.12.1/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/1
     10.0.12.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/1
       10.0.13.0/24  Direct  0    0           D   10.0.13.1       GigabitEthernet0/0/2
       10.0.13.1/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/2
     10.0.13.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet0/0/2
        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

255.255.255.255/32   Direct   0     0             D    127.0.0.1         InLoopBack0


[R1]display ip routing-table 0.0.0.0 verbose

Route Flags: R - relay, D - download to fib

------------------------------------------------------------------------------

Routing Table : Public

Summary Count : 2


Destination: 0.0.0.0/0

     Protocol: Static              Process ID: 0

   Preference: 60                         Cost: 0

      NextHop: 10.0.12.2           Neighbour: 0.0.0.0

        State: Invalid Adv Relied        Age: 00h05m27s

          Tag: 0                       Priority: medium

        Label: NULL                      QoSInfo: 0x0

   IndirectID: 0x80000001

 RelayNextHop: 0.0.0.0             Interface: GigabitEthernet0/0/1

     TunnelID: 0x0                        Flags: R


Destination: 0.0.0.0/0

     Protocol: Static              Process ID: 0

   Preference: 100                        Cost: 0

      NextHop: 10.0.13.2           Neighbour: 0.0.0.0

        State: Active Adv Relied          Age: 00h05m11s

          Tag: 0                       Priority: medium

        Label: NULL                      QoSInfo: 0x0

   IndirectID: 0x80000002
 RelayNextHop: 0.0.0.0            Interface: GigabitEthernet0/0/2
     TunnelID: 0x0                    Flags: RD
```

If BFD is not configured, no mechanism on R1 can detect reachability of static routes. That is, BFD is important in such scenarios.

Device Configuration

```
<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
bfd
#
interface GigabitEthernet0/0/1
 ip address 10.0.12.1 255.255.255.0
#
interface GigabitEthernet0/0/2
 ip address 10.0.13.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.255
#
bfd 1 bind peer-ip 10.0.12.2 source-ip 10.0.12.1 auto
 commit
#
ip route-static 0.0.0.0 0.0.0.0 10.0.12.2 track bfd-session 1
ip route-static 0.0.0.0 0.0.0.0 10.0.13.2 preference 100
```

```
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
bfd
#
interface GigabitEthernet0/0/1
 ip address 10.0.12.2 255.255.255.0
#
interface LoopBack0
 ip address 23.23.23.23 255.255.255.255
#
bfd 1 bind peer-ip 10.0.12.1 source-ip 10.0.12.2 auto
 commit
#
ip route-static 10.0.0.0 255.0.0.0 10.0.12.1
#
return

<R3>display current-configuration
[V200R007C00SPC600]
#
 sysname R3
#
interface GigabitEthernet0/0/2
```

```
 ip address 10.0.13.2 255.255.255.0
#
interface LoopBack0
 ip address 23.23.23.23 255.255.255.255
#
ip route-static 10.0.0.0 255.0.0.0 10.0.13.1
#
return
```

Lab 6-2 Association Between BFD and OSPF

Learning Objectives

The objectives of this lab are to learn and understand:

- How to rapidly configure BFD in the Open Shortest Path First (OSPF) environment

Topology

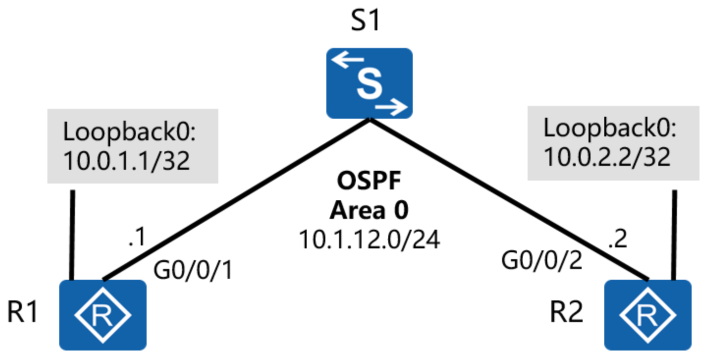


Figure 6-2 Networking of association between BFD and OSPF

Scenario

R1 connects to R2 through S1. Interfaces on R1 and R2 run in OSPF area 0, and are not directly connected. When one interfaces goes Down, the other interface cannot detect the fault immediately and has to wait for four times the Hello time to delete the neighbor. During this period, data is forwarded abnormally. In this case, configure BFD to accelerate the OSPF convergence speed.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses for all routers.

```
<Huawei>system-view

Enter system view, return user view with Ctrl+Z.

[Huawei]sysname R1

[R1]interface GigabitEthernet 0/0/1

[R1-GigabitEthernet0/0/1]ip address 10.0.12.1 24

[R1-GigabitEthernet0/0/1]quit

[R1]interface loopback 0

[R1-LoopBack0]ip address 10.0.1.1 32

[R1-LoopBack0]quit
```

After the configuration is complete, check the IP address of each router.

```
[R1]display ip interface brief

*down: administratively down

^down: standby

(l): loopback

(s): spoofing

(E): E-Trunk down

The number of interface that is UP in Physical is 3

The number of interface that is DOWN in Physical is 9

The number of interface that is UP in Protocol is 3

The number of interface that is DOWN in Protocol is 9
```

```
Interface                         IP Address/Mask      Physical   Protocol
Cellular0/0/0                     unassigned           down       down
Cellular0/0/1                     unassigned           down       down
GigabitEthernet0/0/0              unassigned           *down      down
GigabitEthernet0/0/1              10.0.12.1/24         up         up
GigabitEthernet0/0/2              unassigned           *down      down
GigabitEthernet0/0/3              unassigned           *down      down
LoopBack0                         10.0.1.1/32          up         up(s)
NULL0                             unassigned           up         up(s)
Serial1/0/0                       unassigned           *down      down
Serial2/0/0                       unassigned           *down      down
Serial3/0/0                       unassigned           *down      down
Serial4/0/0                       unassigned           *down      down

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.12.2 24
[R2-GigabitEthernet0/0/1]quit
[R2]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 32
[R2-LoopBack0]quit

[R2]display ip interface brief
*down: administratively down
^down: standby
```

```
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 3
The number of interface that is DOWN in Physical is 10
The number of interface that is UP in Protocol is 3
The number of interface that is DOWN in Protocol is 10

Interface                         IP Address/Mask      Physical   Protocol
Cellular0/0/0                     unassigned           down       down
Cellular0/0/1                     unassigned           down       down
Ethernet4/0/0                     unassigned           *down      down
Ethernet4/0/1                     unassigned           *down      down
GigabitEthernet0/0/0              unassigned           *down      down
GigabitEthernet0/0/1              10.0.12.2/24         up         up
GigabitEthernet0/0/2              unassigned           *down      down
GigabitEthernet0/0/3              unassigned           *down      down
LoopBack0                         10.0.2.2/32          up         up(s)
NULL0                             unassigned           up         up(s)
Serial1/0/0                       unassigned           *down      down
Serial2/0/0                       unassigned           *down      down
Serial3/0/0                       unassigned           *down      down
```

Check the connectivity between R1 and R2.

```
[R1]ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=1 ms

    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=1 ms

    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=1 ms


  --- 10.0.12.2 ping statistics ---

    5 packet(s) transmitted

    4 packet(s) received

    20.00% packet loss

    round-trip min/avg/max = 1/1/1 ms
```

Step 2 **Configure OSPF.**

Assign interfaces of R1 and R2 including Loopback0 interfaces to the OSPF area 0 based on the topology.

```
[R1]ospf 1

[R1-ospf-1]area 0

[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255

[R1-ospf-1-area-0.0.0.0]network 10.0.1.1 0.0.0.0

[R1-ospf-1-area-0.0.0.0]quit

[R1-ospf-1]quit


[R2]ospf 1

[R2-ospf-1]area 0

[R2-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255

[R2-ospf-1-area-0.0.0.0]network 10.0.2.2 0.0.0.0

[R2-ospf-1-area-0.0.0.0]quit

[R2-ospf-1]quit
```

Check the OSPF interface status and neighbor status.

```
[R1]display ospf interface


          OSPF Process 1 with Router ID 10.0.12.1
                  Interfaces


 Area: 0.0.0.0            (MPLS TE not enabled)
 IP Address       Type          State     Cost     Pri    DR               BDR

    10.0.12.1        Broadcast      BDR        1        1      10.0.12.2        10.0.12.1
    10.0.1.1         P2P             P-2-P     0        1      0.0.0.0          0.0.0.0


[R2]display ospf interface


          OSPF Process 1 with Router ID 10.0.12.2
                  Interfaces


 Area: 0.0.0.0            (MPLS TE not enabled)
 IP Address       Type          State     Cost     Pri    DR               BDR

    10.0.12.2        Broadcast      DR         1        1      10.0.12.2        10.0.12.1
    10.0.2.2         P2P             P-2-P     0        1      0.0.0.0          0.0.0.0
```

Check the OSPF neighbor relationship status.

```
[R1]display ospf peer brief


          OSPF Process 1 with Router ID 10.0.12.1
                   Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id            Interface                          Neighbor id       State
 0.0.0.0          GigabitEthernet0/0/1            10.0.12.2        Full
 ----------------------------------------------------------------------------
 Total Peer(s):       1

[R2]display ospf peer brief

          OSPF Process 1 with Router ID 10.0.12.2
                    Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                       Neighbor id      State
 0.0.0.0          GigabitEthernet0/0/1            10.0.12.1        Full
 ----------------------------------------------------------------------------
 Total Peer(s):       1
```

When the OSPF neighbor relationship status is full, the OSPF configuration is complete.

Step 3 **Configure BFD sessions.**

Enable BFD globally and in an OSPF area.

```
[R1]bfd
[R1-bfd]quit
[R1]ospf 1
[R1-ospf-1]bfd all-interfaces enable
[R1-ospf-1]quit

[R2]bfd
[R2-bfd]quit
[R2]ospf 1
[R2-ospf-1]bfd all-interfaces enable
```

```
[R2-ospf-1]quit
```

After the configuration is complete, check the BFD session status.

```
[R1]display bfd session all
-----------------------------------------------------------------------------
Local Remote       PeerIpAddr       State      Type           InterfaceName
-----------------------------------------------------------------------------
8192   8192          10.0.12.2           Up          D_IP_IF        GigabitEthernet0/0/1
-----------------------------------------------------------------------------
      Total UP/DOWN Session Number : 1/0

[R2]display bfd session all
-----------------------------------------------------------------------------
Local Remote       PeerIpAddr       State      Type           InterfaceName
-----------------------------------------------------------------------------
8192   8192          10.0.12.1           Up          D_IP_IF        GigabitEthernet0/0/1
-----------------------------------------------------------------------------
      Total UP/DOWN Session Number : 1/0

[R1]display ospf bfd session all

          OSPF Process 1 with Router ID 10.0.12.1
  Area 0.0.0.0 interface 10.0.12.1(GigabitEthernet0/0/1)'s BFD Sessions

 NeighborId:10.0.12.2          AreaId:0.0.0.0              Interface:GigabitEthernet0/0/1
 BFDState:up                    rx      :1000                  tx           :1000
 Multiplier:3                  BFD Local Dis:8192         LocalIpAdd:10.0.12.1
 RemoteIpAdd:10.0.12.2          Diagnostic Info:No diagnostic information
```

To test the BFD effect, shut down the interface on R2.

```
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]shutdown
```

Enable the debugging function on R1. The following debugging information is displayed on R1.

```
<R1>debug ospf bfd
Sep 23 2016 03:39:25+00:00 R1 %%01BFD/4/STACHG_TODWN(l)[23]:BFD session changed to Down.
(SlotNumber=0, Discriminator=8192, Diagnostic=DetectDown, Applications=OSPF, ProcessPST=False,
BindInterfaceName=GigabitEthernet0/0/1, InterfacePhysicalState=Up, InterfaceProtocolState=Up)
<R1>
Sep 23 2016 03:39:25+00:00 R1 %%01OSPF/3/NBR_CHG_DOWN(l)[24]:Neighbor event:neighbor state changed
to Down. (ProcessId=1, NeighborAddress=10.0.12.2, NeighborEvent=KillNbr, NeighborPreviousState=Full,
NeighborCurrentState=Down)
<R1>
Sep 23 2016 03:39:25+00:00 R1 %%01OSPF/3/NBR_DOWN_REASON(l)[25]:Neighbor state leaves full or changed
to Down. (ProcessId=1, NeighborRouterId=10.0.12.2, NeighborAreaId=0,
NeighborInterface=GigabitEthernet0/0/1,NeighborDownImmediate reason=Neighbor Down Due to Kill
Neighbor, NeighborDownPrimeReason=BFD Session Down, NeighborChangeTime=2016-09-23 03:39:25)
```

Other association logs are not displayed here. Focus on the preceding important logs.

Restart the interface.

```
[R2-GigabitEthernet0/0/1]undo shutdown
```

Check the BFD session status and OSPF neighbor relationship status again.

```
[R1]display bfd session all
-----------------------------------------------------------------------------
Local Remote      PeerIpAddr       State      Type           InterfaceName
-----------------------------------------------------------------------------
8193   8193         10.0.12.2         Up          D_IP_IF        GigabitEthernet0/0/1
-----------------------------------------------------------------------------
      Total UP/DOWN Session Number : 1/0

[R1]display ospf bfd session all

          OSPF Process 1 with Router ID 10.0.12.1
  Area 0.0.0.0 interface 10.0.12.1(GigabitEthernet0/0/1)'s BFD Sessions

 NeighborId:10.0.12.2          AreaId:0.0.0.0              Interface:GigabitEthernet0/0/1
 BFDState:up                    rx      :1000                  tx          :1000
 Multiplier:3                  BFD Local Dis:8193         LocalIpAdd:10.0.12.1
 RemoteIpAdd:10.0.12.2          Diagnostic Info:No diagnostic information

[R2]display bfd session all
-----------------------------------------------------------------------------
Local Remote      PeerIpAddr       State      Type           InterfaceName
-----------------------------------------------------------------------------
8193   8193         10.0.12.1         Up          D_IP_IF        GigabitEthernet0/0/1
-----------------------------------------------------------------------------
      Total UP/DOWN Session Number : 1/0

[R2]display ospf bfd session all
```

```
          OSPF Process 1 with Router ID 10.0.12.2
  Area 0.0.0.0 interface 10.0.12.2(GigabitEthernet0/0/1)'s BFD Sessions

 NeighborId:10.0.12.1        AreaId:0.0.0.0          Interface:GigabitEthernet0/0/1
 BFDState:up                  rx    :1000              tx        :1000
 Multiplier:3               BFD Local Dis:8193      LocalIpAdd:10.0.12.2
 RemoteIpAdd:10.0.12.1        Diagnostic Info:No diagnostic information
```

BFD sessions are established again.

Device Configuration

```
<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
bfd
#
interface GigabitEthernet0/0/1
 ip address 10.0.12.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.255
#
ospf 1
 bfd all-interfaces enable
 area 0.0.0.0
```

```
  network 10.0.1.1 0.0.0.0
  network 10.0.12.0 0.0.0.255
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
bfd
#
interface GigabitEthernet0/0/1
 ip address 10.0.12.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.255
#
ospf 1
 bfd all-interfaces enable
 area 0.0.0.0
  network 10.0.2.2 0.0.0.0
  network 10.0.12.0 0.0.0.255
#
return
```

Lab 6-3 Association Between BFD and VRRP

Learning Objectives

The learning objectives of this lab are to learn and understand:

- How to check indirectly connected interfaces through association between BFD and VRRP

Topology

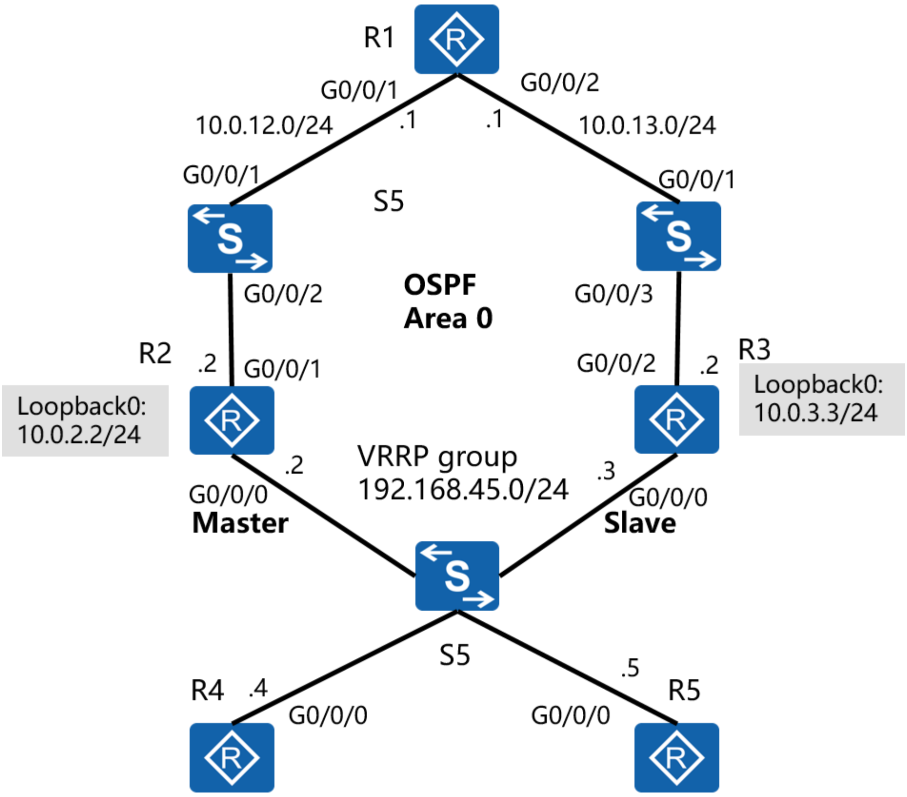


Figure 6-3 Networking of association between BFD and VRRP

Scenario

R1 connects to R2 and R3 through S1 and S2. R2 and R3 are configured with VRRP and function as gateways of R4 and R5 on a LAN. R2 is used as the master device, and R3 is used as the backup device. When the indirectly connected uplink of R2 goes Down, uplink traffic is still forwarded through R2, causing blackhole routes. To prevent such a problem, configure association between BFD and VRRP. When connected interfaces on R1 and R2 go Down, the priority of the VRRP group of R2 is reduced immediately and R3 functions as the master router to forward uplink traffic.

Tasks

Step 1 **Perform basic configurations and configure IP addresses.**

Configure IP addresses for all routers.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface LoopBack 0
[R1-LoopBack0]ip address 10.0.1.1 24
[R1-LoopBack0]quit
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.12.1 24
[R1-GigabitEthernet0/0/1]quit
[R1]interface GigabitEthernet 0/0/2
[R1-GigabitEthernet0/0/2]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/2]quit

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface LoopBack 0
[R2-LoopBack0]ip address 10.0.2.2 24
[R2-LoopBack0]quit
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.12.2 24
[R2-GigabitEthernet0/0/1]quit
```

```
[R2]interface GigabitEthernet 0/0/0
[R2-GigabitEthernet0/0/0]ip address 192.168.45.2 24
[R2-GigabitEthernet0/0/0]quit

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface LoopBack 0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]quit
[R3]interface GigabitEthernet 0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.13.2 24
[R3-GigabitEthernet0/0/2]quit
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ip address 192.168.45.3 24
[R3-GigabitEthernet0/0/0]quit

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R4
[R4]interface GigabitEthernet 0/0/0
[R4-GigabitEthernet0/0/0]ip address 192.168.45.4 24
[R4-GigabitEthernet0/0/0]quit

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R5
[R5]interface GigabitEthernet 0/0/0
[R5-GigabitEthernet0/0/0]ip address 192.168.45.5 24
```

```
[R5-GigabitEthernet0/0/0]quit
```

Configure VLANs on SW1 and SW2 respectively to avoid conflicts.

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname SW1
[SW1]vlan 12
[SW1-vlan12]quit
[SW1]interface GigabitEthernet 0/0/1
[SW1-GigabitEthernet0/0/1]port link-type access
[SW1-GigabitEthernet0/0/1]port default vlan 12
[SW1-GigabitEthernet0/0/1]quit
[SW1]interface GigabitEthernet 0/0/2
[SW1-GigabitEthernet0/0/2]port link-type access
[SW1-GigabitEthernet0/0/2]port default vlan 12
[SW1-GigabitEthernet0/0/2]quit
```

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname SW2
[SW2]vlan 13
[SW2-vlan13]quit
[SW2]interface GigabitEthernet 0/0/1
[SW2-GigabitEthernet0/0/1]port link-type access
[SW2-GigabitEthernet0/0/1]port default vlan 13
[SW2-GigabitEthernet0/0/1]quit
[SW2]interface GigabitEthernet 0/0/3
[SW2-GigabitEthernet0/0/3]port link-type access
```

```
[SW2-GigabitEthernet0/0/3]port default vlan 13
[SW2-GigabitEthernet0/0/3]quit
```

Check IP addresses after the configuration is complete.

```
[R1]display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 9
The number of interface that is DOWN in Physical is 3
The number of interface that is UP in Protocol is 6
The number of interface that is DOWN in Protocol is 6

Interface                   IP Address/Mask      Physical   Protocol
Cellular0/0/0               unassigned           down       down
Cellular0/0/1               unassigned           down       down
GigabitEthernet0/0/0        unassigned           up         down
GigabitEthernet0/0/1        10.0.12.1/24         up         up
GigabitEthernet0/0/2        10.0.13.1/24         up         up
GigabitEthernet0/0/3        unassigned           up         down
LoopBack0                   10.0.1.1/24          up         up(s)
NULL0                       unassigned           up         up(s)
Serial1/0/0                 unassigned           up         up
Serial2/0/0                 unassigned           up         down
Serial3/0/0                 unassigned           up         up
Serial4/0/0                 unassigned           down       down
```

```
[R2]display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 9
The number of interface that is DOWN in Physical is 4
The number of interface that is UP in Protocol is 6
The number of interface that is DOWN in Protocol is 7

Interface                      IP Address/Mask      Physical   Protocol
Cellular0/0/0                  unassigned           down        down
Cellular0/0/1                  unassigned           down        down
Ethernet4/0/0                   unassigned           down        down
Ethernet4/0/1                   unassigned           down        down
GigabitEthernet0/0/0           192.168.45.2/24       up          up
GigabitEthernet0/0/1           10.0.12.2/24          up          up
GigabitEthernet0/0/2           unassigned            up          down
GigabitEthernet0/0/3           unassigned            up          down
LoopBack0                      10.0.2.2/24           up          up(s)
NULL0                           unassigned           up          up(s)
Serial1/0/0                     unassigned           up          up
Serial2/0/0                     unassigned           up          up
Serial3/0/0                     unassigned           up          down

[R3]display ip interface brief
```

```
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 9
The number of interface that is DOWN in Physical is 4
The number of interface that is UP in Protocol is 6
The number of interface that is DOWN in Protocol is 7

Interface                  IP Address/Mask      Physical   Protocol
Cellular0/0/0              unassigned           down       down
Cellular0/0/1              unassigned           down       down
Ethernet4/0/0              unassigned           down       down
Ethernet4/0/1              unassigned           down       down
GigabitEthernet0/0/0       192.168.45.3/24      up         up
GigabitEthernet0/0/1       unassigned           up         down
GigabitEthernet0/0/2       10.0.13.2/24         up         up
GigabitEthernet0/0/3       unassigned           up         down
LoopBack0                  10.0.3.3/24          up         up(s)
NULL0                      unassigned           up         up(s)
Serial1/0/0                unassigned           up         down
Serial2/0/0                unassigned           up         up
Serial3/0/0                unassigned           up         up

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

```
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 6
The number of interface that is DOWN in Physical is 5
The number of interface that is UP in Protocol is 3
The number of interface that is DOWN in Protocol is 8

Interface                    IP Address/Mask     Physical   Protocol
Cellular0/0/0                unassigned          down       down
Cellular0/0/1                unassigned          down       down
Ethernet2/0/0                unassigned          up         down
Ethernet2/0/1                unassigned          down       down
GigabitEthernet0/0/0         192.168.45.4/24     up         up
GigabitEthernet0/0/1         unassigned          up         down
GigabitEthernet0/0/2         unassigned          down       down
GigabitEthernet0/0/3         unassigned          up         down
NULL0                        unassigned          up         up(s)
Serial1/0/0                  unassigned          up         up
Serial1/0/1                  unassigned          down       down

[R5]display ip interface brief
*down: administratively down
^down: standby
(l): loopback
(s): spoofing
(E): E-Trunk down
The number of interface that is UP in Physical is 6
The number of interface that is DOWN in Physical is 5
The number of interface that is UP in Protocol is 3
The number of interface that is DOWN in Protocol is 8

Interface                        IP Address/Mask      Physical   Protocol
Cellular0/0/0                   unassigned           down        down
Cellular0/0/1                   unassigned           down        down
Ethernet2/0/0                   unassigned           up         down
Ethernet2/0/1                   unassigned           down        down
GigabitEthernet0/0/0            192.168.45.5/24      up          up
GigabitEthernet0/0/1            unassigned           up         down
GigabitEthernet0/0/2            unassigned           down        down
GigabitEthernet0/0/3            unassigned             up        down
NULL0                           unassigned           up         up(s)
Serial1/0/0                     unassigned           up         up
Serial1/0/1                     unassigned           down        down
```

Check the connectivity between R1 and R2 and between R1 and R3.

```
[R1]ping 10.0.12.2
  PING 10.0.12.2: 56   data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.12.2 ping statistics ---
    5 packet(s) transmitted
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[R1]ping 10.0.13.2
  PING 10.0.13.2: 56   data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.13.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.13.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.13.2 ping statistics ---
    5 packet(s) transmitted
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Step 2 **Configure OSPF and static routes.**

Configure OSPF on R1, R2, and R3 according to the topology. Use network commands to import OSPF routes and enable the silent interface.

```
[R1]ospf 1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.1.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.13.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]quit
[R1-ospf-1]quit
```

Modify the OSPF cost on R1 so that downlink traffic is forwarded through R2.

```
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ospf cost 90
[R1-GigabitEthernet0/0/1]quit
[R1]interface GigabitEthernet 0/0/2
[R1-GigabitEthernet0/0/2]ospf cost 100
[R1-GigabitEthernet0/0/2]quit

[R2]ospf 1
[R2-ospf-1]silent-interface GigabitEthernet 0/0/0
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.2.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 192.168.45.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]quit
[R2-ospf-1]quit
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]ospf cost 90
[R2-GigabitEthernet0/0/1]quit

[R3]ospf 1
[R3-ospf-1]silent-interface GigabitEthernet 0/0/0
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.0.3.0 0.0.0.255
[R3-ospf-1-area-0.0.0.0]network 192.168.45.0 0.0.0.255
[R3-ospf-1-area-0.0.0.0]network 10.0.13.0 0.0.0.255
[R3-ospf-1-area-0.0.0.0]quit
```

```
[R3-ospf-1]quit

[R3]interface GigabitEthernet 0/0/2

[R3-GigabitEthernet0/0/2]ospf cost 100

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

Check the routing information after OSPF convergence is complete.

```
[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


       10.0.2.2/32   OSPF     10    90            D    10.0.12.2          GigabitEthernet0/0/1

       10.0.3.3/32   OSPF     10    100           D    10.0.13.2          GigabitEthernet0/0/2

   192.168.45.0/24   OSPF     10    91            D    10.0.12.2          GigabitEthernet0/0/1


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 : 3         Routes : 3

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

Destination/Mask    Proto   Pre  Cost        Flags NextHop         Interface

       10.0.1.1/32   OSPF    10    90          D   10.0.12.1       GigabitEthernet0/0/1
       10.0.3.3/32   OSPF    10    190         D   10.0.12.1       GigabitEthernet0/0/1
      10.0.13.0/24   OSPF    10    190         D   10.0.12.1       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

       10.0.1.1/32   OSPF    10    100         D   10.0.13.1       GigabitEthernet0/0/2
       10.0.2.2/32   OSPF    10    190         D   10.0.13.1       GigabitEthernet0/0/2
      10.0.12.0/24   OSPF    10    190         D   10.0.13.1       GigabitEthernet0/0/2
```

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

Configure default routes to the VRRP virtual IP address on R4 and R5.

```
[R4]ip route-static 0.0.0.0 0 192.168.45.1

[R5]ip route-static 0.0.0.0 0 192.168.45.1
```

Step 3 **Configure VRRP.**

Configure VRRP on downlink interfaces of R2 and R3.

```
[R2]interface GigabitEthernet 0/0/0
[R2-GigabitEthernet0/0/0]vrrp vrid 45 virtual-ip 192.168.45.1
[R2-GigabitEthernet0/0/0]vrrp vrid 45 priority 150
[R2-GigabitEthernet0/0/0]quit

[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]vrrp vrid 45 virtual-ip 192.168.45.1
[R3-GigabitEthernet0/0/0]quit
```

Check the VRRP status of devices.

```
[R2]display vrrp
  GigabitEthernet0/0/0 | Virtual Router 45
    State : Master
    Virtual IP : 192.168.45.1
    Master IP : 192.168.45.2
    PriorityRun : 150
    PriorityConfig : 150
    MasterPriority : 150
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-012d
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-09-25 15:18:54
    Last change time : 2016-09-25 15:18:57

[R3]display vrrp
  GigabitEthernet0/0/0 | Virtual Router 45
    State : Backup
    Virtual IP : 192.168.45.1
    Master IP : 192.168.45.2
    PriorityRun : 100
    PriorityConfig : 100
    MasterPriority : 150
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-012d
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Create time : 2016-09-25 15:21:49
    Last change time : 2016-09-25 15:21:49
```

Step 4 **Configure BFD association.**

Enable BFD on R1 and R2, and associate BFD with VRRP. When BFD detects a fault, the priority of the VRRP group is reduced immediately.

```
[R1]bfd
[R1-bfd]quit
[R1]bfd 1 bind peer-ip 192.168.45.2 source-ip 10.0.12.1 auto
[R1-bfd-session-1]commit
[R1-bfd-session-1]quit

[R2]bfd
[R2-bfd]quit
[R2]bfd 1 bind peer-ip 10.0.12.1 source-ip 192.168.45.2 auto
[R2-bfd-session-1]commit
[R2-bfd-session-1]quit
[R2]interface GigabitEthernet 0/0/0
[R2-GigabitEthernet0/0/0]vrrp vrid 45 track bfd-session session-name 1 reduce 60
```

Check association configuration.

```
[R2]display vrrp
  GigabitEthernet0/0/0 | Virtual Router 45
    State : Master
    Virtual IP : 192.168.45.1
    Master IP : 192.168.45.2
    PriorityRun : 150
    PriorityConfig : 150
    MasterPriority : 150
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-012d
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Track BFD : 1    Priority reduced : 60
    BFD-session state : UP
    Create time : 2016-09-25 15:18:54
    Last change time : 2016-09-25 15:18:57
```

Check the BFD session.

```
[R2]display bfd session all
--------------------------------------------------------------------------------
Local Remote      PeerIpAddr       State      Type            InterfaceName
--------------------------------------------------------------------------------
8192   8192        10.0.12.1          Up         S_AUTO_PEER          -
--------------------------------------------------------------------------------
     Total UP/DOWN Session Number : 1/0
```

Test BFD effects. Perform the ping operation for a long time on R4 and shut down the interface on R1.

```
[R4]ping -c 100 10.0.1.1


[R1]interface GigabitEthernet 0/0/1
```

```
[R1-GigabitEthernet0/0/1]shutdown
```

Check the ping operation result on R4.

```
[R4]ping -c 100 10.0.1.1
  PING 10.0.1.1: 56   data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=6 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=7 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=8 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=9 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=10 ttl=254 time=1 ms
    Request time out
    Request time out
    Reply from 10.0.1.1: bytes=56 Sequence=13 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=14 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=15 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=16 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=17 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=18 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=19 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=20 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=21 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=22 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=23 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=24 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=25 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=26 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=27 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=28 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=29 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=30 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=31 ttl=254 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=32 ttl=254 time=1 ms

  --- 10.0.1.1 ping statistics ---
    32 packet(s) transmitted
    30 packet(s) received
    6.25% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

Check the VRRP status.

```
[R2]display vrrp
  GigabitEthernet0/0/0 | Virtual Router 45
    State : Backup
    Virtual IP : 192.168.45.1
    Master IP : 192.168.45.3
    PriorityRun : 90
    PriorityConfig : 150
    MasterPriority : 100
    Preempt : YES     Delay Time : 0 s
    TimerRun : 1 s
    TimerConfig : 1 s
    Auth type : NONE
    Virtual MAC : 0000-5e00-012d
    Check TTL : YES
    Config type : normal-vrrp
    Backup-forward : disabled
    Track BFD : 1    Priority reduced : 60
    BFD-session state : DOWN
    Create time : 2016-09-25 15:18:54
    Last change time : 2016-09-25 15:27:26
```

Association between BFD and VRRP used to detect indirectly connected uplink detections is successful. The result on R5 is similar to that on R4, and the verification is not provided.

Device Configuration

```
<R1>display current-configuration
[V200R007C00SPC600]
#
 sysname R1
#
bfd
#
interface GigabitEthernet0/0/1
 ip address 10.0.12.1 255.255.255.0
 ospf cost 90
#
interface GigabitEthernet0/0/2
 ip address 10.0.13.1 255.255.255.0
 ospf cost 100
```

```
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
bfd 1 bind peer-ip 192.168.45.2 source-ip 10.0.12.1 auto
 commit
#
ospf 1
 area 0.0.0.0
  network 10.0.1.0 0.0.0.255
  network 10.0.12.0 0.0.0.255
  network 10.0.13.0 0.0.0.255
#
return

<R2>display current-configuration
[V200R007C00SPC600]
#
 sysname R2
#
bfd
#
interface GigabitEthernet0/0/0
 ip address 192.168.45.2 255.255.255.0
 vrrp vrid 45 virtual-ip 192.168.45.1
 vrrp vrid 45 priority 150
 vrrp vrid 45 track bfd-session session-name 1 reduced 60
#
interface GigabitEthernet0/0/1
```

```
 ip address 10.0.12.2 255.255.255.0
 ospf cost 90
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
bfd 1 bind peer-ip 10.0.12.1 source-ip 192.168.45.2 auto
 commit
#
ospf 1
 silent-interface GigabitEthernet0/0/0
 area 0.0.0.0
  network 10.0.2.0 0.0.0.255
  network 10.0.12.0 0.0.0.255
  network 192.168.45.0 0.0.0.255
#
return

<R3>display current-configuration
[V200R007C00SPC600]
#
 sysname R3
#
interface GigabitEthernet0/0/0
 ip address 192.168.45.3 255.255.255.0
 vrrp vrid 45 virtual-ip 192.168.45.1
#
interface GigabitEthernet0/0/2
 ip address 10.0.13.2 255.255.255.0
 ospf cost 100
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
ospf 1
 silent-interface GigabitEthernet0/0/0
 area 0.0.0.0
  network 10.0.3.0 0.0.0.255
  network 10.0.13.0 0.0.0.255
  network 192.168.45.0 0.0.0.255
#
return

<R4>display current-configuration
[V200R007C00SPC600]
#
 sysname R4
#
interface GigabitEthernet0/0/0
 ip address 192.168.45.4 255.255.255.0
#
ip route-static 0.0.0.0 0.0.0.0 192.168.45.1
#
return

<R5>display current-configuration
[V200R007C00SPC600]
#
```

```
 sysname R5
#
interface GigabitEthernet0/0/0
 ip address 192.168.45.5 255.255.255.0
#
ip route-static 0.0.0.0 0.0.0.0 192.168.45.1
#
return

<SW1>display current-configuration
!Software Version V200R008C00SPC500
#
sysname SW1
#
vlan batch 12
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 12
#
interface GigabitEthernet0/0/2
 port link-type access
 port default vlan 12
#
return

<SW2>display current-configuration
!Software Version V200R008C00SPC500
#
```

```
sysname SW2
#
vlan batch 13
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 13
#
interface GigabitEthernet0/0/3
 port link-type access
 port default vlan 13
#
return
```

Recommendations

- Huawei Learning Website
  - http://learning.huawei.com/en
- Huawei e-Learning
  - https://ilearningx.huawei.com/portal/#/portal/ebg/51
- Huawei Certification
  - http://support.huawei.com/learning/NavigationAction!createNavi?navId=_31&lang=en
- Find Training
  - http://support.huawei.com/learning/NavigationAction!createNavi?navId=_trainingsearch&lang=en

More Information

- Huawei learning APP