目录

实验 1 Cisco 网络设备基本管理

实验拓扑

实验目的：

- ✓ 熟悉 Cisco IOS 的命令行界面和各种帮助工具
- ✓ 掌握思科路由器配置模式的切换
- ✓ 掌握配置路由器基本参数
- ✓ 灵活使用各种基本的 show 命令来检查路由器状态
- ✓ 掌握路由器配置文件的管理
- ✓ 学会如何恢复路由器到出厂设置状态

任务 1 ：Cisco 路由器的命令行和模式切换

步骤 1：登录到路由器 R1 的命令行界面

步骤 2：如果出现以下询问，输入”no “

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: no
```

如果选择了 YES，可以使用“ctrl+c"回到 CLI 界面

步骤 3：进入用户模式，在用户模式下输入“enable”，进入特权模式

```
Router>enable
Router#
```

步骤 4：在特权模式下输入“disable”，回到用户模式

```
Router#disable
Router>
```

步骤 5：在用户模式下，输入“en”再输入"?"，可以看到系统提示一系列以“en”开头的命令（只有 enable 一个）

```
Router>en?
enable
```

步骤 6：在用户模式下，输入“en”，再按下“Tab”键，可以看到系统自动将命令补全为 enable

```
Router>en          //按下 Tab 键
Router>enable
```

步骤 7：进入特权模式

```
Router>enable
Router#
```

步骤 8：在特权模式下输入“configure terminal”，进入全局配置模式

```
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#
```

步骤 9：在全局配置模式下，输入“exit”，回到特权模式

```
Router(config)#exit
Router#
```

步骤 10：在特权模式下，灵活使用“Tab”键，重新输入“configure terminal”，进入全局配置模式

```
Router#conf                //按下 Tab 键

Router#configure t      //命令自动补全为 configure，然后输入 t

Router#configure terminal //再按下 Tab 键，补全为 terminal
```

步骤 11：在全局配置模式下，输入“exit”，回到特权模式

```
Router(config)#exit
Router#
```

步骤 12：在特权模式下，使用 exit 命令，关闭当前的管理界面

```
Router#exit
```

任务 2：配置思科路由器的基本参数

步骤 1：进入 R1 的命令行界面

步骤 2：进入 R1 的全局配置模式

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#
```

步骤 3：使用 hostname 命令，设置路由器的主机名

```
Router(config)#hostname R1
R1(config)#
```

步骤 4：进入 R2 的命令行界面，如果出现以下询问，输入” no “

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: no
```

步骤 5：进入 R2 的全局配置模式

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#
```

步骤 6：设置 R2 的主机名

```
Router(config)#hostname R2
R2(config)#
```

步骤 7：进入 R1 的 FastEthernet0/0 接口（如果没有 FastEthernet0/0，则进入 Ethernet0/0），配置 IP 地址为 192.168.1.1，掩码为 255.255.255.0，并开启接口

```
R1(config)#interface FastEthernet 0/0
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 8：进入 R2 的 FastEthernet0/0 接口（如果没有 FastEthernet0/0，则进入 Ethernet0/0），配置 IP 地址为 192.168.1.2，掩码为 255.255.255.0，并开启接口

```
R2(config)#interface fastEthernet 0/0
R2(config-if)#ip address 192.168.1.2 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 9：检查 R1 的接口状态，确认 Fa0/0（或 E0/0）的状态是 UP

```
R1#show ip interface brief
Interface          IP-Address     OK? Method Status                Protocol
FastEthernet0/0    192.168.1.1    YES manual up                    up
FastEthernet0/1    unassigned     YES unset  administratively down down
```

每位同学的机架设备类型可能会不同，只需要观察 FastEthernet0/0（或 Ethernet0/0）就可以了，其他接口不用关心

步骤 10：检查 R2 的接口状态，确认 Fa0/0（或 E0/0）的状态是 UP

```
R2#show ip interface brief
Interface          IP-Address     OK? Method Status                Protocol
FastEthernet0/0    192.168.1.2    YES manual up                    up
FastEthernet0/1    unassigned     YES unset  administratively down down
```

步骤 11:使用 show protocols，也可以检查接口状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.1/24
FastEthernet0/1 is administratively down, line protocol is down
```

步骤 12：在 R1 上，使用 ping 命令，测试能否和 192.168.1.2（R2）互相通信

```
R1#ping 192.168.1.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
```

"!"表示发出的 ping 包得到了相应（能 ping 通），“.” 表示发出的 ping 包无法得到相应。

如果是第一次 ping，可能会出现第一个是"."，后面会出现 “!"。

任务 3：在 cisco 路由器和交换机上使用基本的 show 命令

步骤 1：进入 R1 的命令行界面

步骤 2：使用 show version 命令，检查路由器的操作系统及版本信息

```
R1#show version
Cisco IOS Software, 3700 Software (C3745-ADVIPSERVICESK9-M), Version 12.4(3c), RELEASE
SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2006 by Cisco Systems, Inc.
Compiled Fri 06-Jan-06 20:32 by alnguyen

ROM: System Bootstrap, Version 12.2(8r)T2, RELEASE SOFTWARE (fc1)

R1 uptime is 5 minutes
System returned to ROM by power-on
System image file is "flash:c3745-advipservicesk9-mz.124-3c.bin"


This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
Importers, exporters, distributors and users are responsible for
compliance with U.S. and local country laws. By using this product you
agree to comply with applicable laws and regulations. If you are unable
to comply with U.S. and local laws, return this product immediately.

A summary of U.S. laws governing Cisco cryptographic products may be found at:
http://www.cisco.com/wwl/export/crypto/tool/stqrg.html

If you require further assistance please contact us by sending email to
export@cisco.com.

Cisco 3745 (R7000) processor (revision 2.0) with 243712K/18432K bytes of memory.
Processor board ID JPE0820104T
R7000 CPU at 350MHz, Implementation 39, Rev 3.3, 256KB L2, 2048KB L3 Cache
2 FastEthernet interfaces
2 Serial(sync/async) interfaces
DRAM configuration is 64 bits wide with parity disabled.
151K bytes of NVRAM.
```

```
62720K bytes of ATA System CompactFlash (Read/Write)

Configuration register is 0x2102

R1#
```

问题：标注的地方分别表示什么？

步骤 3：使用 show ip interfaces brief 检查接口状态列表

```
R1#show ip interface brief
Interface          IP-Address    OK? Method Status                 Protocol
FastEthernet0/0    192.168.1.1   YES manual up                     up
FastEthernet0/1    unassigned    YES unset  administratively down  down
```

步骤 4：使用 show protocols 检查接口状态列表

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.1/24
FastEthernet0/1 is administratively down, line protocol is down
```

问题：show ip interface brief 和 show protocols 显示的信息有什么区别？

步骤 5：使用 show running-config 检查当前运行的配置文件

```
R1#show running-config
Building configuration...

Current configuration : 709 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
```

```
boot-end-marker
!
no aaa new-model
!
resource policy
!
ip subnet-zero
ip cef
!
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
 no fair-queue
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
 shutdown
!
ip classless
!
!
ip http server
no ip http secure-server
!
control-plane
!
line con 0
line aux 0
line vty 0 4
end
```

任务 4：保存路由器的配置

步骤 1：在 R1 上，使用 copy 命令，保存配置

```
R1#copy running-config startup-config
Destination filename [startup-config]? 按下“回车”键
Building configuration...
[OK]
```

步骤 2：使用 show startup-config 命令，检查保存的配置文件，会发现和 running-config 中一模一样

```
R1#show startup-config
Using 709 out of 155640 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
!
resource policy
!
ip subnet-zero
ip cef
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
```

```
 shutdown
 no fair-queue
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
 shutdown
!
ip classless
!
!
ip http server
no ip http secure-server
!
!
control-plane
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
```

步骤 3：在 R2 上，使用 write 命令保存配置

```
R2#write
Building configuration.. [OK]
```

步骤 4：检查 R2 的 startup-config，也能看到原先 R2 的 running-config 中的内容

```
R1#show startup-config
Using 709 out of 155640 bytes
!
version 12.4
```

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
!
resource policy
!
ip subnet-zero
ip cef
!
!
!
interface FastEthernet0/0
 ip address 192.168.1.2 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
 no fair-queue
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
 shutdown
!
ip classless
!
!
ip http server
no ip http secure-server
```

```
!
control-plane
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
```

任务 5：恢复路由器到出厂设置

步骤 1：使用 erase 命令，清空 R1 的 startup-config

```
R1#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
```

按下回车

```
[OK]
Erase of nvram: complete
```

步骤 2：使用 reload 命令重启 R1

```
R1#reload
System configuration has been modified. Save? [yes/no]: no
                          //如果出现这个提问，选择 NO

Proceed with reload? [confirm]  //按下回车键
```

步骤 3：等待 R1 的重启，待 R1 重启后，会看到以下提问，说明 R1 的配置是空的（初始化）

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
% Please answer 'yes' or 'no'.
```

步骤 4：清空 R2 的 startup-config 并重启，使 R2 也回到出厂设置

```
R2#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
```

按下回车

```
[OK]
Erase of nvram: complete
```

```
R2#reload
```

```
System configuration has been modified. Save? [yes/no]: no
```

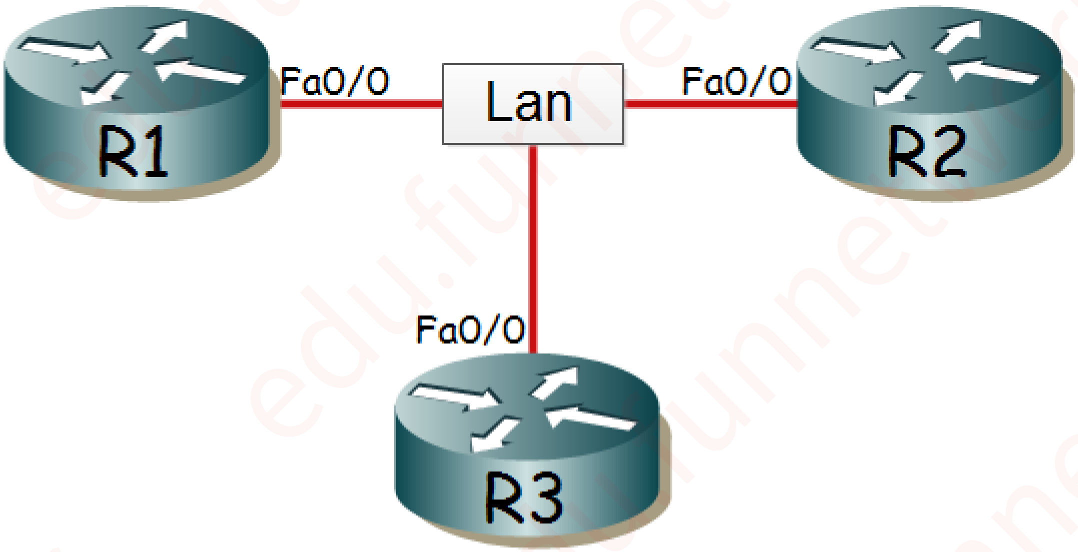
//如果出现这个提问，选择 NO

```
Proceed with reload? [confirm]  //按下回车键


.................
.................
.................
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
% Please answer 'yes' or 'no'.
```

...本次实验完成...

实验 2 思科路由器管理进阶

实验拓扑



实验目的：

- ✓ 掌握配置 console 控制台的密码
- ✓ 掌握配置 VTY 的密码
- ✓ 掌握路由器明文特权密码的配置
- ✓ 掌握路由器密文特权密码的配置
- ✓ 管理路由器的配置寄存器

准备：登录到所有需要的设备，并恢复到出厂设置

步骤 1：在所有路由器上（R1、R2、R3），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：配置路由器的基本参数，确保网络设备互联

步骤 1：登录到 R1 的命令行界面

步骤 2：出现以下提示，选择“NO”，进入命令行

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!
```

步骤 3：进入全局配置模式，配置主机名为 R1

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#
```

步骤 4：进入 FastEthernet0/0（如果没有 FastEthernet0/0，则进入 Ethernet0/0），配置接口 IP 为 192.168.1.1，掩码为 255.255.255.0，并打开接口

```
R1(config)#interface FastEthernet 0/0
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 5：进入 R2 的命令行界面，配置主机名为 R2

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
```

步骤 6：进入 FastEthernet0/0（如果没有 FastEthernet0/0，则进入 Ethernet0/0），配置接口 IP 为 192.168.1.2，掩码为 255.255.255.0，并打开接口

```
R2(config)#interface fastEthernet 0/0
R2(config-if)#ip address 192.168.1.2 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 7：进入 R3 的命令行界面，配置主机名为 R3

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
```

步骤 8：进入 FastEthernet0/0（如果没有 FastEthernet0/0，则进入 Ethernet0/0），配置接口 IP 为 192.168.1.3，掩码为 255.255.255.0，并打开接口

```
R3(config)#interface fastEthernet 0/0
R3(config-if)#ip address 192.168.1.3 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 9：检查 3 台路由器的接口状态列表，确保接口的 Line-Protocol 是状态是“UP”，如果在接口开启（no shutdown）的情况下，Line-Protocol 是“Down”，说明该接口的线缆有问题，请让老师协助解决

```
R1#show protocols   //show ip interface brief 的效果基本一致
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

```
R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.2/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.3/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 10：使用 ping，测试 3 台路由器的互相连通性，请确保 3 台路由器之间都能互相通信

```
R1#ping 192.168.1.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms

R1#ping 192.168.1.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms

R2#ping 192.168.1.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
```

提问：为什么 R3 不用测试？

任务 2：配置 console 密码，保护路由器的管理平台

步骤 1：进入 R1 的命令行界面，使用 exit 命令，关闭对 R1 的 console 管理

```
R1#exit


R1 con0 is now available


Press RETURN to get started.
```

步骤 2：再次按下回车，发现可以直接进入 R1 的用户模式，此时 R1 的 console 界面是开放的，任何用户都可以进入 R1 的命令行

```
Press RETURN to get started.


R1>
```

步骤 3：进入 R1 的全局配置模式

```
R1>enable
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#
```

步骤 4：使用 line console 0，进入 console 会话的管理模式

```
R1(config)#line console 0
R1(config-line)#
```

步骤 5：使用 password 命令，为 console 管理配置密码

```
R1(config-line)#password lab
```

步骤 6：使用 login 命令，开启 console 会话的认证机制

```
R1(config-line)#login
```

步骤 7：回到 R1 的特权模式

```
R1(config-line)#end
R1#
```

步骤 8：使用 exit 关闭 console 管理会话

```
R1#exit


R1 con0 is now available


Press RETURN to get started.
```

步骤 9：再测按下回车，发现此时出现了输入密码的提示，密码是 lab，输入正确后才能进入 R1 的命令行界面。此时只有知道密码的用户才能进入 R1 的命令行界面

```
Press RETURN to get started.

User Access Verification

Password:        //输入 lab，但不会显示您输入的字符
R1>
```

任务 3：使用“ 用户名+密码 ”的方式对用户实施认证

步骤 1：进入 R1 的全局配置模式

```
R1>enable
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#
```

步骤 2：在全局配置模式下，创建一个用户，并设置他的密码，用户名是 yangbang，密码是 ccna

```
R1(config)#username yangbang password ccna
R1(config)#
```

步骤 3：进入 console 管理界面，使用 login local 命令开启对用户的本地数据库认证（路由器会自动查询你在路由器上创建的用户名和密码）

```
R1(config)#line console 0
R1(config-line)#login local
R1(config-line)#
```

步骤 4：回到特权模式，并使用 exit 退出

```
R1(config-line)#end
R1#exit


R1 con0 is now available



Press RETURN to get started.
```

步骤 5：再测按下回车，提示需要输入用户名，然后输入“yangbang”，再提示输入密码，输入“ccna”后才能进入 R1 的命令行界面。

```
User Access Verification

Username: yangbang
Password:      //输入 ccna，按下回车
R1>
```

任务 4：配置 VTY，确保任何用户都可以直接远程登录到 R2

步骤 1：先尝试使用 R1 通过 telnet 登录 R2，发现是无法登陆的

```
R1>telnet 192.168.1.2
Trying 192.168.1.2 ... Open
Password required, but none set

[Connection to 192.168.1.2 closed by foreign host]
R1>
```

步骤 2：进入 R2 的命令行界面，并进入特权模式

```
R2>enable
R2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#
```

步骤 3：进入 R2 的 Line vty 0，使用 no login 命令，关闭 VTY 的认证机制，是任何用户需要进入 VTY0 时，都不用认证直接进入

```
R2(config)#line vty 0
R2(config-line)#no login
R2(config-line)#
```

步骤 4：再次使用 R1 尝试 telnet 到 R2，发现现在可以成功登录 R2

```
R1>telnet 192.168.1.2
Trying 192.168.1.2 ... Open
R2>
```

提问：此时用 R3 登录，为什么不可以？

步骤 5：退出 R1 对 R2 的 telnet 登录

```
R2>exit
[Connection to 192.168.1.2 closed by foreign host]
R1>
```

任务 5：配置基于“用户名+密码”的远程登录控制

步骤 1：登录到 R3 的命令行界面

步骤 2：进入全局配置模式，创建用户名 yangbang，密码为 ccna

```
R3>enable
R3#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#username yangbang password ccna
R3(config)#
```

步骤 3：进入 VTY 0 到 4（共 5 个虚拟终端），开启这 5 个虚拟终端的认证机制，使用本地数据库认证

```
R3(config)#line vty 0 4
R3(config-line)#login local
R3(config-line)#exit
```

步骤 4：使用 R1 和 R2 远程登录到 R3，输入用户名和密码后，可以登录

```
R1>telnet 192.168.1.3
Trying 192.168.1.3 ... Open

User Access Verification

Username: yangbang

Password:          //输入 ccna

R3>



R2>telnet 192.168.1.3
Trying 192.168.1.3 ... Open

User Access Verification
```

```
Username: yangbang
Password:
R3>
```

步骤 5：在 R3 上使用 show users，检查谁在登录 R3

```
R3#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00
  66 vty 0     yangbang   idle                 00:01:40 192.168.1.1
  67 vty 1     yangbang   idle                 00:00:50 192.168.1.2

  Interface    User               Mode         Idle     Peer Address
```

步骤 6：在 R3 上使用 clear 命令，将 R1 的登录关闭

```
R3#clear line vty 0
[confirm]
 [OK]
R3#
```

步骤 7：检查 R1，看到对 R3 的连接被关闭了

```
R3>
[Connection to 192.168.1.3 closed by foreign host]
R1>
```

步骤 8：在 R3 上把 R2 的连接也关掉，避免影响后面的实验

```
R3#clear line vty 1
[confirm]
 [OK]
R3#
```

任务 6：配置明文特权密码

步骤 1：进入 R1 的命令行界面，使用 enable 进入特权模式，此时没有任何限制

```
R1>enable
R1#
```

步骤 2：进入全局配置模式，使用 enable password 命令创建明文的特权密码为 cisco

```
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#enable password cisco
R1(config)#
```

步骤 3：回到特权模式，再使用 disable 回到用户模式

```
R1(config)#exit
R1#disable    //这里不要使用 exit， exit 会关闭 console 连接
R1>
```

步骤 4：尝试用 enable 命令，进入特权模式时，提示输入密码，输入 cisco 后即可进入特权模式

```
R1>enable
Password:
R1#
```

步骤 5：检查 running-config，发现 enable password cisco，说明密码字符串是明文的

```
R1#show running-config
Building configuration...

Current configuration : 792 bytes
!
```

```
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable password cisco
!
no aaa new-model
!
resource policy
!
ip subnet-zero
ip cef
!
!
!
username yangbang password 0 ccna    // “0” 表示不加密
!
!
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
 no fair-queue
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
```

```
 shutdown
!
ip classless
!
!
ip http server
no ip http secure-server
!
!
control-plane
!
!
line con 0
 password lab
 login local
line aux 0
line vty 0 4
!
!
end
```

任务 7：配置密文特权密码

步骤 1：进入 R1 的全局配置模式

```
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#
```

步骤 2：使用 enable secret 命令创建密文特权密码为 cisco123

```
R1(config)#enable secret cisco123
```

步骤 3：回到用户模式

```
R1(config)#exit
R1#disable
R1>
```

步骤 4：尝试进入特权模式，现在输入 cisco 已经没有用了，输入 cisco123 才有用，说明明文特权密码优先于明文特权密码

```
R1>enable
Password:    //输入 cisco，没有用
Password:    //输入 cisco123，能进入特权
R1#
```

步骤 5：检查 running-config，发现特权密文特权密码一串混乱的字符，说明被加密保存了

```
R1#show running-config
```

```
Building configuration...

Current configuration : 839 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$LFnP$YBmgj6Zsso.md7wupXnzF0
enable password cisco
!
no aaa new-model
!
resource policy
!
ip subnet-zero
ip cef
!

。。。。

。。。。

。。。。
```

任务 8：区别寄存器值 0x2102 和 0x2142

步骤 1：将 R1 的将配置寄存器值改成 0x2142

```
R1(config)#config-register 0x2142
```

步骤 2：保存 R1 的配置

```
R1(config)#exit
R1#wri
R1#write
Building configuration...
```

步骤 3：重启 R1

```
R1#reload

Proceed with reload? [confirm]  //按下回车
```

步骤 4：待 R1 重启后，看到了以下提示，说明现在 R1 处于初始化空配置状态，寄存器 0x2142 会使路由器启动时，不从 startup-config 加载配置

```
Cisco 3745 (R7000) processor (revision 2.0) with 243712K/18432K bytes of memory.
Processor board ID JPE0820104T
R7000 CPU at 350MHz, Implementation 39, Rev 3.3, 256KB L2, 2048KB L3 Cache
2 FastEthernet interfaces
2 Serial(sync/async) interfaces
DRAM configuration is 64 bits wide with parity disabled.
151K bytes of NVRAM.
62720K bytes of ATA System CompactFlash (Read/Write)


        --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 5：将 R2 的配置寄存器值配置为 0x2102

```
R2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#config-register 0x2102
```

步骤 6：保存 R2 的配置保存

```
R2#write
Building configuration...
R2#
```

步骤 7：重启 R2

```
R2#reload
Proceed with reload? [confirm]
```

步骤 8：待 R2 重启完毕后，可以看到 R2 的主机名仍然是重启前的“R2”，说明重启前的配置被保存并加载起来了，0x2102 会确保路由器启动时加载 startup-config

```
Press RETURN to get started!

R2>
```

步骤 9：使用 show version，检查 R2 的配置寄存器值

```
R2#show version
Cisco IOS Software, 3700 Software (C3745-ADVIPSERVICESK9-M), Version 12.4(3c), RELEASE
SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2006 by Cisco Systems, Inc.
Compiled Fri 06-Jan-06 20:32 by alnguyen

ROM: System Bootstrap, Version 12.2(8r)T2, RELEASE SOFTWARE (fc1)
```

```
R2 uptime is 2 minutes
System returned to ROM by reload
System image file is "flash:c3745-advipservicesk9-mz.124-3c.bin"


This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
Importers, exporters, distributors and users are responsible for
compliance with U.S. and local country laws. By using this product you
agree to comply with applicable laws and regulations. If you are unable
to comply with U.S. and local laws, return this product immediately.

A summary of U.S. laws governing Cisco cryptographic products may be found at:
http://www.cisco.com/wwl/export/crypto/tool/stqrg.html

If you require further assistance please contact us by sending email to
export@cisco.com.

Cisco 3745 (R7000) processor (revision 2.0) with 243712K/18432K bytes of memory.
Processor board ID JPE08071103
R7000 CPU at 350MHz, Implementation 39, Rev 3.3, 256KB L2, 2048KB L3 Cache
2 FastEthernet interfaces
2 Serial(sync/async) interfaces
16 ISDN Basic Rate interfaces
DRAM configuration is 64 bits wide with parity disabled.
151K bytes of NVRAM.
62720K bytes of ATA System CompactFlash (Read/Write)
```

Configuration register is 0x2102

提问：在实际网络环境中，寄存器值应该是 0x2102 还是 0x2142？

任务 9：将所有设备都恢复到出厂设置

步骤 1：在所有路由器上（R1、R2、R3），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

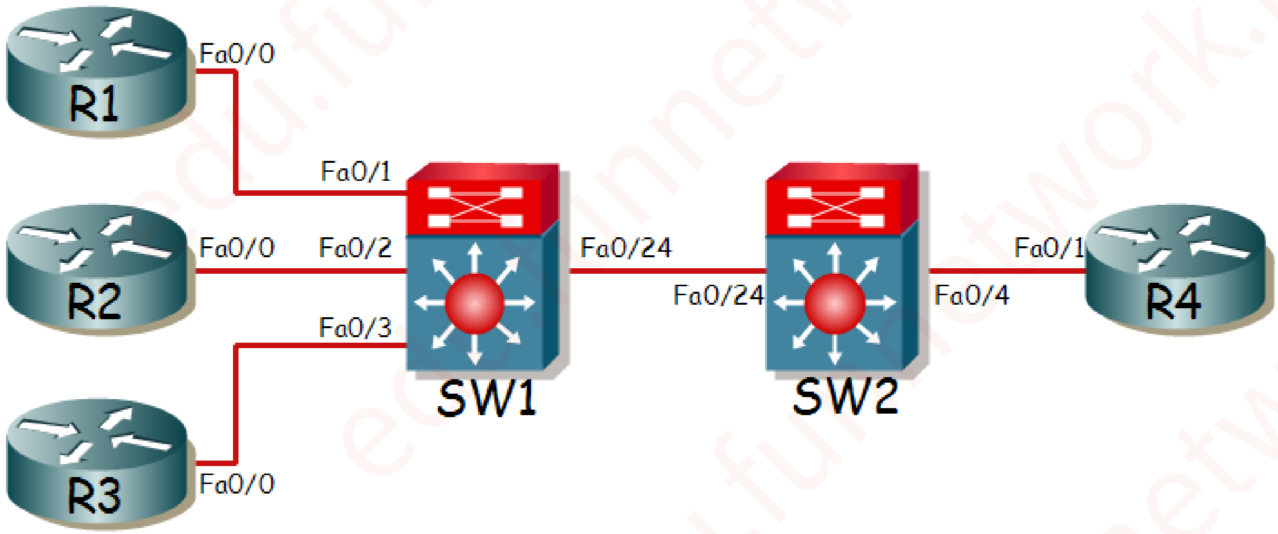
步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

...本次实验完成..

实验 3 配置和管理思科交换机

实验拓扑



实验目的

- ✓ 初始化思科交换机的配置机器 vlan 数据库
- ✓ 掌握交换机上 vlan 的创建、修改、删除
- ✓ 掌握配置 Access 接口的方法
- ✓ 掌握配置 Trunk 链路的方法
- ✓ 掌握 VTP 的配置和管理
- ✓ 掌握单臂路由配置方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1 和 SW2），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：登录到到思科交换机，熟悉命令行界面

步骤 1：登录到交换机 SW1 的命名行界面

步骤 2：在用户模式下，使用 enable 进入特权模式

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!

Switch>enable
Switch#
```

步骤 3：在特权模式下，使用 configure terminal 进入全局配置模式

```
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#
```

步骤 4：在全局配置模式下，使用 interface fastethernet0/1，进入 Fa0/1 的配置模式

```
Switch(config)#interface fastEthernet 0/1
Switch(config-if)#
```

步骤 5：使用 exit 回到用户模式

```
Switch(config-if)#exit
Switch(config)#
```

步骤 6：使用 exit 回到特权模式

```
Switch(config)#exit
Switch#
```

步骤 7：使用 disable 回到用户模式

```
Switch#disable
Switch>
```

任务 2：恢复交换机到初始化设置

步骤 1：进入交换机 SW1 的命令行界面，进入特权模式

```
Switch>enable
Switch#
```

步骤 2：使用 erase startup-config 命令清除启动配置文件

```
Switch#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Switch#
```

步骤 3：使用 delete vlan.dat 命令清除 vlan 数据库文件

```
Switch#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
%Error deleting flash:vlan.dat (No such file or directory)
```

//如果 vlan.dat 已被删除过，则会出现这个提示，没关系继续往下做

```
Switch#
```

步骤 4：使用 reload 命令重启交换机

```
Switch#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]  按下回车
```

步骤 5：待交换机重启后，看到一下提示，说明交换机回到了出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 3：熟悉基本的 show 命令

步骤 1：在初始化提示中选择 NO，直接进入命令行界面

```
Would you like to enter the initial configuration dialog? [yes/no]: no
```

```
Would you like to terminate autoinstall? [yes]:  按下回车
```

```
Press RETURN to get started!
```

步骤 2：进入交换机的特权模式

```
Switch>enable
Switch#
```

步骤 3：使用 show version 命令，可以检查交换机平台和版本信息

```
Switch#show version
Cisco IOS Software, C3550 Software (C3550-IPSERVICESK9-M), Version 12.2(44)SE3, RELEASE
SOFTWARE (fc2)
Copyright (c) 1986-2008 by Cisco Systems, Inc.
Compiled Mon 29-Sep-08 01:21 by nachen
Image text-base: 0x00003000, data-base: 0x012A7BB8

ROM: Bootstrap program is C3550 boot loader

Switch uptime is 3 minutes
System returned to ROM by power-on
System image file is "flash:/c3550-ipservicesk9-mz.122-44.SE3.bin"


This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
Importers, exporters, distributors and users are responsible for
compliance with U.S. and local country laws. By using this product you
agree to comply with applicable laws and regulations. If you are unable
```

```
to comply with U.S. and local laws, return this product immediately.

A summary of U.S. laws governing Cisco cryptographic products may be found at:
http://www.cisco.com/wwl/export/crypto/tool/stqrg.html

If you require further assistance please contact us by sending email to
export@cisco.com.

Cisco WS-C3550-24 (PowerPC) processor (revision H0) with 65526K/8192K bytes of memory.
Processor board ID CAT0716X07A
Last reset from warm-reset
Running Layer2/3 Switching Image

Ethernet-controller 1 has 12 Fast Ethernet/IEEE 802.3 interfaces

Ethernet-controller 2 has 12 Fast Ethernet/IEEE 802.3 interfaces

Ethernet-controller 3 has 1 Gigabit Ethernet/IEEE 802.3 interface

Ethernet-controller 4 has 1 Gigabit Ethernet/IEEE 802.3 interface
```

24 FastEthernet interfaces
2 Gigabit Ethernet interfaces

```
The password-recovery mechanism is enabled.
384K bytes of flash-simulated NVRAM.
Base ethernet MAC Address: 00:0C:CE:40:B2:00
Motherboard assembly number: 73-5700-10
Power supply part number: 34-0966-02
Motherboard serial number: CAT071506AA
Power supply serial number: LIT0709011D
Model revision number: H0
Motherboard revision number: A0
Model number: WS-C3550-24-EMI
System serial number: CAT0716X07A
Configuration register is 0x10F
```

问题：粗体标记的内容分别描述了什么？

步骤 4：使用 show interface status，可以看到所有接口的状态列表（每位同学的交换机平台可能有区别，所有显示的内容可能各不相同）

```
Switch#show interfaces status

Port      Name               Status       Vlan       Duplex  Speed Type
Fa0/1                        connected    1          a-full  a-100 10/100BaseTX
Fa0/2                        connected    1          a-full  a-100 10/100BaseTX
Fa0/3                        connected    1          a-full  a-100 10/100BaseTX
Fa0/4                        connected    1          a-full  a-100 10/100BaseTX
Fa0/5                        notconnect   1            auto   auto 10/100BaseTX
Fa0/6                        notconnect   1            auto   auto 10/100BaseTX
Fa0/7                        notconnect   1            auto   auto 10/100BaseTX
Fa0/8                        notconnect   1            auto   auto 10/100BaseTX
Fa0/9                        notconnect   1            auto   auto 10/100BaseTX
Fa0/10                       connected    1          a-half   a-10 10/100BaseTX
Fa0/11                       notconnect   1            auto   auto 10/100BaseTX
Fa0/12                       notconnect   1            auto   auto 10/100BaseTX
Fa0/13                       notconnect   1            auto   auto 10/100BaseTX
Fa0/14                       notconnect   1            auto   auto 10/100BaseTX
Fa0/15                       notconnect   1            auto   auto 10/100BaseTX
Fa0/16                       notconnect   1            auto   auto 10/100BaseTX
Fa0/17                       notconnect   1            auto   auto 10/100BaseTX
Fa0/18                       notconnect   1            auto   auto 10/100BaseTX
Fa0/19                       connected    trunk      a-full  a-100 10/100BaseTX
Fa0/20                       connected    trunk      a-full  a-100 10/100BaseTX
Fa0/21                       notconnect   1            auto   auto 10/100BaseTX

Port      Name               Status       Vlan       Duplex  Speed Type
Fa0/22                       notconnect   1            auto   auto 10/100BaseTX
Fa0/23                       connected    trunk      a-full  a-100 10/100BaseTX
Fa0/24                       connected    trunk      a-full  a-100 10/100BaseTX
Gi0/1                        notconnect   1            auto   auto unknown
Gi0/2                        notconnect   1            auto   auto unknown
Switch#
```

步骤 5：使用 show running-config 可以看到交换机当前运行的配置

```
Switch#show running-config
Building configuration...

Current configuration : 2123 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
```

```
no service password-encryption
!
hostname Switch
!
!
no aaa new-model
ip subnet-zero
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
......略......
!
interface Vlan1
 no ip address
 shutdown
!
ip classless
ip http server
ip http secure-server
!
!
!
control-plane
!
!
line con 0
line vty 5 15
!
end
```

任务 4：创建、修改、删除 vlan

步骤 1：进入交换机 SW1 的全局配置模式

```
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#
```

步骤 2：使用 hostname 命令指定主机名为 SW1

```
Switch(config)#hostname SW1
SW1(config)#
```

步骤 3：创建一个 vlan，vlan 号为 100， 名字为“SALES”

```
SW1(config)#vlan 100
SW1(config-vlan)#name SALES
SW1(config-vlan)#exit
SW1(config)#
```

步骤 4：回到特权模式

```
SW1(config)#exit
SW1#
```

步骤 5：使用 show vlan brief 命令，检查 vlan 数据库，并确认 vlan100

```
SW1#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                                Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                                Fa0/9, Fa0/10, Fa0/11, Fa0/12
                                                Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                                Fa0/17, Fa0/18, Fa0/21, Fa0/22
                                                Gi0/1, Gi0/2
100  SALES                            active
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

步骤 6：进入全局配置模式，将 vlan100 的名称改为“SUPPORTS”

```
SW1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SW1(config)#vlan 100
SW1(config-vlan)#name SUPPORTS
SW1(config-vlan)#exit
SW1(config)#exit
```

步骤 7：再次检查 vlan 数据库，确认 vlan100 的名称已被更改

```
SW1#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                                Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                                Fa0/9, Fa0/10, Fa0/11, Fa0/12
                                                Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                                Fa0/17, Fa0/18, Fa0/21, Fa0/22
                                                Gi0/1, Gi0/2
100  SUPPORTS                         active
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

步骤 8：进入全局配置模式，将 vlan100 删除

```
SW1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SW1(config)#no vlan 100
SW1(config)#exit
SW1#
```

步骤 9：检查 vlan 数据库，确认 vlan100 已被删除

```
SW1#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                                Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                                Fa0/9, Fa0/10, Fa0/11, Fa0/12
                                                Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                                Fa0/17, Fa0/18, Fa0/21, Fa0/22
                                                Gi0/1, Gi0/2
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

任务 5：观察二层交换的转发过程

步骤 1：登录到 R1 的命令行界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!
```

步骤 2：配置 R1 的主机名为“R1”，并配置 Fa0/0 的 IP 为 192.168.0.1/24（如果没有 Fa0/0 则使用 E0/0）

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#ip address 192.168.0.1 255.255.255.0
R1(config-if)#no shutdown
```

步骤 3：登录到 R2 的命令行界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!
```

步骤 4：配置 R2 的主机名为“R2”，并配置 Fa0/0 的 IP 为 192.168.0.2/24（如果没有 Fa0/0 则使用 E0/0）

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
```

```
R2(config)#interface fastEthernet 0/0
R2(config-if)#ip address 192.168.0.2 255.255.255.0
R2(config-if)#no shutdown
```

步骤 5：登录到 R3 的命令行界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!
```

步骤 6：配置 R3 的主机名为“R3”，并配置 Fa0/0 的 IP 为 192.168.0.3/24（如果没有 Fa0/0 则使用 E0/0）

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#ip address 192.168.0.3 255.255.255.0
R3(config-if)#no shutdown
```

步骤 7：使用 ping 命令，确认现在 3 台路由器之间能互通。此时，交换机的配置是默认配置，连接在这台交换机上的所有网络设备（主机、路由器）都能互相通信

```
R1#ping 192.168.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms

R1#ping 192.168.0.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
```

```
R1#

R2#ping 192.168.0.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
R2#
```

步骤 8：检查 R1 的 Fa0/0 口的详细信息，找到这个接口的 MAC 地址（每台设备各不相同）

```
R1#show interfaces fastEthernet 0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is 000f.9057.fdd0 (bia 000f.9057.fdd0)
  Internet address is 192.168.0.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s, 100BaseTX/FX
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:00, output 00:00:03, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 7000 bits/sec, 3 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     376 packets input, 154470 bytes
     Received 366 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog
     0 input packets with dribble condition detected
     38 packets output, 4685 bytes, 0 underruns
     0 output errors, 0 collisions, 4 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

步骤 9：检查 R2 的 ARP 缓存，会看到 192.168.0.1 的 MAC 地址和步骤 8 中看到的一致

```
R2#show arp
Protocol  Address       Age (min)  Hardware Addr   Type   Interface
Internet  192.168.0.1          2   000f.9057.fdd0  ARPA   FastEthernet0/0
Internet  192.168.0.2          -   000f.2306.f2c0  ARPA   FastEthernet0/0
Internet  192.168.0.3          2   0008.a3e5.13e0  ARPA   FastEthernet0/0
```

步骤 10：检查交换机的 MAC 地址表，也会看到交换机的 Fa0/1 口上有 R1 的 MAC 地址

```
SW1#show mac address-table dynamic
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

。。。。。。。

   1    000f.2306.f2c0    DYNAMIC     Fa0/2
   1    000f.9057.fdd0    DYNAMIC     Fa0/1
   1    0010.7b36.a5ce    DYNAMIC     Fa0/10

。。。。。。。
Total Mac Addresses for this criterion: 12
SW1#
```

步骤 11：完整地写出 R2(192.168.0.2)发数据给 R1（192.168.0.1）的过程

1. R2 要发送数据给 192.168.0.1，先检查自己的_________，来得到对方 R1 的 MAC 地址

2. R2 将 R1 的 MAC 地址封装为数据帧的目标 MAC 地址发出

3. SW1 接收到这个数据后，检查数据帧的目标 MAC 地址

4. SW1 会检查自己的________，来判断这个数据从哪个接口发出

5. SW1 将数据从指定接口发出后就能成功的到达 R1

任务 6：划分 vlan，理解 vlan 的作用

步骤 1：在 SW1 上创建 2 个 vlan，vlan100 和 vlan200，名称保持默认

```
SW1(config)#vlan 100
SW1(config-vlan)#exit
SW1(config)#vlan 200
SW1(config-vlan)#exit
SW1(config)#
```

步骤 2：进入 SW1 的 Fa0/1 口，将该接口配置为 vlan100 的 Access 接口

```
SW1(config)#interface fastEthernet 0/1
SW1(config-if)#switchport mode access
SW1(config-if)#switchport access vlan 100
SW1(config-if)#exit
```

步骤 3：使用 range 命令，同时进入 Fa0/2 和 Fa0/3 的接口配置模式，将这两个接口配置为 vlan4：的 Access 接口

```
SW1(config)#interface range fastEthernet 0/2 - 3
SW1(config-if-range)#switchport mode access
SW1(config-if-range)#switchport access vlan 200
SW1(config-if-range)#end
SW1#
```

步骤 5：使用 show vlan brief 命令，确认 vlan100 和 vlan200，以及和它们关联的接口

```
SW1#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/4, Fa0/5, Fa0/6, Fa0/7
                                                Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                                Fa0/12, Fa0/13, Fa0/14, Fa0/15
                                                Fa0/16, Fa0/17, Fa0/18, Fa0/21
                                                Fa0/22, Gi0/1, Gi0/2
100  VLAN0100                         active    Fa0/1
200  VLAN0200                         active    Fa0/2, Fa0/3
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

步骤 6：再测试用 ping 命令作测试，现在发现 R2 和 R3 之间能互通，但 R1 无法和其他路由器通信，体会 vlan 的作用

```
R2#ping 192.168.0.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

R1#ping 192.168.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)

R1#ping 192.168.0.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

任务 7：配置和实施交换机之间的 Trunk 链路

步骤 1：登录到 SW2 的命令行界面，清空启动配置，删除 vlan.dat，并重启，确保 SW2 回到初始化状态

```
Switch>enable
Switch#erase startup-config
Switch#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
Switch#reload
Proceed with reload? [confirm]


        --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:no
```

步骤 2：进去全局配置模式，将主机名改为 “SW2”

```
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#hostname SW2
SW2(config)#
```

步骤 3：使用 interface range 命令，进入 Fa0/5-Fa0/23 的配置模式，将这些接口全部关闭，这些接口实验中不需要

```
SW2(config)#interface range fastEthernet 0/5 - 23
SW2(config-if-range)#shutdown
SW2(config-if-range)#exit
```

步骤 4：进入 Fa0/24 口，将该接口配置为 Trunk（如果需要，先指定封装为 802.1q）

```
SW2(config)#interface fastEthernet 0/24
```

SW2(config-if)#switchport trunk encapsulation dot1q //可能您输入这条命令时

报错，说明该交换机只支持 802.1q，所有不需要再明确指定了，没问题，继续往下做

```
SW2(config-if)#switchport mode trunk
SW2(config-if)#end
SW2#
```

步骤 5：回到 SW1 的界面，使用 interface range 命令，进入 Fa0/5-Fa0/23 的配置模式，将这些接口全部关闭，这些接口实验中不需要

```
SW1(config)#interface range fastEthernet 0/5 - 23
SW1(config-if-range)#shutdown
SW1(config-if-range)#exit
```

步骤 6：进入 SW1 的 Fa0/24，将该接口配置为 Trunk（如果需要，先指定封装为 802.1q）

SW1(config)#interface fastEthernet 0/24

SW1(config-if)#switchport trunk encapsulation dot1q //可能您输入这条命令时

报错，说明该交换机只支持 802.1q，所有不需要再明确指定了，没问题，继续往下做

```
SW1(config-if)#switchport mode trunk
SW1(config-if)#end
SW1#
```

步骤 7：在 SW1 的特权模式下，使用 show interface trunk 检查 Trunk 线路的状态，需要看到“status”显示为“Trunking”

```
SW1#show interfaces trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/24      on               802.1q         trunking      1

Port        Vlans allowed on trunk
Fa0/24      1-4094

Port        Vlans allowed and active in management domain
Fa0/24      1,100,200
```

```
Port        Vlans in spanning tree forwarding state and not pruned
Fa0/24      1,100,200
SW1#
```

步骤 8：在 SW2 的特权模式下，也确认 Trunk 线路正常工作

```
SW2#show interfaces trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/24      on               802.1q         trunking      1

Port        Vlans allowed on trunk
Fa0/24      1-4094

Port        Vlans allowed and active in management domain
Fa0/24      1

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/24      1
```

步骤 9：在 SW2 上创建 vlan200

```
SW2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SW2(config)#vlan 200
SW2(config-vlan)#exit
SW2(config)#
```

步骤 10：将 SW2 的 Fa0/4 配置为 vlan200 的 Access 接口

```
SW2(config)#interface fastEthernet 0/4
SW2(config-if)#switchport mode access
SW2(config-if)#switchport access vlan 200
SW2(config-if)#exit
```

步骤 11：登录到 R4 的界面，将主机名改为“R4”，并配置 Fa0/1（如果没有 Fa0/1，则使用 E0/1），指定 IP 为 192.168.0.4/24

```
Router>enable
```

```
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/1
R4(config-if)#ip address 192.168.0.4 255.255.255.0
R4(config-if)#no shutdown
R4(config-if)#exit
R4(config)#
```

步骤 12：使用 ping 测试，确认 R4 现在能 ping 通 R2 和 R3，说明 Trunk 链路可以帮助同一个 vlan 的设备跨越交换机通信

```
R4#ping 192.168.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms

R4#ping 192.168.0.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
R4#
```

R4 没法 ping 通 R1，为什么？

```
R4#ping 192.168.0.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

任务 8：通过 VTP 同步 vlan 数据库

步骤 1：进入 SW1 的全局配置模式

```
SW1>enable
SW1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SW1(config)#
```

步骤 2：指定 SW1 的 VTP 域名为 yangbang

```
SW1(config)#vtp domain yangbang
Changing VTP domain name from NULL to yangbang
SW1(config)#
```

步骤 3：指定 SW1 的 VTP 密码为 12345

```
SW1(config)#vtp password 12345
Setting device VLAN database password to 12345
SW1(config)#
```

步骤 4：指定 SW1 的 VTP 模式为 Server（默认就是 Server）

```
SW1(config)#vtp mode server
Device mode already VTP SERVER.
SW1(config)#
```

步骤 5：进入 SW2 的全局配置模式

```
SW2>enable
SW2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SW2(config)#
```

步骤 6：指定 SW2 的 VTP 域名为 yangbang

```
SW2(config)#vtp domain yangbang
Domain name already set to yangbang.
SW2(config)#
```

步骤 7：指定 SW2 的 VTP 密码为 12345

```
SW2(config)#vtp password 12345
Setting device VLAN database password to 12345
SW2(config)#
```

步骤 8：指定 SW2 的 VTP 模式为为 Client

```
SW2(config)#vtp mode client
Setting device to VTP CLIENT mode.
SW2(config)#
```

步骤 9：在 SW1 上增加 vlan300，名称保持默认

```
SW1(config)#vlan 300
SW1(config-vlan)#exit
SW1(config)#exit
SW1#
```

步骤 10：检查 SW1 的 vlan 数据库，确保 vlan300 已加入数据库

```
SW1#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/4, Fa0/5, Fa0/6, Fa0/7
                                                Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                                Fa0/12, Fa0/13, Fa0/14, Fa0/15
                                                Fa0/16, Fa0/17, Fa0/18, Fa0/19
                                                Fa0/20, Fa0/21, Fa0/22, Fa0/23
                                                Gi0/1, Gi0/2
100  VLAN0100                         active    Fa0/1
200  VLAN0200                         active    Fa0/2, Fa0/3
300  VLAN0300                         active
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

步骤 11：检查 SW2 的 vlan 数据库，会发现 vlan300 也出现了，说明 VTP 可以帮助我们集中管理 vlan 数据库

```
SW2#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/5
                                                Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                                Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                                Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                                Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                                Fa0/22, Fa0/23, Gi0/1, Gi0/2
100  VLAN0100                         active
200  VLAN0200                         active    Fa0/4
300  VLAN0300                         active
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

步骤 12：在 SW1 上，删除 vlan300

```
SW1(config)#no vlan 300
SW1(config)#exit
SW1#
```

步骤 13：再检查 2 台交换机的 vlan 数据库，发现 vlan300 都被删除了

```
SW1#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/4, Fa0/5, Fa0/6, Fa0/7
                                                Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                                Fa0/12, Fa0/13, Fa0/14, Fa0/15
                                                Fa0/16, Fa0/17, Fa0/18, Fa0/19
                                                Fa0/20, Fa0/21, Fa0/22, Fa0/23
                                                Gi0/1, Gi0/2
100  VLAN0100                         active    Fa0/1
200  VLAN0200                         active    Fa0/2, Fa0/3
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

```
SW2#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/5
                                                Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                                Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                                Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                                Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                                Fa0/22, Fa0/23, Gi0/1, Gi0/2
100  VLAN0100                         active
200  VLAN0200                         active    Fa0/4
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

步骤 14：使用 Show vtp status，观察 VTP 的域名和模式等信息

```
SW1#show vtp status
VTP Version                     : running VTP1 (VTP2 capable)
Configuration Revision          : 7
Maximum VLANs supported locally : 1005
Number of existing VLANs        : 7
VTP Operating Mode              : Server
VTP Domain Name                 : yangbang
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0x13 0x97 0x61 0xF9 0x4E 0x90 0x4B 0x14
Configuration last modified by 0.0.0.0 at 3-1-93 00:56:45
Local updater ID is 0.0.0.0 (no valid interface found)

SW2#show vtp status
VTP Version                     : running VTP1 (VTP2 capable)
Configuration Revision          : 7
Maximum VLANs supported locally : 1005
Number of existing VLANs        : 7
VTP Operating Mode              : Client
VTP Domain Name                 : yangbang
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0x13 0x97 0x61 0xF9 0x4E 0x90 0x4B 0x14
Configuration last modified by 0.0.0.0 at 3-1-93 00:56:45
```

步骤 15：使用 show vtp password，观察 VTP 的密码

```
SW1#show vtp password
VTP Password: 12345
SW1#
```

步骤 16：尝试在 SW2 上创建 vlan400，但失败了，说明在 client 交换机上，不能对 vlan 数据库进行修改

```
SW2(config)#vlan 400
%VTP VLAN configuration not allowed when device is in CLIENT mode.
SW2(config)#
```

任务 9：配置 802.1q 子接口，使路由器能同时连入多个 vlan

步骤 1：将 R1 的 Fa0/0 的 IP 改为 192.168.100.1/24（R1 现在是 vlan100 的网络设备）

```
R1>enable
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface fastEthernet 0/0
R1(config-if)#ip address 192.168.100.1 255.255.255.0
R1(config-if)#exit
```

步骤 2：进入 SW2 的 Fa0/4，将该接口配置为 Trunk 接口（如果需要，先指定封装为 802.1q）

```
SW2>enable
SW2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
SW2(config)#interface fastEthernet 0/4
SW2(config-if)#switchport trunk encapsulation dot1q
SW2(config-if)#switchport mode trunk
SW2(config-if)#end
SW2#
```

步骤 3：检查 SW2 的 trunk 接口，确保 Fa0/4 的状态是 “Trunking”

```
SW2#show interfaces trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/4       on               802.1q         trunking      1
Fa0/24      on               802.1q         trunking      1

Port        Vlans allowed on trunk
Fa0/4       1-4094
Fa0/24      1-4094

Port        Vlans allowed and active in management domain
Fa0/4       1,100,200
Fa0/24      1,100,200

Port        Vlans in spanning tree forwarding state and not pruned
```

```
Fa0/4       1,100,200
Fa0/24      1,100,200
SW2#
```

步骤 4：进入 R4 的 Fa0/1(如果没有 Fa0/1，则使用 E0/1)，将该接口原先的 IP 配置去掉，并保持该接口开启

```
R4>enable
R4#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)#interface fastEthernet 0/1
R4(config-if)#no ip address
R4(config-if)#exit
```

步骤 5：在 R4 的全局配置模式下，创建一个子接口 Fa0/1.1

```
R4(config)#interface fastEthernet 0/1.1
R4(config-subif)#
```

步骤 6：指定 Fa0/1.1 的 dot1q 标记值为 100，表示该子接口连入 vlan100

```
R4(config-subif)#encapsulation dot1Q 100
R4(config-subif)#
```

步骤 7：配置 Fa0/1.1 的 IP 为 192.168.100.4/24

```
R4(config-subif)#ip address 192.168.100.4 255.255.255.0
R4(config-subif)#exit
R4(config)#
```

步骤 8：在 R4 的全局配置模式下，再创建一个子接口 Fa0/1.2

```
R4(config)#interface fastEthernet 0/1.2
R4(config-subif)#
```

步骤 9：指定 Fa0/1.2 的 dot1q 标记值为 200，表示该子接口连入 vlan200

```
R4(config-subif)#encapsulation dot1Q 200
R4(config-subif)#
```

步骤 10：配置 Fa0/1.2 的 IP 为 192.168.0.4/24

```
R4(config-subif)#ip address 192.168.0.4 255.255.255.0
R4(config-subif)#exit
```

步骤 11：检查 R4 的接口状态列表，会看到 2 个网段的虚拟接口，这两个接口分别可以和各自 vlan 的设备通信

```
R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is up, line protocol is up
FastEthernet0/1.1 is up, line protocol is up
  Internet address is 192.168.100.4/24
FastEthernet0/1.2 is up, line protocol is up
  Internet address is 192.168.0.4/24
Serial0/1 is administratively down, line protocol is down
```

步骤 12：在 R4 上，使用 ping 测试，发现 R4 能同时 ping 通 vlan100 的主机（R1，192.168.100.1）以及 vlan200 的主机（R2，192.168.0.2 和 R3，192.168.0.3）

```
R4#ping 192.168.100.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
R4#ping 192.168.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms

R4#ping 192.168.0.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
```

任务 10：将所有设备都恢复到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1 和 SW2），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

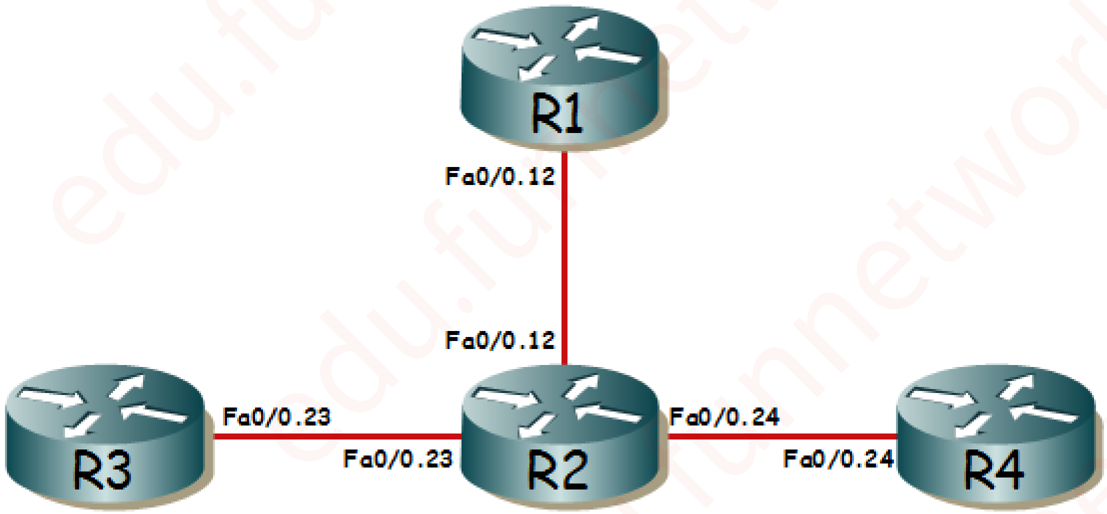
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………………本次实验完成……………………………………………

实验 4 配置和实施静态路由

实验拓扑



实验目的：

- ✓ 回顾路由基本概念和原理
- ✓ 掌握配置静态路由器的方法
- ✓ 掌握配置默认路由的方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1 ：建立逻辑拓扑

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:



Press RETURN to get started!


Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注 :输入“switchport trunk encapsulation dot1q”时如果出现报错 ,就说明您的交换机只支持 dot1q，

就不需要再明确指定 trunk 的标记格式，不用管它，继续往下做。

步骤 2：登录到 R1 的命名行界面，配置主机为 “R1”

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Router(config)#hostname R1
```

步骤 3：打开 R1 的 Fa0/0（如果没有 Fa0/0 则使用 E0/0）

```
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤4 创建连接R2的Fa0/0.12子接口 指定dot1q标记为100 ,IP地址为192.168.12.1/24

```
R1(config)#interface fastEthernet 0/0.12
R1(config-subif)#encapsulation dot1Q 100
R1(config-subif)#ip address 192.168.12.1 255.255.255.0
R1(config-subif)#exit
```

步骤 5：登录到 R2 的命令行界面，配置主机名为“R2”

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#
```

步骤 6：开启 R2 的 Fa0/0（如果没有 Fa0/0，则使用 E0/0）

```
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 7：在 R2 上创建 3 个子接口，分别是 Fa0/0.12、Fa0/0.23 和 Fa0/0.24，dot1q 标记分别为 100、200 和 300，IP 地址分别是 192.168.12.2/24、192.168.23.2/24 和 192.168.24.2/24

```
R2(config)#interface fastEthernet 0/0.12
R2(config-subif)#encapsulation dot1Q 100
R2(config-subif)#ip address 192.168.12.2 255.255.255.0
R2(config-subif)#exit
R2(config)#interface fastEthernet 0/0.23
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#ip address 192.168.23.2 255.255.255.0
R2(config-subif)#exit
R2(config)#interface fastEthernet 0/0.24
R2(config-subif)#encapsulation dot1Q 300
R2(config-subif)#ip address 192.168.24.2 255.255.255.0
R2(config-subif)#exit
```

步骤 8 :登录到 R3 的命令行界面，定义主机名为 R3，打开 Fa0/0 口(如果没有则使用 E0/0)，并创建 Fa0/0.23，dot1q 为 200，IP 地址为 192.168.23.3

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#interface fastEthernet 0/0.23
R3(config-subif)#encapsulation dot1Q 200
R3(config-subif)#ip address 192.168.23.3 255.255.255.0
```

步骤 9 :登录到 R4 的命令行界面 ,定义主机名为 R4 ,打开 Fa0/0 口(如果没有则使用 E0/0),

并创建 Fa0/0.24，dot1q 为 300，IP 地址为 192.168.24.4/24

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n


Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
R4(config-if)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#encapsulation dot1Q 300
R4(config-subif)#ip address 192.168.24.4 255.255.255.0
R4(config-subif)#exit
```

步骤 10：使用 show 命令检查每台路由器创建的子接口都是 “UP” 状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.12 is up, line protocol is up
  Internet address is 192.168.12.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
FastEthernet1/0 is administratively down, line protocol is down
R1#

R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.12 is up, line protocol is up
  Internet address is 192.168.12.2/24
```

```
FastEthernet0/0.23 is up, line protocol is up
  Internet address is 192.168.23.2/24
FastEthernet0/0.24 is up, line protocol is up
  Internet address is 192.168.24.2/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
FastEthernet1/0 is administratively down, line protocol is down


R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.23 is up, line protocol is up
  Internet address is 192.168.23.3/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
FastEthernet1/0 is administratively down, line protocol is down


R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.24 is up, line protocol is up
  Internet address is 192.168.24.4/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
FastEthernet1/0 is administratively down, line protocol is down
```

步骤 11：使用 ping 测试，确保 R2 能和其他 3 台路由器通信

```
R2#ping 192.168.12.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 12/30/44 ms

R2#ping 192.168.23.3
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 192.168.23.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 32/37/44 ms

R2#ping 192.168.24.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.24.4, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 32/40/48 ms
```

任务 2：观察默认情况下的路由表

步骤 1：在 R1 上创建 Loopback0 接口，IP 为 192.168.1.1/24，模拟 R1 连接着一个 192.168.1.0/24 的局域网

```
R1(config)#interface loopback 0
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
```

步骤 2：使用 show ip route 命令检查 R1 的路由表，发现 R1 的路由表中只有直连网络的路由，分别是 192.168.1.0/24（Loopback0）和 192.168.12.0/24（连接 R2 的 Fa0/0.12）

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.1.0/24 is directly connected, Loopback0
```

步骤 3：在 R3 上增加 Loopback0 接口，IP 为 192.168.3.1/24，模拟 R3 连接着一个 192.168.3.0/24 的局域网

```
R3(config)#interface loopback 0
R3(config-if)#ip address 192.168.3.1 255.255.255.0
R3(config-if)#exit
```

步骤 4：检查 R3 的路由表，只能看到 192.168.3.0/24 和 192.168.23.0/24，这两个网段是 R3 的直连网络

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.3.0/24 is directly connected, Loopback0
```

步骤 5：在 R4 上增加 Loopback0，IP 为 192.168.4.1/24，模拟 R4 连接着一个 192.168.4.0/24 的局域网

```
R4(config)#interface loopback 0
R4(config-if)#ip address 192.168.4.1 255.255.255.0
R4(config-if)#exit
```

步骤 6：检查 R4 的路由表，只能看到 192.168.4.0/24 和 192.168.24.0/24，这两个网段是 R4 的直连网络

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
```

```
Gateway of last resort is not set

C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.4.0/24 is directly connected, Loopback0
```

步骤 7：检查 R2 的路由表，发现现在只有 192.168.12.0/24、192.168.23.0/24 和 192.168.24.0/24，这 3 个网段都是 R2 的直连网络

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
```

由此可见，路由器的路由表中默认只有直连网络的路由条目

步骤 8：使用 ping 测试，发现任何一台路由器都只能 ping 通自己的接口和自己链路对面的接口，比如 R1，只能 ping 通 192.168.1.1（自己）、192.168.12.1（自己的 Fa0/0.12）和 192.168.12.2（自己 Fa0/0.12 对面的接口），而除此之外的其他 IP 是无法 ping 通的

```
R1#ping 192.168.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/5/8 ms
```

```
R1#ping 192.168.12.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/5/8 ms
R1#ping 192.168.12.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/32/44 ms
R1#ping 192.168.23.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.23.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

任务 3：配置基于下一跳 IP 的静态路由

步骤 1：在 R2 上，创建一条到 192.168.1.0/24 的静态路由，下一跳 IP 地址为 192.168.12.1

```
R2(config)#ip route 192.168.1.0 255.255.255.0 192.168.12.1
```

步骤 2：检查 R2 的路由表，发现了一条“S”的路由

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
```

步骤 3：在 R2 上，尝试再增加到 192.168.1.0/24，但下一跳为 192.168.12.2，这个下一跳是自己的 IP 地址，看看发生了什么？为什么会出现报错？错在哪里？

```
R2(config)#ip route 192.168.1.0 255.255.255.0 192.168.12.2
%Invalid next hop address (it's this router)
```

步骤 4：在 R2 上，尝试增加一条静态路由，目标网络 192.168.1.0，掩码为 255.255.0.0，下一跳是 192.168.12.2，看看发生了什么？为什么会出现报错？错在哪里？

```
R2(config)#ip route 192.168.1.0 255.255.0.0 192.168.12.1
%Inconsistent address and mask
```

步骤 5 :在 R2 上 ,创建一条静态路由 ,目标网络是 192.168.1.0/24 ,下一跳是 192.168.23.3（R3），显然这条路由是错误的，通过 R3 根本无法到达 192.168.1.0/24

```
R2(config)#ip route 192.168.1.0 255.255.255.0 192.168.23.3
```

步骤 6:观察 R2 的路由表，会发现到 192.168.1.0/24 有 2 个下一跳 IP，说明静态路由没有唯一性，到一个目标网段完全可以有多个下一跳

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24    [1/0] via 192.168.23.3
                       [1/0] via 192.168.12.1
```

步骤 7：在 R2 上，使用 no 命令，将错误的静态路由删掉

```
R2(config)#no ip route 192.168.1.0 255.255.255.0 192.168.23.3
```

步骤 8：再次检查 R2 的路由表，发现到 192.168.1.0/24 只有一个下一跳

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
```

步骤 9：使用 show ip route static 可以把路由表中的静态路由提取出来单独查看

```
R2#show ip route static
S    192.168.1.0/24 [1/0] via 192.168.12.1
R2#
```

任务 4：配置基于出站接口的静态路由

步骤 1：在 R2 上创建一条到 192.168.3.0/24 的路由，以 Fa0/0.23 为出站接口

```
R2(config)#ip route 192.168.3.0 255.255.255.0 fastEthernet 0/0.23
```

步骤 2：检查 R2 的路由表，会看到一条到 192.168.3.0/24 的静态路由

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
S    192.168.3.0/24 is directly connected, FastEthernet0/0.23
```

步骤 3：再配置一条到 192.168.4.0/24 的静态路由，以 fa0/0.24 为出站接口

```
R2(config)#ip route 192.168.4.0 255.255.255.0 fastEthernet 0/0.24
```

步骤 4：检查 R2 的路由表，到目前为止，R2 已经获得了所有网络的路由（3 个直连网络和到 3 个 Loopback0 的静态路由）

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
S    192.168.4.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
S    192.168.3.0/24 is directly connected, FastEthernet0/0.23
R2#
```

任务 5：配置默认路由

步骤 1：在 R1 上配置静态路由，确保 R1 的路由表中获得本来自己没有的路由（非直连路由）

```
R1(config)#ip route 192.168.23.0 255.255.255.0 192.168.12.2
R1(config)#ip route 192.168.24.0 255.255.255.0 192.168.12.2
R1(config)#ip route 192.168.3.0 255.255.255.0 192.168.12.2
R1(config)#ip route 192.168.4.0 255.255.255.0 192.168.12.2
```

分析这个步骤中的配置，发现配置的所有静态路由的下一跳都是 192.168.12.2，所有完全可以用一条路由（目标地址为所有 IP）来替代步骤 1 配置的多条静态路由

步骤 2：在 R1 上，使用 no ip routing 关闭路由功能，再用 ip routing 开启路由功能，这样可以删除所有关于路由的配置

```
R1(config)#no ip routing
R1(config)#ip routing
```

步骤 3：检查 R1 的路由表，确保现在确实只有直连网络路由

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.1.0/24 is directly connected, Loopback0
```

步骤 4：在 R1 上，创建一条默认路由，下一跳是 192.168.12.2（R2）

```
R1(config)#ip route 0.0.0.0 0.0.0.0 192.168.12.2
```

步骤 5：检查 R1 的路由表，会看到一条“S*”的路由，这条就是默认路由

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.12.2 to network 0.0.0.0

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.1.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 [1/0] via 192.168.12.2
```

步骤 6：在 R3 和 R4 上也分别增加默认路由，分别以 Fa0/0.23 和 Fa0/0.24 为出站接口

```
R3(config)#ip route 0.0.0.0 0.0.0.0 fastEthernet 0/0.23

R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.3.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 is directly connected, FastEthernet0/0.23
```

```
R3#
```

```
R4(config)#ip route 0.0.0.0 0.0.0.0 fastEthernet 0/0.24

R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.4.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 is directly connected, FastEthernet0/0.24
```

步骤 7：到这一步为止，这个网络的任何两个接口之间都实现了互通，可以使用 ping 测试，

下面以 R1 的 Loopback0 到 R3 的 Loopback0 的测试为例：

```
R1#ping 192.168.3.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/31/40 ms
R1#
```

任务 6：分析静态路由和默认路由的冲突问题

步骤 1：在 R1 上增加 Loopback100 和 Loopback200，IP 分别为 192.168.100.1/24 和 192.168.200.1/24，模拟 R1 连接着骨干网络的多个网段

```
R1(config)#interface loopback 100
R1(config-if)#ip address 192.168.100.1 255.255.255.0
R1(config-if)#exit
R1(config)#interface loopback 200
R1(config-if)#ip address 192.168.200.1 255.255.255.0
R1(config-if)#exit
```

步骤 2：在 R2 上配置一条默认路由，下一跳是 192.168.12.1(R1)

```
R2(config)#ip route 0.0.0.0 0.0.0.0 192.168.12.1
```

步骤 3：检查 R2 的路由表，发现了多条静态路由和一条默认路由，说明静态路由和默认路由可以共存于路由表

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.12.1 to network 0.0.0.0

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
S    192.168.4.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
S    192.168.3.0/24 is directly connected, FastEthernet0/0.23
S*   0.0.0.0/0 [1/0] via 192.168.12.1
```

步骤 4：在 R2 上，使用 ping 测试到 192.168.100.1 的通信，发现能通，为什么？路由表的哪条条目能转发到 192.168.100.1 的数据包？

```
R2#ping 192.168.100.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/33/48 ms
R2#

R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.12.1 to network 0.0.0.0

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
S    192.168.4.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
S    192.168.3.0/24 is directly connected, FastEthernet0/0.23
S*   0.0.0.0/0 [1/0] via 192.168.12.1
```

默认路由匹配了 192.168.100.1！

步骤 5：如果 R2 有数据包要去 192.168.3.1，路由表中有哪些路由可以匹配？

路由表中有 192.168.3.0/24 和 0.0.0.0/0 都可以匹配 192.168.3.1

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.12.1 to network 0.0.0.0

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
S    192.168.4.0/24 is directly connected, FastEthernet0/0.24
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
S    192.168.1.0/24 [1/0] via 192.168.12.1
S    192.168.3.0/24 is directly connected, FastEthernet0/0.23
S*   0.0.0.0/0 [1/0] via 192.168.12.1
```

步骤 6 :使用 ping 测试 ,发现能 ping 通 192.168.3.1 ,接着用 tracroute 测试到 192.168.3.1 的路径，发现下一跳是 192.168.23.3，说明路由走的是 R3。说明但数据包能同时匹配静态路由和默认路由时，它会优先被静态路由转发（静态路由更精确）

```
R2#ping 192.168.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 24/32/40 ms


R2#traceroute 192.168.3.1

Type escape sequence to abort.
Tracing the route to 192.168.3.1

  1 192.168.23.3 24 msec
```

任务 7：恢复所有设备到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

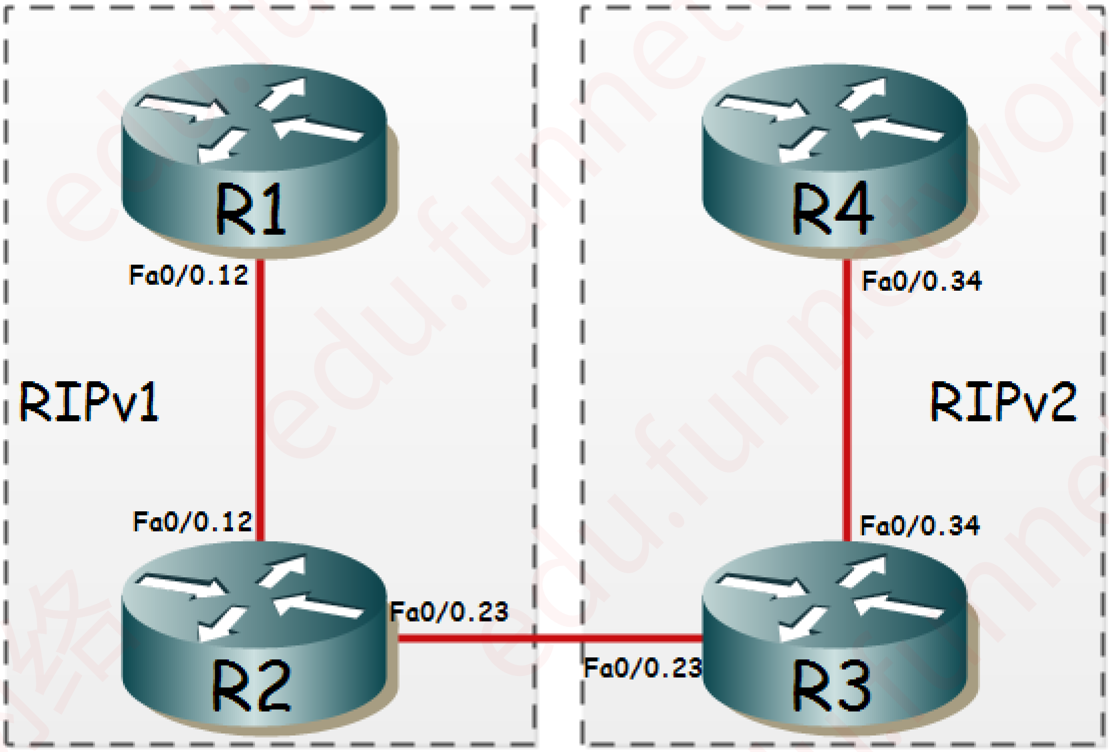
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

..本次实验完成..

实验 5 配置和实施 RIP 协议

实验拓扑



实验目的：

2. 回顾 RIP 协议基本原理和特点

3. 学会配置 RIP 协议及其各个基本参数

4. 了解 RIPv1 和 RIPv2 的区别

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：搭建逻辑拓扑

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:

Press RETURN to get started!

Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注：输入“switchport trunk encapsulation dot1q”时如果出现报错，就说明您的交换机只支持 dot1q，

就不需要再明确指定 trunk 的标记格式，不用管它，继续往下做。

步骤 2：登录到 R1，配置主机名为“R1”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3：在 R1 上，创建子接口 Fa0/0.12（或 E0/0.12），指定 dot1q 为 100，并配置 IP 地址为 192.168.12.1/24

```
R1(config)#interface fastEthernet 0/0.12
R1(config-subif)#encapsulation dot1Q 100
R1(config-subif)#ip address 192.168.12.1 255.255.255.0
R1(config-subif)#exit
```

步骤 4：登录到 R2 配置主机名为“R2”，并开启 Fa0/0 接口（如果没有 Fa0/0，则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 5：在 R2 上，创建子接口 Fa0/0.12（或 E0/0.12）和 Fa0/0.23（或 E0/0.23），指定 dot1q 为 100 和 200，并配置 IP 地址为 192.168.12.2/24 和 192.168.23.2/24

```
R2(config)#interface fastEthernet 0/0.12
R2(config-subif)#encapsulation dot1Q 100
R2(config-subif)#ip address 192.168.12.2 255.255.255.0
R2(config-subif)#exit
R2(config)#interface fastEthernet 0/0.23
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#ip address 192.168.23.2 255.255.255.0
R2(config-subif)#exit
```

步骤 6 :登录到 R3 配置主机名为“R3”,并开启 Fa0/0 接口(如果没有 Fa0/0 ,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 7：在 R3 上，创建子接口 Fa0/0.23（或 E0/0.23）和 Fa0/0.34（或 E0/0.34），指定 dot1q 为 200 和 300，并配置 IP 地址为 192.168.23.3/24 和 192.168.34.3/24

```
R3(config)#interface fastEthernet 0/0.23
R3(config-subif)#encapsulation dot1Q 200
R3(config-subif)#ip address 192.168.23.3 255.255.255.0
R3(config-subif)#exit
R3(config)#interface fastEthernet 0/0.34
R3(config-subif)#encapsulation dot1Q 300
R3(config-subif)#ip address 192.168.34.3 255.255.255.0
R3(config-subif)#exit
```

步骤 8 :登录到 R4 配置主机名为“R4”,并开启 Fa0/0 接口(如果没有 Fa0/0 ,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
R4(config-if)#exit
```

步骤 9：在 R4 上，创建子接口 Fa0/0.34（或 E0/0.34），指定 dot1q 为 300，并配置 IP 地址为 192.168.34.4/24

```
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#encapsulation dot1Q 300
R4(config-subif)#ip address 192.168.34.4 255.255.255.0
R4(config-subif)#exit
```

步骤 10：检查 4 台路由器的接口，确保需要的接口的是 UP 状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.12 is up, line protocol is up
  Internet address is 192.168.12.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

```
R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.12 is up, line protocol is up
  Internet address is 192.168.12.2/24
FastEthernet0/0.23 is up, line protocol is up
  Internet address is 192.168.23.2/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
```

```
R3#show protocols
```

```
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.23 is up, line protocol is up
  Internet address is 192.168.23.3/24
FastEthernet0/0.34 is up, line protocol is up
  Internet address is 192.168.34.3/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

```
R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.34 is up, line protocol is up
  Internet address is 192.168.34.4/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 11：使用 ping 测试，确保 R1 和 R2、R2 和 R3 以及 R3 和 R4 能互相通信

```
R1#ping 192.168.12.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
```

```
R2#ping 192.168.23.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.23.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
```

```
R3#ping 192.168.34.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.34.4, timeout is 2 seconds:
```

```
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/2/4 ms
```

任务 2：配置 RIPv1

步骤 1：进入 R1 的全局配置模式，使用 interface 命令，创建一个 Loopback0 接口，IP 为 192.168.1.1/24

```
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface loopback 0
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
```

步骤 2：在 R1 上，使用 router rip 命令，开启 RIP 协议，进入路由协议配置模式

```
R1(config)#router rip
R1(config-router)#
```

步骤 3：使用 network 命令，将 192.168.1.0 和 192.168.12.0 这两个网络加入 RIP 协议，确保 R1 的 Loopback0 和 Fa0/0.12 开启到 RIP 中

```
R1(config-router)#network 192.168.1.0
R1(config-router)#network 192.168.12.0
R1(config-router)#exit
R1(config)#
```

步骤 4：进入 R2 的全局配置模式，使用 router rip 命令开启 RIP 协议，进入路由协议配置模式，并使用 network 命令，将 192.168.12.0 加入 RIP 协议，确保 Fa0/0.12 开启到 RIP 中

```
R2(config)#router rip
R2(config-router)#network 192.168.12.0
R2(config-router)#end
R2#
```

步骤 5：检查 R2 的路由表，会看到有一个标记为“R”的路由，目标为 192.168.1.0/24，说明 R2 已经从 R1 通过 RIP 协议获得了路由信息

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
R    192.168.1.0/24 [120/1] via 192.168.12.1, 00:00:19, FastEthernet0/0.12
R2#
```

任务 3：观察 RIPv1 的工作和特点

步骤 1：进入 R1 的特权模式，使用 show ip protocols 命令观察动态路由的工作情况，会看到 RIP 协议的信息，重点关注标记的部分，回答一下问题：

1. RIP 每多少秒发出一次路由更新（Update）？
2. 默认 RIP 发出的是 version1 还是 version2 的路由？
3. 为什么 Fa0/0.12 和 Loopback0 出现在了“Interface”列表中？如果有一个接口的 IP 是 192.168.100.1，它会不会出现在 RIP 的接口列表中，为什么？

```
R1#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 21 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 1, receive any version
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.12     1     1 2
    Loopback0              1     1 2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.12.0
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: (default is 120)
```

步骤 2：在 R1 的特权模式下，开启 Debug ip rip，观察 RIP 的工作过程，过 1 分钟左右后，

用 no debug all 关闭监控，回答以下问题：

1. RIPv1 发出的路由，目标地址是什么？

2. RIPv1 发出的路由，是否会携带子网掩码？

3. RIPv1 从 Fa0/0.12 多次发出路由，时间间隔是多少？

```
R1#debug ip rip
RIP protocol debugging is on
R1#
*Mar  4 08:43:54.271: RIP: sending v1 update to 255.255.255.255 via FastEthernet0/0.12 
(192.168.12.1)
*Mar  4 08:43:54.271: RIP: build update entries
*Mar  4 08:43:54.271:   network 192.168.1.0 metric 1
*Mar  4 08:44:01.751: RIP: sending v1 update to 255.255.255.255 via Loopback0 
(192.168.1.1)
*Mar  4 08:44:01.751: RIP: build update entries
*Mar  4 08:44:01.751:   network 192.168.12.0 metric 1
*Mar  4 08:44:22.851: RIP: sending v1 update to 255.255.255.255 via FastEthernet0/0.12 
(192.168.12.1)
*Mar  4 08:44:22.851: RIP: build update entries
*Mar  4 08:44:22.851:   network 192.168.1.0 metric 1
*Mar  4 08:44:28.103: RIP: sending v1 update to 255.255.255.255 via Loopback0 
(192.168.1.1)
*Mar  4 08:44:28.103: RIP: build update entries
*Mar  4 08:44:28.103:   network 192.168.12.0 metric 1
*Mar  4 08:44:51.335: RIP: sending v1 update to 255.255.255.255 via FastEthernet0/0.12 
(192.168.12.1)
*Mar  4 08:44:51.335: RIP: build update entries
*Mar  4 08:44:51.335:   network 192.168.1.0 metric 1
*Mar  4 08:44:57.399: RIP: sending v1 update to 255.255.255.255 via Loopback0 
(192.168.1.1)
*Mar  4 08:44:57.399: RIP: build update entries
*Mar  4 08:44:57.399:   network 192.168.12.0 metric 1
*Mar  4 08:45:20.523: RIP: sending v1 update to 255.255.255.255 via FastEthernet0/0.12 
(192.168.12.1)

R1#no debug all
All possible debugging has been turned off
```

任务 4：观察 RIPv1 在子网环境中的运行情况

步骤 1：在 R1 上增加一个 Loopback1 口，IP 为 192.168.100.1/28，该接口所在的网段是 C 类地址 192.168.1.0 下的一个子网

```
R1(config)#interface loopback 1
R1(config-if)#ip address 192.168.100.1 255.255.255.240
R1(config-if)#exit
```

步骤 2：使用 network 命令将 Loopback1 通告到 RIP 协议中去

```
R1(config)#router rip
R1(config-router)#network 192.168.100.0
R1(config-router)#exit
```

步骤 3：在 R1 上，使用 show 命令，确认 Loopback1 已被加入到 RIP 中

```
R1#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 24 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 1, receive any version
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.12     1     1 2
    Loopback0             1     1 2
    Loopback1             1     1 2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.12.0
    192.168.100.0
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: (default is 120)
```

步骤 4：检查 R2 的路由表，会看到 192.168.100.0/24 而不是 192.168.100.0/28，说明在这种情况下，RIPv1 无法将子网信息传输到 R2

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C 192.168.12.0/24 is directly connected, FastEthernet0/0.12
C 192.168.23.0/24 is directly connected, FastEthernet0/0.23
R 192.168.1.0/24 [120/1] via 192.168.12.1, 00:00:06, FastEthernet0/0.12
R 192.168.100.0/24 [120/1] via 192.168.12.1, 00:00:06, FastEthernet0/0.12
```

任务 5：配置和实施 RIPv2 并观察它的工作

步骤 1：进入 R3 的全局配置模式，使用 router rip 命令开启 RIP 协议，并使用 network 命令确保 Fa0/0.34 开启到 RIP 协议

```
R3(config)#router rip
R3(config-router)#network 192.168.34.0
R3(config-router)#
```

步骤 2：在 R3 的 RIP 协议下，使用 version 2 命令，将 RIP 协议的工作版本调整为版本 2

```
R3(config-router)#version 2
R3(config-router)#exit
R3(config)#
```

步骤 3：进入 R4 的全局配置模式，使用 router rip 命令开启 RIP 协议，并使用 network 命令确保 Fa0/0.34 开启到 RIP 协议

```
R4(config)#router rip
R4(config-router)#network 192.168.34.0
R4(config-router)#
```

步骤 4：在 R4 的 RIP 协议下，使用 version 2 命令，将 RIP 协议的工作版本调整为版本 2

```
R4(config-router)#version 2
R4(config-router)#exit
R4(config)#exit
R4#
```

步骤 5：在 R4 上，使用 show protocol 命令，确认 RIP 已被调整为 verison2

```
R4#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 16 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 2, receive version 2
```

```
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.34      2     2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.34.0
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: (default is 120)
```

步骤 6：在 R4 上，增加 Loopback0 接口，IP 为 192.168.4.1/24，并开启到 RIP 协议

```
R4#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)#interface loopback 0
R4(config-if)#ip address 192.168.4.1 255.255.255.0
R4(config-if)#exit
R4(config)#router rip
R4(config-router)#network 192.168.4.0
R4(config-router)#exit
R4(config)#
```

步骤 7 在 R4 上 使用 debug ip rip 开启对 RIP 工作过程的监控 过 1 分钟后再使用 no debug all 关闭监控，回答以下问题：

1. RIPv2 发出的路由是否会携带掩码信息？

2. RIPv2 发出的路由目标地址是什么？

```
R4#
*Mar  1 01:28:37.595: RIP: sending v2 update to 224.0.0.9 via Loopback0 (192.168.4.1)
*Mar  1 01:28:37.595: RIP: build update entries
*Mar  1 01:28:37.595:   192.168.34.0/24 via 0.0.0.0, metric 1, tag 0
*Mar  1 01:28:37.599: RIP: ignored v2 packet from 192.168.4.1 (sourced from one of our
addresses)
*Mar  1 01:28:55.783: RIP: sending v2 update to 224.0.0.9 via FastEthernet0/0.34
(192.168.34.4)
*Mar  1 01:28:55.783: RIP: build update entries
*Mar  1 01:28:55.783:   192.168.4.0/24 via 0.0.0.0, metric 1, tag 0
*Mar  1 01:29:03.447: RIP: sending v2 update to 224.0.0.9 via Loopback0 (192.168.4.1)
```

```
*Mar  1 01:29:03.447: RIP: build update entries
*Mar  1 01:29:03.447:   192.168.34.0/24 via 0.0.0.0, metric 1, tag 0
*Mar  1 01:29:03.447: RIP: ignored v2 packet from 192.168.4.1 (sourced from one of our addresses)
*Mar  1 01:29:23.739: RIP: sending v2 update to 224.0.0.9 via FastEthernet0/0.34 (192.168.34.4)
*Mar  1 01:29:23.739: RIP: build update entries
*Mar  1 01:29:23.739:   192.168.4.0/24 via 0.0.0.0, metric 1, tag 0
*Mar  1 01:29:29.151: RIP: sending v2 update to 224.0.0.9 via Loopback0 (192.168.4.1)
*Mar  1 01:29:29.151: RIP: build update entries
*Mar  1 01:29:29.151:   192.168.34.0/24 via 0.0.0.0, metric 1, tag 0
*Mar  1 01:29:29.151: RIP: ignored v2 packet from 192.168.4.1 (sourced from one of our addresses)
R4#
R4#no debug all
All possible debugging has been turned off
R4#
```

步骤 8：观察 R3 的路由表，会发现一条 192.168.4.0/24，标记为“R”的路由，说明 R3 能从 R4 那里收到 RIPv2 的路由，同时还说明在路由表中，是无法区分该路由是 RIPv1 还是 RIPv2

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:21, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

任务 6：观察子网环境中 RIPv2 的默认行为

步骤 1：在 R4 上增加 Loopback1，IP 为 192.168.40.1/28，该接口所在的网段是 C 类地址 192.168.40.0/24 的一个子网

```
R4(config)#interface loopback 1
R4(config-if)#ip address 192.168.40.1 255.255.255.240
R4(config-if)#exit
```

步骤 2：使用 network，命令将 Loopback1 开启到 RIP 协议中去

```
R4(config)#router rip
R4(config-router)#network 192.168.40.0
R4(config-router)#exit
```

步骤 3：观察 R3 的路由表，会发现一条 192.168.40.0/24 的路由，虽然开启的是 RIPv2，但此时还无法获得子网路由

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

R    192.168.40.0/24 [120/1] via 192.168.34.4, 00:00:10, FastEthernet0/0.34
R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:18, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

步骤 4：在 R4 上使用 show ip protocols，会发现 RIPv2 的“自动汇总”功能被默认开启了，这个功能导致 R4 无法向 R3 发送 192.168.40.0/28 这个子网路由，而只能发送 192.168.40.0/24 的默认 C 类网络，此时 RIPv2 工作起来很像 RIPv1

```
R4#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 18 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 2, receive version 2
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.34     2     2
    Loopback0             2     2
    Loopback1             2     2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.4.0
    192.168.34.0
    192.168.40.0
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: (default is 120)
```

任务 7：关闭默认的自动汇总，使 RIPv2 能正确传输子网路由

步骤 1：关闭 R4 和 R3 的自动汇总

```
R3(config)#router rip
R3(config-router)#no auto-summary
R3(config-router)#end

R4(config)#router rip
R4(config-router)#no auto-summary
R4(config-router)#end
```

提示：这里，R3 是否关闭自动汇总不影响后面几个步骤的显示，但习惯上，所有 RIPv2 路由器都应该关闭自动汇总

步骤 2：检查 R3 的路由表，会看到一条 192.168.40.0/28 的子网路由，说明 R4 已经向 R3 发出了子网信息，RIPv2 开始传输子网了

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.40.0/24 is variably subnetted, 2 subnets, 2 masks
R    192.168.40.0/28 [120/1] via 192.168.34.4, 00:00:22, FastEthernet0/0.34
R    192.168.40.0/24 [120/1] via 192.168.34.4, 00:02:43, FastEthernet0/0.34
R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:22, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

步骤 3：再仔细观察 R3 的路由表，会看到原来 192.168.40.0/24 的默认 C 类路由还在，原因是这条路由是前面关闭自动汇总前遗留下来的，没有及时刷新

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.40.0/24 is variably subnetted, 2 subnets, 2 masks
R    192.168.40.0/28 [120/1] via 192.168.34.4, 00:00:22, FastEthernet0/0.34
R    192.168.40.0/24 [120/1] via 192.168.34.4, 00:02:43, FastEthernet0/0.34
R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:22, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

步骤 4：在 R3 上使用 clear ip route * 来刷新路由表

```
R3#clear ip route *
R3#
```

步骤 5：再测检查 R3 的路由表，原来遗留的那条 192.168.40.0/24 已经不再出现了，现在 R3 路由表中都是我们希望看到的路由

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
```

```
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.40.0/28 is subnetted, 1 subnets
R       192.168.40.0 [120/1] via 192.168.34.4, 00:00:08, FastEthernet0/0.34
R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:08, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

任务 8：观察 RIPv1 和 RIPv2 之间的兼容性

步骤 1：在 R2 上，使用 network 命令将 Fa0/0.23 开启到 RIP 协议，使 Fa0/0.23 可以收发 RIP 路由

```
R2(config)#router rip
R2(config-router)#network 192.168.23.0
R2(config-router)#exit
R2(config)#
```

步骤 2：在 R3 上，使用 network 命令将 Fa0/0.23 开启到 RIP 协议，使 Fa0/0.23 可以收发 RIP 路由

```
R3(config)#router rip
R3(config-router)#network 192.168.23.0
R3(config-router)#exit
```

步骤 3：观察 R2 的路由表发现 R2 可以收到 R3、R4 的路由，说明默认的 RIP 协议虽然发出的是 version1 的路由，但它是可以接收 version2 路由的

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is not set

C    192.168.12.0/24 is directly connected, FastEthernet0/0.12
     192.168.40.0/28 is subnetted, 1 subnets
R       192.168.40.0 [120/2] via 192.168.23.3, 00:00:01, FastEthernet0/0.23
R    192.168.4.0/24 [120/2] via 192.168.23.3, 00:00:01, FastEthernet0/0.23
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
R    192.168.34.0/24 [120/1] via 192.168.23.3, 00:00:01, FastEthernet0/0.23
R    192.168.1.0/24 [120/1] via 192.168.12.1, 00:00:07, FastEthernet0/0.12
R    192.168.100.0/24 [120/1] via 192.168.12.1, 00:00:08, FastEthernet0/0.12
```

步骤 4：观察 R3 的路由表，发现 R3 的路由表中没有 R1、R2 的路由，说明开启了 version2 以后，就无法接收 version1 的路由了

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.40.0/28 is subnetted, 1 subnets
R       192.168.40.0 [120/1] via 192.168.34.4, 00:00:03, FastEthernet0/0.34
R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:03, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

步骤 5：在 R2 上，使用 show protocols，可以看到默认的 RIP 协议，发送版本 1 但可以接收任何版本的路由

```
R2#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 22 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 1, receive any version
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.12     1     1 2
    FastEthernet0/0.23     1     1 2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.12.0
    192.168.23.0
```

```
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.12.1         120      00:00:00
    192.168.23.3         120      00:00:23
  Distance: (default is 120)
```

步骤 6：在 R3 上，使用 show protocols，可以看到开启 version2 的 RIP 协议，只能发送和接受版本 2 的路由

```
R3#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 13 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 2, receive version 2
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.23    2     2
    FastEthernet0/0.34    2     2
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    192.168.23.0
    192.168.34.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.34.4         120      00:00:11
  Distance: (default is 120)
```

提示：在为了避免路由传输的问题，建议所有开启 RIP 的路由器要使用同一种版本

任务 9：研究 RIP 中 network 命令的灵活性问题

步骤 1：在 R4 上，增加 Loopback10 和 Loopback20，IP 分别为 172.16.10.1/24 和 172.16.20.1/24，它们都是 B 类网络 172.16.0.0/16 下的子网

```
R4(config)#interface loopback 10
R4(config-if)#ip address 172.16.10.1 255.255.255.0
R4(config-if)#exit
R4(config)#interface loopback 20
R4(config-if)#ip address 172.16.20.1 255.255.255.0
R4(config-if)#exit
```

步骤 2：思考，有没有方法只将 Loopback10 开启到 RIP 而不将 Loopback20 开启到 RIP

步骤 3:尝试 1，在 Router rip 下先输入 network 172.16.10.0 再输入 “？”，发现这里无法输入子网掩码

```
R4(config)#router rip
R4(config-router)#network 172.16.10.0 ?
  <cr>

R4(config-router)#network 172.16.10.0
```

步骤 4：尝试 2，在 Router rip 下直接输入 network 172.16.10.0 ，按下回车

```
R4(config-router)#network 172.16.10.0
R4(config-router)#
```

步骤 5：检查 running-config，发现我们输入的 network 172.16.10.0 变成了 “network 172.16.0.0”，说明在配置 RIP 时，network 命令无法精确到某个子网

```
R4#show running-config
Building configuration...

Current configuration : 1157 bytes
```

```
!
version 12.3
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R4
no ip domain lookup
!
ip audit po max-events 100
!
interface Loopback0
 ip address 192.168.4.1 255.255.255.0
!
interface Loopback1
 ip address 192.168.40.1 255.255.255.240
!
interface Loopback10
 ip address 172.16.10.1 255.255.255.0
!
interface Loopback20
 ip address 172.16.20.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.34
 encapsulation dot1Q 300
 ip address 192.168.34.4 255.255.255.0
!
!
router rip
 version 2
 network 172.16.0.0
 network 192.168.4.0
 network 192.168.34.0
 network 192.168.40.0
 no auto-summary
!
```

。。。略。。。。。

步骤 6：在 R4 上使用 show ip protocol，也会发现 Loopback10 和 Loopback20 出现在了接口列表中

```
R4#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 28 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 2, receive version 2
    Interface            Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0.34    2     2
    Loopback0            2     2
    Loopback1            2     2
    Loopback10           2     2
    Loopback20           2     2
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.4.0
    192.168.34.0
    192.168.40.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.34.3         120      00:00:07
  Distance: (default is 120)
```

步骤 7：检查 R3 的路由表，会同时看到 172.16.10.0/24 和 172.16.20.0/24

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set
```

```
     192.168.40.0/28 is subnetted, 1 subnets
R       192.168.40.0 [120/1] via 192.168.34.4, 00:00:09, FastEthernet0/0.34
     172.16.0.0/24 is subnetted, 2 subnets
R       172.16.20.0 [120/1] via 192.168.34.4, 00:00:09, FastEthernet0/0.34
R       172.16.10.0 [120/1] via 192.168.34.4, 00:00:09, FastEthernet0/0.34
R    192.168.4.0/24 [120/1] via 192.168.34.4, 00:00:09, FastEthernet0/0.34
C    192.168.23.0/24 is directly connected, FastEthernet0/0.23
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
```

总结：在 RIP 中使用 network 命令通告接口时，是无法精确到子网的，比如我们需要通告 172.16.10.0/24 时，只能别无选择地使用“network 172.16.0.0”，因为这是个 B 类地址，B 类地址的掩码是 16 位。那么就会导致路由器将其他 172.16.0.0/16 下的接口（如实验中的 172.16.20.1/24）开启到 RIP 协议，这个显然是我们不希望看见的。后面学些的其他协议（EIGRP、OSPF）都能很好地解决这个问题

任务 10：恢复所有路由器到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

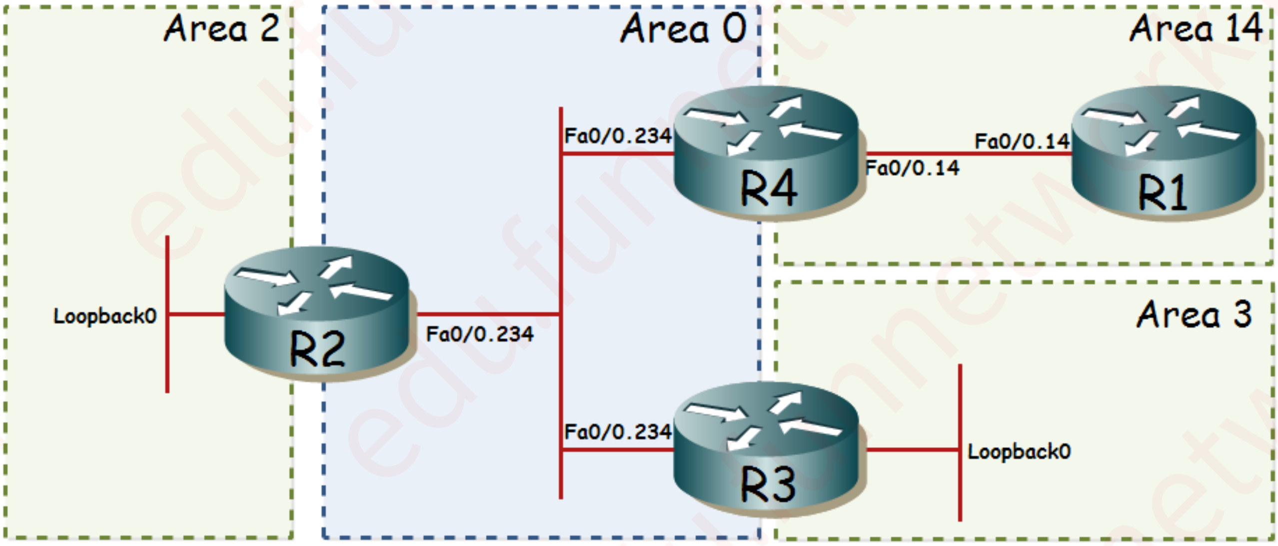
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

..本次实验完成..

实验 6 配置和实施 OSPF 协议

实验拓扑



实验目的：

6. 巩固 OSPF 协议的基本原理

7. 掌握 OSPF 协议的基本配置

8. 掌握 OSPF 协议的多区域配置

9. 学会查看 OSPF 协议的工作状态和链路状态数据库

10. 掌握 OSPF 的 Router-id 的配置和管理方法

11. 掌握 OSPF 选举 DR/BDR 的原则和控制方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：搭建逻辑拓扑

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:

Press RETURN to get started!

Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注：输入“switchport trunk encapsulation dot1q”时如果出现报错，就说明您的交换机只支持 dot1q，

就不需要再明确指定 trunk 的标记格式，不用管它，继续往下做。

步骤 2 登录到 R1，配置主机名为“R1”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
```

```
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3：在 R1 上，创建子接口 Fa0/0.14（或 E0/0.14），指定 dot1q 为 100，并配置 IP 地址为 192.168.14.1/24

```
R1(config)#interface fastEthernet 0/0.14
R1(config-subif)#encapsulation dot1Q 100
R1(config-subif)#ip address 192.168.14.1 255.255.255.0
R1(config-subif)#exit
```

步骤 4：登录到 R2 配置主机名为"R2"，并开启 Fa0/0 接口（如果没有 Fa0/0，则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 5：在 R2 上，创建子接口 Fa0/0.234（或 E0/0.234），指定 dot1q 为 200，并配置 IP 地址为 192.168.234.2/24，指定带宽为 10000（单位是 kbps，所有结果是 10M）

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#ip address 192.168.234.2 255.255.255.0
R2(config-subif)#bandwidth 10000

R2(config-subif)#exit
```

步骤 6 :登录到 R3 配置主机名为“R3”,并开启 Fa0/0 接口(如果没有 Fa0/0,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 7：在 R3 上，创建子接口 Fa0/0.234（或 E0/0.234）,指定 dot1q 为 200，并配置 IP 地址为 192.168.234.3/24，指定带宽为 10000（单位是 kbps，所有结果是 10M）

```
R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#encapsulation dot1Q 200
R3(config-subif)#ip address 192.168.234.3 255.255.255.0
R3(config-subif)#bandwidth 10000
R3(config-subif)#exit
```

步骤 8 :登录到 R4 配置主机名为“R4”,并开启 Fa0/0 接口(如果没有 Fa0/0,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
```

```
R4(config-if)#exit
```

步骤 9：在 R4 上，创建子接口 Fa0/0.14（或 E0/0.14），指定 dot1q 为 100，并配置 IP 地址为 192.168.14.4/24,再创建一个子接口 Fa0/0.23（或 E0/0.234）,指定 dot1q 为 200，并配置 IP 地址为 192.168.234.4/24，指定带宽为 10000（单位是 kbps，所有结果是 10M）

```
R4(config)#interface fastEthernet 0/0.234
R4(config-subif)#encapsulation dot1Q 200
R4(config-subif)#ip address 192.168.234.4 255.255.255.0
R4(config-subif)#bandwidth 10000
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#encapsulation dot1Q 100
R4(config-subif)#ip address 192.168.14.4 255.255.255.0
R4(config-subif)#bandwidth 10000
R4(config-subif)#exit
```

步骤 10：在路由器 R2 上创建 Fa0/0.20，dot1q 值为 20，IP 为 192.168.2.1/24，在 R2 上创建 Fa0/0.30 口，dot1q 值为 30，IP 为 192.168.3.1/24，模拟 R2 和 R3 连接着 2 个 LAN，并指定带宽为 10000（单位是 kbps，所有结果是 10M）

```
R2(config)#interface fastEthernet 0/0.20
R2(config-subif)#encapsulation dot1Q 20
R2(config-subif)#ip address 192.168.2.1 255.255.255.0
R2(config-subif)#bandwidth 10000
R2(config-subif)#exit

R3(config)#interface fastEthernet 0/0.30
R3(config-subif)#encapsulation dot1Q 30
R3(config-subif)#ip address 192.168.3.1 255.255.255.0
R3(config-subif)#bandwidth 10000
R3(config-subif)#exit
```

步骤 11：检查所有路由器的接口列表，确认需要的接口状态都是 UP

```
R1#show protocols
```

```
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down


R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.234 is up, line protocol is up
  Internet address is 192.168.234.2/24
FastEthernet0/0.20 is up, line protocol is up
  Internet address is 192.168.2.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
R2#


R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.234 is up, line protocol is up
  Internet address is 192.168.234.3/24
FastEthernet0/0.30 is up, line protocol is up
  Internet address is 192.168.3.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
R3#


R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.4/24
```

```
FastEthernet0/0.234 is up, line protocol is up
  Internet address is 192.168.234.4/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
R4#
```

步骤 12：使用 ping 测试，直连设备之间能否互通

```
R4#ping 192.168.14.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.14.1, timeout is 2 seconds:
.!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

R4#ping 192.168.234.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.234.2, timeout is 2 seconds:
.!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

R4#ping 192.168.234.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.234.3, timeout is 2 seconds:
.!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R4#
```

任务 2：配置基本的 OSPF 参数，保证网络互联

步骤 1：进入 R1 的全局配置模式，使用 router ospf 开启 OSPF 协议，并定义进程号为 1

```
R1(config)#router ospf 1
R1(config-router)#
```

步骤 2：在 OSPF 协议模式下使用 network 命令将 192.168.14.0/24 下的所有接口都开启到 OSPF，并加入 Area 14

```
R1(config-router)#network 192.168.14.0 0.0.0.255 area 14
R1(config-router)#end
R1#
```

步骤 3：进入 R2 的全局配置模式，使用 router ospf 开启 OSPF 协议，并定义进程号为 2

```
R2(config)#router ospf 2
R2(config-router)#
```

步骤 4：在 OSPF 协议模式下使用 network 命令将 192.168.234.0/24 下的所有接口都开启到 OSPF，并加入 Area 0，同时 192.168.2.0/24 的所有接口开启到 Area2

```
R2(config-router)#network 192.168.234.0 0.0.0.255 area 0
R2(config-router)#network 192.168.2.0 0.0.0.255 area 2
R2(config-router)#end
R2#
```

步骤 5：进入 R3 的全局配置模式，使用 router ospf 开启 OSPF 协议，并定义进程号为 3

```
R3(config)#router ospf 3
R3(config-router)#
```

步骤 6：在 OSPF 协议模式下使用 network 命令将 192.168.234.0/24 下的所有接口都开启到 OSPF，并加入 Area 0，同时 192.168.3.0/24 的所有接口开启到 Area3

```
R3(config-router)#network 192.168.234.0 0.0.0.255 area 0
```

```
R3(config-router)#network 192.168.3.0 0.0.0.255 area 3
R3(config-router)#end
R3#
```

步骤 7：进入 R4 的全局配置模式，使用 router ospf 开启 OSPF 协议，并定义进程号为 4

```
R4(config)#router ospf 4
R4(config-router)#
```

步骤 8：在 OSPF 协议模式下使用 network 命令将 192.168.234.0/24 下的所有接口都开启到 OSPF，并加入 Area 0，同时 192.168.14.0/24 的所有接口开启到 Area14

```
R4(config-router)#network 192.168.234.0 0.0.0.255 area 0
R4(config-router)#network 192.168.14.0 0.0.0.255 area 14
R4(config-router)#end
R4#
```

步骤 9：检查 R1 的路由表，会看到全网的路由

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.14.0/24 is directly connected, FastEthernet0/0.14
O IA 192.168.234.0/24 [110/20] via 192.168.14.4, 00:00:14, FastEthernet0/0.14
O IA 192.168.2.0/24 [110/30] via 192.168.14.4, 00:00:14, FastEthernet0/0.14
O IA 192.168.3.0/24 [110/30] via 192.168.14.4, 00:00:14, FastEthernet0/0.14

R1#
```

步骤 10：R1 上能 ping 通全网任何地址，到这里全网实现了互联

```
R1#ping 192.168.2.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

R1#ping 192.168.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R1#
```

任务 3：掌握各个 show 命令的使用

步骤 1：在 R4 上，使用 show protocols 可以看到 OSPF 的基本工作信息，回答以下问题

1. R4 的 Router-id 是多少？
2. R4 是一台区域边界路由器吗？
3. R4 的 OSPF 配置了哪些 network 命令？
4. R4 分别从哪些路由器那里收到过 OSPF 路由？

```
R4#show ip protocols
Routing Protocol is "ospf 4"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.234.4
  It is an area border router
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.14.0 0.0.0.255 area 14
    192.168.234.0 0.0.0.255 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.14.1         110      00:01:02
    192.168.234.2        110      00:01:07
    192.168.234.3        110      00:01:07
    192.168.234.4        110      00:28:50
  Distance: (default is 110)
```

步骤 2：在 R4 上，使用 show ip ospf 可以看到 OSPF 进程（运算）情况，回答以下问题：

R4 连接着几个区域，它们分别是什么？

```
R4# show ip ospf
 Routing Process "ospf 4" with ID 192.168.234.4
```

```
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
It is an area border router
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
        Number of interfaces in this area is 1
        Area has no authentication
        SPF algorithm last executed 00:56:52.348 ago
        SPF algorithm executed 4 times
        Area ranges are
        Number of LSA 7. Checksum Sum 0x030682
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
  Area 14
        Number of interfaces in this area is 1
        Area has no authentication
        SPF algorithm last executed 00:55:13.740 ago
        SPF algorithm executed 4 times
        Area ranges are
        Number of LSA 6. Checksum Sum 0x0213C1
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

步骤 3：在 R4 上使用 show ip ospf interface brief 命令，可以看到所有开启到 OSPF 的接口，回答以下问题：

1. 有哪些接口开启了 OSPF 协议，它们加入的协议 ID 分别是什么？
2. Fa0/0.234 加入的是哪个区域？
3. Fa0/0.14 加入的是哪个区域？

```
R4#show ip ospf interface brief
Interface      PID   Area      IP Address/Mask    Cost  State Nbrs F/C
Fa0/0.234      4     0         192.168.234.4/24   1     DROTH   2/2
Fa0/0.14       4     14        192.168.14.4/24    1     DR      1/1
```

步骤 4 在 R4 上 ,使用 show ip ospf interface Fa0/0.234(没有 Fa0/0.234 就用 E0/0.234) 可以看到 Fa0/0.234 的 OSPF 详细参数，回答以下问题：

1. Fa0/0.234 的 OSPF 开销现在是多少？
2. Fa0/0.234 接口每多少时间发送一个 OSPF 的 Hello 包
3. Fa0/0.234 接口多少时间内都收不到邻居的 Hello 包就判定邻居“死亡”
4. R4 通过 Fa0/0.234 和哪些路由器建立了 OSPF 邻居，它们分别是谁？

```
R4#show ip ospf interface fastEthernet 0/0.234
FastEthernet0/0.234 is up, line protocol is up
  Internet Address 192.168.234.4/24, Area 0
  Process ID 4, Router ID 192.168.234.4, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.2.1, Interface address 192.168.234.2
  Backup Designated router (ID) 192.168.3.1, Interface address 192.168.234.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:03
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
```

```
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.2.1  (Designated Router)
    Adjacent with neighbor 192.168.3.1  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
R4#
```

步骤 6：使用 show ip route ospf，可以将路由表中 OSPF 的路由调出来，掌握这个技巧

```
R4#show ip route ospf
O IA 192.168.2.0/24 [110/20] via 192.168.234.2, 00:56:00, FastEthernet0/0.234
O IA 192.168.3.0/24 [110/20] via 192.168.234.3, 00:56:00, FastEthernet0/0.234
R4#
```

任务 4：体会 OSPF 中 network 命令

步骤 1：在 R4 上增加 4 个 Loopback 接口

- ✓ Loopback101: 172.16.1.1/24
- ✓ Loopback102: 172.16.2.1/24
- ✓ Loopback103: 172.16.3.1/24
- ✓ Loopback104: 172.16.4.1/24

```
R4(config)#interface loopback 101
R4(config-if)#ip address 172.16.1.1 255.255.255.0
R4(config-if)#exit
R4(config)#interface loopback 102
R4(config-if)#ip address 172.16.2.1 255.255.255.0
R4(config-if)#exit
R4(config)#interface loopback 103
R4(config-if)#ip address 172.16.3.1 255.255.255.0
R4(config-if)#exit
R4(config)#interface loopback 104
R4(config-if)#ip address 172.16.4.1 255.255.255.0
R4(config-if)#exit
```

步骤 2：在 OSPF 下，使用 network 命令，将 172.16.0.0/16 这个 B 类主网络下的所有接口开启 OSPF，并加入区域 4

```
R4(config)#router ospf 4
R4(config-router)#network 172.16.0.0 0.0.255.255 area 4
R4(config-router)#end
```

步骤 3：使用 show ip ospf interface brief 确认 4 个 Loopback 接口都已开启到了 OSPF 协议中，并加入了区域 4

```
R4#show ip ospf interface brief
Interface     PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/0.234      4     0               192.168.234.4/24   10     DR    2/2
Lo104          4     4              172.16.4.1/24       1     LOOP  0/0
Lo103          4     4              172.16.3.1/24       1     LOOP  0/0
Lo102          4     4              172.16.2.1/24       1     LOOP  0/0
Lo101          4     4              172.16.1.1/24       1     LOOP  0/0
Fa0/0.14       4     14              192.168.14.4/24    10     BDR   1/1
```

步骤 4：使用 no 命令将步骤 2 的操作删除

```
R4#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)#router ospf 4
R4(config-router)#no network 172.16.0.0 0.0.255.255 area 4
R4(config-router)#exit
```

步骤 5：使用 network 命令，将路由器上 172.16.1.0/24 子网下的接口开启 OSPF 协议，并加入区域 4

```
R4(config)#router ospf 4
R4(config-router)#network 172.16.1.0 0.0.0.255 area 4
R4(config-router)#end
```

步骤 6：使用 show ip ospf interface brief，确认现在只有 Loopback101 被加入了区域 4

```
R4#show ip ospf interface brief
Interface     PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/0.234     4     0              192.168.234.4/24   1     DROTH 2/2
Lo101         4     4              172.16.1.1/24      1     LOOP  0/0
Fa0/0.14      4     14             192.168.14.4/24    1     DR    1/1
```

步骤 7：使用 no 命令将步骤 5 的操作删除

```
R4#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
R4(config)#router ospf 4
R4(config-router)#no network 172.16.1.0 0.0.0.255 area 4
R4(config-router)#exit
```

步骤 8：使用 network 命令，将路由器上匹配 172.16.1.1 这一个 IP 的接口开启到 OSPF 的区域 4

```
R4(config)#router ospf 4
R4(config-router)#network 172.16.1.1 0.0.0.0 area 4
R4(config-router)#end
R4#
```

步骤 9：使用 show ip ospf interface brief，确认现在也只有 Loopback101 被加入了区域 4

```
R4#show ip ospf interface brief
Interface     PID    Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/0.234     4      0              192.168.234.4/24   1     DROTH 2/2
Lo101         4      4              172.16.1.1/24      1     LOOP  0/0
Fa0/0.14      4      14             192.168.14.4/24    1     DR    1/1
```

步骤 10：使用 network 172.16.0.0 0.0.3.255 area 40,分析该命令达到的效果

```
R4(config)#router ospf 4
R4(config-router)#network 172.16.0.0 0.0.3.255 area 40
R4(config-router)#exit
```

步骤 11：使用 show ip ospf interface brief,观察 OSPF 接口列表，看到 Loopback101 属于区域 4，Loopback102 和 Loopback103 属于区域 40，分析原因。

```
R4#show ip ospf interface brief
Interface     PID    Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/0.234     4      0              192.168.234.4/24   1     DROTH 2/2
Lo101         4      4              172.16.1.1/24      1     LOOP  0/0
Fa0/0.14      4      14             192.168.14.4/24    1     DR    1/1
Lo103         4      40             172.16.3.1/24      1     LOOP  0/0
Lo102         4      40             172.16.2.1/24      1     LOOP  0/0
```

步骤 12：登录到 R1，增加以下 Loopback 接口

- ✓ Loopback1:192.168.1.1/27
- ✓ Loopback2:192.168.11.1/28
- ✓ Loopback3:192.168.111.1/29

```
R1(config)#interface loopback 1
R1(config-if)#ip address 192.168.1.1 255.255.255.224
R1(config-if)#exit
R1(config)#interface loopback 2
R1(config-if)#ip address 192.168.11.1 255.255.255.240
R1(config-if)#exit
R1(config)#interface loopback 3
R1(config-if)#ip address 192.168.111.1 255.255.255.248
R1(config-if)#exit
```

步骤 13：使用 network 命令，将 R1 上所有的接口都开启到 OSPF 的区域 14 中去

```
R1(config)#router ospf 1
R1(config-router)#network 0.0.0.0 0.0.0.0 area 14
R1(config-router)#end
R1#
```

步骤 14：确认 R1 的所有接口都开启到了 OSPF 的区域 14

```
R1#show ip ospf interface brief
Interface    PID   Area          IP Address/Mask    Cost  State Nbrs F/C
Lo3           1     14            192.168.111.1/29   1     LOOP   0/0
Lo2           1     14            192.168.11.1/28    1     LOOP   0/0
Lo1           1     14            192.168.1.1/27     1     LOOP   0/0
Fa0/0.14      1     14            192.168.14.1/24    1     BDR    1/1
```

任务 5：OSPF 协议中的 Loopback 接口

步骤 1：观察 R1 的接口列表，确认 Loopback1、Loopback2 和 Loopback3 接口的掩码分别都是/27、/28 和/29

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
Loopback1 is up, line protocol is up
  Internet address is 192.168.1.1/27
Loopback2 is up, line protocol is up
  Internet address is 192.168.11.1/28
Loopback3 is up, line protocol is up
  Internet address is 192.168.111.1/29
```

步骤 2：检查 R1 的 OSPF 接口列表，确认 3 个 Loopback 接口都已加入到了 OSPF 协议，并加入了区域 14

```
R1#show ip ospf interface brief
Interface     PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo3           1     14              192.168.111.1/29   1     LOOP  0/0
Lo2           1     14              192.168.11.1/28    1     LOOP  0/0
Lo1           1     14              192.168.1.1/27     1     LOOP  0/0
Fa0/0.14      1     14              192.168.14.1/24    10    BDR   1/1
```

步骤 3：检查 R4 的路由表，会发现在 R4 的路由表中，R1 上的 3 个 Loopback 接口的路由都是 32 位的，还有 R2 和 R3 的 Loopback0 接口也是这个问题

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
```

```
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set
C    192.168.14.0/24 is directly connected, FastEthernet0/0.14
     192.168.111.0/32 is subnetted, 1 subnets
O       192.168.111.1 [110/11] via 192.168.14.1, 00:03:27, FastEthernet0/0.14
     172.16.0.0/24 is subnetted, 4 subnets
C       172.16.4.0 is directly connected, Loopback104
C       172.16.1.0 is directly connected, Loopback101
C       172.16.2.0 is directly connected, Loopback102
C       172.16.3.0 is directly connected, Loopback103
     192.168.11.0/32 is subnetted, 1 subnets
O       192.168.11.1 [110/11] via 192.168.14.1, 00:03:28, FastEthernet0/0.14
C    192.168.234.0/24 is directly connected, FastEthernet0/0.234
     192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.1 [110/11] via 192.168.14.1, 00:03:28, FastEthernet0/0.14
O IA 192.168.2.0/24 [110/20] via 192.168.234.2, 01:06:36, FastEthernet0/0.234
O IA 192.168.3.0/24 [110/20] via 192.168.234.3, 01:06:36, FastEthernet0/0.234
R4#
```

知识点：OSPF 默认会把 Loopback 接口的掩码一律以/32 通告出去，导致其他路由器无法分辨出 Loopback 接口的子网和掩码

步骤 4：在 R1 的 3 个 Loopback 接口下，分别使用“ip ospf network point-to-point”命令，这样 OSPF 就会把 Loopback 接口看作一个点到点的线路，那么就会保留 Loopback 接口的掩码，另外， R4 的 Loopback101 到 104 都可以使用这个命令

```
R1(config)#interface loopback 1
R1(config-if)#ip ospf network point-to-point
R1(config-if)#exit
R1(config)#interface loopback 2
R1(config-if)#ip ospf network point-to-point
R1(config-if)#exit
```

```
R1(config)#interface loopback 3
R1(config-if)#ip ospf network point-to-point
R1(config-if)#exit

R4(config)#interface loopback 101
R4(config-if)#ip ospf network point-to-point
R4(config-if)#exit
R4(config)#interface loopback 102
R4(config-if)#ip ospf network point-to-point
R4(config-if)#exit
R4(config)#interface loopback 103
R4(config-if)#ip ospf network point-to-point
R4(config-if)#exit
```

步骤 5：再测检查 R4 的路由表，发现 R1 的 3 个 Loopback 接口都携带了自己正确的掩码

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is not set

C    192.168.14.0/24 is directly connected, FastEthernet0/0.14
     192.168.111.0/29 is subnetted, 1 subnets
O       192.168.111.0 [110/11] via 192.168.14.1, 00:00:29, FastEthernet0/0.14
     172.16.0.0/24 is subnetted, 4 subnets
C       172.16.4.0 is directly connected, Loopback104
C       172.16.1.0 is directly connected, Loopback101
C       172.16.2.0 is directly connected, Loopback102
C       172.16.3.0 is directly connected, Loopback103
     192.168.11.0/28 is subnetted, 1 subnets
O       192.168.11.0 [110/11] via 192.168.14.1, 00:00:30, FastEthernet0/0.14
C    192.168.234.0/24 is directly connected, FastEthernet0/0.234
     192.168.1.0/27 is subnetted, 1 subnets
O       192.168.1.0 [110/11] via 192.168.14.1, 00:00:30, FastEthernet0/0.14
O IA 192.168.2.0/24 [110/20] via 192.168.234.2, 01:08:22, FastEthernet0/0.234
O IA 192.168.3.0/24 [110/20] via 192.168.234.3, 01:08:22, FastEthernet0/0.234
```

任务 6：研究 OSPF 的 Cost

步骤 1：在 R3 上，增加一个 Fa0/0.300 接口，dot1q 值为 300，IP 为 172.16.33.1/24

```
R3(config)#interface fastEthernet 0/0.300
R3(config-subif)#encapsulation dot1Q 300
R3(config-subif)#ip address 172.16.33.1 255.255.255.0
R3(config-subif)#exit
```

步骤 2：使用 network 命令，将该接口加入区域 3

```
R3(config)#router ospf 3
R3(config-router)#network 172.16.33.1 0.0.0.0 area 3
R3(config-router)#exit
R3(config)#
```

步骤 3：使用 bandwidth 命令，将 Fa0/0.300 的带宽改成 2M

```
R3(config)#interface fastEthernet 0/0.300
R3(config-subif)#bandwidth 2000
R3(config-subif)#exit
R3(config)#
```

步骤 4：使用 show ip ospf interface 命令，可以看到 Fa0/0.300 的 OSPF 开销，看到开销值是 50，这个值是怎么得来的？

```
R3#show ip ospf interface fastEthernet 0/0.300
FastEthernet0/0.300 is up, line protocol is up
  Internet Address 172.16.33.1/24, Area 3
  Process ID 3, Router ID 192.168.3.1, Network Type BROADCAST, Cost: 50
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.3.1, Interface address 172.16.33.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:08
  Index 2/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
```

```
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

步骤 5：在 R2 上，再使用 bandwidth 命令，将 R2 的 Fa0/0.234 的带宽改成 4M

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#bandwidth 4000
R2(config-subif)#exit
```

步骤 6：使用 show ip ospf interface 命令，可以看到 Fa0/0.300 的 OSPF 开销，看到开销值是 25，这个值是怎么得来的？

```
R2#show ip ospf interface fastEthernet 0/0.234
FastEthernet0/0.234 is up, line protocol is up
  Internet Address 192.168.234.2/24, Area 0
  Process ID 2, Router ID 192.168.2.1, Network Type BROADCAST, Cost: 25
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.2.1, Interface address 192.168.234.2
  Backup Designated router (ID) 192.168.3.1, Interface address 192.168.234.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:04
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 5
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.3.1  (Backup Designated Router)
    Adjacent with neighbor 192.168.234.4
  Suppress hello for 0 neighbor(s)
```

步骤 7：在 R2 上，检查路由表，观察 172.16.33.0/24 的度量值是多少？这个值是怎样计算的来的？（其他路由的度量值可能和资料显示的不一样，只需要关心 172.16.33.0/24 即可）

```
R2#show ip route ospf
O IA 192.168.14.0/24[110/26] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
     192.168.111.0/29 is subnetted, 1 subnets
O IA  192.168.111.0
```

```
        [110/27] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
     172.16.0.0/24 is subnetted, 4 subnets
O IA    172.16.33.0 [110/75] via 192.168.234.3, 00:00:40, FastEthernet0/0.234
O IA    172.16.1.0 [110/26] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
O IA    172.16.2.0 [110/26] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
O IA    172.16.3.0 [110/26] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
     192.168.11.0/28 is subnetted, 1 subnets
O IA    192.168.11.0 [110/27] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
     192.168.1.0/27 is subnetted, 1 subnets
O IA    192.168.1.0 [110/27] via 192.168.234.4, 00:02:55, FastEthernet0/0.234
O IA 192.168.3.0/24 [110/26] via 192.168.234.3, 00:02:55, FastEthernet0/0.234
```

步骤 8：回到 R3，在 Fa0/0.300 下，使用 ip ospf cost 命令直接将该接口的开销值指定为 200

```
R3(config)#interface fastEthernet 0/0.300
R3(config-subif)#ip ospf cost 200
R3(config-subif)#exit
```

步骤 9：检查 Fa0/0.300 的开销，确认现在该接口的开销已变成了 200

```
R3#show ip ospf interface fastEthernet 0/0.300
FastEthernet0/0.300 is up, line protocol is up
  Internet Address 172.16.33.1/24, Area 3
  Process ID 3, Router ID 192.168.3.1, Network Type BROADCAST, Cost: 200
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.3.1, Interface address 172.16.33.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:07
  Index 2/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 0
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

步骤 10：检查 R2 的路由表，看到 172.16.33.0/24 的开销值变成了 225（200+25）

```
R2#show ip route ospf
O IA 192.168.14.0/24[110/26] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
     192.168.111.0/29 is subnetted, 1 subnets
O IA 192.168.111.0 [110/27] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
     172.16.0.0/24 is subnetted, 4 subnets
O IA  172.16.33.0 [110/225] via 192.168.234.3, 00:02:32, FastEthernet0/0.234
O IA  172.16.1.0 [110/26] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
O IA  172.16.2.0 [110/26] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
O IA  172.16.3.0 [110/26] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
     192.168.11.0/28 is subnetted, 1 subnets
O IA 192.168.11.0 [110/27] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
     192.168.1.0/27 is subnetted, 1 subnets
O IA    192.168.1.0 [110/27] via 192.168.234.4, 00:04:47, FastEthernet0/0.234
O IA 192.168.3.0/24 [110/26] via 192.168.234.3, 00:04:47, FastEthernet0/0.234
```

任务 7：控制路由器的 Router-id

步骤 1：登录到 R1，增加一个 Loopback0 接口，配置 IP 为 192.168.255.1/32

```
R1(config)#interface loopback 0
R1(config-if)#ip address 192.168.255.1 255.255.255.255
R1(config-if)#
```

步骤 2：确保配置寄存器是 0x2102,并保存配置，重启 R1

```
R1(config)#config-register 0x2102
R1(config)#end
R1#write
Building configuration...
[OK]
R1#reload
```

Proceed with reload? [confirm] 按下回车

步骤 3:待 R1 重启后 使用 show ip protocols 观察 R1 的 Router-id 是 192.168.255.1，

因为 192.168.255.1 是 R1 上 Loopback 接口中的最大 IP 地址

```
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.255.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.14.0 0.0.0.255 area 14
    0.0.0.0 255.255.255.255 area 14
 Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.234.4        110      00:02:04
    192.168.255.1        110      00:02:29
  Distance: (default is 110)
```

知识点：OSPF 选择 Router-id 的依据：

1.手动配置

2.最大的 Loopback 接口 IP

3.最大的物理接口 IP

步骤 4：在 R1 上再增加一个 Loopback1000，IP 为 223.255.255.1/32，这个接口比 192.168.255.1 都大

```
R1(config)#interface loopback 1000
R1(config-if)#ip address 223.255.255.1 255.255.255.255
R1(config-if)#exit
```

步骤 5：检查 R1 的 OSPF 协议，发现 Router-id 还是 192.168.255.1，说明 Router-id 一旦被决定了，是稳定的，除非设备重启或 OSPF 进程重启

```
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.255.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.14.0 0.0.0.255 area 14
    0.0.0.0 255.255.255.255 area 14
 Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.234.4        110      00:03:05
    192.168.255.1        110      00:00:15
  Distance: (default is 110)
```

步骤 6：保存重启 R1，重启后，会看到 R1 的 Router-id 变成了 223.255.255.1

```
R1#write
Building configuration...
[OK]
```

```
R1#reload
```

Proceed with reload? [confirm] 按下回车

重启。。。。

```
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 223.255.255.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.14.0 0.0.0.255 area 14
    0.0.0.0 255.255.255.255 area 14
 Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway          Distance      Last Update
    192.168.234.4         110      00:01:01
    223.255.255.1         110      00:01:41
  Distance: (default is 110)
```

步骤 8：在 R4 上，使用 router-id 命令，将 R4 的 Router-id 指定为 192.168.255.4

```
R4(config)#router ospf 4
R4(config-router)#router-id 192.168.255.4
Reload or use "clear ip ospf process" command, for this to take effect
R4(config-router)#end
```

步骤 9：在 R4 上，使用 clear ip ospf process 重启 OSPF 进程，Router-id 的设置才生效（重启路由器也可以）

```
R4#clear ip ospf process
Reset ALL OSPF processes? [no]: yes
R4#
```

步骤 10：确认现在 R4 的 Router-id 是 192.168.255.4

```
R4#show ip protocols
Routing Protocol is "ospf 4"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.255.4
  It is an area border router
  Number of areas in this router is 4. 4 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.1 0.0.0.0 area 4
    172.16.0.0 0.0.3.255 area 40
    192.168.14.0 0.0.0.0 area 14
    192.168.14.4 0.0.0.0 area 14
    192.168.234.0 0.0.0.255 area 0
 Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.14.1         110      00:08:46
    192.168.234.2        110      01:30:03
    192.168.234.3        110      00:09:37
    192.168.234.4        110      00:00:12
    192.168.255.4        110      00:00:11
    192.168.255.1        110      00:03:53
    223.255.255.1        110      00:02:06
  Distance: (default is 110)
```

任务 8：观察 DR/BDR 的选择

步骤 1：在 R2 上，使用 router-id 命令，确保 R2 的 OSPF Router-id 为 192.168.255.2

```
R2(config)#router ospf 2
R2(config-router)#router-id 192.168.255.2
Reload or use "clear ip ospf process" command, for this to take effect
R2(config-router)#end
R2#clear ip ospf process
Reset ALL OSPF processes? [no]: yes
R2#
```

步骤 2：在 R3 上，使用 router-id 命令，确保 R3 的 OSPF Router-id 为 192.168.255.3

```
R3(config)#router ospf 3
R3(config-router)#router-id 192.168.255.3
Reload or use "clear ip ospf process" command, for this to take effect
R3(config-router)#end
R3#clear ip ospf process
Reset ALL OSPF processes? [no]: yes
R3#
```

步骤 3：关闭 R2、R3、R4 的 Fa0/0.234 接口，使它们之间互相断开 OSPF 邻居关系

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#shutdown
R2(config-subif)#exit

R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#shutdown
R3(config-subif)#exit

R4(config)#interface fastEthernet 0/0.234
R4(config-subif)#shutdown
R4(config-subif)#exit
```

步骤 4：以尽量快的速度，连续打开 R2、R3 和 R4 的 Fa0/0.234，使它们三台路由器同时互相建立邻居关系

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#no shutdown

R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#no shutdown

R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#no shutdown
```

步骤 5：待邻居建立完成后，观察 R2 的 OSPF 邻居关系，会看到 R4(192.168.255.4)是 DR，R3（192.168.255.3）是 BDR

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.255.3     1   FULL/BDR        00:00:35    192.168.234.3   FastEthernet0/0.234
192.168.255.4     1   FULL/DR         00:00:36    192.168.234.4   FastEthernet0/0.234
```

步骤 6：检查 R2 的 Fa0/0.234 状态，能看到自己的角色是 DROther

```
R2#show ip ospf interface fastEthernet 0/0.234
FastEthernet0/0.234 is up, line protocol is up
  Internet Address 192.168.234.2/24, Area 0
  Process ID 2, Router ID 192.168.255.2, Network Type BROADCAST, Cost: 25
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.255.4, Interface address 192.168.234.4
  Backup Designated router (ID) 192.168.255.3, Interface address 192.168.234.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:00
 ....
 ....
```

知识点：在没有配置优先级的情况下，Router-id 越大越有可能成为 DR

步骤 7：关闭 R4 的 Fa0/0.234 口

```
R4(config)#interface fastEthernet 0/0.234
R4(config-subif)#shutdown
R4(config-subif)#exit
```

步骤 8：再次检查 R2 的邻居表，会看到 R3（192.168.255.3）变成了 DR(如果还能看到 R4，再等 30 秒左右，R4 就不出现了）

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.255.3     1   FULL/DR         00:00:36    192.168.234.3   FastEthernet0/0.234
R2#
```

步骤 9：检查 R2 的 Fa0/0.234 的 OSPF 状态，现在 R2 变成了 BDR

```
R2#show ip ospf interface fastEthernet 0/0.234
FastEthernet0/0.234 is up, line protocol is up
  Internet Address 192.168.234.2/24, Area 0
  Process ID 2, Router ID 192.168.255.2, Network Type BROADCAST, Cost: 25
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.255.3, Interface address 192.168.234.3
  Backup Designated router (ID) 192.168.255.2, Interface address 192.168.234.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
```

步骤 10：重新打开 R4 的 Fa0/0.234，等待 OSPF 邻居建立完成

```
R4(config)#interface fastEthernet 0/0.234
R4(config-subif)#no shutdown
R4(config-subif)#exit
```

步骤 11：检查 R2 的邻居，发现现在 R4 变成了 DRother，虽然 R4 的 Router-id 比现在的 DR（R3）要大。

```
R2#show ip ospf neighbor
```

```
Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.255.3     1   FULL/DR         00:00:37    192.168.234.3   FastEthernet0/0.234
192.168.255.4     1   FULL/DROTHER    00:00:34    192.168.234.4   FastEthernet0/0.234
R2#
```

知识点：DR 选举是稳定的，一旦 DR 被确定，其他路由器是不能取代他的，除非 DR 自行退出 OSPF 邻居

步骤 12：在 R2 上使用 ip ospf priority 命令，将 OSPF 优先级调整为 100

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#ip ospf priority 100
R2(config-subif)#end
```

步骤 13：关闭 R2、R3、R4 的 Fa0/0.234

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#shutdown
R2(config-subif)#exit

R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#shutdown
R3(config-subif)#exit

R4(config)#interface fastEthernet 0/0.234
R4(config-subif)#shutdown
R4(config-subif)#exit
```

步骤 14：再以最快的速度连续开启 R2、R3 和 R4 的 Fa0/0.234 口，等待 OSPF 邻居建立完成

```
R2(config)#interface fastEthernet 0/0.234
R2(config-subif)#no shutdown

R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#no shutdown

R3(config)#interface fastEthernet 0/0.234
R3(config-subif)#no shutdown
```

步骤 15：观察 R2 的邻居表，发现 R3 和 R4 分别变成了 DRother 和 BDR

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.255.3     1   FULL/DROTHER     00:00:32    192.168.234.3   FastEthernet0/0.234
192.168.255.4     1   FULL/BDR        00:00:32    192.168.234.4   FastEthernet0/0.234
R2#
```

步骤 16：检查 R2 自己的 Fa0/0.234 的 OSPF 状态，发现 R2 现在是 DR

```
R2#show ip ospf interface fastEthernet 0/0.234
FastEthernet0/0.234 is up, line protocol is up
  Internet Address 192.168.234.2/24, Area 0
  Process ID 2, Router ID 192.168.255.2, Network Type BROADCAST, Cost: 25
  Transmit Delay is 1 sec, State DR, Priority 100
  Designated Router (ID) 192.168.255.2, Interface address 192.168.234.2
  Backup Designated router (ID) 192.168.255.4, Interface address 192.168.234.4
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
```

知识点：如果优先级被配置了，那么就优先选择优先级大的路由器成为 DR（优先级默认是 1）

任务 9：恢复所有设备到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

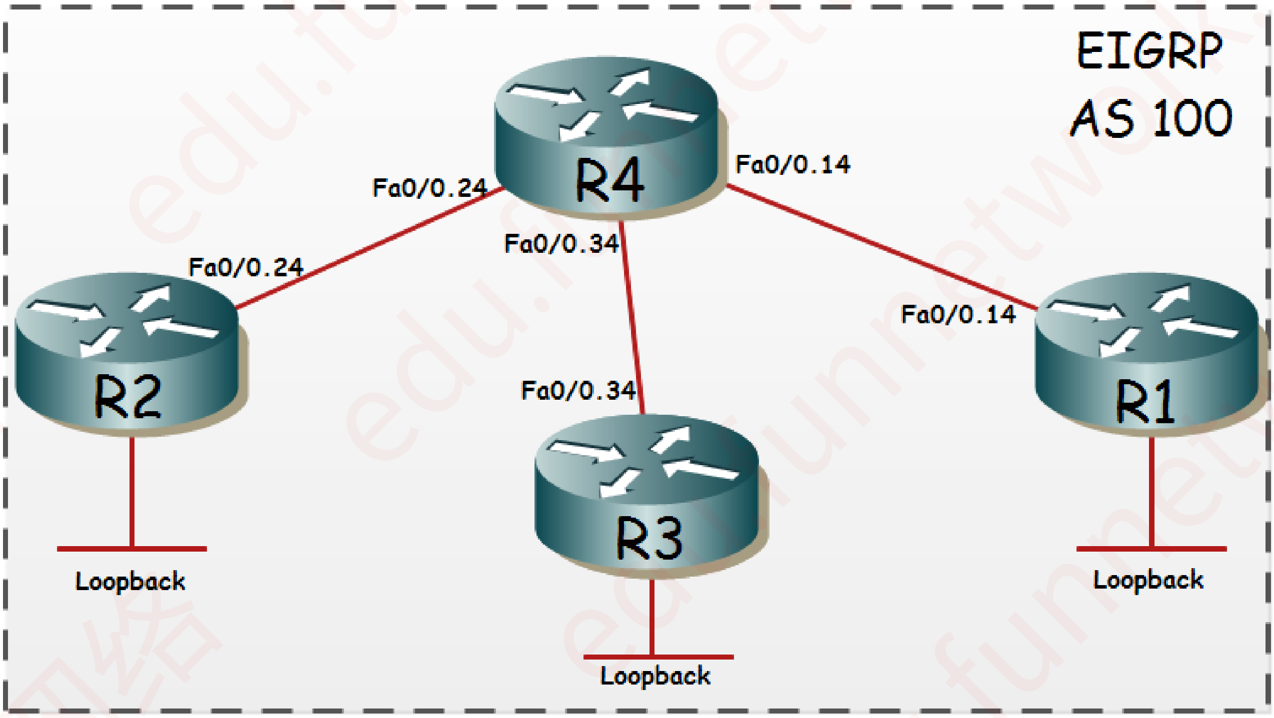
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………………本次实验完成……………………………………………

实验 7 配置和实施 EIGRP 协议

实验拓扑



实验目的：

13. 巩固 EIGRP 协议的基本原理

14. 掌握 EIGRP 协议的基本配置

15. 学会查看 EIGRP 邻居关系和拓扑数据库

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：搭建逻辑拓扑和配置基本通信参数

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:

Press RETURN to get started!

Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注:输入"switchport trunk encapsulation dot1q"时如果出现报错,就说明您的交换机只支持 dot1q,

就不需要再明确指定 trunk 的标记格式,不用管它,继续往下做。

步骤 2 :登录到 R1 ,配置主机名为"R1" ,并将 Fa0/0 接口开启(如果没有 Fa0/0,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3 在 R1 上，创建子接口 Fa0/0.14，dot1q 标记值为 100，IP 地址是 192.168.14.1/24，指定 Fa0/0.14 的带宽是 2Mbps，再创建一个 Loopback0 接口，IP 为 192.168.1.1/24

```
R1(config)#interface fastEthernet 0/0.14
R1(config-subif)#encapsulation dot1Q 100
R1(config-subif)#ip address 192.168.14.1 255.255.255.0
R1(config-subif)#bandwidth 2000
R1(config-subif)#exit
R1(config)#interface loopback 0
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
```

步骤 4 登录到 R2，配置主机名为“R2”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 5 在 R2 上，创建子接口 Fa0/0.24，dot1q 标记值为 200，IP 地址是 192.168.24.2/24，指定 Fa0/0.24 的带宽是 2Mbps，再创建一个 Loopback0 接口，IP 为 192.168.2.1/24

```
R2(config)#interface fastEthernet 0/0.24
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#ip address 192.168.24.2 255.255.255.0
R2(config-subif)#bandwidth 2000
R2(config-subif)#exit
R2(config)#interface loopback 0
R2(config-if)#ip address 192.168.2.1 255.255.255.0
```

```
R2(config-if)#exit
```

步骤 6 登录到 R3，配置主机名为“R3”，并将 Fa0/0 接口开启(如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 7 在 R3 上，创建子接口 Fa0/0.34，dot1q 标记值为 300，IP 地址是 192.168.34.3/24，

指定 Fa0/0.34 的带宽是 2Mbps，再创建一个 Loopback0 接口，IP 为 192.168.3.1/24

```
R3(config)#interface fastEthernet 0/0.34
R3(config-subif)#encapsulation dot1Q 300
R3(config-subif)#ip address 192.168.34.3 255.255.255.0
R3(config-subif)#bandwidth 2000
R3(config-subif)#exit
R3(config)#interface loopback 0
R3(config-if)#ip address 192.168.3.1 255.255.255.0
R3(config-if)#exit
R3(config)#
```

步骤 8 登录到 R4，配置主机名为“R4”，并将 Fa0/0 接口开启(如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no
```

```
Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
R4(config-if)#exit
```

步骤 9：在 R4 上创建 3 个子接口，Fa0/0.14、Fa0/0.24、Fa0/0.34，它们的 dot1q 标记值分别是 100、200、300，IP 地址分别是 192.168.14.4/24、192.168.24.4/24 和 192.168.34.4/24，并指定它们的带宽是 2Mbps

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#encapsulation dot1Q 100
R4(config-subif)#ip address 192.168.14.4 255.255.255.0
R4(config-subif)#bandwidth 2000
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#encapsulation dot1Q 200
R4(config-subif)#ip address 192.168.24.4 255.255.255.0
R4(config-subif)#bandwidth 2000
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#encapsulation dot1Q 300
R4(config-subif)#ip address 192.168.34.4 255.255.255.0
R4(config-subif)#bandwidth 2000
R4(config-subif)#exit
```

步骤 10：检查所有路由器的接口列表，确认所有需要的接口都处于 UP 状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
```

Loopback0 is up, line protocol is up
Internet address is 192.168.1.1/24

R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.24 is up, line protocol is up
Internet address is 192.168.24.2/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Loopback0 is up, line protocol is up
Internet address is 192.168.2.1/24

R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.34 is up, line protocol is up
Internet address is 192.168.34.3/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
Loopback0 is up, line protocol is up
Internet address is 192.168.3.1/24

R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
Internet address is 192.168.14.4/24
FastEthernet0/0.24 is up, line protocol is up
Internet address is 192.168.24.4/24
FastEthernet0/0.34 is up, line protocol is up
Internet address is 192.168.34.4/24
Serial0/0 is administratively down, line protocol is down

```
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 11：在 R4 使用 ping 作测试，确保 R4 能 ping 通 R1、R2 和 R3

```
R4#ping 192.168.14.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.14.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 32/48/68 ms

R4#ping 192.168.24.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.24.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 48/49/52 ms

R4#ping 192.168.34.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.34.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 36/42/44 ms
R4#
```

任务 2：配置基本的 EIGRP 协议，实现网络互联

步骤 1：在 R1 上，使用 router eigrp 命令，开启 EIGRP 协议，并指定自治系统号为 100

```
R1(config)#router eigrp 100
R1(config-router)#
```

步骤 2：使用 network 命令，将 192.168.14.0 和 192.168.1.0 通告进 EIGRP 协议

```
R1(config-router)#network 192.168.14.0
R1(config-router)#network 192.168.1.0
R1(config-router)#exit
```

步骤 3：在 R2 上，使用 router eigrp 命令，开启 EIGRP 协议，并指定自治系统号为 100

```
R2(config)#router eigrp 100
R2(config-router)#
```

步骤 4：使用 network 命令，将 192.168.24.0 和 192.168.2.0 通告进 EIGRP 协议

```
R2(config-router)#network 192.168.24.0
R2(config-router)#network 192.168.2.0
R2(config-router)#exit
```

步骤 5：在 R3 上，使用 router eigrp 命令，开启 EIGRP 协议，并指定自治系统号为 100

```
R3(config)#router eigrp 100
R3(config-router)#
```

步骤 6：使用 network 命令，将 192.168.34.0 和 192.168.3.0 通告进 EIGRP 协议

```
R3(config-router)#network 192.168.34.0
R3(config-router)#network 192.168.3.0
R3(config-router)#exit
```

步骤 7：在 R4 上，使用 router eigrp 命令，开启 EIGRP 协议，并指定自治系统号为 100

```
R4(config)#router eigrp 100
R4(config-router)#
```

步骤 8：使用 network 命令，将 192.168.14.0、192.168.24.0 和 192.168.34.0 通告进 EIGRP 协议

```
R4(config-router)#network 192.168.14.0
R4(config-router)#network 192.168.24.0
R4(config-router)#network 192.168.34.0
R4(config-router)#end
R4#
```

步骤 9：检查 R4 的路由表，会看到 3 条“D”的路由，分别是 R1、R2、R3 的 Loopback0 接口的路由，说明现在 EIGRP 已完成了路由的传递

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

C 192.168.14.0/24 is directly connected, FastEthernet0/0.14
C 192.168.24.0/24 is directly connected, FastEthernet0/0.24
C 192.168.34.0/24 is directly connected, FastEthernet0/0.34
D 192.168.1.0/24 [90/1433600] via 192.168.14.1, 00:00:41, FastEthernet0/0.14
D 192.168.2.0/24 [90/1433600] via 192.168.24.2, 00:00:38, FastEthernet0/0.24
D 192.168.3.0/24 [90/1433600] via 192.168.34.3, 00:00:36, FastEthernet0/0.34
```

步骤 10：在 R4 上，确认能 ping 通拓扑中所有的地址，如 192.168.1.1、192.168.2.1 和 192.168.3.1

```
R4#ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 44/48/52 ms
R4#ping 192.168.2.1
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/47/48 ms

R4#ping 192.168.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/48/52 ms
R4#
```

任务 3：学会各种 show 命令

步骤 1：在 R4 上，使用 show ip route eigrp ，可以找出路由表中所有 EIGRP 协议得到的路由

```
R4#show ip route eigrp
D     192.168.1.0/24
           [90/1433600] via 192.168.14.1, 00:03:09, FastEthernet0/0.14
D     192.168.2.0/24
           [90/1433600] via 192.168.24.2, 00:03:06, FastEthernet0/0.24
D     192.168.3.0/24
           [90/1433600] via 192.168.34.3, 00:03:04, FastEthernet0/0.34
```

步骤 2：在 R4 上，使用 show ip protocols，可以看到 EIGRP 的基本工作参数，观察输出的内容，回答以下问题

1. EIGRP 自治系统号是多少？

2. 使用 network 通告了哪些网段？

3. 从哪些邻居路由器那里收到过路由？

```
R4#show ip protocols
Routing Protocol is "eigrp 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 100
  EIGRP NSF-aware route hold timer is 240s
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.34.0/24 for FastEthernet0/0.14, FastEthernet0/0.24
    192.168.24.0/24 for FastEthernet0/0.14, FastEthernet0/0.34
    192.168.14.0/24 for FastEthernet0/0.24, FastEthernet0/0.34
  Maximum path: 4
```

```
  Routing for Networks:
    192.168.14.0
    192.168.24.0
    192.168.34.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.34.3          90      00:03:16
    192.168.14.1          90      00:03:22
    192.168.24.2          90      00:03:19
  Distance: internal 90 external 170
```

步骤 3：在 R4 上，使用 show ip eigrp neighbors 命令可以看到 EIGRP 邻居的列表信息，回答以下问题：

1. R4 分别和哪些路由器的建立了 EIGRP 邻居，它们的 IP 分别是什么？
2. R4 是通过哪些接口建立的邻居关系？

```
R4#show ip eigrp neighbors
IP-EIGRP neighbors for process 100
H   Address           Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                      (sec)         (ms)       Cnt Num
2   192.168.34.3       Fa0/0.34         10 00:04:28  115   690  0  3
1   192.168.24.2       Fa0/0.24         14 00:04:30   93   558  0  3
0   192.168.14.1       Fa0/0.14         10 00:04:33   78   468  0  3
```

步骤 4：在 R4 上，使用 show ip eigrp interface 可以看到所有开启 EIGRP 协议的接口

```
R4#show ip eigrp interfaces
IP-EIGRP interfaces for process 100

                    Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface    Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.14       1        0/0        78       0/12         308          0
Fa0/0.24       1        0/0        93       0/12         356          0
Fa0/0.34       1        0/0       115       0/12         640          0
```

步骤 5：在 R4 上，使用 show ip eigrp topology 可以看到 EIGRP 拓扑表，这里存放着所有可能的正确路径（最佳路径和备用路径）

```
R4#show ip eigrp topology
IP-EIGRP Topology Table for AS(100)/ID(192.168.34.4)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 192.168.34.0/24, 1 successors, FD is 1305600
       via Connected, FastEthernet0/0.34
P 192.168.14.0/24, 1 successors, FD is 1305600
       via Connected, FastEthernet0/0.14
P 192.168.1.0/24, 1 successors, FD is 1433600
       via 192.168.14.1 (1433600/128256), FastEthernet0/0.14
P 192.168.2.0/24, 1 successors, FD is 1433600
       via 192.168.24.2 (1433600/128256), FastEthernet0/0.24
P 192.168.3.0/24, 1 successors, FD is 1433600
       via 192.168.34.3 (1433600/128256), FastEthernet0/0.34
P 192.168.24.0/24, 1 successors, FD is 1305600
       via Connected, FastEthernet0/0.24
```

任务 4：管理 EIGRP 的自动汇总

步骤 1：在 R1 上，增加 loopback1 口，IP 为 172.16.1.1/24，并使用 network 命令将其开启到 EIGRP100 中

```
R1(config)#interface loopback 1
R1(config-if)#ip address 172.16.1.1 255.255.255.0
R1(config-if)#exit
R1(config)#router eigrp 100
R1(config-router)#network 172.16.0.0
R1(config-router)#exit
```

步骤 2：在 R2 上，增加 loopback1 口，IP 为 172.16.2.1/24，并使用 network 命令将其开启到 EIGRP100 中

```
R2(config)#interface loopback 1
R2(config-if)#ip address 172.16.2.1 255.255.255.0
R2(config-if)#exit
R2(config)#router eigrp 100
R2(config-router)#network 172.16.0.0
R2(config-router)#exit
```

步骤 3：在 R3 上，增加 loopback1 口，IP 为 172.16.3.1/24，并使用 network 命令将其开启到 EIGRP100 中

```
R3(config)#interface loopback 1
R3(config-if)#ip address 172.16.3.1 255.255.255.0
R3(config-if)#exit
R3(config)#router eigrp 100
R3(config-router)#network 172.16.0.0
R3(config-router)#exit
```

步骤 4：观察 R4 的路由表，会看到一个 172.16.0.0/16 的路由，有 3 个下一跳（R1、R2、R3），此时 R4 是无法区别出 R1、R2 和 R3 上所连接的 3 个不同的子网。分析发生这种情况的原因

```
R4#show ip route eigrp
D  172.16.0.0/16 [90/1433600] via 192.168.34.3, 00:00:13, FastEthernet0/0.34
                 [90/1433600] via 192.168.24.2, 00:00:13, FastEthernet0/0.24
                 [90/1433600] via 192.168.14.1, 00:00:13, FastEthernet0/0.14
D    192.168.1.0/24
          [90/1433600] via 192.168.14.1, 00:10:05, FastEthernet0/0.14
D    192.168.2.0/24
          [90/1433600] via 192.168.24.2, 00:10:01, FastEthernet0/0.24
D    192.168.3.0/24
          [90/1433600] via 192.168.34.3, 00:09:59, FastEthernet0/0.34
```

知识点：EIGRP 的自动汇总默认被开启，路由器在向邻居传输子网路由时，往往会将其汇总成默认类比的地址传输。比如在传递 172.16.1.0/24 的路由时，由于自动汇总被开启了，路由器会将 172.16.1.0/24 自动汇总成 172.16.0.0/16 传输出去。

步骤 5：关闭 4 台路由器的自动汇总

```
R1(config)#router eigrp 100
R1(config-router)#no auto-summary
R1(config-router)#exit

R2(config)#router eigrp 100
R2(config-router)#no auto-summary
R2(config-router)#exit

R3(config)#router eigrp 100
R3(config-router)#no auto-summary
R3(config-router)#exit

R4(config)#router eigrp 100
R4(config-router)#no auto-summary
R4(config-router)#exit
```

步骤 6：使用 show ip protocols，确认现在自动汇总已被关闭

```
R1#show ip protocols
Routing Protocol is "eigrp 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 100
  EIGRP NSF-aware route hold timer is 240s
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.1.0
    192.168.14.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)         90      00:01:42
    192.168.14.4          90      00:00:12
  Distance: internal 90 external 170
```

步骤 7：再检查 R4 的路由表，会看到 172.16.1.0/24、172.16.2.0/24 和 172.16.3.0/24 的路由，下一跳分别是 R1、R2 和 R3，现在 R4 能正确区分出其他 3 台路由器上的子网了

```
R4#show ip route eigrp
     172.16.0.0/24 is subnetted, 3 subnets
D       172.16.1.0 [90/1433600] via 192.168.14.1, 00:00:51, FastEthernet0/0.14
D       172.16.2.0 [90/1433600] via 192.168.24.2, 00:00:43, FastEthernet0/0.24
D       172.16.3.0 [90/1433600] via 192.168.34.3, 00:00:37, FastEthernet0/0.34
D    192.168.1.0/24
           [90/1433600] via 192.168.14.1, 00:11:22, FastEthernet0/0.14
D    192.168.2.0/24
           [90/1433600] via 192.168.24.2, 00:11:19, FastEthernet0/0.24
D    192.168.3.0/24
           [90/1433600] via 192.168.34.3, 00:11:17, FastEthernet0/0.34
```

任务 5：研究 EIGRP 的 network 命令

步骤 1：在 R2 上，增加以下 Loopback 接口

1. Loopback101:172.32.101.1/28
2. Loopback102:172.32.101.17/28
3. Loopback103:172.32.101.33/28
4. Loopback104:172.32.102.1/24

```
R2(config)#interface loopback 101
R2(config-if)#ip address 172.32.101.1 255.255.255.240
R2(config-if)#exit
R2(config)#interface loopback 102
R2(config-if)#ip address 172.32.101.17 255.255.255.240
R2(config-if)#exit
R2(config)#interface loopback 103
R2(config-if)#ip address 172.32.101.33 255.255.255.240
R2(config-if)#exit
R2(config)#interface loopback 104
R2(config-if)#ip address 172.32.102.1 255.255.255.0
R2(config-if)#exit
```

步骤 2：使用 network 172.32.0.0 命令，可以将步骤 1 中的四个接口同时开启到 EIGRP，此时 network 包含的是默认类别网络 172.32.0.0/16

```
R2(config)#router eigrp 100
R2(config-router)#network 172.32.0.0
R2(config-router)#end
R2#
```

步骤 3：使用 show ip eigrp interface 命令确认现在 4 个 Loopback 接口加入了 EIGRP 协议

```
R2#show ip eigrp interfaces
IP-EIGRP interfaces for process 100

                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.24            1        0/0       47       0/12          160          0
Lo0                 0        0/0        0        0/1            0          0
Lo1                 0        0/0        0        0/1            0          0
Lo101               0        0/0        0        0/1            0          0
Lo102               0        0/0        0        0/1            0          0
Lo103               0        0/0        0        0/1            0          0
Lo104               0        0/0        0        0/1            0          0
```

步骤 4：使用 no 命令将步骤 2 的配置删除

```
R2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router eigrp 100
R2(config-router)#no network 172.32.0.0
R2(config-router)#exit
```

步骤 5：使用 network 172.32.101.0 0.0.0.255 命令，可以将所有 172.32.101.X 的接口（Loopback101、Loopback102、Loopback103）开启到 EIGRP

```
R2(config)#router eigrp 100
R2(config-router)#network 172.32.101.0 0.0.0.255
R2(config-router)#end
R2#
```

步骤 6：使用 show ip eigrp interface 命令确认现在 3 个 Loopback 接口加入了 EIGRP 协议

```
R2#show ip eigrp interfaces
```

```
IP-EIGRP interfaces for process 100

                    Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface    Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.24       1        0/0       44       0/12          188          0
Lo0            0        0/0        0        0/1            0          0
Lo1            0        0/0        0        0/1            0          0
Lo101          0        0/0        0        0/1            0          0
Lo102          0        0/0        0        0/1            0          0
Lo103          0        0/0        0        0/1            0          0
```

步骤 7：使用 no 命令将步骤 5 的配置删除

```
R2(config)#router eigrp 100
R2(config-router)#no network 172.32.101.0 0.0.0.255
R2(config-router)#exit
```

步骤 8：使用 network 172.32.102.1 0.0.0.0 命令，可以精确地将 172.32.102.1（Loopback104）这个接口开启到 EIGRP 协议

```
R2(config)#router eigrp 100
R2(config-router)#network 172.32.102.1 0.0.0.0
R2(config-router)#end
R2#
```

步骤 9：使用 show ip eigrp interface 命令确认现在 Loopback104 接口加入了 EIGRP 协议

```
R2#show ip eigrp interfaces
IP-EIGRP interfaces for process 100

                    Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface    Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.24       1        0/0       41       0/12          172          0
Lo0            0        0/0        0        0/1            0          0
Lo1            0        0/0        0        0/1            0          0
Lo104          0        0/0        0        0/1            0          0
```

步骤 10：使用 network 172.32.101.0 255.255.255.0 命令，这里 network 命令中加上的是掩码而不是通配符

```
R2(config)#router eigrp 100
R2(config-router)#network 172.32.101.0 255.255.255.0
R2(config-router)#end
```

步骤 11：检查配置文件，发现配置文件中刚刚数据的命令变成了“network 172.32.101.0 0.0.0.255”，说明 EIGRP 能自动将掩码翻成通配符；EIGRP 的 Network 中可以使用掩码，而 OSPF 中只能使用通配符

```
R2#show running-config
Building configuration...
.......
.......
!
!
router eigrp 100
 network 172.16.0.0
 network 172.32.101.0 0.0.0.255
 network 172.32.102.1 0.0.0.0
 network 192.168.2.0
 network 192.168.24.0
 no auto-summary
.......
.......
!
!
end
```

步骤 12：检查 EIGRP 的接口列表，确认现在本任务中创建的 4 个 Loopback 接口都开启到了 EIGRP 协议

```
R2#show ip eigrp interfaces
```

```
IP-EIGRP interfaces for process 100

                      Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface      Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.24         1       0/0        56       0/12           50          0
Lo0              0       0/0         0       0/1             0          0
Lo1              0       0/0         0       0/1             0          0
Lo104            0       0/0         0       0/1             0          0
Lo101            0       0/0         0       0/1             0          0
Lo102            0       0/0         0       0/1             0          0
Lo103            0       0/0         0       0/1             0          0
```

步骤 13：检查其他路由器的路由表，确认能收到 172.32.0.0 下的四个不等长的子网路由

```
R4# show ip route eigrp
     172.16.0.0/24 is subnetted, 3 subnets
D    172.16.1.0 [90/1433600] via 192.168.14.1, 00:22:23, FastEthernet0/0.14
D    172.16.2.0 [90/1433600] via 192.168.24.2, 00:02:07, FastEthernet0/0.24
D    172.16.3.0 [90/1433600] via 192.168.34.3, 00:22:08, FastEthernet0/0.34
     172.32.0.0/16 is variably subnetted, 4 subnets, 2 masks
D       172.32.101.32/28
           [90/1433600] via 192.168.24.2, 00:02:07, FastEthernet0/0.24
D       172.32.101.0/28
           [90/1433600] via 192.168.24.2, 00:02:07, FastEthernet0/0.24
D       172.32.102.0/24
           [90/1433600] via 192.168.24.2, 00:02:07, FastEthernet0/0.24
D       172.32.101.16/28
           [90/1433600] via 192.168.24.2, 00:02:07, FastEthernet0/0.24
D   192.168.1.0/24[90/1433600] via 192.168.14.1, 00:32:54, FastEthernet0/0.14
D   192.168.2.0/24[90/1433600] via 192.168.24.2, 00:02:07, FastEthernet0/0.24
D   192.168.3.0/24[90/1433600] via 192.168.34.3, 00:32:48, FastEthernet0/0.34
```

任务 7：恢复所有设备到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

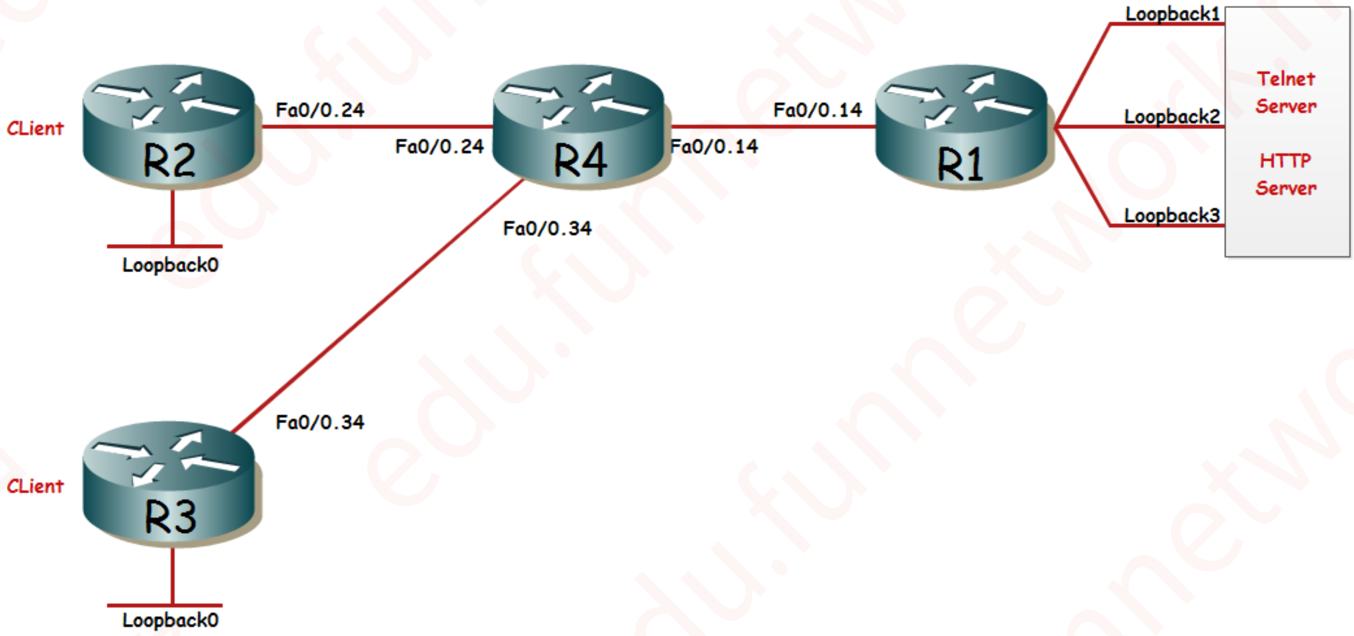
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………本次实验完成……………………………………………

实验 8 配置和实施访问控制列表

实验拓扑



实验目的：

1. 掌握标准访问控制列表的配置和实施方法
2. 掌握扩展访问控制列表的配置和实施方法
3. 掌握命名访问控制列表的配置和实施方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：搭建逻辑拓扑

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:

Press RETURN to get started!

Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注：输入“switchport trunk encapsulation dot1q”时如果出现报错，就说明您的交换机只支持 dot1q，

就不需要再明确指定 trunk 的标记格式，不用管它，继续往下做。

步骤 2：登录到 R1，配置主机名为“R1”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3：在 R1 上，创建子接口 Fa0/0.14，dot1q 标记值为 100，IP 地址是 192.168.14.1/24

```
R1(config)#interface fastEthernet 0/0.14
R1(config-subif)#encapsulation dot1Q 100
R1(config-subif)#ip address 192.168.14.1 255.255.255.0
R1(config-subif)#exit
```

步骤 4：登录到 R2，配置主机名为“R2”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 5：在 R2 上，创建子接口 Fa0/0.24，dot1q 标记值为 200，IP 地址是 192.168.24.2/24

```
R2(config)#interface fastEthernet 0/0.24
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#ip address 192.168.24.2 255.255.255.0
R2(config-subif)#exit
```

步骤 6：登录到 R3，配置主机名为“R3”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!
```

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 7：在 R3 上，创建子接口 Fa0/0.34，dot1q 标记值为 300，IP 地址是 192.168.34.3/24

```
R3(config)#interface fastEthernet 0/0.34
R3(config-subif)#encapsulation dot1Q 300
R3(config-subif)#ip address 192.168.34.3 255.255.255.0
R3(config-subif)#exit
```

步骤 8 登录到 R4，配置主机名为“R4”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
R4(config-if)#exit
```

步骤 9：在 R4 上创建 3 个子接口，Fa0/0.14、Fa0/0.24、Fa0/0.34，它们的 dot1q 标记值分别是 100、200、300，IP 地址分别是 192.168.14.4/24、192.168.24.4/24 和 192.168.34.4/24，并指定它们的带宽是 2Mbps

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#encapsulation dot1Q 100
R4(config-subif)#ip address 192.168.14.4 255.255.255.0
R4(config-subif)#bandwidth 2000
```

```
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#encapsulation dot1Q 200
R4(config-subif)#ip address 192.168.24.4 255.255.255.0
R4(config-subif)#bandwidth 2000
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#encapsulation dot1Q 300
R4(config-subif)#ip address 192.168.34.4 255.255.255.0
R4(config-subif)#bandwidth 2000
R4(config-subif)#exit
```

步骤 10：检查所有路由器的接口列表，确认所有需要的接口都处于 UP 状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
```

```
R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.24 is up, line protocol is up
  Internet address is 192.168.24.2/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
```

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.34 is up, line protocol is up
  Internet address is 192.168.34.3/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
```

```
Serial0/1 is administratively down, line protocol is down




R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.4/24
FastEthernet0/0.24 is up, line protocol is up
  Internet address is 192.168.24.4/24
FastEthernet0/0.34 is up, line protocol is up
  Internet address is 192.168.34.4/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 11：在 R4 使用 ping 作测试，确保 R4 能 ping 通 R1、R2 和 R3

```
R4#ping 192.168.14.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.14.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 32/48/68 ms

R4#ping 192.168.24.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.24.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 48/49/52 ms

R4#ping 192.168.34.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.34.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 36/42/44 ms
R4#
```

任务 2：配置 IP 参数，实现互联

步骤 1 在 R1 上增加 3 个 Loopback 接口 配置 IP 地址为 192.168.1.1/24、192.168.11.1/24 和 192.168.111.1/24 ，模拟 R1 连接的 3 个服务器

```
R1(config)#interface loopback 1
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
R1(config)#interface loopback 2
R1(config-if)#ip address 192.168.11.1 255.255.255.0
R1(config-if)#exit
R1(config)#inter
R1(config)#interface loopback 3
R1(config-if)#ip add
R1(config-if)#ip address 192.168.111.1 255.255.255.0
R1(config-if)#exit
```

步骤 2：配置 R1 的 EIGRP 协议，AS 为 100，关闭自动汇总，并将 192.168.0.0/16 下的所有接口开启协议

```
R1(config)#router eigrp 100
R1(config-router)#no auto-summary
R1(config-router)#network 192.168.0.0 0.0.255.255
R1(config-router)#exit
```

步骤 2：在 R2 上增加 Loopback0，IP 为 192.168.2.1/24，并开启到 EIGRP 100 中

```
R2(config)#interface loopback 0
R2(config-if)#ip address 192.168.2.1 255.255.255.0
R2(config-if)#exit
R2(config)#router eigrp 100
R2(config-router)#no auto-summary
R2(config-router)#network 192.168.0.0 0.0.255.255
R2(config-router)#exit
```

步骤 3：在 R3 上增加 Loopback 接口，IP 为 192.168.3.1/24，并开启到 EIGRP 100 中

```
R3(config)#interface loopback 0
R3(config-if)#ip address 192.168.3.1 255.255.255.0
R3(config-if)#exit
R3(config)#router eigrp 100
R3(config-router)#no auto-summary
R3(config-router)#network 192.168.0.0 0.0.255.255
R3(config-router)#exit
```

步骤 4：配置 R4 的 EIGRP，AS 为 100，关闭自动汇总，并将 192.168.0.0/16 下的所有接口都开启到 EIGRP

```
R4(config)#router eigrp 100
R4(config-router)#no auto-summary
R4(config-router)#network 192.168.0.0 0.0.255.255
R4(config-router)#exit
```

步骤 5：观察 R4 的路由表，确保 R4 能获得全部路由

```
R4#show ip route eigrp
D    192.168.111.0/24
          [90/1433600] via 192.168.14.1, 00:00:45, FastEthernet0/0.14
D    192.168.11.0/24
          [90/1433600] via 192.168.14.1, 00:00:50, FastEthernet0/0.14
D    192.168.1.0/24
          [90/1433600] via 192.168.14.1, 00:03:53, FastEthernet0/0.14
D    192.168.2.0/24
          [90/1433600] via 192.168.24.2, 00:00:50, FastEthernet0/0.24
D    192.168.3.0/24
          [90/1433600] via 192.168.34.3, 00:00:46, FastEthernet0/0.34
```

步骤 6：使用 ping 测试，确保 R1、R2、R3 的 Loopback 接口都能互通

```
R2#ping 192.168.1.1 source loopback 0
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/57/64 ms


R3#ping 192.168.11.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/48/52 ms
```

步骤 7：开启 R1 的 telnet 服务（VTY）和 HTTP 服务

```
R1(config)#line vty 0 4
R1(config-line)#no login
R1(config-line)#exit
R1(config)#ip http server
```

步骤 8：使用 R2 对 R1 的 Loopback 接口做 telnet 连接，进入 R1 后使用 exit 退出，确保 R2 可以通过 telnet 访问到 R1 的 Loopback 接口（也可以测试一下对 192.168.11.1 和 192.168.111.1 的连接，都是能打开的）

```
R2#telnet 192.168.1.1
Trying 192.168.1.1 ... Open

R1>exit

[Connection to 192.168.1.1 closed by foreign host]
```

步骤 9：使用 telnet 命令，后面跟上“80”，来连接 R1 的 HTTP 服务，如果看到 Open，说明能连上 HTTP 服务，最后用 exit 关闭连接

```
R2#telnet 192.168.1.1 80
```

```
Trying 192.168.1.1, 80 ... Open
exit

[Connection to 192.168.1.1 closed by foreign host]
R2#
```

任务 3：配置和实施标准 ACL

步骤 1：在 R4 上创建一个 ACL，号码为 1，该 ACL 是一个标准访问控制列表，允许来自 192.168.2.0/24 的所有数据包

```
R4(config)#access-list 1 permit 192.168.2.0 0.0.0.255
```

步骤 2：将步骤 1 创建的 ACL1 应用到 Fa0/0.14 的 out 方向，过滤 R4 发往 R1 的所有数据包

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 1 out
R4(config-subif)#exit
```

步骤 3：在 R2 的 Loopback0 上增加 2 个辅助 IP，192.168.2.2/24 和 192.168.2.3/24

```
R2(config)#interface loopback 0
R2(config-if)#ip address 192.168.2.2 255.255.255.0 secondary
R2(config-if)#ip address 192.168.2.3 255.255.255.0 secondary
R2(config-if)#exit
```

步骤 4：使用 ping 测试，发现只要是 R2 用 192.168.2.×的地址作为源去向 R1 发 ping 包，都是通的，说明源地址只要是 192.168.2.0/24 的数据包都会被 R4 的 ACL 放行

```
R2#ping 192.168.1.1 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/48/56 ms


R2#ping 192.168.1.1 source 192.168.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
```

```
Packet sent with a source address of 192.168.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/61/80 ms


R2#ping 192.168.1.1 source 192.168.2.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/54/80 ms
R2#
```

步骤 5：在 R3 上用 192.168.3.1 作为源向 192.168.1.1 发送 ping 包，发现不可达，说明只要不是来自 192.168.2.0/24 的数据包，都会被 R4 丢弃

```
R3#ping 192.168.1.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
U.U.U
Success rate is 0 percent (0/5)
R3#
```

步骤 6：使用 show access-list 命令可以看到 ACL 的情况，最后还能看到有多少个数据包被该规则匹配到

```
R4#show access-lists
Standard IP access list 1
    10 permit 192.168.2.0, wildcard bits 0.0.0.255 (15 matches)
R4#
```

步骤 7：删除 ACL1，并将 Fa0/0.14 的 OUT 方向规则去掉

```
R4(config)#no access-list 1
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#no ip access-group 1 out
R4(config-subif)#exit
```

步骤 8：在 R4 上重新创建 ACL1，定义 3 条规则，分别允许 192.168.2.1、192.168.2.2 和 192.168.2.3 三个主机，这里使用 3 种方法，都能描述一个主机

```
R4(config)#access-list 1 permit 192.168.2.1
R4(config)#access-list 1 permit 192.168.2.2 0.0.0.0
R4(config)#access-list 1 permit host 192.168.2.3
```

步骤 9：将 ACL1 应用到 Fa0/0.14 的 out 方向，过滤所有发送 R1 的数据包

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 1 out
R4(config-subif)#exit
```

步骤 10：使用 ping 测试，发现只要数据包来自 192.168.2.1、192.168.2.2 和 192.168.2.3，都能通过 R4 到达 R1，而来自其他 IP（如 192.168.2.4），就会被 R4 丢弃

```
R2#ping 192.168.1.1 source 192.168.2.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/50/60 ms

R2#ping 192.168.1.1 source 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/59/68 ms
```

```
R2#ping 192.168.1.1 source 192.168.2.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/52/68 ms

R2#ping 192.168.1.1 source 192.168.2.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.4
U.U.U
Success rate is 0 percent (0/5)
```

步骤 11：观察 ACL 状态，会看到 3 个规则分别匹配到了一些数据包

```
R4#show access-lists
Standard IP access list 1
    20 permit 192.168.2.2 (5 matches)
    30 permit 192.168.2.3 (5 matches)
    10 permit 192.168.2.1 (5 matches)
R4#
```

步骤 12：在 R4 上创建一个 ACL2，规则是丢弃来自 192.168.2.0/24 的数据包，应用到 Fa0/0.14 的 out 方向，过滤发往 R1 的数据包，注意该接口的 out 方向原先捆绑了 ACL1

```
R4(config)#access-list 2 deny 192.168.2.0 0.0.0.255
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 2 out
R4(config-subif)#exit
```

步骤 13 观察 R4 的配置文件中关于 fa0/0.14 的配置，发现原先的"ip access-group 1 out"命令已经没有了，只有“ip access-group 2 out”，说明一个接口的一个方向上，只能应用一个 ACL

```
R4#show running-config interface fastEthernet 0/0.14
Building configuration...

Current configuration : 139 bytes
!
interface FastEthernet0/0.14
 bandwidth 2000
 encapsulation dot1Q 100
 ip address 192.168.14.4 255.255.255.0
 ip access-group 2 out
end
```

步骤 14：观察 Fa0/0.14 的 IP 信息，会看到 Outgoing 上的 ACL2

```
R4#show ip interface fastEthernet 0/0.14
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.4/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.10
  Outgoing access list is 2
  Inbound  access list is not set
  Proxy ARP is enabled
  Local Proxy ARP is disabled
```

步骤 15：在 R2 上用 192.168.2.1 作为源无法 ping 通 R1，应为 ACL2 丢弃所有来自 192.168.2.0/24 的数据包

```
R2#ping 192.168.1.1 source 192.168.2.1
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
U.U.U
Success rate is 0 percent (0/5)
```

步骤 16：但使用 R3 去 ping，发现也无法 ping 通 R1，因为 ACL 有默认丢弃所有数据包的隐含规则（其实 ACL2 会丢弃所有数据包）

```
R3#ping 192.168.1.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
U.U.U
Success rate is 0 percent (0/5)
```

步骤 17：在 R4 上，为 ACL2 追加一条允许所有的语句，那么 ACL2 会只丢弃来自 192.168.2.0/24 的数据包，而来自其他 IP 的数据包都会被放行

```
R4(config)#access-list 2 permit any
```

步骤 18：观察 R4 的 ACL，发现 ACL2 有一条允许任何数据包的语句

```
R4#show access-lists
Standard IP access list 1
    20 permit 192.168.2.2 (5 matches)
    30 permit 192.168.2.3 (5 matches)
    10 permit 192.168.2.1 (5 matches)
Standard IP access list 2
    10 deny   192.168.2.0, wildcard bits 0.0.0.255 (8 matches)
    20 permit any
```

步骤 19：使用 ping 测试，发现只有来自 192.168.2.0/24 的数据包（如 192.168.2.1）是无法达到 R1 的，其他地址的数据包都能到达 R1

```
R2#ping 192.168.1.1 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
U.U.U
Success rate is 0 percent (0/5)
```

```
R3#ping 192.168.1.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/49/56 ms
```

步骤 20：在 R4 上再为 ACL2 创建一条规则，拒绝来自 192.168.3.0/24 的数据包

```
R4(config)#access-list 2 deny 192.168.3.0 0.0.0.255
```

步骤 21：使用 ping 测试，发现 192.168.3.1 还能 ping 通 192.168.1.1

```
R3#ping 192.168.1.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/59/68 ms
```

步骤 22：观察 R4 的 ACL，发现步骤 20 创建的规则位于 permit any 后面，那么这条规则将失去意义，所有 permit any 语句应该在所有规则创建好后最后添加

```
R4#show access-lists
Standard IP access list 1
    20 permit 192.168.2.2 (5 matches)
    30 permit 192.168.2.3 (5 matches)
    10 permit 192.168.2.1 (5 matches)
Standard IP access list 2
    10 deny   192.168.2.0, wildcard bits 0.0.0.255 (16 matches)
    20 permit any (10 matches)
    30 deny   192.168.3.0, wildcard bits 0.0.0.255
```

步骤 23：删除本任务中的 ACL1 和 ACL2，避免影响后面的实验

```
R4(config)#no access-list 1
R4(config)#no access-list 2
```

任务 4：配置和实施扩展 ACL

步骤 1：在 R4 上创建扩展 ACL，ID 为 100，允许任何网络对 192.168.1.0/24 和 192.168.11.0/24 的所有访问

```
R4(config)#access-list 100 permit ip any 192.168.1.0 0.0.0.255
R4(config)#access-list 100 permit ip any 192.168.11.0 0.0.0.255
```

步骤 2：将 ACL 100 应用到 Fa0/0.14 的 out 方向，控制所有 R4 发往 R1 的数据包

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 100 out
R4(config-subif)#end
```

步骤 3：测试，R2 能 ping 通 192.16.1.0/24 和 192.168.11.0/24 的 IP 地址，但无法 ping 通这两个网段以外的 IP 地址（如 192.168.111.0/24 的 IP），说明扩展 ACL 能根据目标地址控制数据包

```
R2#ping 192.168.1.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/64/68 ms

R2#ping 192.168.11.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/51/68 ms


R2#ping 192.168.111.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.111.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
U.U.U
```

```
Success rate is 0 percent (0/5)
R2#
```

步骤 4：观察 ACL，会看到 2 个规则，而且有数据包被匹配到了

```
R4#show access-lists
Extended IP access list 100
    10 permit ip any 192.168.1.0 0.0.0.255 (5 matches)
    20 permit ip any 192.168.11.0 0.0.0.255 (5 matches)
```

步骤 5：创建 ACL 101，拒绝任何地址对 192.168.1.0/24 的访问，但其他数据包都允许

```
R4(config)#access-list 101 deny ip any 192.168.1.0 0.0.0.255
R4(config)#access-list 101 permit ip any any
```

步骤 6：将 ACL101 应用到 Fa0/0.14 的 out 方向，过滤 R4 发往 R1 的数据包

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 101 out
```

步骤 7：测试，R2 或 R3 都无法 ping 通 192.168.1.0/24 的 IP，而其他目标地址都能正常 ping 通

```
R2#ping 192.168.11.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/47/48 ms

R2#ping 192.168.1.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
U.U.U
Success rate is 0 percent (0/5)
```

步骤 8：创建 ACL102，允许任何网络到任何网络的 telnet 访问，并应用到 Fa0/0.14 的 out 方向

```
R4(config)#access-list 102 permit tcp any any eq 23
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 102 out
R4(config-subif)#exit
```

步骤 9：测试，R2 或 R3，在访问 R1 的地址（如 192.168.1.1）时，只有 telnet 是被允许的，其他访问（如 ping）都会被拒绝

```
R2#telnet 192.168.1.1
Trying 192.168.1.1 ... Open

R1>exit

[Connection to 192.168.1.1 closed by foreign host]


R2#ping 192.168.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
U.U.U
Success rate is 0 percent (0/5)
```

步骤 10：创建 ACL103，允许 192.168.2.0/24 可以 telnet 访问 192.168.1.0/24，其他地址都不能 telnet 访问 192.168.1.0/24，任何其他方式和其他目标的访问都被允许

```
R4(config)# access-list 103 permit tcp 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255 eq
23
R4(config)#access-list 103 deny tcp any 192.168.1.0 0.0.0.255 eq 23
R4(config)#access-list 103 permit ip any any
R4(config)#
```

步骤 11：将 ACL103 应用到 Fa0/0.14 的 out 方向

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ip access-group 103 out
R4(config-subif)#exit
```

步骤 12 :测试、发现用 R2 的 Loopback0(192.168.2.1)可以 telnet 访问 192.168.1.0/24 的地址，但其他源（如 192.168.3.10)的 telnet 都被拒绝。同时，Telnet 以外的其他访问（如 ping）或对其他目标地址的访问都是允许通过的

```
R2#telnet 192.168.1.1 /source-interface loopback 0
Trying 192.168.1.1 ... Open
R1>exit
[Connection to 192.168.1.1 closed by foreign host]

R3#telnet 192.168.1.1 /source-interface loopback 0
Trying 192.168.1.1 ...
% Destination unreachable; gateway or host down

R3#ping 192.168.1.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/48/52 ms
```

步骤 13：删除本任务的所有 ACL

```
R4(config)#no access-list 100
R4(config)#no access-list 101
R4(config)#no access-list 102
R4(config)#no access-list 103
```

任务 5：配置和实施命名的 ACL

步骤 1：创建 ACL1，定义 4 条规则

```
R4(config)#access-list 1 permit 192.168.2.0 0.0.0.255
R4(config)#access-list 1 permit 192.168.3.0 0.0.0.255
R4(config)#access-list 1 permit 192.168.22.0 0.0.0.255
R4(config)#access-list 1 permit 192.168.33.0 0.0.0.255
```

步骤 2：检查 ACL，会看到 4 条规则

```
R4#show access-lists
Standard IP access list 1
    10 permit 192.168.2.0, wildcard bits 0.0.0.255
    20 permit 192.168.3.0, wildcard bits 0.0.0.255
    30 permit 192.168.22.0, wildcard bits 0.0.0.255
    40 permit 192.168.33.0, wildcard bits 0.0.0.255
```

步骤 3：尝试删除 ACL1 中的其中一条规则

```
R4(config)#no access-list 1 permit 192.168.22.0 0.0.0.255
```

步骤 4：再次检查 ACL，会发现 ACL1 的所有规则都没有了，说明以号码定义的标准 ACL 无法对规则进行编辑（如删除规则、插入规则）

```
R4#show access-lists

R4#
```

步骤 5：创建 ACL100，并定义 3 条规则

```
R4(config)#access-list 100 permit tcp 192.168.2.0 0.0.0.255 any eq 23
R4(config)#access-list 100 permit tcp 192.168.2.0 0.0.0.255 any eq 80
R4(config)#access-list 100 permit tcp 192.168.2.0 0.0.0.255 any eq 22
R4(config)#end
```

步骤 6：检查 ACL，确认 ACL100 有 3 条规则

```
R4#show access-lists
Extended IP access list 100
    10 permit tcp 192.168.2.0 0.0.0.255 any eq telnet
    20 permit tcp 192.168.2.0 0.0.0.255 any eq www
    30 permit tcp 192.168.2.0 0.0.0.255 any eq 22
```

步骤 7：尝试删除其中 1 条规则

```
R4(config)#no access-list 100 permit tcp 192.168.2.0 0.0.0.255 any eq 22
```

步骤 8：会看到 ACL100 没有了，说明以号码定义的扩展 ACL 无法也对规则进行编辑（如删除规则、插入规则）

```
R4#show access-lists

R4#
```

步骤 9：创建一个命名的标准 ACL，名称为"ACL-1"

```
R4(config)#ip access-list standard ACL-1
R4(config-std-nacl)#permit 192.168.2.0 0.0.0.255
R4(config-std-nacl)#permit 192.168.3.0 0.0.0.255
R4(config-std-nacl)#permit 192.168.22.0 0.0.0.255
R4(config-std-nacl)#permit 192.168.33.0 0.0.0.255
R4(config-std-nacl)#exit
```

步骤 10：检查 ACL，会看到一个"ACL-1"，有 4 条规则，每条规则前有个序号，这个序号是规则的 ID 号可以方便我们管理

```
R4#show access-lists
Standard IP access list ACL-1
    10 permit 192.168.2.0, wildcard bits 0.0.0.255
    20 permit 192.168.3.0, wildcard bits 0.0.0.255
    30 permit 192.168.22.0, wildcard bits 0.0.0.255
    40 permit 192.168.33.0, wildcard bits 0.0.0.255
```

步骤 11：进入 ACL-1，删除序号为 30 的规则

```
R4(config)#ip access-list standard ACL-1
R4(config-std-nacl)#no 30
R4(config-std-nacl)#exit
```

步骤 12：会发现 ACL-1 中少了一条序号为 30 的规则

```
R4#show access-lists
Standard IP access list ACL-1
    10 permit 192.168.2.0, wildcard bits 0.0.0.255
    20 permit 192.168.3.0, wildcard bits 0.0.0.255
    40 permit 192.168.33.0, wildcard bits 0.0.0.255
```

步骤 13：在 ACL1 中，创建一条序号为 25 的规则

```
R4(config)#ip access-list standard ACL-1
R4(config-std-nacl)#25 permit 192.168.20.0 0.0.0.255
R4(config-std-nacl)#exit
```

步骤 14：会看到步骤 13 创建的规则出现在了第 3 条（20 和 40 之间），说明命名的标准 ACL 可以方便地对规则进行编辑（删除、插入）

```
R4#show access-lists
Standard IP access list ACL-1
    10 permit 192.168.2.0, wildcard bits 0.0.0.255
    20 permit 192.168.3.0, wildcard bits 0.0.0.255
    25 permit 192.168.20.0, wildcard bits 0.0.0.255
    40 permit 192.168.33.0, wildcard bits 0.0.0.255
```

步骤 15：创建一个命名的扩展 ACL,名字为 ACL-2，并创建 3 条规则

```
R4(config)#ip access-list extended ACL-2
R4(config-ext-nacl)#permit icmp any any
R4(config-ext-nacl)#permit tcp 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255 eq 23
R4(config-ext-nacl)#permit tcp 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255 eq 23
```

步骤 16：检查 ACL，会看到创建的 ACL2，同样每个规则前有序号

```
R4#show access-lists
Standard IP access list ACL-1
    10 permit 192.168.2.0, wildcard bits 0.0.0.255
    20 permit 192.168.3.0, wildcard bits 0.0.0.255
    25 permit 192.168.20.0, wildcard bits 0.0.0.255
    40 permit 192.168.33.0, wildcard bits 0.0.0.255
Extended IP access list ACL-2
    10 permit icmp any any
    20 permit tcp 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255 eq telnet
    30 permit tcp 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255 eq telnet
```

步骤 17：在 show access-list 后加上 ACL 的名称（如 ACL-2），可以直接调出这个 ACL 的信息

```
R4#show ip access-lists ACL-2
Extended IP access list ACL-2
    10 permit icmp any any
    20 permit tcp 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255 eq telnet
    30 permit tcp 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255 eq telnet
```

步骤 18：进入 ACL2，添加一条序号为 15 的规则

```
R4(config)#ip access-list extended ACL-2
R4(config-ext-nacl)#15 deny tcp 192.168.3.1 0.0.0.0 192.168.1.0 0.0.0.255 eq 23
R4(config-ext-nacl)#exit
```

步骤 19：检查 ACL，可以看到步骤 18 的规则出现在了第 2 条（10 和 20 之间）

```
R4#show access-lists ACL-2
Extended IP access list ACL-2
    10 permit icmp any any
    15 deny tcp host 192.168.3.1 192.168.1.0 0.0.0.255 eq telnet
    20 permit tcp 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255 eq telnet
    30 permit tcp 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255 eq telnet
```

任务 6：将所有设备都恢复到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1 和 SW2）, 实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

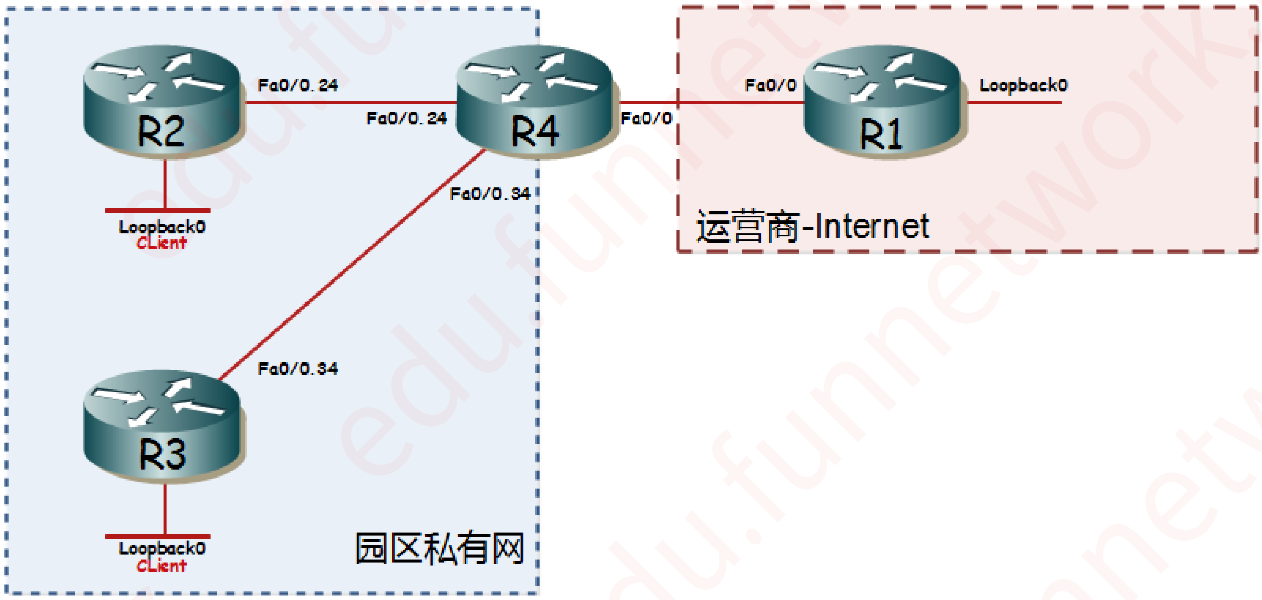
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………………本次实验完成……………………………………………

实验 9 配置和实施网络地址转换

实验拓扑



实验目的：

4. 掌握静态 NAT 的配置和实施方法
5. 掌握动态 NAT 的配置和实施方法
6. 掌握 PAT 的配置和实施方法
7. 掌握使用 NAT 发布内部服务器的配置方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：搭建逻辑拓扑

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:

Press RETURN to get started!

Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注 :输入“switchport trunk encapsulation dot1q”时如果出现报错 ,就说明您的交换机只支持 dot1q，

就不需要再明确指定 trunk 的标记格式，不用管它，继续往下做。

步骤 2 :登录到 R1 ,配置主机名为“R1” ,并将 Fa0/0 接口开启(如果没有 Fa0/0,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3：在 R1 上，配置 fa0/0 口的 IP 地址是 100.100.14.1/24，并创建 Loopback0，IP 为 100.100.1.1/32（模拟互联网上的 IP 地址）

```
R1(config)#interface fastEthernet 0/0
R1(config-if)#ip address 100.100.14.1 255.255.255.0
R1(config-if)#exit
R1(config)#interface loopback0
R1(config-if)#ip address 100.100.1.1 255.255.255.255
R1(config-if)#exit
```

步骤 4：登录到 R2，配置主机名为"R2"，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 5：在 R2 上，创建子接口 Fa0/0.24，dot1q 标记值为 200，IP 地址是 192.168.24.2/24，再创建一个 Loopback0（192.168.2.1/24），模拟内部网络的主机

```
R2(config)#interface fastEthernet 0/0.24
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#ip address 192.168.24.2 255.255.255.0
R2(config-subif)#exit
R2(config)#interface loopback0
R2(config-if)#ip address 192.168.2.1 255.255.255.0
R2(config-if)#exit
```

步骤 6 登录到 R3，配置主机名为“R3”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
    --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 7 在 R3 上，创建子接口 Fa0/0.34，dot1q 标记值为 300，IP 地址是 192.168.34.3/24，

再创建一个 Loopback0 接口，IP 为 192.168.3.1/24，模拟内部网络的主机

```
R3(config)#interface fastEthernet 0/0.34
R3(config-subif)#encapsulation dot1Q 300
R3(config-subif)#ip address 192.168.34.3 255.255.255.0
R3(config-subif)#exit
R3(config)#interface loopback0
R3(config-if)#ip address 192.168.3.1 255.255.255.0
R3(config-if)#exit
```

步骤 8 登录到 R4，配置主机名为“R4”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
    --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
```

```
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
R4(config-if)#exit
```

步骤 9 :在 R4 上创建 2 个子接口，Fa0/0.24、Fa0/0.34 ,它们的 dot1q 标记值分别是 200、300，IP 地址分别是 192.168.24.4/24 和 192.168.34.4/24。然后配置 Fa0/0 的 IP 为 100.100.14.4/24。Fa0/0.24 和 Fa0/0.34 是连接内部网络的线路，Fa0/0 是连接外部网络（运营商-internet）的线路

```
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#encapsulation dot1Q 200
R4(config-subif)#ip address 192.168.24.4 255.255.255.0
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#encapsulation dot1Q 300
R4(config-subif)#ip address 192.168.34.4 255.255.255.0
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0
R4(config-if)#ip address 100.100.14.4 255.255.255.0
R4(config-if)#exit
```

步骤 10：检查所有路由器的接口列表，确认所有需要的接口都处于 UP 状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
  Internet address is 192.168.14.1/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Loopback0 is up, line protocol is up
  Internet address is 100.100.1.1/32
```

```
R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.24 is up, line protocol is up
  Internet address is 192.168.24.2/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Loopback0 is up, line protocol is up
  Internet address is 192.168.2.1/24
```

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.34 is up, line protocol is up
  Internet address is 192.168.34.3/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
Loopback0 is up, line protocol is up
  Internet address is 192.168.3.1/24
```

```
R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 100.100.14.4/24
FastEthernet0/0.24 is up, line protocol is up
  Internet address is 192.168.24.4/24
FastEthernet0/0.34 is up, line protocol is up
  Internet address is 192.168.34.4/24
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 11：在 R4 使用 ping 作测试，确保 R4 能 ping 通 R1、R2 和 R3

```
R4#ping 100.100.14.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.14.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 32/48/68 ms

R4#ping 192.168.24.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.24.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 48/49/52 ms

R4#ping 192.168.34.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.34.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 36/42/44 ms
R4#
```

任务 2：配置 IP 参数，实现内部网络互联

步骤 1：配置 3 台路由器的 EIGRP 协议，AS 为 100，将 192.168.0.0/16 下的所有接口开启到 EIGRP 协议

```
R4(config)#router eigrp 100
R4(config-router)#network 192.168.0.0 0.0.255.255
R4(config-router)#no auto-summary
R4(config-router)#exit

R2(config)#router eigrp 100
R2(config-router)#network 192.168.0.0 0.0.255.255
R2(config-router)#no auto-summary
R2(config-router)#

R3(config)#router eigrp 100
R3(config-router)#network 192.168.0.0 0.0.255.255
R3(config-router)#no auto-summary
R3(config-router)#
```

步骤 2：在 R4 上增加一条默认路由，下一跳为 R1（100.100.14.1），确保 R4 可以正确地将去往 Internet 的数据包转发到 R1

```
R4(config)#ip route 0.0.0.0 0.0.0.0 100.100.14.1
R4(config)#
```

步骤 3 :在 R2 和 R3 上创建一条默认路由，下一跳为 R4(192.168.24.4 和 192.168.34.4)，确保 R2 和 R3 能正确地将去往 Internet 的数据包转发到 R4

```
R2(config)#ip route 0.0.0.0 0.0.0.0 192.168.24.4
R2(config)#

R3(config)#ip route 0.0.0.0 0.0.0.0 192.168.34.4
R3(config)#
```

步骤 4：观察 R2、R3 和 R4 的路由表，确认他们能获得内部网络中所有 192.168.X.0/24 的路由（共 4 条）和一条默认路由

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is 192.168.24.4 to network 0.0.0.0

C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
D    192.168.34.0/24 [90/30720] via 192.168.24.4, 00:01:25, FastEthernet0/0.24
C    192.168.2.0/24 is directly connected, Loopback0
D    192.168.3.0/24 [90/158720] via 192.168.24.4, 00:01:03, FastEthernet0/0.24
S*   0.0.0.0/0 [1/0] via 192.168.24.4
```

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is 192.168.34.4 to network 0.0.0.0

D    192.168.24.0/24 [90/30720] via 192.168.34.4, 00:00:52, FastEthernet0/0.34
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
D    192.168.2.0/24 [90/158720] via 192.168.34.4, 00:00:52, FastEthernet0/0.34
C    192.168.3.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 [1/0] via 192.168.34.4
```

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
Gateway of last resort is 100.100.14.1 to network 0.0.0.0

     100.0.0.0/24 is subnetted, 1 subnets
C       100.100.14.0 is directly connected, FastEthernet0/0
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
D    192.168.2.0/24 [90/156160] via 192.168.24.2, 00:01:47, FastEthernet0/0.24
D    192.168.3.0/24 [90/156160] via 192.168.34.3, 00:01:23, FastEthernet0/0.34
S*   0.0.0.0/0 [1/0] via 100.100.14.1
```

步骤 5：观察 R1 的路由表，确认 R1 只有自己的路由（互联网路由）而没有园区网内部的路由

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       100.100.1.1/32 is directly connected, Loopback0
C       100.100.14.0/24 is directly connected, FastEthernet0/0
```

任务 2：观察网络通信状态，了解 NAT 需要解决问题

步骤 1：使用 R4 做 ping 测试，确认 R4 能 ping 通互联网 IP（100.100.1.1）

```
R4#ping 100.100.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R4#
```

步骤 2：使用 R2 或 R3 做 ping 测试，发现它们是无法 ping 通 100.100.1.1 的

```
R2#ping 100.100.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

步骤 3：检查 R2 的路由表，其中有了一条指向 R4 的默认路由，说明去往互联网的数据包都会被转发到 R4，R2 这里的转发没有问题

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.24.4 to network 0.0.0.0

C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
D    192.168.34.0/24 [90/30720] via 192.168.24.4, 00:05:06, FastEthernet0/0.24
```

```
C    192.168.2.0/24 is directly connected, Loopback0
D    192.168.3.0/24 [90/158720] via 192.168.24.4, 00:04:44, FastEthernet0/0.24
S*   0.0.0.0/0 [1/0] via 192.168.24.4
```

步骤 4：检查 R4 的路由表，有一条默认路由会把去往互联网的数据包都转发给 R1，R4 这里的转发有问题

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 100.100.14.1 to network 0.0.0.0

     100.0.0.0/24 is subnetted, 1 subnets
C       100.100.14.0 is directly connected, FastEthernet0/0
C    192.168.24.0/24 is directly connected, FastEthernet0/0.24
C    192.168.34.0/24 is directly connected, FastEthernet0/0.34
D    192.168.2.0/24 [90/156160] via 192.168.24.2, 00:05:26, FastEthernet0/0.24
D    192.168.3.0/24 [90/156160] via 192.168.34.3, 00:05:02, FastEthernet0/0.34
S*   0.0.0.0/0 [1/0] via 100.100.14.1
```

步骤 5：在 R1 上开启对 ICMP（Ping）的监控

```
R1#debug ip icmp
ICMP packet debugging is on
R1#
```

步骤 6：在 R2 上再做一次 ping 测试

```
R2#ping 100.100.1.1 source loopback 0

Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.....
Success rate is 0 percent (0/5)
```

步骤 7：回到 R1 的界面，会看到 R1 准备发出 5 个 ping 回应，目的地是 192.168.2.1。这个信息告诉我们 R1 已经得到了 R2 发过来的数据包。所以，R2 到达 Internet 的数据转发路径是没有问题的。

```
R1#
*May 27 16:58:43.755: ICMP: echo reply sent, src 100.100.1.1, dst 192.168.2.1
*May 27 16:58:45.751: ICMP: echo reply sent, src 100.100.1.1, dst 192.168.2.1
*May 27 16:58:47.751: ICMP: echo reply sent, src 100.100.1.1, dst 192.168.2.1
*May 27 16:58:49.751: ICMP: echo reply sent, src 100.100.1.1, dst 192.168.2.1
*May 27 16:58:51.751: ICMP: echo reply sent, src 100.100.1.1, dst 192.168.2.1
```

步骤 8：观察 R1 的路由表，由于 R1 的路由表中没有到达网络中 192.168.×.0/24 的路由，所有 R1 无法正确的回应来自私网（如 R2、R3 上的客户主机）的访问。问题找到了

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       100.100.1.1/32 is directly connected, Loopback0
C       100.100.14.0/24 is directly connected, FastEthernet0/0
```

步骤 9：为了解决 R1 无法回应访问的问题，先尝试在 R1 上增加一条默认路由，目标为 192.168.0.0/16，可以包含现在实验中的所有私网地址，下一跳是 R4

```
R1(config)#ip route 192.168.0.0 255.255.0.0 100.100.14.4
R1(config)#
```

步骤 10：再用 R2 或 R3 测试 ping，发现通了。说明只要解决数据能回到从互联网回到企业入口这个问题，就能完成企业园区网和互联网的通信问题

```
R2#ping 100.100.1.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

步骤 11：删除 R1 的静态路由，因为实际网络环境中，互联网设备是不会出现直线企业或个人客户的静态路由器

```
R1(config)#no ip route 192.168.0.0 255.255.0.0 100.100.14.4
R1(config)#
```

步骤 12：再做 ping 测试，又不通了

```
R2#ping 100.100.1.1 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.....
Success rate is 0 percent (0/5)
```

总结：下面我们要解决的问题是：在不更改互联网设备（R1）的路由表的前提下，能确保 R1 将来自企业内部（R2、R3）的访问，正确地的回应道企业入口(R4）再由企业入口路由器将数据转发会客户主机

任务 3：配置静态的 NAT

步骤 1：在 R4 上配置静态 NAT，将所有源地址为 192.168.2.1 的访问，在转发出去时，将源地址改为 100.100.14.21；将所有源地址为 192.168.3.1 的访问，在转发出去时，将源地址改为 100.100.14.31

```
R4(config)#ip nat inside source static 192.168.2.1 100.100.14.21
R4(config)#ip nat inside source static 192.168.3.1 100.100.14.31
```

步骤 2：把连接互联网（R1）的接口 Fa0/0 配置为 NAT 的 outside 端，把连接内部的接口 Fa0/0.24 和 Fa0/0.34 配置为 NAT 的 inside 端

```
R4(config)#interface fastEthernet 0/0
R4(config-if)#ip nat outside
R4(config-if)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#ip nat inside
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#ip nat inside
R4(config-subif)#exit
```

步骤 3：观察 R4 的 NAT 转换表，发现了 2 个条目，就是步骤 1 中配置的 2 个规则

```
R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
--- 100.100.14.31      192.168.3.1        ---                ---
```

步骤 4：再用 R2 做 ping 测试，以 192.168.2.1 作为源向 100.100.1.1 发出访问，发现通了

```
R2#ping 100.100.1.1 source 192.168.2.1
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms
R2#
```

步骤 5：切换到 R1 的界面，看到 R1 产生了 Ping 回应，这是目标是 100.100.14.21，说明在互联网上，看到了来自 100.100.14.21 的访问，这个地址对于 R1 是可路由的（发往 R4 就可以）

```
R1#
*May 27 17:01:53.967: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:01:55.967: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:01:55.967: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:01:55.971: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:01:55.971: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
R1#
```

步骤 6：R3 使用 192.168.3.1 作为源对 100.100.1.1 做 ping 测试，可以看到也通了，在 R1 的界面中看到 R1 得到的请求来自 100.100.14.31

```
R3#ping 100.100.1.1 source 192.168.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/2/4 ms

R1#
*May 27 17:02:34.819: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.31
*May 27 17:02:36.819: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.31
*May 27 17:02:36.823: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.31
*May 27 17:02:36.823: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.31
*May 27 17:02:36.827: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.31
```

任务 4：通过动态 NAT，简化静态 NAT 的配置

步骤 1 在 R2 的 Loopback0 接口下增加 2 个 IP(辅助 IP)模拟 192.168.2.2 和 192.168.2.3 两个客户主机

```
R2(config)#interface loopback 0
R2(config-if)#ip address 192.168.2.2 255.255.255.0 secondary
R2(config-if)#ip address 192.168.2.3 255.255.255.0 secondary
R2(config-if)#exit
```

步骤 2：在 R2 上做 ping 测试，发现用 192.168.2.1 去访问 100.100.1.1 是通的，而用 192.168.2.2 和 192.168.2.3 去访问，则不通

```
R2#ping 100.100.1.1 source 192.168.2.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms

R2#ping 100.100.1.1 source 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
.....
Success rate is 0 percent (0/5)

R2#ping 100.100.1.1 source 192.168.2.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
.....
Success rate is 0 percent (0/5)
```

步骤 3：观察 R4 的 NAT 转换表，发现没有 192.168.2.2 和 192.168.2.3 的规则，从这 2 个 IP 发出的数据包是到达 Intenret 后是回不来的，再配置静态 NAT 是可以解决这个问题，但在内部主机多的情况下，静态 NAT 配置会非常繁琐

```
R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
--- 100.100.14.31      192.168.3.1        ---                ---
```

步骤 4：在 R4 上配置动态 NAT，首先在 R4 上创建一个 ACL，匹配所有的 192.168.*.*地址，然后创建一个 NAT 地址池，名字为 POOL-1，地址范围是 100.100.14.100 到 100.100.14.200，最后将 ACL 和 POOL-1 关联起来

```
R4(config)#access-list 1 permit 192.168.0.0 0.0.255.255
R4(config)#ip nat pool POOL-1 100.100.14.100 100.100.14.200 netmask 255.255.255.0
R4(config)#ip nat inside source list 1 pool POOL-1
```

步骤 5：确认配置 OUTSIDE 和 INSIDE 接口（其实这个步骤不用再做，上一个任务已经做了）

```
R4(config)#interface fastEthernet 0/0
R4(config-if)#ip nat outside
R4(config-if)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#ip nat inside
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#ip nat inside
R4(config-subif)#exit
```

步骤 6：R2 上，再使用 192.168.2.2 和 192.168.2.3 去对 Internet 做访问，发现通了

```
R2#ping 100.100.1.1 source 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
```

```
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/4 ms

R2#ping 100.100.1.1 source 192.168.2.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
```

步骤 7：回到 R1 的界面，发现收到的所有访问分别是来自 100.100.14.100 和 100.100.14.101（这两个地址是地址池中的前 2 个地址）

```
R1#
*May 27 17:08:21.775: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.100
*May 27 17:08:23.771: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.100
*May 27 17:08:23.771: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.100
*May 27 17:08:23.771: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.100
*May 27 17:08:23.771: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.100
*May 27 17:08:42.255: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.101
*May 27 17:08:44.251: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.101
*May 27 17:08:44.251: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.101
*May 27 17:08:44.255: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.101
*May 27 17:08:44.255: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.101
```

步骤 8：检查 R4 的 NAT 转换表，会看到 2 条新的规则，是自动创建出来的，只要出现匹配 ACL 的数据包，就会自动从地址池中取一个地址建立 NAT 规则（原先的两条静态 NAT，不受影响）

```
R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
--- 100.100.14.31      192.168.3.1        ---                ---
--- 100.100.14.100     192.168.2.2        ---                ---
--- 100.100.14.101     192.168.2.3        ---                ---
```

步骤 9：在 R2 或 R3 上，使用 192.168.2.1 或 192.168.3.1 测试，发现 R1 收到的访问还是来自 100.100.14.21 和 100.100.14.31，说明静态 NAT 是优先于动态 NAT 的

```
R2#ping 100.100.1.1 source 192.168.2.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms

R1#
*May 27 17:09:23.395: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:09:23.395: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:09:23.395: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:09:23.399: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21
*May 27 17:09:23.399: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.21

R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
--- 100.100.14.31      192.168.3.1        ---                ---
--- 100.100.14.100     192.168.2.2        ---                ---
--- 100.100.14.101     192.168.2.3        ---                ---
```

任务 5：管理静态和动态 NAT 的配置

步骤 1：在 R2 上，使用 192.168.2.2 和 192.168.2.3 再做一次对 internet 的 ping 测试

```
R2#ping 100.100.1.1 source 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms

R2#ping 100.100.1.1 source 192.168.2.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
R2#
```

步骤 2：确认动态条目已被创建在 NAT 转换表中

```
R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
--- 100.100.14.31      192.168.3.1        ---                ---
--- 100.100.14.100     192.168.2.2        ---                ---
--- 100.100.14.101     192.168.2.3        ---                ---
```

步骤 3：使用 show ip nat translations verbose，观察转换条目的详细信息，可以看到条目创建的时间和剩余时间(多少时间后删除),静态条目是没有剩余时间的,说明永远有效。创建时间+剩余时间是 24 小时。说明一旦一个动态条目被创建，会保留 24 小时

```
R4#show ip nat translations verbose
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
    create 00:18:26, use 00:01:28,
    flags:
```

```
static, use_count: 0
--- 100.100.14.31     192.168.3.1       ---               ---
    create 00:18:14, use 00:16:40,
    flags:
static, use_count: 0
--- 100.100.14.100    192.168.2.2       ---               ---
    create 00:10:55, use 00:00:33, left 23:59:27, Map-Id(In): 1,
    flags:
none, use_count: 0
--- 100.100.14.101    192.168.2.3       ---               ---
    create 00:10:35, use 00:00:25, left 23:59:35, Map-Id(In): 1,
    flags:
none, use_count: 0
```

步骤 4：将 NAT 的超时时间改为 300 秒（5 分钟），一个动态条目创建后，保留 5 分钟

```
R4(config)#ip nat translation timeout 300
R4(config)#
```

步骤 5:清空所有的动态转换条目

```
R4#clear ip nat translation *
```

步骤 6：确认只有静态转换条目（如果还发现有动态条目，步骤 5 多做几遍）

```
R4#show ip nat translations
Pro Inside global     Inside local      Outside local      Outside global
--- 100.100.14.21     192.168.2.1       ---               ---
--- 100.100.14.31     192.168.3.1       ---               ---
```

步骤 7：再使用 R2 的 192.168.2.2 做 ping 测试

```
R2#ping 100.100.1.1 source 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
.!!!!
```

```
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
R2#
```

步骤 8：看到 R4 创建了一个新的条目

```
R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
--- 100.100.14.31      192.168.3.1        ---                ---
--- 100.100.14.102     192.168.2.2        ---                ---
```

步骤 9 :显示 NAT 条目详细信息后会发现 ,剩余时间和创建时间相加是 5 分钟 ,创建 5 分钟后，该条目会自动删除

```
R4#show ip nat translations verbose
Pro Inside global      Inside local       Outside local      Outside global
--- 100.100.14.21      192.168.2.1        ---                ---
    create 00:21:40, use 00:04:42,
    flags:
static, use_count: 0
--- 100.100.14.31      192.168.3.1        ---                ---
    create 00:21:28, use 00:19:54,
    flags:
static, use_count: 0
--- 100.100.14.102     192.168.2.2        ---                ---
    create 00:01:57, use 00:01:55, left 00:03:04, Map-Id(In): 1,
    flags:
none, use_count: 0
```

步骤 10:尝试删除 R4 的 POOL-1，但报错，内容是 POOL-1 正在被使用，不能删除（POOL-1 中的地址确实被 NAT 占用了 ,步骤 9 中出现的那个动态条目的外网地址就是 POOL-1 中的一个地址）

```
R4(config)#no ip nat pool POOL-1
%Pool POOL-1 in use, cannot destroy
R4(config)#
```

步骤 11：清空 NAT 规则表

```
R4#clear ip nat translation *
```

步骤 12：现在可以删除动态 NAT 的 POOL-1 以及内部、外部地址的关联了。说明要更改动态 NAT 或删除动态 NAT，需要清除所有的动态 NAT 规则

```
R4(config)#no ip nat pool POOL-1
R4(config)#no ip nat inside source list 1 pool POOL-1
```

步骤 13:删除前面配置的静态 NAT

```
R4(config)#no ip nat inside source static 192.168.2.1 100.100.14.21
R4(config)#no ip nat inside source static 192.168.3.1 100.100.14.31
```

步骤 14：确保现在没有一条 NAT 规则

```
R4#show ip nat translations

R4#
```

任务 6:配置 PAT，实现内部主机共用一个 IP 访问外网

步骤 1：在 R4 上常见 ACL10，匹配所有 192.168.*.*的地址

```
R4(config)#access-list 10 permit 192.168.0.0 0.0.255.255
R4(config)#
```

步骤 2：配置 PAT，将 ACL10 关联到 fa0/0（外网接口），overload 参数保证了可以多个内部 IP 共用一个外部 IP（外网接口的 IP）

```
R4(config)#ip nat inside source list 10 interface fastEthernet 0/0 overload
R4(config)#
```

步骤 3：确认 outside 和 inside 接口配置

```
R4(config)#interface fastEthernet 0/0
R4(config-if)#ip nat outside
R4(config-if)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#ip nat inside
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.34
R4(config-subif)#ip nat inside
R4(config-subif)#exit
```

步骤 4：在 R2 上，分别使用 3 个 192.168.2.0/24 的地址作为源，却访问 100.100.1.1，发现都是通的，再用 R3 的 192.168.3.1 去访问 100.100.1.1 也是通的

```
R2#ping 100.100.1.1 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

```
R2#ping 100.100.1.1 source 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms

R2#ping 100.100.1.1 source 192.168.2.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R2#

R3#ping 100.100.1.1 source 192.168.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/4 ms
R3#
```

步骤 5：观察 R1 的输出，发现收到的所有访问都来自 100.100.14.4（R4 的外网接口），说明内部所有主机发出的访问都被转换成了 R4 的外部接口 IP

```
R1>
*May 27 17:28:03.703: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:03.707: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:03.707: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:03.707: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:03.711: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:06.755: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:06.759: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:06.759: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:06.759: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:06.759: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:08.923: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:08.923: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:08.927: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:08.927: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:08.927: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
```

```
*May 27 17:28:29.871: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:29.875: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:29.875: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:29.879: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
*May 27 17:28:29.879: ICMP: echo reply sent, src 100.100.1.1, dst 100.100.14.4
```

步骤 6：检查 R4 的转换表，发现内部 192.168.*.*的地址都关联到了 100.100.14.4，且记录下了端口号，这个是 PAT 的特点

```
R4#show ip nat translations
Pro Inside global      Inside local      Outside local      Outside global
icmp 100.100.14.4:1    192.168.3.1:1     100.100.1.1:1      100.100.1.1:1
icmp 100.100.14.4:16   192.168.2.1:16    100.100.1.1:16     100.100.1.1:16
icmp 100.100.14.4:17   192.168.2.2:17    100.100.1.1:17     100.100.1.1:17
icmp 100.100.14.4:18   192.168.2.3:18    100.100.1.1:18     100.100.1.1:18
```

步骤 7：开启 R1 的 telnet

```
R1(config)#line vty 0 4
R1(config-line)#no login
R1(config-line)#exit
```

步骤 8：在 R2 上对 R1 所 telnet 连接（以 Loopback0 为源），连上后暂时不要退出

```
R2#telnet 100.100.1.1 /source-interface loopback 0
Trying 100.100.1.1 ... Open

R1>
```

步骤 9：在 R3 上对 R1 所 telnet 连接（以 Loopback0 为源），连上后暂时不要退出

```
R3#telnet 100.100.1.1 /source-interface loopback 0
Trying 100.100.1.1 ... Open

R1>
```

步骤 10：关闭 R1 的域名解析功能（可以加快后面 show 命令的显示速度），使用 show users 观察哪些用户（主机）连接着自己，会看大了 2 个来自 100.100.14.4 的访问（R2 和 R3 产生的访问都被伪装成了 R4 产生的访问）

```
R1(config)#no ip domain-lookup
R1(config)#end
R1#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00
 162 vty 0                idle                 00:00:38 100.100.14.4
 163 vty 1                idle                 00:00:26 100.100.14.4
```

步骤 11：观察 R4 的转换表，发现了 2 个 TCP 规则，而且是携带了端口号做的转换

```
R4#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
tcp 100.100.14.4:11000 192.168.3.1:11000  100.100.1.1:23     100.100.1.1:23
tcp 100.100.14.4:16127 192.168.2.1:16127  100.100.1.1:23     100.100.1.1:23
```

步骤 12：关闭 R2 和 R3 对 R1 的 telnet 连接

```
R1>exit

[Connection to 100.100.1.1 closed by foreign host]
R2#


R1>exit

[Connection to 100.100.1.1 closed by foreign host]
R3#
```

任务 7：通过 NAT，使内部服务器能被外部网络访问到

步骤 1：创建一个静态 NAT，将 192.168.2.1 和 100.100.14.201 关联起来

```
R4(config)#ip nat inside source static 192.168.2.1 100.100.14.201
R4(config)#
```

步骤 2：开启 R2、R3 和 R4 的 telnet

```
R2(config)#line vty 0 4
R2(config-line)#no login
R2(config-line)#exit

R3(config)#line vty 0 4
R3(config-line)#no login
R3(config-line)#exit

R4(config)#line vty 0 4
R4(config-line)#no login
R4(config-line)#exit
```

步骤 3：使用 R1 做 telnet 测试，尝试登录 192.168.2.1，由于没有路由，是无法连接的

```
R1#telnet 192.168.2.1
Trying 192.168.2.1 ...
% Destination unreachable; gateway or host down
```

步骤 4：R1 尝试 telnet 连接 100.100.14.201，该地址在 R4 上关联了 192.168.2.1，所有可以直接进入 R2

```
R1#telnet 100.100.14.201
Trying 100.100.14.201 ... Open

R2>
R2>exit

[Connection to 100.100.14.201 closed by foreign host]
```

```
R1#
```

步骤 5：在 R2 上开启 ping 的 debug

```
R2#debug ip icmp
ICMP packet debugging is on
R2#
```

步骤 6：R1 测试到 100.100.14.201 的 ping

```
R1#ping 100.100.14.201

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.14.201, timeout is 2 seconds:
!!!!!
```

步骤 7：发现 R2 收到了 ping，此时互联网对 100.100.14.201 的任何访问都会被转发到 192.168.2.1,如果 192.168.2.1 是企业内部一台服务器的话，这种配置可以很轻松地让外部用户能访问到这台服务器

```
R2#
*Mar  1 01:53:38.635: ICMP: echo reply sent, src 192.168.2.1, dst 100.100.14.1
*Mar  1 01:53:38.639: ICMP: echo reply sent, src 192.168.2.1, dst 100.100.14.1
*Mar  1 01:53:38.639: ICMP: echo reply sent, src 192.168.2.1, dst 100.100.14.1
*Mar  1 01:53:38.643: ICMP: echo reply sent, src 192.168.2.1, dst 100.100.14.1
*Mar  1 01:53:38.647: ICMP: echo reply sent, src 192.168.2.1, dst 100.100.14.1
```

步骤 8：在 R4 上配置基于 TCP 的静态 NAT ， 将 192.168.3.1 的 23 端口（Telnet 服务）和 100.100.14.203 的 23 端口关联起来

```
R4(config)#ip nat inside source static tcp 192.168.3.1 23 100.100.14.203 23
R4(config)#
```

步骤 9：在 R1 上 telnet 连接 100.100.14.203，发现进入了 R3

```
R1#telnet 100.100.14.203
Trying 100.100.14.203 ... Open

R3>exit

[Connection to 100.100.14.203 closed by foreign host]
R1#
```

步骤 10：在 R3 和 R4 上开启 ping 的 debug

```
R3#debug ip icmp
ICMP packet debugging is on
R3#

R4#debug ip icmp
ICMP packet debugging is on
R4#
```

步骤 11：在 R1 上 ping 测试到 100.100.14.203 的通信

```
R1#ping 100.100.14.203

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 100.100.14.203, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

步骤 12：发现是 R4 接收并恢复的 ping 消息，说明步骤 8 的配置只会将对 100.100.14.203 的 telnet 访问转发给 192.168.3.1，其他对 100.100.14.203 的访问是不会向内转发的。

步骤 8 的配置可以将内部某个服务器的某个服务精确的发布到互联网上。

```
R4#
*Mar  1 01:54:24.271: ICMP: echo reply sent, src 100.100.14.203, dst 100.100.14.1
*Mar  1 01:54:24.275: ICMP: echo reply sent, src 100.100.14.203, dst 100.100.14.1
*Mar  1 01:54:24.279: ICMP: echo reply sent, src 100.100.14.203, dst 100.100.14.1
*Mar  1 01:54:24.279: ICMP: echo reply sent, src 100.100.14.203, dst 100.100.14.1
*Mar  1 01:54:24.283: ICMP: echo reply sent, src 100.100.14.203, dst 100.100.14.1
```

步骤 13：删除步骤 1 创建的静态 NAT

```
R4(config)#no ip nat inside source static 192.168.2.1 100.100.14.201
```

步骤 14：配置一条基于 TCP 的静态 NAT，将 192.168.2.1 的 23 端口（telnet 服务）和 100.100.14.201 的 2323 端口起来

```
R4(config)#ip nat inside source static tcp 192.168.2.1 23 100.100.14.201 2323
R4(config)#
```

步骤 15：R1 尝试 telnet 连接 100.100.14.201，端口为默认的 23，发现连接被拒绝，因为 R4 上没有关于 100.100.14.201 的 23 端口映射

```
R1#telnet 100.100.14.201
Trying 100.100.14.201 ...
% Connection refused by remote host
```

步骤 16：再次尝试 telnet，这次在 telnet 后加上 2323，作为手工指定的目标端，发现可以进入 R2 ,因为到 100.100.14.201 的 2323 访问会被转发到 192.168.2.1 的 23 端口(telnet 服务）

```
R1#telnet 100.100.14.201 2323
Trying 100.100.14.201, 2323 ... Open
R2>exit

[Connection to 100.100.14.201 closed by foreign host]
R1#
```

任务 8：将所有设备都恢复到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1 和 SW2），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

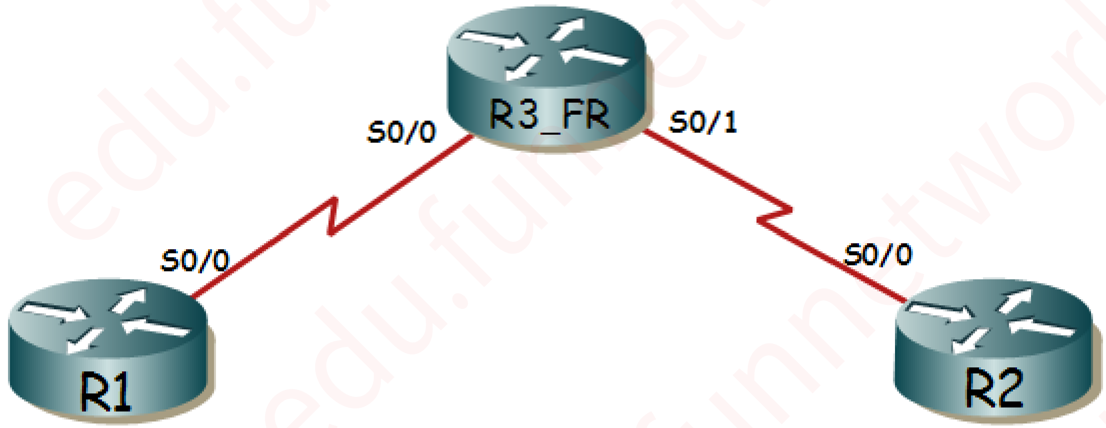
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

…………………………………………本次实验完成…………………………………………………

实验 10 配置和实施 WAN 线路

实验拓扑



实验目的：

19. 掌握 WAN 专线的基本配置方法

20. 掌握 PPP 专线的配置方法

21. 掌握 PPP 上 CHAP 和 PAP 认证的实施方法

22. 掌握帧中继网络的构建方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：配置基本的 WAN 线路

步骤 1：配置 R3 的 S0/0 接口，正确配置 IP 地址为 192.168.13.3/24，并指定始终速率为 128k，并开启接口

```
R3(config)#interface serial 0/0
R3(config-if)#ip address 192.168.13.3 255.255.255.0
R3(config-if)#clock rate 128000
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 2：配置 R1 的 s0/0 接口，配置 IP 为 192.168.13.1/24，并开启，这里由于该接口是 DTE 接口，故不需要配置始终速率

```
R1(config)#interface serial 0/0
R1(config-if)#ip address 192.168.13.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3：检查 R3 和 R1 的接口列表，确认 Serial0/0 是 UP 状态

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down

R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.1/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 4：使用 ping 测试，确认 R3 和 R1 能正常通信

```
R3#ping 192.168.13.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.13.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/14/16 ms
R3#
```

步骤 5：检查 R1 的 Serial0/0 的连接器状态，看到该接口是 DTE 接口，所有该接口不需要指定时钟速率

```
R1#show controllers  s0/0
Interface Serial0/0
Hardware is GT96K
DTE V.35 TX and RX clocks detected.
idb at 0x66910910, driver data structure at 0x6691801C
wic_info 0x66918648
Physical Port 1, SCC Num 1
MPSC Registers:
MMCR_L=0x000304C0, MMCR_H=0x00000000, MPCR=0x00000000
CHR1=0x00FE007E, CHR2=0x00000000, CHR3=0x0000064A, CHR4=0x00000000
CHR5=0x00000000, CHR6=0x00000000, CHR7=0x00000000, CHR8=0x00000000
```

步骤 6：尝试在 R1 的 Serial0/0 下配置时钟速率，会报错

```
R1(config)#interface serial 0/0
R1(config-if)#clock rate 128000
This command applies only to DCE interfaces
R1(config-if)#
```

步骤 7：检查 R3 的 Serial0/0，看到该接口是 DCE 接口，并指定了时钟速率为 128000

```
R3#show controllers serial 0/0
Interface Serial0/0
Hardware is PowerQUICC MPC860
DCE V.35, clock rate 128000
idb at 0x82C16EEC, driver data structure at 0x82C1EC80
SCC Registers:
General [GSMR]=0x2:0x00000030, Protocol-specific [PSMR]=0x8
```

```
Events [SCCE]=0x0000, Mask [SCCM]=0x001F, Status [SCCS]=0x06
Transmit on Demand [TODR]=0x0, Data Sync [DSR]=0x7E7E
```

步骤 8：尝试再在 Serial0/0 口上配置时钟速率，发现能配上去，这次将速率改为 64000

```
R3(config)#interface serial 0/0
R3(config-if)#clock rate 64000
R3(config-if)#exit
```

步骤 9 再次观察 R3 的 Serial0/0 的连接器信息，现在速率为 64000

```
R3#show controllers serial 0/0
Interface Serial0/0
Hardware is PowerQUICC MPC860
DCE V.35, clock rate 64000
idb at 0x82C16EEC, driver data structure at 0x82C1EC80
SCC Registers:
General [GSMR]=0x2:0x00000030, Protocol-specific [PSMR]=0x8
Events [SCCE]=0x0000, Mask [SCCM]=0x001F, Status [SCCS]=0x06
Transmit on Demand [TODR]=0x0, Data Sync [DSR]=0x7E7E
Interrupt Registers:
```

步骤 10：删除 R3 的时钟速率，并关闭再打开该接口，看看发生了什么

```
R3(config)#interface serial 0/0
R3(config-if)#no clock rate
R3(config-if)#shutdown
R3(config-if)#no shutdown
R3(config-if)#
```

步骤 11 :检查 R1 和 R3 的接口列表 ,发现 Serial0/0 的 Line protocol 变成了 down 状态，

说明时钟速率是必不可少的

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is down
  Internet address is 192.168.13.1/24
FastEthernet0/1 is administratively down, line protocol is down
```

```
Serial0/1 is administratively down, line protocol is down

R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is down
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 12：重新配置 R3 的时钟速率

```
R3(config)#interface serial 0/0
R3(config-if)#clock rate 128000
R3(config-if)#exit
```

步骤 13：再测观察 R3 和 R1 的接口列表，发现 serial0/0 回到了 up 状态

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 14：现在 R3 和 R1 又能互相通信了

```
R3#ping 192.168.13.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.13.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/14/16 ms
R3#
```

任务 2：配置基本的 PPP 封装

步骤 1：定义 R1 的 S0/0 口为 PPP 封装

```
R1(config)#interface serial 0/0
R1(config-if)#encapsulation ppp
R1(config-if)#exit
```

步骤 2：检查 R1 的接口状态，发现 S0/0 口的 line protocol 是 down，因为对方 R3 的封装是默认的 HDLC，和本地不匹配

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is down
  Internet address is 192.168.13.1/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 3：配置 R3 的封装也为 PPP

```
R3(config)#interface serial 0/0
R3(config-if)#encapsulation ppp
R3(config-if)#exit
```

步骤 4：检查 R3 的接口，S0/0 口进入了 UP 状态

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 5：R3 现在能 ping 通 R1 了

```
R3#ping 192.168.13.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.13.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/14/16 ms
R3#
```

步骤 6：检查 R1 和 R3，发现 2 个接口都是 PPP 封装

```
R1#show interfaces s0/0
Serial0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 192.168.13.1/24
  MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Open
  Open: IPCP, CDPCP, loopback not set
  Keepalive set (10 sec)

R3#show interfaces s0/0
Serial0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.13.3/24
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Open
  Open: CDPCP, IPCP, loopback not set
  Keepalive set (10 sec)
```

任务 3：配置 PPP 的 PAP 认证

步骤 1：在 R3 上创建用户名和密码（用户名为 user001，密码为 yangbang）

```
R3(config)#username user001 password yangbang
```

步骤 2：在 R3 的 S0/0 口上开启 PPP 的 PAP 认证

```
R3(config)#interface serial 0/0
R3(config-if)#ppp authentication pap
```

步骤 3：检查 R3 的接口，现在 S0/0 的 line-proctocol 是 down 的，因为 R1 没有通过认证

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is down
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 4 在 R1 的 S0/0 口上 配置 PPP 的认证 ,向 R3 发送用户名为 user001 密码为 yangbang，将 R1 配置为 PPP 的验证客户端

```
R1(config)#interface serial 0/0
R1(config-if)#ppp pap sent-username user001 password yangbang
```

步骤 5:再检查接口状态，发现 UP 了

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 6：打开 R3 的 PPP 认证的监控功能

```
R3#debug ppp authentication
PPP authentication debugging is on
R3#
```

步骤 7：关闭并打开 R1 的 S0/0

```
R1(config)#interface serial 0/0
R1(config-if)#shutdown
R1(config-if)#no shutdown
R1(config-if)#
```

步骤 8：观察 R3 的界面会看到一连 PPP 验证的信息

```
R3#
*Mar  1 03:38:07.011: %LINK-3-UPDOWN: Interface Serial0/0, changed state to down
*Mar  1 03:38:08.011: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed
state to down
*Mar  1 03:38:09.079: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
*Mar  1 03:38:09.079: Se0/0 PPP: Using default call direction
*Mar  1 03:38:09.079: Se0/0 PPP: Treating connection as a dedicated line
*Mar  1 03:38:09.079: Se0/0 PPP: Authorization required
*Mar  1 03:38:09.087: Se0/0 PAP: I AUTH-REQ id 2 len 21 from "user001"
*Mar  1 03:38:09.087: Se0/0 PAP: Authenticating peer user001
*Mar  1 03:38:09.087: Se0/0 PPP: Sent PAP LOGIN Request
*Mar  1 03:38:09.091: Se0/0 PPP: Received LOGIN Response PASS
*Mar  1 03:38:09.091: Se0/0 PPP: Sent LCP AUTHOR Request
*Mar  1 03:38:09.091: Se0/0 PPP: Sent IPCP AUTHOR Request
*Mar  1 03:38:09.095: Se0/0 LCP: Received AAA AUTHOR Response PASS
*Mar  1 03:38:09.095: Se0/0 IPCP: Received AAA AUTHOR Response PASS
*Mar  1 03:38:09.095: Se0/0 PAP: O AUTH-ACK id 2 len 5
*Mar  1 03:38:09.099: Se0/0 PPP: Sent CDPCP AUTHOR Request
*Mar  1 03:38:09.099: Se0/0 PPP: Sent IPCP AUTHOR Request
*Mar  1 03:38:09.103: Se0/0 CDPCP: Received AAA AUTHOR Response PASS
R3#no debug all
All possible debugging has been turned off
```

步骤 9 在 R1 上配置用户名和密码为 user003 和 yangbang

```
R1(config)#username user003 password yangbang
```

步骤 10：开启 R1 的 PPP 认证 PAP 功能

```
R1(config)#interface serial 0/0
R1(config-if)#ppp authentication pap
R1(config-if)#
```

步骤 11：在 R3 上，指定向 R1 发送用户名为 user003，密码为 yangbang

```
R3(config)#interface serial 0/0
R3(config-if)#ppp pap sent-username user003 password yangbang
R3(config-if)#
```

步骤 12：观察 R3 的接口，看到 S0/0 的状态是 UP，现在 R1 和 R3 的 PPP 线路实现了双向认证

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.3/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

任务 4：配置单向的 CHAP 认证

步骤 1：恢复 R1 和 R3 的 S0/0 口为默认配置

```
R1(config)#default interface serial 0/0
Building configuration...

Interface Serial0/0 set to default configuration
R1(config)#

R3(config)#default interface serial 0/0
Building configuration...

Interface Serial0/0 set to default configuration
R3(config)#
```

步骤 2：配置 R1 的 S0/0 口，指定 PPP 封装，并指定 R1 向 R3 发送用户名 user001、密码为 yangbang

```
R1(config)#interface serial 0/0
R1(config-if)#encapsulation ppp
R1(config-if)#ip address 192.168.13.1 255.255.255.0
R1(config-if)#ppp chap hostname user001
R1(config-if)#ppp chap password yangbang
R1(config-if)#no shutdown
```

步骤 3：配置 R3 的 S0/0 口，指定 PPP 封装和时钟速率（因为是 DCE 接口），并开启 CHAP 认证，接收并验证来自 R1 的用户名和密码，此时 R3 是 CHAP 的服务器端，R1 是 CHAP 的客户端

```
R3(config)#interface serial 0/0
R3(config-if)#encapsulation ppp
R3(config-if)#clock rate 128000
R3(config-if)#ip address 192.168.13.3 255.255.255.0
R3(config-if)#ppp authentication chap
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 4：检查 R1 或 R3 的接口信息，看到 S0/0 是 UP 状态的

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.13.1/24
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

步骤 5：使用 ping 测试，确认 R1 和 R3 能互相通信

```
R1# ping 192.168.13.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.13.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/13/16 ms
R1#
```

任务 5：配置双向的 CHAP 认证

步骤 1：配置 R3 的 S0/1 口，指定时钟速率和 PPP 封装，并开启 CHAP 认证

```
R3(config)#interface serial 0/1
R3(config-if)#encapsulation ppp
R3(config-if)#clock rate 128000
R3(config-if)#ip address 192.168.23.3 255.255.255.0
R3(config-if)#ppp authentication chap
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 2：在 R3 上创建一个用户名和密码，用户名是 R2，密码是 yangbang

```
R3(config)#username R2 password yangbang
R3(config)#
```

步骤 3：配置 R2 的 S0/0 口，指定时钟速率和 PPP 封装，并开启 CHAP 认证

```
R2(config)#interface serial 0/0
R2(config-if)#encapsulation ppp
R2(config-if)#ip address 192.168.23.2 255.255.255.0
R2(config-if)#ppp authentication chap
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 4：在 R2 上创建一个用户名和密码，用户名是 R2，密码是 yangbang

```
R2(config)#username R3 password yangbang
R2(config)#
```

步骤 5：在 R2 和 R3 上检查接口状态，会看到状态是 UP 的

```
R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol is down
Serial0/0 is up, line protocol is up
  Internet address is 192.168.23.2/24
FastEthernet0/1 is administratively down, line protocol is down
```

```
Serial0/1 is administratively down, line protocol is down
```

步骤 6：开启 R3 的 d e b u g

```
R3#debug ppp authentication
PPP authentication debugging is on
R3#
```

步骤 7：关闭并开启 R2 的接口

```
R2(config)#interface serial 0/0
R2(config-if)#shutdown
R2(config-if)#no shutdown
R2(config-if)#
```

步骤 8：观察 R3 的界面，会看到 R2 发来的用户名是“R2”，发往 R2 的用户名是“R3”

```
R3#
*Mar  1 03:52:11.167: Se0/1 PPP: Using default call direction
*Mar  1 03:52:11.167: Se0/1 PPP: Treating connection as a dedicated line
*Mar  1 03:52:11.167: Se0/1 PPP: Authorization required
*Mar  1 03:52:11.167: %LINK-3-UPDOWN: Interface Serial0/1, changed state to up
*Mar  1 03:52:11.171: Se0/1 CHAP: O CHALLENGE id 2 len 23 from "R3"
*Mar  1 03:52:11.171: Se0/1 CHAP: I CHALLENGE id 2 len 23 from "R2"
*Mar  1 03:52:11.175: Se0/1 CHAP: Using hostname from unknown source
*Mar  1 03:52:11.175: Se0/1 CHAP: Using password from AAA
*Mar  1 03:52:11.175: Se0/1 CHAP: O RESPONSE id 2 len 23 from "R3"
*Mar  1 03:52:11.179: Se0/1 CHAP: I RESPONSE id 2 len 23 from "R2"
*Mar  1 03:52:11.179: Se0/1 PPP: Sent CHAP LOGIN Request
*Mar  1 03:52:11.183: Se0/1 PPP: Received LOGIN Response PASS
*Mar  1 03:52:11.187: Se0/1 LCP: Received AAA AUTHOR Response PASS
*Mar  1 03:52:11.187: Se0/1 IPCP: Received AAA AUTHOR Response PASS
*Mar  1 03:52:11.187: Se0/1 CHAP: O SUCCESS id 2 len 4
*Mar  1 03:52:11.191: Se0/1 PPP: Sent CDPCP AUTHOR Request
*Mar  1 03:52:11.191: Se0/1 PPP: Sent IPCP AUTHOR Request
*Mar  1 03:52:11.195: Se0/1 CDPCP: Received AAA AUTHOR Response PASS
R3#no debug all
All possible debugging has been turned off
```

任务 6：配置帧中继

步骤 1：配置 R3 为帧中继交换机，本步骤不属于 CCNA 学习范围，照着输入命令即可

```
R3(config)#frame-relay switching
R3(config)#interface serial 0/0
R3(config-if)#encapsulation frame-relay
R3(config-if)#frame-relay intf-type dce
R3(config-if)#clock rate 128000
R3(config-if)#frame-relay route 102 interface serial 0/1 201
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#interface serial 0/1
R3(config-if)#encapsulation frame-relay
R3(config-if)#frame-relay intf-type dce
R3(config-if)#clock rate 128000
R3(config-if)#frame-relay route 201 interface serial 0/0 102
R3(config-if)#no shutdown
R3(config-if)#exit
```

完成步骤 1 后，R3 向 R1、R2 提供了一个双向通信的 PVC，DLCI 分别是 102、201

步骤 2 检查 R3 的帧中继交换机交换规则 看到 S0/0 和 S0/1 的入站 DLCI 分别是 102 和 201，

出站 DLCI 分别是 201 和 102

```
R3#show frame-relay route
Input Intf      Input Dlci      Output Intf     Output Dlci     Status
Serial0/0       102             Serial0/1       201             inactive
Serial0/1       201             Serial0/0       102             inactive
```

步骤 3：恢复 R1 的 S0/0 口

```
R1(config)#default interface serial 0/0
Building configuration...

Interface Serial0/0 set to default configuration
R1(config)#
```

步骤 4：；配置 S0/0 口，指定封装为帧中继，IP 地址为 192.168.12.1/24，并开启

```
R1(config)#interface serial 0/0
R1(config-if)#encapsulation frame-relay
R1(config-if)#ip address 192.168.12.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 5：恢复 R2 的 S0/0

```
R2(config)#default interface serial 0/0
Building configuration...

Interface Serial0/0 set to default configuration
R2(config)#
```

步骤 6：配置 S0/0 口，指定封装为帧中继，配置 IP 地址为 192.168.12.2/24，并开启

```
R2(config)#interface serial 0/0
R2(config-if)#encapsulation frame-relay
R2(config-if)#ip address 192.168.12.2 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 7：检查 R3 的帧中继规则表，看到现在状态都是 active

```
R3#show frame-relay route
Input Intf      Input Dlci      Output Intf     Output Dlci     Status
Serial0/0       102             Serial0/1       201             active
Serial0/1       201             Serial0/0       102             active
```

步骤 8：R1 现在能 ping 通 R2

```
R1#ping 192.168.12.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
R1#
```

步骤 9 :检查 R1 的帧中继映射 ,看到到对方 192.168.12.2(R2 的 IP 地址)和虚电路(DLCI)的映射关系，这个是通过反向 ARP 自动获取的

```
R1#show frame-relay map
Serial0/0 (up): ip 192.168.12.2 dlci 102(0x66,0x1860), dynamic,
              broadcast,, status defined, active
R1#
```

步骤 10：在 R2 上也能看到映射关系，也只自动获取的

```
R2#show frame-relay map
Serial0/0 (up): ip 192.168.12.1 dlci 201(0xC9,0x3090), dynamic,
              broadcast,, status defined, active
R2#
```

任务 7：配置静态映射的帧中继

步骤 1：关闭 R1 和 R2 的 S0/0 的方向 ARP 映射，使它们无法自动的到映射关系，并关闭再重新打开接口

```
R1(config)#interface serial 0/0
R1(config-if)#no frame-relay inverse-arp
R1(config-if)#shutdown
R1(config-if)#no shutdown
R1(config-if)#

R2(config)#interface serial 0/0
R2(config-if)#no frame-relay inverse-arp
R2(config-if)#shutdown
R2(config-if)#no shutdown
```

步骤 2：检查 R1 和 R2 的映射，看到现在是空的

```
R1#show frame-relay map

R1#

R2#show frame-relay map

R2#
```

步骤 3：现在 R1 和 R2 之间无法通信

```
R1#ping 192.168.12.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

步骤 4：在 R1 的 S0/0 口上配置静态映射，关联对方的 IP 地址和虚电路号

```
R1(config)#interface serial 0/0
R1(config-if)#frame-relay map ip 192.168.12.2 102 broadcast
```

步骤 5：在 R2 的 S0/0 口上配置静态映射，关联对方的 IP 地址和虚电路号

```
R2(config)#interface serial 0/0
R2(config-if)#frame-relay map ip 192.168.12.1 201 broadcast
```

步骤 6：检查 R1 的帧中继映射表，看到了映射信息，状态是 active

```
R1#show frame-relay map
Serial0/0 (up): ip 192.168.12.2 dlci 102(0x66,0x1860), static,
              broadcast,
              CISCO, status defined, active
```

步骤 7：现在 R1 和 R2 能互相 ping 通了

```
R1#ping 192.168.12.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/32 ms

R2#ping 192.168.12.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
```

任务 8：配置帧中继的点对点子接口

步骤 1：恢复 R1 和 R2 的 S0/0 口

```
R1(config)#default interface serial 0/0
Building configuration...

Interface Serial0/0 set to default configuration


R2(config)#default interface serial 0/0
Building configuration...

Interface Serial0/0 set to default configuration
```

步骤 2：配置 R1 和 R2 的 S0/0 口，只配置帧中继封装，不配置 IP 地址，最后开启接口

```
R1(config)#interface serial 0/0
R1(config-if)#encapsulation frame-relay
R1(config-if)#no shutdown
R1(config-if)#exit

R2(config)#interface serial 0/0
R2(config-if)#encapsulation frame-relay
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 3：在 R1 上创建点对点子接口 S0/0.12，配置 IP 地址，指定绑定的虚电路号

```
R1(config)#interface serial 0/0.12 point-to-point
R1(config-subif)#ip address 192.168.12.1 255.255.255.0
R1(config-subif)#frame-relay interface-dlci 102
R1(config-fr-dlci)#exit
R1(config-subif)#exit
```

步骤 4：在 R2 上创建点对点子接口 S0/0.12，配置 IP 地址，指定绑定的虚电路号

```
R2(config)#interface serial 0/0.12 point-to-point
R2(config-subif)#ip address 192.168.12.2 255.255.255.0
```

```
R2(config-subif)#frame-relay interface-dlci 201
R2(config-fr-dlci)#exit
R2(config-subif)#exit
```

步骤 5：检查 R1 和 R2 的帧中继映射，看到“点对点映射”，状态是 active

```
R1#show frame-relay map
Serial0/0.12 (up): point-to-point dlci, dlci 102(0x66,0x1860), broadcast
         status defined, active

 R2#show frame-relay map
Serial0/0.12 (up): point-to-point dlci, dlci 201(0xC9,0x3090), broadcast
         status defined, active
```

步骤 6：现在 R1 和 R2 能互相通信

```
R1#ping 192.168.12.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
R1#
```

任务 9：将所有设备都恢复到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1 和 SW2），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

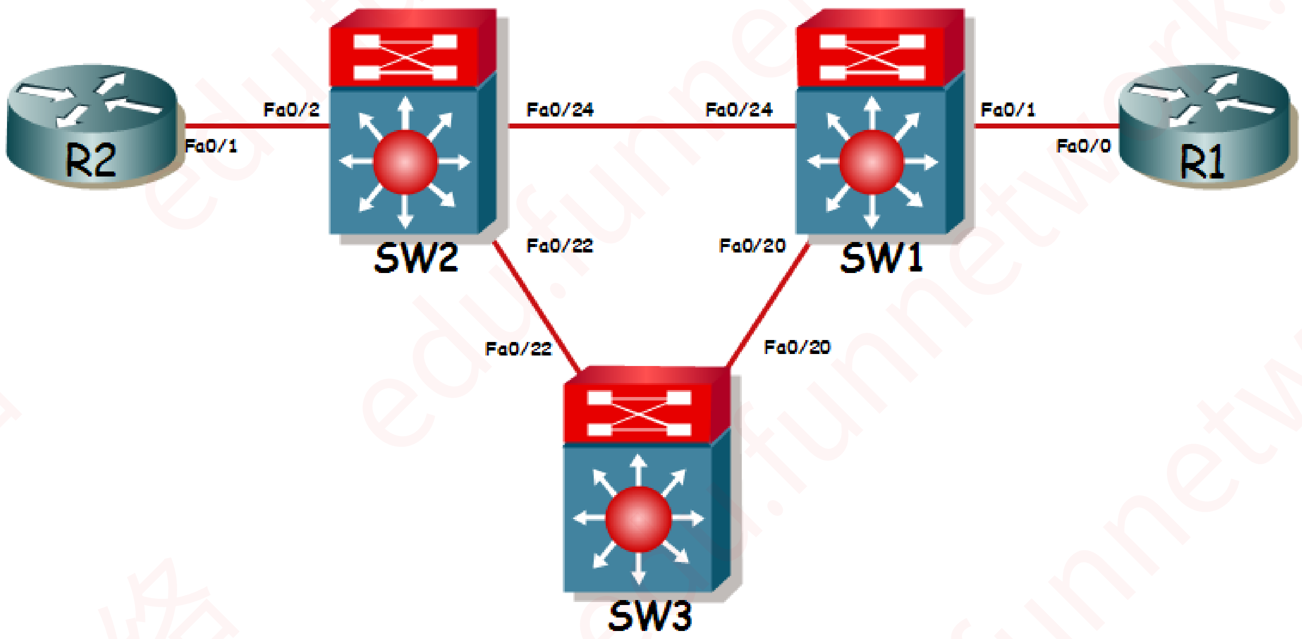
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………………本次实验完成……………………………………………

实验 11 配置和实施生成树协议

实验拓扑



实验目的：

8. 掌握生成树的工作过程
9. 掌握如何查看生成树状态
10. 掌握调整生成树的优先级和 portfast 特性
11. 掌握实施快速生成树

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到以下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1、SW2 和 SW3），实施以下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到以下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：观察生成树

步骤 1：登录到 R1 的界面，设置主机名，并将 Fa0/0（如果没有 Fa0/0 则使用 E0/0）的 IP 配置为 192.168.1.1/24，并开启

```
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
```

步骤 2：登录到 R2 的界面，设置主机名，并将 **Fa0/1**（如果没有 Fa0/1 则使用 E0/1）的 IP 配置为 192.168.1.2/24，并开启

```
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/1
R2(config-if)#no shutdown
R2(config-if)#ip address 192.168.1.2 255.255.255.0
R2(config-if)#exit
```

步骤 3：登录到 3 台交换机将 3 台交换机的主机名分别定义为 SW1、SW2 和 SW3

```
Switch(config)#hostname SW1
SW1(config)#

Switch(config)#hostname SW2
SW2(config)#

Switch(config)#hostname SW3
SW3(config)#
```

步骤 4：将 3 台交换机的所有接口都关闭，后续实验中需要哪个接口就开启，避免其他接口的状态影响实验效果

```
SW1(config)#interface range fastEthernet 0/1 - 24
SW1(config-if-range)#shutdown
SW1(config-if-range)#exit
SW1(config)#

SW2(config)#interface range fastEthernet 0/1 - 24
SW2(config-if-range)#shutdown
SW2(config-if-range)#exit

SW3(config)#interface range fastEthernet 0/1 - 24
SW3(config-if-range)#shutdown
SW3(config-if-range)#exit
```

步骤 5：使用 show interfaces status，确认所有接口的状态是 disabled，说明这些接口都被关闭了

```
SW1#show interfaces status

Port      Name               Status       Vlan       Duplex  Speed Type
Fa0/1                        disabled     1            auto   auto 10/100BaseTX
Fa0/2                        disabled     1            auto   auto 10/100BaseTX
Fa0/3                        disabled     1            auto   auto 10/100BaseTX
Fa0/4                        disabled     1            auto   auto 10/100BaseTX
Fa0/5                        disabled     1            auto   auto 10/100BaseTX
Fa0/6                        disabled     1            auto   auto 10/100BaseTX
Fa0/7                        disabled     1            auto   auto 10/100BaseTX
Fa0/8                        disabled     1            auto   auto 10/100BaseTX
Fa0/9                        disabled     1            auto   auto 10/100BaseTX
Fa0/10                       disabled     1            auto   auto 10/100BaseTX
Fa0/11                       disabled     1            auto   auto 10/100BaseTX
Fa0/12                       disabled     1            auto   auto 10/100BaseTX
Fa0/13                       disabled     1            auto   auto 10/100BaseTX
Fa0/14                       disabled     1            auto   auto 10/100BaseTX
Fa0/15                       disabled     1            auto   auto 10/100BaseTX
Fa0/16                       disabled     1            auto   auto 10/100BaseTX
Fa0/17                       disabled     1            auto   auto 10/100BaseTX
```

```
Fa0/18                    disabled     1          auto    auto 10/100BaseTX
Fa0/19                    disabled     1          auto    auto 10/100BaseTX
Fa0/20                    disabled     1          auto    auto 10/100BaseTX
Fa0/21                    disabled     1          auto    auto 10/100BaseTX
Fa0/22                    disabled     1          auto    auto 10/100BaseTX
Fa0/23                    disabled     1          auto    auto 10/100BaseTX
Fa0/24                    disabled     1          auto    auto 10/100BaseTX
```

步骤 6：将 SW1 和 SW2 的 Fa0/24 口配置为 vlan1 的 access 接口，并开启，建立 SW1 和 SW2 的线路

```
SW1(config)#interface fastEthernet 0/24
SW1(config-if)#switchport mode access
SW1(config-if)#switchport access vlan 1
SW1(config-if)#no shutdown
SW1(config-if)#exit

SW2(config)#interface fastEthernet 0/24
SW2(config-if)#switchport mode access
SW2(config-if)#switchport access vlan 1
SW2(config-if)#no shutdown
SW2(config-if)#exit
```

步骤 7：将 SW1 和 SW3 的 Fa0/20 口配置为 vlan1 的 access 接口，并开启，建立 SW1 和 SW3 的线路

```
SW1(config)#interface fastEthernet 0/20
SW1(config-if)#switchport mode access
SW1(config-if)#switchport access vlan 1
SW1(config-if)#no shutdown
SW1(config-if)#exit

SW3(config)#interface fastEthernet 0/20
SW3(config-if)#switchport mode access
SW3(config-if)#switchport access vlan 1
SW3(config-if)#no shutdown
SW3(config-if)#exit
```

步骤 8：将 SW2 和 SW3 的 Fa0/22 口配置为 vlan1 的 access 接口，并开启，建立 SW2 和 SW3 的线路

```
SW2(config)#interface fastEthernet 0/22
SW2(config-if)#switchport mode access
SW2(config-if)#switchport access vlan 1
SW2(config-if)#no shutdown
SW2(config-if)#exit

SW3(config)#interface fastEthernet 0/22
SW3(config-if)#switchport mode access
SW3(config-if)#switchport access vlan 1
SW3(config-if)#no shutdown
SW3(config-if)#exit
```

步骤 9：观察 SW1 的 CDP 邻居，确保 Fa0/24 口上连接的是 SW2、Fa0/20 口上连接的是 SW3

```
SW1#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
SW2             Fas 0/24         129          S I       WS-C3550- Fas 0/24
SW3             Fas 0/20         125          S I       WS-C3560- Fas 0/20
SW1#
```

步骤 10：观察 SW2 的 CDP 邻居，确保 Fa0/24 口上连接的是 SW2、Fa0/22 口上连接的是 SW3

```
SW2#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
SW1             Fas 0/24         150          S I       WS-C3550- Fas 0/24
SW3             Fas 0/22         174          S I       WS-C3560- Fas 0/22
```

步骤 11：观察 SW3 的 CDP 邻居，确保 Fa0/22 口上连接的是 SW2、Fa0/20 口上连接的是 SW1

```
SW3#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone,
                  D - Remote, C - CVTA, M - Two-port Mac Relay

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
SW1             Fas 0/20          130             S I   WS-C3550- Fas 0/20
SW2             Fas 0/22          139             S I   WS-C3550- Fas 0/22
```

步骤 12：使用 show spanning-tree 命令观察 3 台交换机的生成树状态

```
SW1#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     000b.fdb6.7580
             Cost        19
             Port        24 (FastEthernet0/24)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Root FWD 19        128.24   P2p
```

```
SW2#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     000b.fdb6.7580
             This bridge is the root
```

```
            Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

 Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
            Address     000b.fdb6.7580
            Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
            Aging Time 300

Interface          Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/22             Desg FWD 19        128.22   P2p
Fa0/24             Desg FWD 19        128.24   P2p


SW3#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
            Address     000b.fdb6.7580
            Cost        19
            Port        24 (FastEthernet0/22)
            Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
            Address     0021.1c5f.d880
            Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
            Aging Time  300 sec

Interface          Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/20             Altn BLK 19        128.22   P2p
Fa0/22             Root FWD 19        128.24   P2p
```

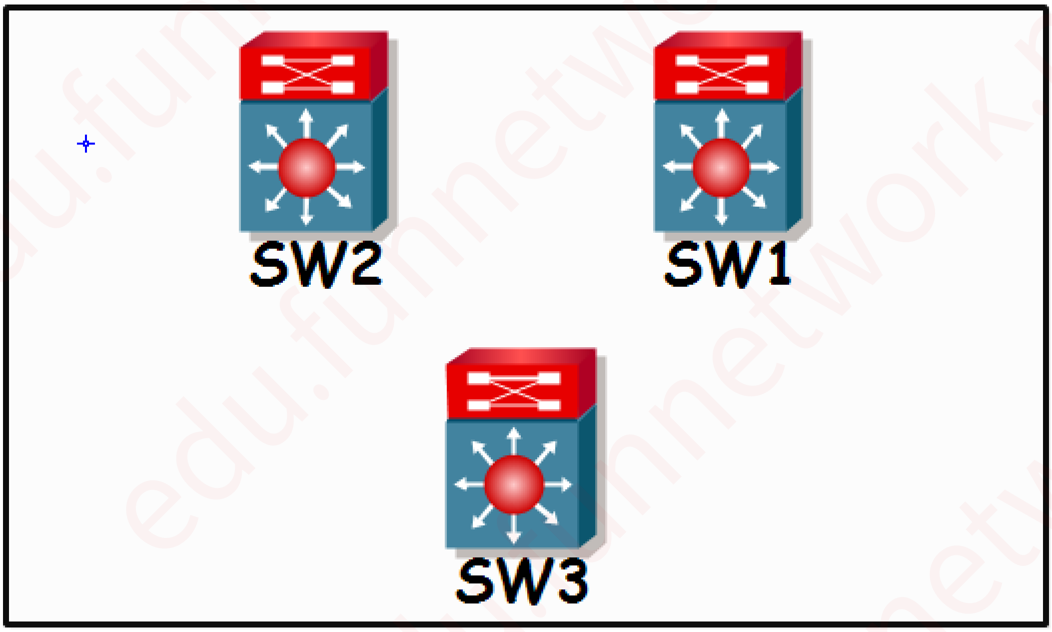
完成以下问答：

1.哪台交换机是根桥？

2.为什么优先级是 32769？

3.端口状态中 FWD 和 BLK 代表了什么？

4.画出生成树的逻辑拓扑，被阻塞掉的线路不要描述


SW2
SW1
SW3

任务 2：调整 STP

步骤 1：配置 SW1 为 vlan1 生成树的主根桥

```
SW1(config)#spanning-tree vlan 1 root primary
SW1(config)#
```

步骤 2：配置 SW2 为 vlan1 的生成树的备份根桥

```
SW2(config)#spanning-tree vlan 1 root secondary
SW2(config)#
```

步骤 3：观察 R1 的 STP 的状态，看到 R1 现在是根桥

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    24577
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
  Bridge ID  Priority    24577  (priority 24576 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15
Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

步骤 4：保存 SW1 的配置，并重启，模拟 SW1 下线无法正常工作的情况

```
SW1#write
Building configuration...
[OK]
SW1#reload
Proceed with reload? [confirm]
```

步骤 5：在 SW1 重启过程中，SW2 会成为根桥

```
SW2#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    28673
             Address     000b.fdb6.7580
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    28673  (priority 28672 sys-id-ext 1)
             Address     000b.fdb6.7580
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15
Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/22              Desg FWD 19        128.22   P2p
Fa0/24              Desg LIS 19        128.24   P2p
```

步骤 6：待 SW1 重启完成，会发现 SW1 成为了根桥，而 SW2 放弃了根桥角色

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    24577
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    24577  (priority 24576 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

```
SW2#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    24577
             Address     000c.ce40.b200
             Cost        19
             Port        24 (FastEthernet0/24)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    28673  (priority 28672 sys-id-ext 1)
             Address     000b.fdb6.7580
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/22             Desg FWD 19        128.22   P2p
Fa0/24             Root FWD 19        128.24   P2p
```

步骤 7：更改 SW1 的 vlan1 生成树优先级为 0，这样可以确保 SW1 成为根桥（这是确保交换机成为根桥的第 2 种方法）

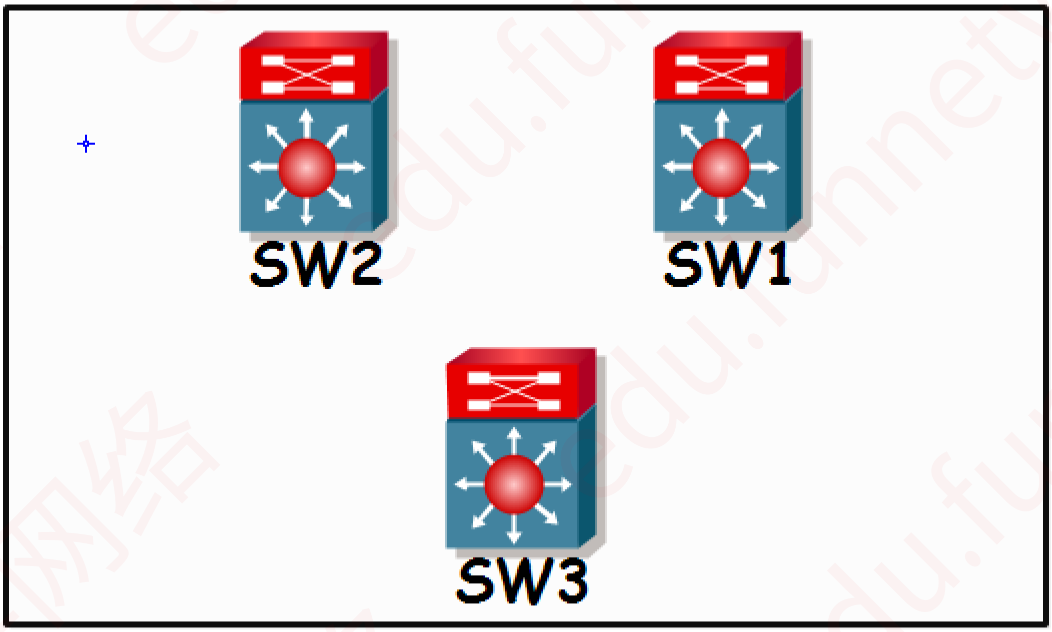
```
SW1(config)#spanning-tree vlan 1 priority 0
SW1(config)#exit
```

步骤 8：看到 SW1 成为了根桥，优先级为 1（配置的优先级 0+ 扩展系统 vlanID 1）

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
```

```
          Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
          Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

步骤 9：画出现在生成树的计算结果



任务 3：实施 PortFast 特性

步骤 1：将 SW1 的 Fa0/1 配置为 vlan1 的 Access 接口，并开启接口，不要等待立即进入步骤 2

```
SW1(config)#interface fastEthernet 0/1
SW1(config-if)#switchport mode acces
SW1(config-if)#switchport access vlan 1
SW1(config-if)#no shutdown
SW1(config-if)#end
```

步骤 2 检查交换机的 STP 状态，会看到 Fa0/1 口加入了 vlan1 的生成树，但此时状态是“LIS”，处于 Listening 状态，此时这个接口是无法通信的，紧接着进入步骤 3

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface          Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1              Desg LIS 19        128.1    P2p
Fa0/20             Desg FWD 19        128.20   P2p
Fa0/24             Desg FWD 19        128.24   P2p
```

步骤 3：再检查 STP，会看到 Fa0/1 的状态是 LRN，表示 Learning 状态，此时还是无法通信的。（如果还看到 LIS，多 show 几次，会看到 LRN）

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg LRN 19        128.1    P2p
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

步骤 4：再检查 STP 状态，终于看到了 FWD 状态（从接口开启，到进入 FWD 状态需要 30 秒）

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface           Role Sts Cost      Prio.Nbr Type
```

```
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

步骤 5：将 SW2 的 Fa0/2 配置为 vlan1 的 access 接口，并开启，紧接着进入步骤 6

```
SW2(config)#interface fastEthernet 0/2
SW2(config-if)#switchport mode access
SW2(config-if)#switchport access vlan 1
SW2(config-if)#no shutdown
SW2(config-if)#exit
```

步骤 6：在 R2 上，尝试向 R1 发 100 个 ping 测试，但发现需要等很长时间（最多 30 秒）才能 ping 通 R1，说明普通生成树的接口开启到正常工作需要经历一段时间

```
R2#ping 192.168.1.1 repeat 100

Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
............!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Success rate is 88 percent (88/100), round-trip min/avg/max = 1/1/4 ms
```

步骤 7：将 SW1 的 Fa0/1 口配置为 PortFast 接口

```
SW1(config)#interface fastEthernet 0/1
SW1(config-if)#spanning-tree portfast
%Warning: portfast should only be enabled on ports connected to a single
 host. Connecting hubs, concentrators, switches, bridges, etc... to this
 interface  when portfast is enabled, can cause temporary bridging loops.
 Use with CAUTION
%Portfast has been configured on FastEthernet0/1 but will only
 have effect when the interface is in a non-trunking mode.
SW1(config-if)#
```

步骤 8：观察 Fa0/1 的 STP 详细工作状态，会看到 PortFast 被开启的提示

```
SW1#show spanning-tree interface fastEthernet 0/1 detail
 Port 1 (FastEthernet0/1) of VLAN0001 is designated forwarding
   Port path cost 19, Port priority 128, Port Identifier 128.1.
   Designated root has priority 1, address 000c.ce40.b200
   Designated bridge has priority 1, address 000c.ce40.b200
   Designated port id is 128.1, designated path cost 0
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   The port is in the portfast mode
   Link type is point-to-point by default
   BPDU: sent 114, received 0
```

步骤 9：关闭并重新打开 Fa0/1，立即进入步骤 10

```
SW1(config)#interface fastEthernet 0/1
SW1(config-if)#shutdown
SW1(config-if)#no shutdown
SW1(config-if)#end
```

步骤 10：观察 STP 的状态，看到 Fa0/1 已经是 FWD 状态了，说明 PortFast 特性可以使连接主机的接口立即进入 FWD 状态，加快 STP 收敛

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300
```

```
Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p Edge
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

步骤 11:在 SW2 上，配置 PortFast 为默认参数，使所有 Access 接口都自动进入 PortFast

```
SW2(config)#spanning-tree portfast default
%Warning: this command enables portfast by default on all interfaces. You
 should now disable portfast explicitly on switched ports leading to hubs,
 switches and bridges as they may create temporary bridging loops.

SW2(config)#
```

步骤 12：检查 SW2 的 Fa0/2 的 STP 详细参数，看到该接口也是 PortFast

```
SW2#show spanning-tree interface fastEthernet 0/2 detail
 Port 2 (FastEthernet0/2) of VLAN0001 is designated forwarding
   Port path cost 19, Port priority 128, Port Identifier 128.2.
   Designated root has priority 1, address 000c.ce40.b200
   Designated bridge has priority 28673, address 000b.fdb6.7580
   Designated port id is 128.2, designated path cost 19
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   The port is in the portfast mode by default
   Link type is point-to-point by default
   BPDU: sent 97, received 0
```

步骤 13：关闭并打开 SW2 的 Fa0/2，并立即观察生成树状态，会看到 Fa0/2 立即进入了 FWD 状态

```
SW2(config)#interface fastEthernet 0/2
SW2(config-if)#shutdown
SW2(config-if)#no shutdown
SW2(config-if)#end
```

```
SW2#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    1
             Address     000c.ce40.b200
             Cost        19
             Port        24 (FastEthernet0/24)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    28673  (priority 28672 sys-id-ext 1)
             Address     000b.fdb6.7580
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Desg FWD 19        128.2    P2p Edge
Fa0/22              Desg FWD 19        128.22   P2p Edge
Fa0/24              Root FWD 19        128.24   P2p
```

步骤 14：关闭并打开 R2 的 Fa0/1，并立即对 R1 做 ping 测试，发现马上就能通，说明配置了 PortFast 特性的交换机可以是主机网卡激活后立即和网络中其他主机互通

```
R2(config)#interface fastEthernet 0/1
R2(config-if)#shutdown
R2(config-if)#no shutdown
R2(config-if)#end
R2#ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
```

任务 4：配置快速生成树

步骤 1：在 R1 上向 R2 发 10000000 个 ping 测试，确保 R1 一直在用 ping 测试到 R2 的通信

```
R1#ping 192.168.1.2 repeat 10000000

Type escape sequence to abort.
Sending 10000000, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

步骤 2：切换到 SW1 的界面，关闭 Fa0/24 口，使 R1 和 R2 之间的线路失效，使 STP 重新计算

```
SW1(config)#int fa0/24
SW1(config-if)#shutdown
SW1(config-if)#
```

步骤 3:观察 R1 的 ping 测试，发现要等一段时间才能重新 ping 通 R2，说明默认的 STP 协议在骨干线路出问题后，重新计算并得到新的通信路径的时间比较长（可能需要 30 秒），带重新 ping 通后，使用 ctrl+shift+6 的组合键停止 ping（可能需要连续按 2 次）

```
R1#
........................!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

按下 ctrl+shift+6 ， 可以停止 ping

步骤 4：重新打开 R1 的 Fa0/1，恢复拓扑

```
SW1(config)#interface fastEthernet 0/24
SW1(config-if)#no shutdown
```

```
SW1(config-if)#exit
SW1(config)#
```

步骤 5：调整 3 台交换机的生成树协议为 rapid-pvst（快速生成树）

```
SW1(config)#spanning-tree mode rapid-pvst

SW2(config)#spanning-tree mode rapid-pvst

SW3(config)#spanning-tree mode rapid-pvst
```

步骤 6：观察交换机的生成树状态，会看到当前运行的是 RSTP

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p Edge
Fa0/20              Desg FWD 19        128.20   P2p
Fa0/24              Desg FWD 19        128.24   P2p
```

步骤 7：再测连续 ping 测试

```
R1#ping 192.168.1.2 repeat 10000000
```

```
Type escape sequence to abort.
Sending 10000000, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

步骤 8：切换到 SW1，关闭 Fa0/24

```
SW1(config)#interface fastEthernet 0/24
SW1(config-if)#shutdown
SW1(config-if)#
```

步骤 9：回到 R1，会看到 ping 几乎终端（最多看到 1 个"."），说明 RSTP 有着更快的收敛速度

```
R1#
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

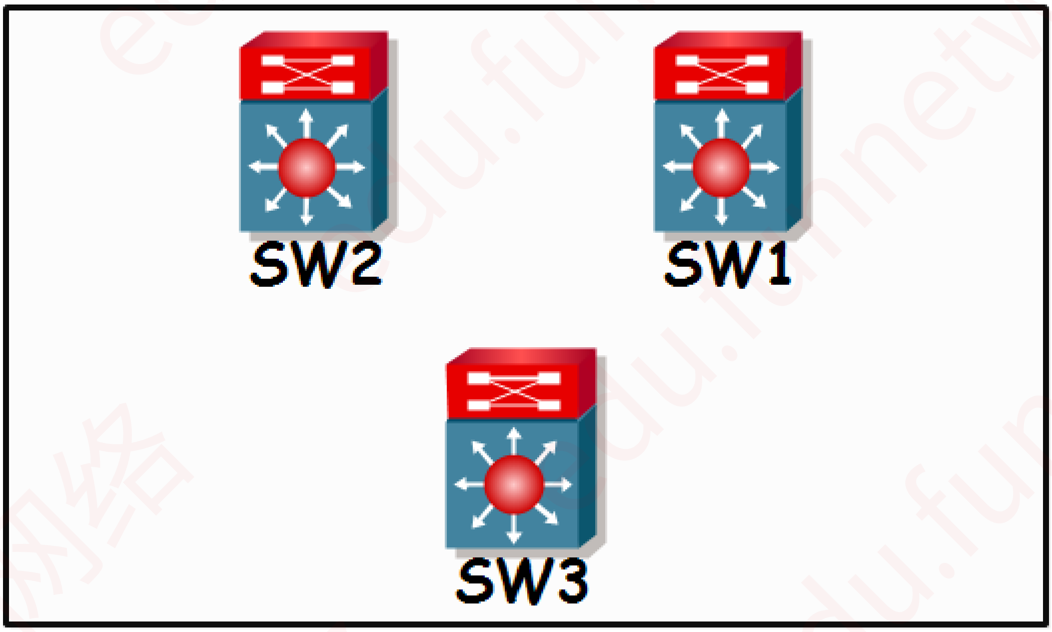
按下 ctrl+shift+6 ， 可以停止 ping

步骤 10：观察 3 台交换机的当前 STP 状态，画出 SW1、SW2 上 Fa0/24 失效后的新拓扑

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    1
             Address     000c.ce40.b200
             This bridge is the root
```

```
            Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
             Address     000c.ce40.b200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p Edge
Fa0/20              Desg FWD 19        128.20   P2p



SW2#show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    1
             Address     000c.ce40.b200
             Cost        38
             Port        22 (FastEthernet0/22)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    28673  (priority 28672 sys-id-ext 1)
             Address     000b.fdb6.7580
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Desg FWD 19        128.2    P2p Edge
Fa0/22              Root FWD 19        128.22   P2p


SW3#show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    1
             Address     000c.ce40.b200
             Cost        19
             Port        22 (FastEthernet0/20)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
```

```
  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0021.1c5f.d880
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/20              Root FWD 19        128.22   P2p
Fa0/22              Desg FWD 19        128.24   P2p
```



任务 5：恢复所有设备到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机，实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

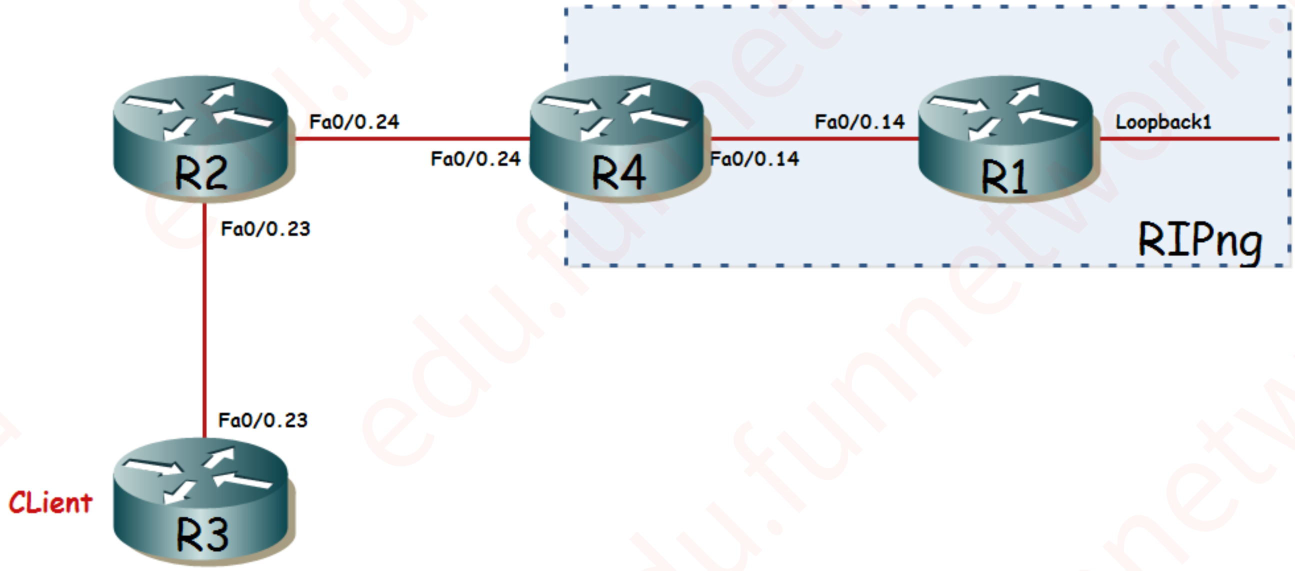
步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………本次实验完成……………………………………………

实验 12 配置和实施 IPv6

实验拓扑



实验目的：

24. 掌握 IPv6 基本参数配置

25. 掌握 IPv6 的 auto-config 特点

26. 掌握 IPv6 的静态路由的配置方法

27. 掌握 IPv6 的 RIPng 的配置方法

准备：登录到所有需要的设备，并将配置恢复到初始化状态

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

任务 1：搭建逻辑拓扑和配置基本通信参数

步骤 1：登录到 SW1 的界面

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: n

Would you like to terminate autoinstall? [yes]:

Press RETURN to get started!

Switch>
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 100,200,300,400,500
Switch(config-vlan)#exit
Switch(config)#interface range fastEthernet 0/1 - 4
Switch(config-if-range)#switchport trunk encapsulation dot1q
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
```

注：输入“switchport trunk encapsulation dot1q”时如果出现报错，就说明您的交换机只支持 dot1q，

就不需要再明确指定 trunk 的标记格式，不用管它，继续往下做。

步骤 2：登录到 R1，配置主机名为“R1”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fastEthernet 0/0
R1(config-if)#no shutdown
R1(config-if)#exit
```

步骤 3：在 R1 上，创建子接口 Fa0/0.14，dot1q 标记值为 100

```
R1(config)#interface fastEthernet 0/0.14
R1(config-subif)#encapsulation dot1Q 100
R1(config-subif)#exit
```

步骤 4 登录到 R2 配置主机名为“R2”并将 Fa0/0 接口开启(如果没有 Fa0/0,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#interface fastEthernet 0/0
R2(config-if)#no shutdown
R2(config-if)#exit
```

步骤 5：在 R2 上，创建子接口 Fa0/0.24 和 Fa0/0.23，dot1q 标记值为 200 和 300

```
R2(config)#interface fastEthernet 0/0.24
R2(config-subif)#encapsulation dot1Q 200
R2(config-subif)#exit
R2(config)#interface fastEthernet 0/0.23
R2(config-subif)#encapsulation dot1Q 300
```

步骤 6 登录到 R3 配置主机名为“R3”并将 Fa0/0 接口开启(如果没有 Fa0/0,则使用 E0/0)

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!
```

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#interface fastEthernet 0/0
R3(config-if)#no shutdown
R3(config-if)#exit
```

步骤 7：在 R3 上，创建子接口 Fa0/0.23，dot1q 标记值为 300

```
R3(config)#interface fastEthernet 0/0.34
R3(config-subif)#encapsulation dot1Q 300
R3(config-subif)#exit
```

步骤 8 登录到 R4，配置主机名为“R4”，并将 Fa0/0 接口开启（如果没有 Fa0/0,则使用 E0/0）

```
   --- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R4
R4(config)#interface fastEthernet 0/0
R4(config-if)#no shutdown
R4(config-if)#exit
```

步骤 9：在 R4 上创建 3 个子接口，Fa0/0.14、Fa0/0.24、Fa0/0.34，它们的 dot1q 标记值分别是 100、200

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#encapsulation dot1Q 100
R4(config-subif)#exit
R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#encapsulation dot1Q 200
R4(config-subif)#exit
```

步骤 10：使用 show protocol，确保需要的接口都处于 UP 状态

```
R1#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down

R2#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.23 is up, line protocol is up
FastEthernet0/0.24 is up, line protocol is up
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down

R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.23 is up, line protocol is up
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down

R4#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
FastEthernet0/0.14 is up, line protocol is up
FastEthernet0/0.24 is up, line protocol is up
Serial0/0 is administratively down, line protocol is down
FastEthernet0/1 is administratively down, line protocol is down
Serial0/1 is administratively down, line protocol is down
```

任务 2：配置基本的 IPv6 参数

步骤 1：开启 R1、R2 和 R4 的 IPv6 单播路由功能，本实验中 R3 充当 IP6 的客户主机

```
R1(config)#ipv6 unicast-routing

R2(config)#ipv6 unicast-routing

R4(config)#ipv6 unicast-routing
```

步骤 2：配置 R2 的 Fa0/0.23 的 IPv6 接口 IP，指定 IPv6 地址是 2000:23:23:23::2/64

```
R2(config)#interface fastEthernet 0/0.23
R2(config-subif)#ipv6 address 2000:23:23:23::2/64
R2(config-subif)#exit
```

步骤 3：检查接口列表，会看到 Fa0/0.23 下出现了步骤 2 配置的 IPv6 地址，以及一个 FE80 开头的链路本地地址，链路本地地址会自动产生

```
R2#show ipv6 interface brief
FastEthernet0/0            [up/up]
    unassigned
FastEthernet0/0.23         [up/up]
    FE80::20F:23FF:FE06:F2C0
    2000:23:23:23::2
FastEthernet0/0.24         [up/up]
    unassigned
Serial0/0                  [administratively down/down]
    unassigned
FastEthernet0/1            [administratively down/down]
    unassigned
Serial0/1                  [administratively down/down]
    unassigned
```

步骤 4：检查 IPv6 路由表，会看到 C（直连路由）以及 L（本地接口）路由这个和先前学习的 IPv4 路由表有区别

```
R2#show ipv6 route
IPv6 Routing Table - 4 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2000:23:23:23::/64 [0/0]
     via ::, FastEthernet0/0.23
L   2000:23:23:23::2/128 [0/0]
     via ::, FastEthernet0/0.23
L   FE80::/10 [0/0]
     via ::, Null0
L   FF00::/8 [0/0]
     via ::, Null0
```

步骤 5 配置 R2 的 Fa0/0.24 指定 IPv6 地址为 2000:24:24:24::2/64 指定 R4 的 Fa0/0.24 口的 IPv6 地址是 2000:24:24:24::4/64

```
R2(config)#interface fastEthernet 0/0.24
R2(config-subif)#ipv6 address 2000:24:24:24::2/64
R2(config-subif)#exit

R4(config)#interface fastEthernet 0/0.24
R4(config-subif)#ipv6 address 2000:24:24:24::4/64
R4(config-subif)#exit
```

步骤 6：检查 Fa0/0.24 的 IPv6 详细信息，也能看到 IPv6 地址（配置的单播地址和链路本地地址）

```
R2#show ipv6 interface fastEthernet 0/0.24
FastEthernet0/0.24 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::20F:23FF:FE06:F2C0
  Global unicast address(es):
```

```
    2000:24:24:24::2, subnet is 2000:24:24:24::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:2
    FF02::1:FF06:F2C0
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses.
```

步骤 7：使用 ping，测试 R2 和 R4 的通信

```
R2#ping 2000:24:24:24::4

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2000:24:24:24::4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/1/4 ms
R2#
```

步骤 8：配置 R1 和 R4 的 Fa0/0.14，指定前缀是 2000:14:14:14::/64，接口 ID 部分使用 EUI-64 自动填充

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ipv6 address 2000:14:14:14::/64 eui-64
R4(config-subif)#exit

R1(config)#interface fastEthernet 0/0.14
R1(config-subif)#ipv6 address 2000:14:14:14::/64 eui-64
R1(config-subif)#exit
```

步骤 9：检查 R4 和 R1 的接口列表，会看到 Fa0/0.14 下获得了一个 2000:14:14:14::/64 为前缀，通过 EUI-64 规则填充了接口 ID 的 IPv6 地址

```
R4#show ipv6 interface brief
FastEthernet0/0            [up/up]
    unassigned
FastEthernet0/0.14         [up/up]
    FE80::209:7CFF:FEB7:C20
    2000:14:14:14:209:7CFF:FEB7:C20
FastEthernet0/0.24         [up/up]
    FE80::209:7CFF:FEB7:C20
    2000:24:24:24::4
Serial0/0                  [administratively down/down]


R1#show ipv6 interface brief
FastEthernet0/0            [up/up]
    unassigned
FastEthernet0/0.14         [up/up]
    FE80::20F:90FF:FE57:FDD0
    2000:14:14:14:20F:90FF:FE57:FDD0
Serial0/0                  [administratively down/down]
    unassigned
```

步骤 10：在 R1 和 R4 上创建 Loopback1 接口，IP 为 ipv6 address 2000:1:1:1::1/128 和 2000:4:4:4::4/128

```
R1(config)#int loopback1
R1(config-if)#ipv6 address 2000:1:1:1::1/128
R1(config-if)#exit

R4(config)#interface loopback 1
R4(config-if)#ipv6 address 2000:4:4:4::4/128
R4(config-if)#exit
```

任务 3：配置 IPv6 的静态路由

步骤 1：观察 R4 的路由表，现在路由表中只有 C 的路由和直连路由

```
R4#show ipv6 route
IPv6 Routing Table - 8 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
LC  2000:4:4:4::4/128 [0/0]
     via ::, Loopback1
C   2000:14:14:14::/64 [0/0]
     via ::, FastEthernet0/0.14
L   2000:14:14:14:209:7CFF:FEB7:C20/128 [0/0]
     via ::, FastEthernet0/0.14
C   2000:24:24:24::/64 [0/0]
     via ::, FastEthernet0/0.24
L   2000:24:24:24::4/128 [0/0]
     via ::, FastEthernet0/0.24
L   FE80::/10 [0/0]
     via ::, Null0
L   FF00::/8 [0/0]
     via ::, Null0
```

步骤 2：在 R4 上创建一条静态路由，目标前缀是 2000:23:23:23::/64，下一跳是 2000:24:24:24::2，使 R4 能正确转发到 R2-R3 网段的数据

```
R4(config)#ipv6 route 2000:23:23:23::/64 2000:24:24:24::2
```

步骤 3：观察 R4 的路由表，会看到一条 S（静态路由）

```
R4#show ipv6 route
IPv6 Routing Table - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
```

```
LC  2000:4:4:4::4/128 [0/0]
     via ::, Loopback1
C   2000:14:14:14::/64 [0/0]
     via ::, FastEthernet0/0.14
L   2000:14:14:14:209:7CFF:FEB7:C20/128 [0/0]
     via ::, FastEthernet0/0.14
S   2000:23:23:23::/64 [1/0]
     via 2000:24:24:24::2
C   2000:24:24:24::/64 [0/0]
     via ::, FastEthernet0/0.24
L   2000:24:24:24::4/128 [0/0]
     via ::, FastEthernet0/0.24
L   FE80::/10 [0/0]
     via ::, Null0
L   FF00::/8 [0/0]
     via ::, Null0
```

步骤 4：使用 show ipv6 route static 可以看到 R4 的静态路由

```
R4#show ipv6 route static
IPv6 Routing Table - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   2000:23:23:23::/64 [1/0]
     via 2000:24:24:24::2
```

步骤 5：配置 R2 的默认路由，下一跳指向 2000:24:24:24 :: 4

```
R2(config)#ipv6 route ::/0 2000:24:24:24::4
R2(config)#
```

步骤 6：观察 R2 的路由表，会看到一条默认路由

```
R2#show ipv6 route
IPv6 Routing Table - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
```

```
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   ::/0 [1/0]
     via 2000:24:24:24::4
C   2000:23:23:23::/64 [0/0]
     via ::, FastEthernet0/0.23
L   2000:23:23:23::2/128 [0/0]
     via ::, FastEthernet0/0.23
C   2000:24:24:24::/64 [0/0]
     via ::, FastEthernet0/0.24
L   2000:24:24:24::2/128 [0/0]
     via ::, FastEthernet0/0.24
L   FE80::/10 [0/0]
     via ::, Null0
L   FF00::/8 [0/0]
     via ::, Null0
```

步骤 7：配置 R1 的静态路由，目标地址分别是 2000:14:14:14::/14 和 2000:23:23:23::/64,下一跳是 2000:4:4:4::4

```
R1(config)#ipv6 route 2000:24:24:24::/64 2000:4:4:4::4
R1(config)#ipv6 route 2000:23:23:23::/64 2000:4:4:4::4
```

步骤 8：观察 R1 的静态路由，发现步骤 7 的静态路由不出现，原因是静态路由的下一跳 2000:4:4:4::4，对于 R1 本来就是不可达的。后面实验会使用 RIPng，可以确保 R1 和 R4 的 Loopback1 互联，到那个时候，静态路由就可达了

```
R1#show ipv6 route static
IPv6 Routing Table - 5 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
R1#
```

任务 4：配置 RIPng

步骤 1：在 R1 上创建 RIPng，进程名为 RIP-R1

```
R1(config)#ipv6 router rip RIP-R1
R1(config-rtr)#exit
```

步骤 2：将 R1 的 Fa0/0.14 和 Loopback1 开启到 RIPng（RIP-R1）中

```
R1(config)#interface fastEthernet 0/0.14
R1(config-subif)#ipv6 rip RIP-R1 enable
R1(config-subif)#exit
R1(config)#interface loopback 1
R1(config-if)#ipv6 rip RIP-R1 enable
R1(config-if)#exit
```

步骤 3：在 R4 上创建 RIPng，进程名为 RIP-R4，进程名是本地有效，2 台路由器不需要一致

```
R4(config)#ipv6 router rip RIP-R4
R4(config-rtr)#exit
```

步骤 4：将 R4 的 Fa0/0.14 和 Loopback1 开启到 RIPng（RIP-R4）中

```
R4(config)#interface fastEthernet 0/0.14
R4(config-subif)#ipv6 rip RIP-R4 enable
R4(config-subif)#exit
R4(config)#interface loopback 1
R4(config-if)#ipv6 rip RIP-R4 enable
R4(config-if)#exit
```

步骤 5：使用 show ipv6 protocols 可以看到路由协议的基本信息

```
R4#show ipv6 protocols
IPv6 Routing Protocol is "connected"
```

```
IPv6 Routing Protocol is "static"
IPv6 Routing Protocol is "rip RIP-R4"
  Interfaces:
    Loopback1
    FastEthernet0/0.14
  Redistribution:
    None
```

步骤 6：show ipv6 rip RIP-R4 可以看到 R4 上进程名为 RIP-R4 的 RIPng 的工作参数

```
R4#show ipv6 rip RIP-R4
RIP process "RIP-R4", port 521, multicast-group FF02::9, pid 124
     Administrative distance is 120. Maximum paths is 16
     Updates every 30 seconds, expire after 180
     Holddown lasts 0 seconds, garbage collect after 120
     Split horizon is on; poison reverse is off
     Default routes are not generated
     Periodic updates 3, trigger updates 3
  Interfaces:
    Loopback1
    FastEthernet0/0.14
  Redistribution:
    None
R4#
```

步骤 7：观察 R4 的路由表，可以看到通过 RIPng 获得了 R1 的 Loopback1 口路由

```
R4#show ipv6 route rip
IPv6 Routing Table - 9 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
R   2000:1:1:1::1/128 [120/2]
     via FE80::20F:90FF:FE57:FDD0, FastEthernet0/0.14
```

步骤 8：观察 R1 的路由表，可以看到通过 RIPng 获得了 R4 的 Loopback1 接口路由

```
R1#show ipv6 route rip
IPv6 Routing Table - 7 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
R   2000:4:4:4::4/128 [120/2]
     via FE80::209:7CFF:FEB7:C20, FastEthernet0/0.14
```

步骤 9：观察 R1 的静态路由，看到了上一个任务配置了但没出现的静态路由，因为现在这 2 条静态路由的下一跳（2000:4:4:4::4)现在可达了

```
R1#show ipv6 route static
IPv6 Routing Table - 8 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   2000:23:23:23::/64 [1/0]
     via 2000:4:4:4::4
S   2000:24:24:24::/64 [1/0]
     via 2000:4:4:4::4
```

任务 5：使用 auto-config 为客户主机自动分配 IPv6 参数

步骤 1：配置 R3 的 Fa0/0.23，配置该接口的 IPv6 地址为 auto-config

```
R3(config)#interface fastEthernet 0/0.23
R3(config-subif)#ipv6 address autoconfig
R3(config-subif)#exit
```

步骤 2：检查 R3 的 Fa0/0.23 的 IPv6 信息，会看到该接口自动获得了一个单播地址，前缀是 2000:23:23:23::/64（这个前缀由局域网路由器 R2 分配），并通过 EUI-64 自动填充了接口 ID 部分，同时看到了默认网关（Default-Router),指向了一个链路本地地址，这个地址就是 R2 的 Fa0/0.23 的链路本地地址

```
R3#show ipv6 interface fastEthernet 0/0.23
FastEthernet0/0.23 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::208:A3FF:FEE5:13E0
  Global unicast address(es):
    2000:23:23:23:208:A3FF:FEE5:13E0, subnet is 2000:23:23:23::/64 [AUTOCONFIG]
      valid lifetime 2591982 preferred lifetime 604782
  Joined group address(es):
    FF02::1
    FF02::1:FFE5:13E0
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  Default router is FE80::20F:23FF:FE06:F2C0 on FastEthernet0/0.23
```

步骤 3：现在 R3 作为客户主机可以 ping 通网络中的任意节点

```
R3#ping 2000:1:1:1::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2000:1:1:1::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/4 ms
```

任务 6：恢复所有设备到出厂设置

步骤 1：在所有路由器上（R1、R2、R3、R4），实施以下操作

```
RX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 2：待路由器重启后，要看到一下提示，说明路由器已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

步骤 3：登录到所有交换机（SW1），实施一下操作

```
SWX#erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
SWX#delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:vlan.dat? [confirm]
SWX#reload
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

步骤 4：待交换机重启后，要看到一下提示，说明交换机已经恢复到出厂设置

```
--- System Configuration Dialog ---

Would you like to enter the initial configuration dialog? [yes/no]:
```

……………………………………本次实验完成……………………………………………