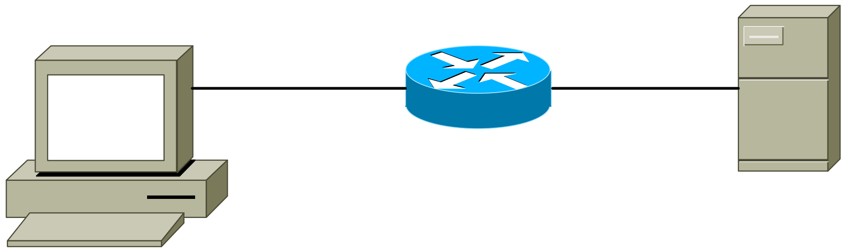
AAA 实验

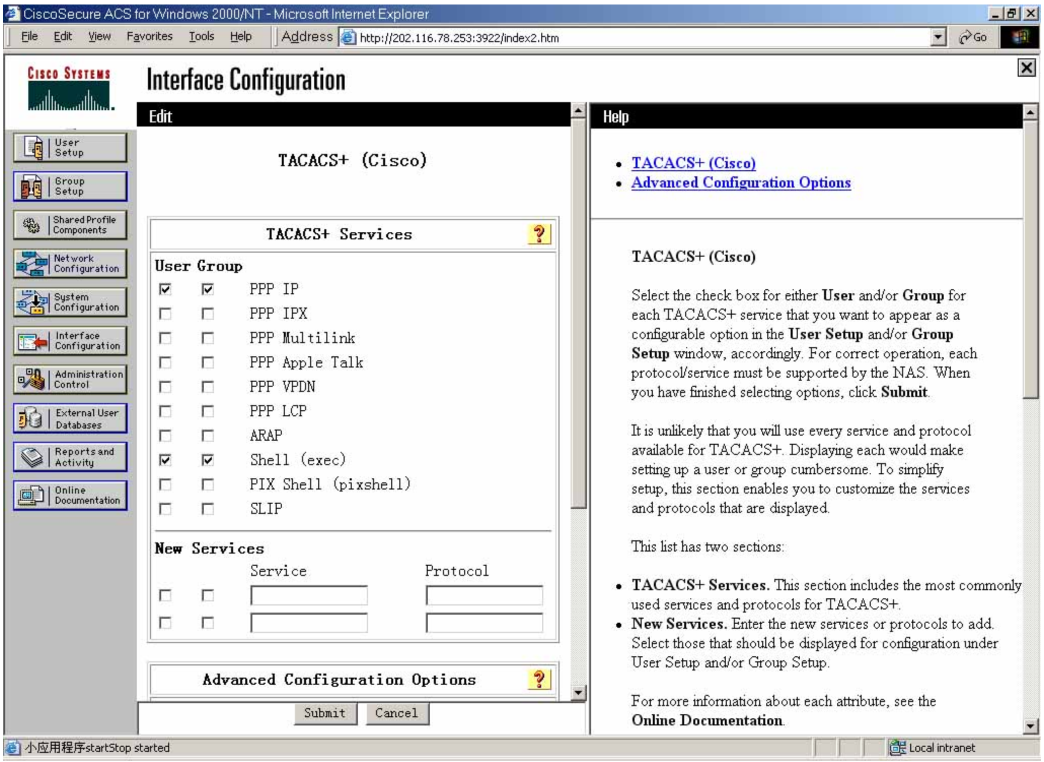
【实验拓扑】



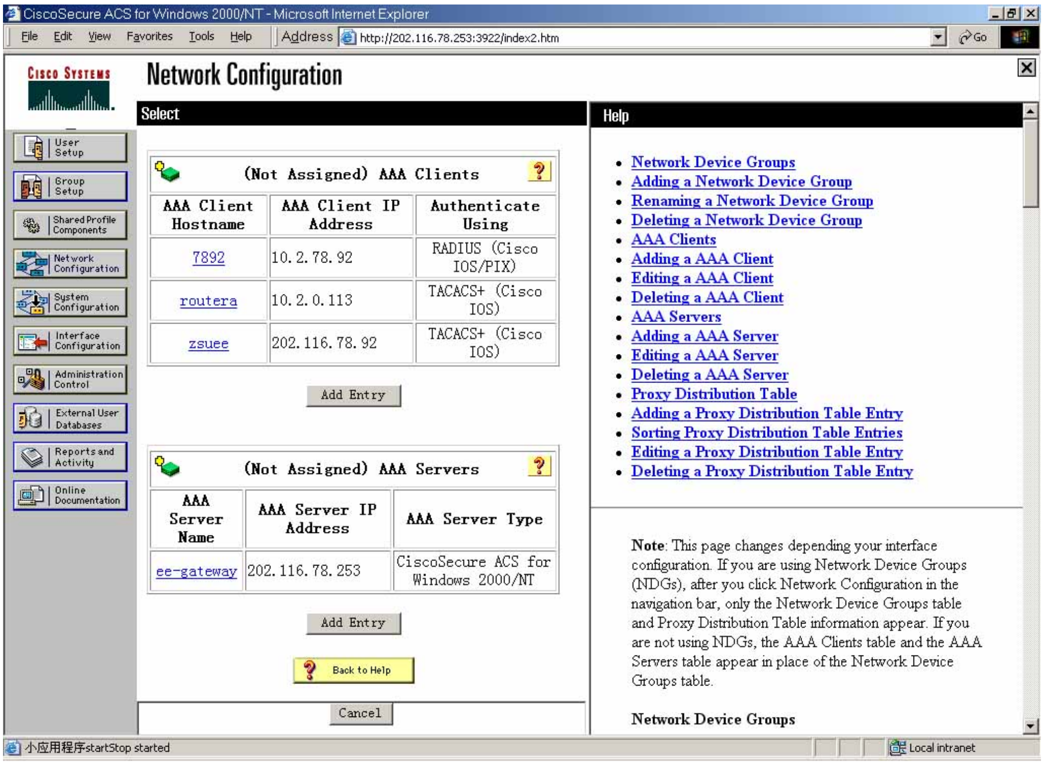
【配置 AAA 服务器】

加管理员帐号，点“Administration Control”按钮，在添加管理员帐号

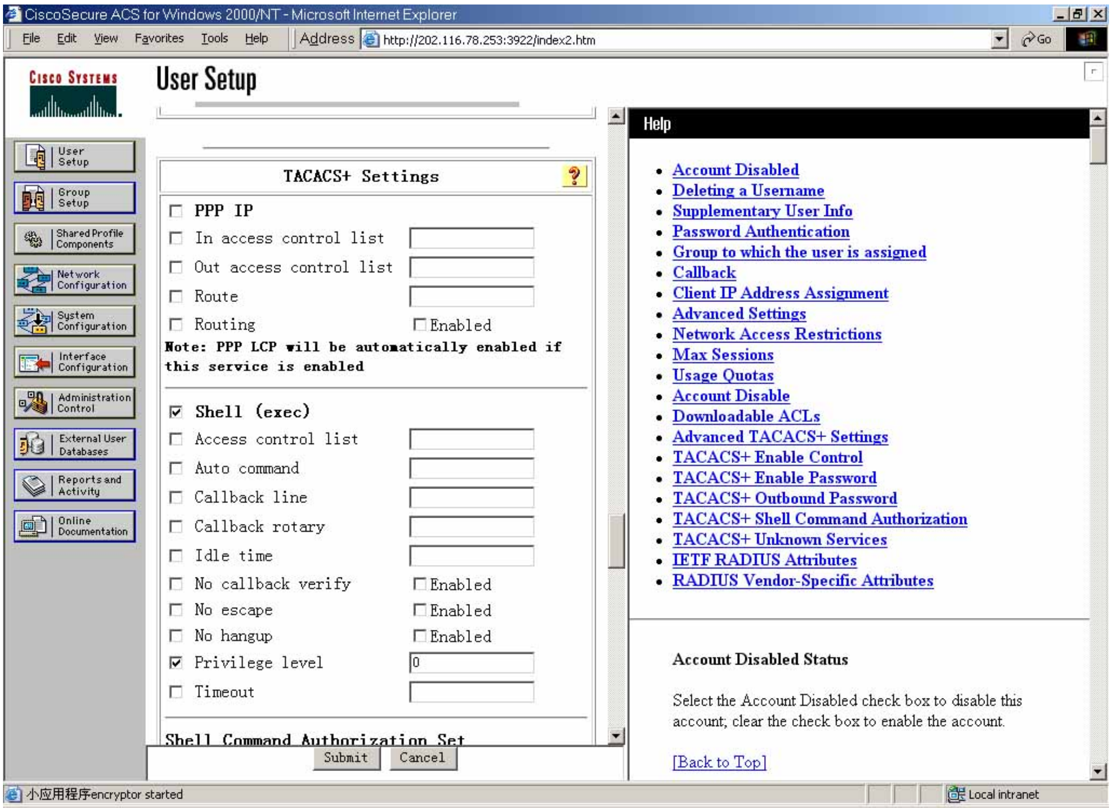
配置 cisco secure acs HTML interface，点 interface configuration。在选择所需的服务，对这次实验，选 shell （exec）即可。



Network configuration，添加对应的 AAA client，设置其 IP 地址及 Key。如下图：



配置用户信息，点“User Setup”，设置用户密码，选中 shell（exec），设置 Privilege Level



【路由器上的配置】

1、 enable AAA：

Router(config)#**aaa new-model**

2、Configuring TACACS+ and RADIUS clients：

对 TACACS＋：

Router(config)#**tacacs-server host** *ip-address*

Router(config)#**tacacs-server key** *word*

对 RADIUS：

Router(config)#**radius-server host** *ip-address*

Router(config)#**radius-server key** *word*

3、Configuring AAA authentication：

Router(config)#aaa authentication *type* {default|*list-name*} *method1 […[method4]]*

type 分为：**login**、**enable**、**ppp**、**local-override**、**arap**、**nasi**、**password-prompt** 和 **username-prompt**，其中常用的为前面四个。

login：为想进入到 EXEC 命令行模式的用户认证。

enable：决定用户是否可以访问特权级命令级。

ppp：在运行 PPP 的串行口上指定认证。

local-override：用于某些特殊用户（如系统管理员）快速登录，先使用本地数据库，如果失败再使用后面的认证方式。

List type 分两种，一种是 **default**，一种是命名 list。用来指代后面的认证方式列表 *method1 […[method4]]*

不同的 **type** 对应不同的 **Method**，后面的认证方式只有当前面的认证方式返回了一个出错信息时使用（最多四种 Method），而不是在前面的认证失败时使用。一般分为以下几种：

enable	使用 enable 口令进行认证
krb5	使用 Kerberos 5 进行认证
line	使用线路口进行认证
local	使用本地用户数据库进行认证
none	不认证
group radius	使用 RADIUS 进行认证
group tacacs+	使用 TACACS＋进行认证
krb5-telnet	当用 Telnet 连接路由器时，使用 Kerberos 5 Telnet 认证协议
if-neede	如果用户已在 TTY 上进行了认证，就不再进行认证（用于 enable type）

4、Configuring AAA authorization：

Router(config)#aaa authorization *type* {default|*list-name*} *method1 […[method2]]*

type 分为：

network	所有网络服务，包括 SLIP、PPP 和 ARAP
Exec	EXEC 进程
commands *level*	所指定级别（0 到 15）的所有 EXEC 命令
config-commands	配置命令
reverse-access	用于反向 Telnet

Method 分为：

if-authenticated	如果用户已经通过认证，则允许该用户使用所要求的功能
local	使用本地用户数据库进行授权
none	不进行授权
group radius	使用 RADIUS 进行授权
group tacacs+	使用 TACACS+进行授权
krb5-instance	使用由“kerberos instance map”命令所定义的例子

List type 与 authentication 一样分两种：**default** 和命名 list

5、Configuring AAA accounting：

Router(config)#**aaa accounting** *type* {default|*list-name*} *Record-type* *method1* *[…[method2]]*

type 分为：

commonds *level*	监察所指定特权级（0 到 15）的所有命令
Connection	监察所有外出连接，例如 Telnet 和 rlogin
Exec	监察 EXEC 进程
Network	监察所有网络请求服务，如 SLIP、PPP 和 ARAP
System	监察所有系统级事件，例如系统重启

Record－type 分为：

Start-stop	在一个进程开始和结束分别发送一个开始统计和停止统计的通知
Stop-only	只在用户所请求的进程结束后发送一个停止统计通知
wait-start	和“start-stop”不同在于开始统计通知被服务器确认之前，用户所请求的服务不会开始

Method 分为：**group tacacs+**和 **group radius**

List type 与 authentication 一样，分为：default 和命名 list

【配置示例】 (RADIUS 的 authentication 配置与下相似，可选做，但其不能实行 authorization

Building configuration...

Current configuration : 4102 bytes
!
version 12.2
aaa new-model
!
!
aaa authentication login TELNET group tacacs+ local enable none
aaa authorization exec TELNET group tacacs+ local
aaa accounting exec TELNET start-stop group tacacs+
aaa accounting commands 15 TELNET start-stop group tacacs+
aaa accounting network TELNET start-stop group tacacs+
aaa accounting connection TELNET start-stop group tacacs+
aaa accounting system default start-stop group tacacs+
aaa session-id common
enable password 7 070C285F4D060D00161F
!
tacacs-server host 10.2.0.1
tacacs-server key ciscoteam
privilege configure level 7 snmp-server host
privilege configure level 7 snmp-server enable
privilege configure level 7 snmp-server

```
privilege exec level 7 ping
privilege exec level 7 configure terminal
privilege exec level 7 configure
!
line con 0
 exec-timeout 0 0
 logging synchronous
line aux 0

line vty 0 4
 insecure
 authorization exec TELNET
 accounting connection TELNET
 accounting commands 15 TELNET
 accounting exec TELNET
 logging synchronous
 login authentication TELNET
 transport input telnet
!
no scheduler allocate
end
```

Backup Interface

实验目的：

配置拨号连接，使其成为一个帧中继网络的备份。在帧中继网络失效时自动启动。

实验设备：

Cisco 1720 三台。其中一台用来模拟帧中继交换机。

实验原理：

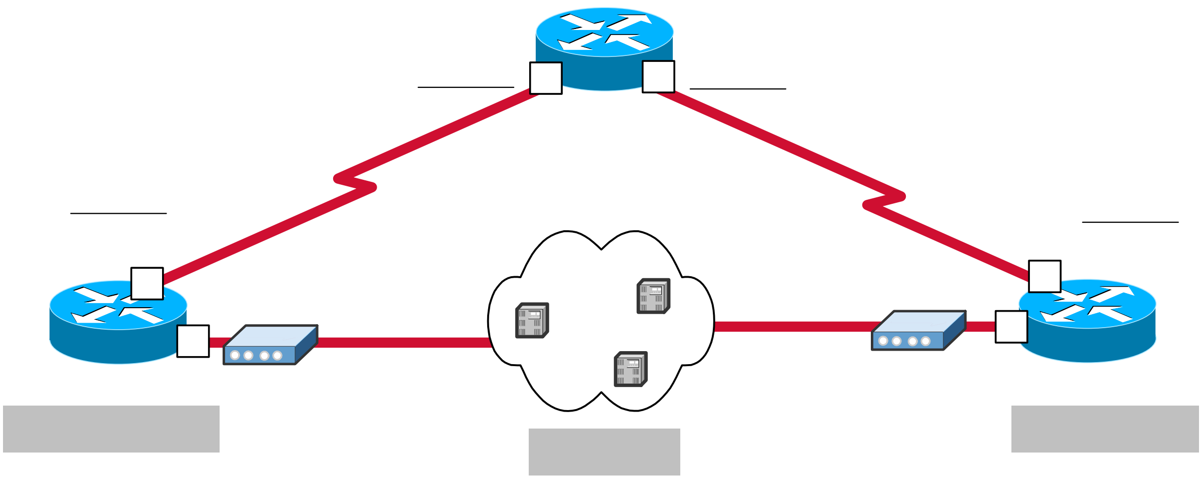
一、备份接口

备份接口提供了一条冗余的链路，在主链路失效时，备份链路会建立起一条到目的地的连接来代替该主链路。

二、用 Dialer Profiles 配置拨号备份

拨号接口（Dialer interface）可以配置成为物理接口之间的逻辑中介。当拨号接口被设置为主链路的备份接口时，如果主链路失效或发生过载，拨号接口就会启动，并从拨号接口中选择一个空闲的物理接口，让它发起呼叫以建立一条备份链路。

三、实验拓朴图：



说明：远程节点 RouterA 通过帧中继与中心 RouterB 连接，该连接是主连接，另外还有一条异步线路（使用 Modem）作为备份的连接。要实现的是当主链路失效时，备份链路能自动启动，代替主链路连接到中心，当主链路恢复后，备份链路重新回到 Stanby 状态。FRswitch 是模拟帧中继交换网。

实验内容：

- **配置基本的 Backup Interface** （使用物理接口）
  - 一、路由器的基本配置
  - 二、配置拨号连接(物理接口)
  - 三、配置帧中继
  - 四、配置Backup Interface
  - 五、使用动态路由协议
- 选做实验
  - 六、使用Dialer Profile 配置Backup Interface

实验步骤：

一、 路由器的基本配置

RouterA:

```
hostname RouterA
!
enable password cisco
!
interface Loopback0
 ip address 192.168.216.1 255.255.255.0
!
interface Serial0
 ip address 192.168.192.4 255.255.255.0
!
interface Serial1
 ip address 192.168.16.4 255.255.255.0
!
!
line vty 0 4
 password cisco
 login
!
end
```

Router B:

```
hostname RouterB
!
enable password cisco
!
interface Loopback0
 ip address 192.168.0.1 255.255.255.0
!
interface Loopback1
 ip address 192.168.20.1 255.255.255.0
!
interface Serial0
 ip address 192.168.192.1 255.255.255.0
!
interface Serial1
 ip address 192.168.16.2 255.255.255.0
!
!
line vty 0 4
 password cisco
 login
!
end
```

二、 配置拨号连接(物理接口)

1. RouterA

a) 配置串行口为异步模式

```
interface Serial 1
 physical-layer async
 ip address 192.168.16.4 255.255.255.0
 encapsulation ppp
 dialer in-band                                           ！表示端口支持 DDR
 dialer map ip 192.168.16.2 name RouterB broadcast 88     ！中心的 ip 是 16.2 号码是 88
 dialer-group 1                                           ！使用 dialer-list 1
 async default routing                                    ！允许发布路由更新
 async mode dedicated
 ppp authentication chap                                  ！使用 chap 认证
!
```

b) 配置异步线路

```
line 2
 password cisco
 login
 modem InOut
```

```
  modem autoconfigure discovery                      ! 使用自动配置
  transport input all
  stopbits 1
  speed 115200
  flowcontrol hardware
!
```

c) 配置 Dialer list

```
dialer-list 1 protocol ip permit                     ! ip 数据流出发 ddr
!
```

d) 配置 chap 认证用户名密码 （全局配置模式下）

```
username RouterB password cisco                      ! 配置 chap 用户名密码（远端）
!
```

2. RouterB

a) 配置串行口为异步模式

```
interface Serial1
  physical-layer async
  ip address 192.168.16.2 255.255.255.0
  encapsulation ppp
  async default routing
  async mode dedicated
  ppp authentication chap
!
```

b) 配置异步线路

```
line 2
  password cisco
  login
  modem InOut
  modem autoconfigure discovery
  transport input all
  stopbits 1
  speed 115200
  flowcontrol hardware
!
```

c) 配置 chap 认证用户名密码 （全局配置模式下）

```
username RouterA password cisco
!
```

3. 测试拨号连接

在 RouterA 尝试 ping RouterB 的 s1 接口 ip 地址（192.168.16.2），看是否能拨号成功

三、 配置帧中继

1. RouterA

```
interface Serial 0
  ip address 192.168.192.4 255.255.255.0
  encapsulation frame-relay
  ip ospf network point-to-point     ! FR 为非广播式网络，为了运行 OSPF，将其配置为点到点模式
```

```
  frame-relay interface-dlci 16
!
```

2. RouterB

```
interface Serial0
  ip address 192.168.192.1 255.255.255.0
  encapsulation frame-relay
  ip ospf network point-to-point ! FR 为非广播式网络，为了运行 OSPF，将其配置为点到点模式
  frame-relay interface-dlci 17
!
```

3. FR-Switching

```
hostname FR-Switching
!
enable password cisco
!
frame-relay switching
!
interface Serial0
  no ip address
  encapsulation frame-relay
  clockrate 56000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 16 interface Serial1 17
!
interface Serial1
  no ip address
  encapsulation frame-relay
  clockrate 56000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 17 interface Serial0 16
!
```

4. 测试帧中继连接

在 RouterA 尝试 ping RouterB 的 s0 接口 ip 地址（192.168.192.1），看是否连通

四、 配置 Backup Interface

1. RouterA

a) 在 RouterA 的 s0 接口（帧中继接口）配置备份接口

```
!
interface Serial 0
   backup interface Serial 1
   backup delay 6 8
!
```

b) 配置静态路由

设置浮动路由，将备份链路的管理距离设大，令其在主链路失效的时候才生效。正常情况下，在路由表内看不见备份链路的路由存在。

ip route 0.0.0.0 0.0.0.0 192.168.192.1 ！主链路使用帧中继

ip route 0.0.0.0 0.0.0.0 192.168.16.2 222 ！备份链路路由，管理距离设为 222，当主链路路由失效时才启用

2. RouterB

配置静态路由

ip route 0.0.0.0 0.0.0.0 192.168.192.4

ip route 0.0.0.0 0.0.0.0 192.168.16.4 222

3. 测试 Backup Interface

正常工作时，检查 RouterA 的路由表：

1、在 RouterA 上面手动关闭帧中继接口

此时 RouterA 没有拨号，因为主接口状态被认为是人为需要关闭，而不是意外中断，不需要备份接口的介入，所以当主接口关闭时，备份接口也不会启用。

2、重新启用端口 S1 后，在帧中继交换机上关闭与 RouterA 的连接

RouterA#show backup

Primary Interface	Secondary Interface	Status
Serial1	Serial 0	backup mode

可以看到，备份接口自动启用，作为主链路的冗余。

察看路由表：

可以用 ping 命令检查联通性。

3、在交换机上打开帧中继的连接

RouterA#show backup

4、中心路由器的路由表：

使用主链路时：

使用备份链路时：

5、用于检验的命令还有 debug backup

五、 使用动态路由协议

问题：当 RouterA 连接到 FR 的链路失效时，RouterB 的 FR 链路没有失效的话，虽然 RouterA 可以更新路由表而启用备份链路，但是 RouterB 的 FR 端口没有失效，路由表和之前的一样，仍然选用 FR 作为和 RouterA 通信的通道，导致数据包不能回去 A。即只有当两端路由直连的时候，静态路由才可以顺利生效。使用扩展 ping 改变源端口 ip 地址测试

1. RouterA

先将静态路由删除并确认已在帧中继端口配置了ip ospf network point-to-point 命令

```
router ospf 2
 network 192.168.16.0 0.0.0.255 area 0
 network 192.168.192.0 0.0.0.255 area 0
 network 192.168.216.0 0.0.0.255 area 0
!
```

2. RouterB

先将静态路由删除并确认已在帧中继端口配置了ip ospf network point-to-point 命令

```
router ospf 1
```

network 192.168.0.0 0.0.0.255 area 0

network 192.168.16.0 0.0.0.255 area 0

network 192.168.192.0 0.0.0.255 area 0

!

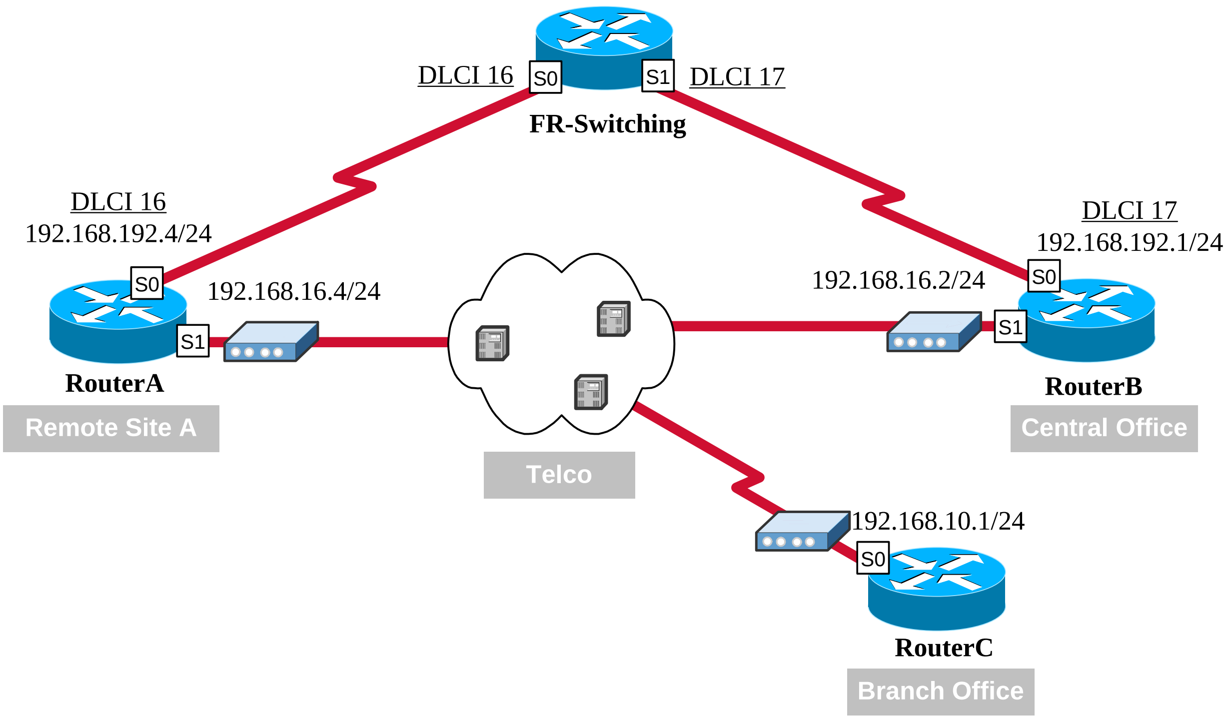
3. 测试 Backup Interface

同上

六、 使用 Dialer Profile 配置 Backup Interface

当主链路正常时，用作 backup 的拨号链路处于准备状态（Standby mode），会一直断开除非主链路失效。在这种情况下，作备份用的拨号链路就不能用作 DDR。为了解决这个问题，我们可以使用 Dialer Profile 来配置 Backup Interface，使得主链路失效时，拨号链路能用于备份，主链路正常时，拨号链路可以用作 DDR。

实验拓扑图



说明：远程节点 RouterA 通过帧中继连接着中心 RouterB，并且用一条拨号链路作为帧中继主链路的备份。同时这条拨号链路也用于连接 Branch Office RouterC。目的是要实现帧中继主链路正常时，拨号链路可以用于连接 Branch Office，当帧中继主链路失效时，拨号链路能用于帧中继链路的备份。

配置文件 (RouterB 与 FR-Switching 无需修改配置)

1． RouterA

配置要点：设置两个 Interface Dialer，一个用于备份，一个用于 ddr，绑到同一个接口 Interface S0

hostname RouterA

!

```
username RouterB password cisco                ！配置中心 chap 用户名密码
username RouterC password cisco                ！配置分支 chap 用户名密码
!
interface Loopback1
 ip address 192.168.216.1 255.255.255.0
!
interface Serial 0
 backup interface Dialer1             ！设置 interface Dialer1 为备份接口
 backup delay 6 8
 ip address 192.168.192.4 255.255.255.0
 encapsulation frame-relay
 ip ospf network point-to-point
!
interface Serial 1
 physical-layer async
 no ip address
 encapsulation ppp
 dialer in-band
 dialer pool-member 1                 ！绑定 dialer pool 1, pool 1 含有 Dialer1 和 Dialer2
 async default routing
 async mode dedicated
 ppp authentication chap
!
interface Dialer1                          ！配置 Dialer1，用于到中心的备份链路
 ip address 192.168.16.4 255.255.255.0     ！拨号后为 16 网段
 dialer pool 1                             ！属于 dialer pool 1
 dialer remote-name RouterB                ！拨号远端为中心路由器
 dialer string 88                              !88 为中心号码，配置时请注意修正
 dialer-group 1                            ！使用 dialer-list 1 触发拨号
!
interface Dialer2                          ！配置 Dialer2，用于到分支的 DDR 链路
 ip address 192.168.10.2 255.255.255.0     ！拨号后为 10 网段
 dialer pool 1                             ！属于 dialer pool 1
 dialer remote-name RouterC                ！拨号远端为分支路由器
 dialer string 85                              !85 为中心号码，配置时请注意修正
```

```
 dialer-group 1                          ! 使用 dialer-list 1 触发拨号
!
router ospf 2
 network 192.168.10.0 0.0.0.255 area 0
 network 192.168.16.0 0.0.0.255 area 0
 network 192.168.192.0 0.0.0.255 area 0
 network 192.168.216.0 0.0.0.255 area 0
!
!
access-list 101 deny ip any host 224.0.0.5        ! 为防止 ospf 的 hello 包触发拨号，加入 acl 作限制
access-list 101 permit ip any any
dialer-list 1 protocol ip list 101       ! dialer-list 1 使用扩展 acl
!
line 2
 password cisco
 login
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
line aux 0
line vty 0 4
 password cisco
 login
!
end
```

2． RouterC

```
!
hostname RouterC
!
username RouterA password cisco          ! 配置远程节点的 chap 认证用户名密码
!
interface Loopback0
```

```
  ip address 192.168.11.1 255.255.255.0
 !
 interface Serial0
  physical-layer async
  ip address 192.168.10.1 255.255.255.0                  ！接口在 10 网段
  encapsulation ppp
  async default routing
  async mode dedicated
   ppp authentication chap
 !
 router ospf 1
  network 192.168.10.0 0.0.0.255 area 0
  network 192.168.11.0 0.0.0.255 area 0
 !
 line con 0
 line 1
  password cisco
  login
  modem InOut
  modem autoconfigure discovery
  transport input all
  stopbits 1
  speed 115200
  flowcontrol hardware
 line aux 0
 line vty 0 4
   password cisco
   login
!
end
```

注意：

1．因为 ospf 的 hello 包使用 ip 协议，在启动 ospf 时会自动打开拨号连接，为了防止这种情况发生，我们可以在 dialer-list 使用扩展 acl，使得 ospf 的更新不触发拨号（ospf 的 hello 包发向 224.0.0.5 这个组播地址）。但因为 ospf 不能更新，这时路由器上的路由表是不完整的，只能通过与拨号接口直连的网段上的主机通信时才能触发拨号。

2. 如果当前的拨号连接处于空闲状态（仍然保持连接），新的拨号将取代原有连接，举例来说：RouterA 正在通过 DDR 与分支 RouterC 建立连接，如果此连接出于 Idle 状态，而正好这时 RouterA 与中心 RouterB 的帧中继主链路突然失效了，RouterA 会自动断开与 RouterC 的连接，进入备份状态，拨号连接到中心 RouterB，无需等到空闲超时。反过来也一样。
3. 如果当前的拨号连接处于活跃状态（即链路上有数据流传输），则新的连接必须等到原链路的数据传输完毕，进入空闲状态后才能建立。

BGP TroubleShooting

【实验目的】

1. 利用学过的知识对实施 BGP 后而出现的问题进行故障排除；
2. 熟悉和掌握系统地进行 trouble shooting 的方法。

【Troubleshooting 系统方法】

STEP1:

Define the problem you are experiencing.

STEP2:

Gather relevant facts about the situation.

STEP3:

Consider the possibilities. Use the information you have and your knowledge of Cisco products to isolate the problem.

STEP4:

Formulate an action plan to solve this problem.

STEP5:

Implement your action plan and attempt to fix the problem.

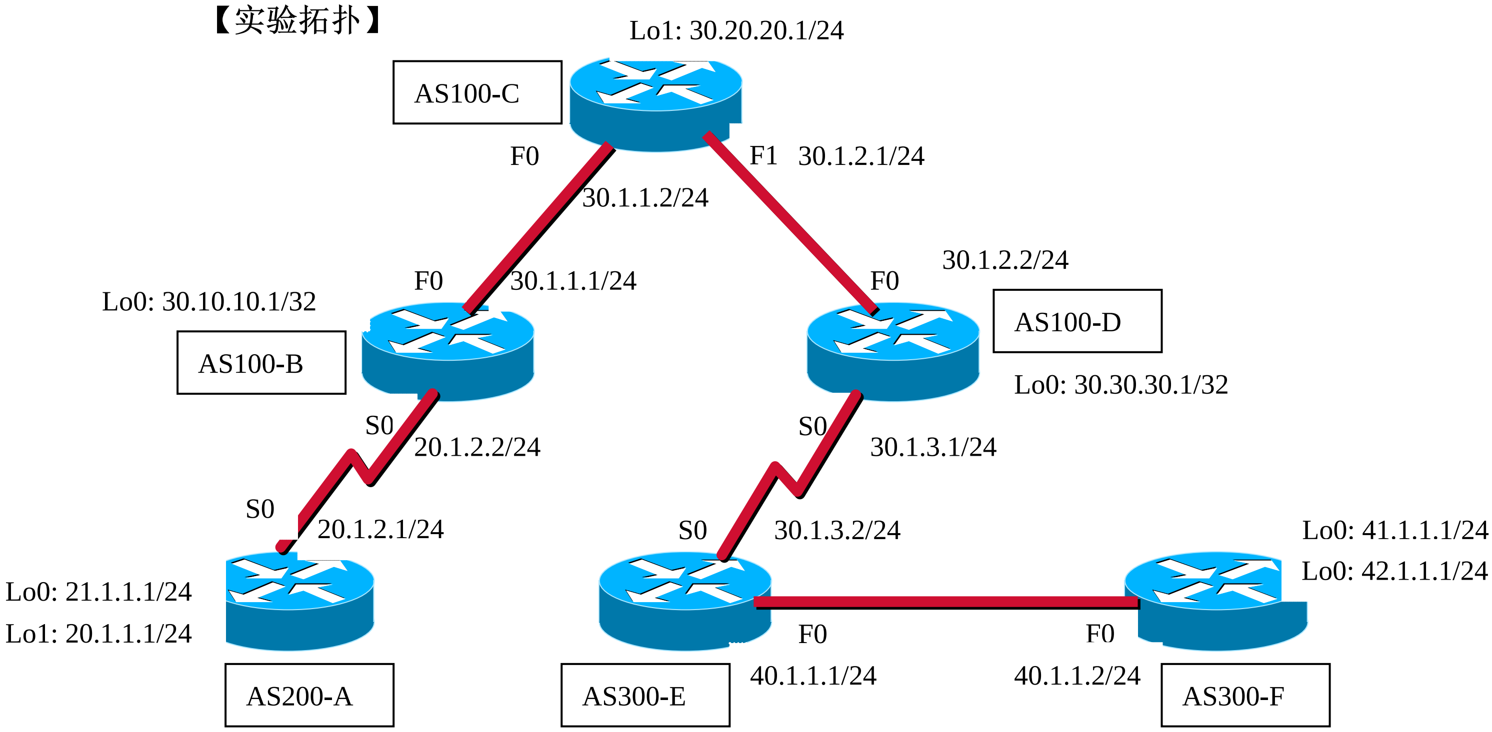
STEP6:

What were the results of your implementation? Did it fix the problem? List your results and observations below.

STEP7:

If you solution did not fix the problem, repeat the process again. If your solution did fix the problem, document your fix below.

【实验拓扑】



【故障描述和排障目标】

1．故障描述

上述为某公司合并几个子公司并实施 BGP 路由器协议后形成的拓扑结构。其中，各子公司原来的网络运行状况为：AS100 运行 RIP，AS200 为一小的分支机构，AS300 运行 OSPF。各个 AS 之间实施 BGP 路由协议，但由于 AS300-E 路由器硬件资源不足，无法采用 BGP 协议。在实施 BGP 后，发现有部分路由信息丢失，无法在所有路由器之间实现互相访问。

2．排障目标

- 使得除 AS300-E 外的所有路由器都有如下几个网段的路由条目：
  （1） 20.1.1.0/24
  （2） 21.1.1.0/24
  （3） 20.1.2.0/24
  （4） 30.1.1.0/24
  （5） 30.1.2.0/24
  （6） 30.1.3.0/24
  （7） 30.20.20.0/24
  （8） 40.1.1.0/24
  （9） 41.1.1.0/24
  （10） 42.1.1.0/24
- 使得各台路由器之间都能互相访问。
- AS100 和 AS300 必须使用不同的 IGP 协议。
- 各路由协议之间不能重发布
- 此外，还应该：
  - 在 AS100 内的三台路由器除了上述的几个网段外，还必须**都**获得 30.10.10.0/24、30.20.20.0/24 和 30.30.30.0/24 这三个网段的信息；
  - 在 AS300-E 上有 30.1.3.0/24、40.1.1.0、41.1.1.0 和 42.1.1.0/24 的网段信息。

【配置链接】

一、Broken configuration

1. AS200-A的配置
2. AS100-B的配置
3. AS100-C的配置
4. AS100-D的配置
5. AS100-E的配置
6. AS100-F的配置

二、Complete and correct configuration

1. AS200-A的配置
2. AS100-B的配置
3. AS100-C的配置
4. AS100-D的配置
5. AS100-E的配置

6．AS100-F的配置

【故障设置】

1．在 AS200-A 上：

（1） 将 neighbor 20.1.2.2 设为 remote-as 101；

（2） 配置了 no auto-summary，但 BGP 中配置一条 network 20.0.0.0，不配置 mask。（见 sem 8 14.3.2 的 note）

2．在 AS100-B 上

（1） 物理端口插错，AS100-C 的 f0 口应该连接 AS100-B 的，f1 口连接 AS100-D 的，现在刚好倒过来，但配置 IP 地址时却又按照正确的拓扑连接进行配置。

（2） 跟 AS100-C 和 AS100-D 形成 IBGP。与 AS100-D 时用 loopback 口的地址进行更新，但不配置 update-source loopback0；

（3） 与 AS200-A 形成 EBGP 时，指错对端的 AS 为 201;

（4） 启用同步；

（5） 不启用 IGP，即不启用 RIP；

3．在 AS100-C 上

（1） 如 2 中所说，颠倒两个物理接口；

（2） 启用同步；

（3） 启动 IGP，即启用 RIP；

（4） 不配置 loopback1 口（IP 地址为 30.20.20.1/24），但在配置 BGP 时却又通告此 network；

4．在 AS100-D 上

（1） 如 2 中所说，和 AS100-B 形成 IBGP，用 loopback 口地址建立邻居关系，但不配置 update-source 命令；

（2） 与 AS300-F 形成 multihop，但不显式配置；

（3） 不启用 IGP，即不启用 RIP；

（4） 启用同步；

（5） 由于 AS100 和 AS300 之间采用的路由协议是不同的，且它们之间不能采用同发布，因此 AS100-B 和 AS100-C 都无法知道下一跳 40.1.1.2 如何走，所以正常配置应该采用 next-hop-self。但这里 AS100-D 对两个邻居 AS100-B 和 AS100-C 都不配置 next-hop-self。

（6） 不配到 40.1.1.0/24 的静态路由，则此时路由表会不断的变动，时而安装通过 OSPF 学到的路由，时而安装 BGP 学到的路由，使得路由表非常不稳定；

解决方法是配置一条关于下一跳所在网段为目的网段的静态路由。**注意，只有配置静态路由才能解决问题，配置默认路由同样不能解决问题，已经用实验证明过此结论。**原因大致如下：开始时 router 知道通过默认路由知道下一跳可达，因此安装 BGP 学到的路哟信息；但当下一次 scan 它的 BGP 表时，可能因为没有下一跳的确切路由条目（默认路由是 last restore 的，可能认为此条路由条目不算），结果会把 BGP

学到的路由条目从路由表中删除。如此反复，出现路由 flapping 的状态。

（7） 如果它的 s0 口是 DCE，则不配时钟，使得与 AS300-E 的串行链路的 line protocol 是 down 的；

5．在 AS300-E 上

（1） 因硬件资源问题无法运行 BGP，故不运行 BGP。这不是什么故障，只是提醒一下；

（2） 如果它的 s0 口是 DCE，则不配时钟，使得与 AS100-D 的串行链路的 line protocol 是 down 的；

（3） 由于此台路由器只是在 AS300 内运行 OSPF，且 BGP 不重发布到 OSPF 中，因此它学不到 AS100 和 AS200 的路由信息。考虑到它的硬件资源，最简便的方法是配置默认路由到 AS100-D 的 S0 接口，但这里我们不配置该默认路由；

（4） 将 OSPF 的 hello 时间和 dead-time 时间该得与 AS300-F 的不相同。

6．在 AS300-F 上

（1） 与 AS100-D 形成 EBGP，但不配 multihop；

（2） 如 4 中的分析，不配置到 30.1.3.0/24 的静态路由；

（3） 如 5 所述，OSPF 的时间参数配置成与 AS300-E 的不同；

（4） 不配置 IP 地址为 41.1.1.1/24 的 loopback 口，但在 BGP 中将其发布出去；原因同 AS100-D 中的分析

（5） 配置 route-map，过滤 42.1.1.0/24 网段，使得在 A 上看不到此网段；

【Troubleshooting 过程】

1．检查物理拓扑，形成整个网络拓扑的图景；

2．查看各直连线缆端口的配置，查看端口状态，检查 IP 地址是否对，看能否 ping 通对端，以此进一步形成正确的网络图景，包括物理接口、IP 地址的划分和配置等；

3．Show ip route 查看路由信息，看是否满足实验目标；

4．Show ip bgp、show ip bgp summary、show ip bgp neighbors 查看相关的 BGP 的信息，以决定下一步如何做；

5．启用相应的 debug 信息，查看相关信息，以判断问题出在哪里；

6．根据 3~5 收集的信息，用学过的知识进行分析，并根据分析采用相应的策略；

7．重复 3~6，解决相应的问题，直至达到目标为止。

【Broken Configuration】

1． AS200-A的配置 TOP

AS200-A#show run
Building configuration...

Current configuration : 998 bytes
!

```
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS200-A
!
enable password cisco
!
memory-size iomem 15
mmi polling-interval 60
no mmi auto-configure
no mmi pvc
mmi snmp-timeout 180
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
!
!
!
!
interface Loopback0
 ip address 21.1.1.1 255.255.255.0
!
interface Loopback1
 ip address 20.1.1.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 no ip address
 shutdown
 speed auto
!
interface Serial0
 ip address 20.1.2.1 255.255.255.0
 clockrate 56000
!
```

```
interface Serial1
 no ip address
 shutdown
!
router bgp 200
 no synchronization
 bgp log-neighbor-changes
 network 20.0.0.0
 network 21.1.1.0 mask 255.255.255.0
 neighbor 20.1.2.2 remote-as 101
 no auto-summary
!
ip classless
no ip http server
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end

AS200-A#
```

2． AS100-B的配置 TOP

```
AS100-B#show run
Building configuration...

Current configuration : 990 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS100-B
```

```
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
no ip domain-lookup
no ftp-server write-enable
!
!
!
interface Loopback0
 ip address 30.10.10.1 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
!
interface BRI0/0
 no ip address
 shutdown
!
interface FastEthernet0/1
 ip address 30.1.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/1
 ip address 20.1.2.2 255.255.255.0
!
!                              //不启动 IGP：RIP
router bgp 100
 synchronization   //启用同步
 bgp log-neighbor-changes
 network 20.1.2.0 mask 255.255.255.0
 network 30.1.1.0 mask 255.255.255.0
 neighbor 20.1.2.1 remote-as 201 //指错 AS
 neighbor 30.1.1.2 remote-as 100
 neighbor 30.30.30.1 remote-as 100 //  不用 update-source
```

```
 no auto-summary
!
ip http server
ip classless
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
end

AS100-B#
```

3．AS100-C的配置 [TOP]

```
AS100-C#show run
Building configuration...

Current configuration : 911 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS100-C
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
no ip domain-lookup
no ftp-server write-enable
!
!
!
interface FastEthernet0/0
 ip address 30.1.1.2 255.255.255.0
```

```
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
 no fair-queue
!
interface BRI0/0
 no ip address
 shutdown
!
interface FastEthernet0/1
 ip address 30.1.2.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
 shutdown
!
！                                   //不启用 IGP：RIP
router bgp 100
 synchronization                      //启用同步
 bgp log-neighbor-changes
 network 30.1.2.0 mask 255.255.255.0
 network 30.20.20.0 mask 255.255.255.0  //没有起 30.20.20.1/24 的 loopback 口
 neighbor 30.1.1.1 remote-as 100
 neighbor 30.1.2.2 remote-as 100
 no auto-summary
!
ip http server
ip classless
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
```

end

AS100-C#

4．AS100-D的配置 [TOP]

```
AS100-D#show run
Building configuration...

Current configuration : 918 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname "AS100-D"
!
enable password cisco
!
ip subnet-zero
no ip domain lookup
ip host E 30.1.3.2
!
!
!
!
interface Loopback0
 ip address 30.30.30.1 255.255.255.255
!
interface Ethernet0
 ip address 30.1.2.2 255.255.255.0
 no cdp enable
!
interface Ethernet1
 no ip address
 shutdown
 no cdp enable
!
interface Serial0
 ip address 30.1.3.1 255.255.255.0
 no fair-queue                        //不配时钟
 no cdp enable
!
```

```
interface Serial1
 no ip address
 shutdown
 no cdp enable
!
router rip                 //启用 RIP
 network 30.0.0.0
 passive-interface s0
!
router bgp 100
 no synchronization     //关闭同步
 bgp log-neighbor-changes
 network 30.1.3.0 mask 255.255.255.0
 neighbor 30.1.2.1 remote-as 100      //不配 nexthop-self
 neighbor 30.10.10.1 remote-as 100 //不配 update-source, 不配 nexthop-self
 neighbor 40.1.1.2 remote-as 300    //不配 multihop
 no auto-summary
!
ip classless
ip http server
!                                   //不配到 40.1.1.0/24 的静态路由
!
no cdp run
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
end

AS100-D#
```

5． AS300-E的配置 [TOP]

```
AS300-E#sh run
Building configuration...

Current configuration : 971 bytes
!
version 12.2
```

```
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS300-E
!
boot system flash
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
interface FastEthernet0
 ip address 40.1.1.1 255.255.255.0
 ip ospf hello-interval 5     //时间值与 AS300-F 的不同
 ip ospf dead-interval 20
 speed auto
!
interface Serial0
 ip address 30.1.3.2 255.255.255.0     //不配置时钟
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
!
interface Serial2
 no ip address
 shutdown
!
interface Serial3
```

```
 no ip address
 shutdown
!
router ospf 1
 log-adjacency-changes
 network 30.1.3.0 0.0.0.255 area 0
 network 40.1.1.0 0.0.0.255 area 0
!
ip classless
no ip http server
ip pim bidir-enable
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end

AS300-E#
```

6．AS300-F的配置 [TOP]

```
AS300-F#show run
Building configuration...

Current configuration : 1064 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS300-F
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
```

```
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
interface Loopback1
 ip address 42.1.1.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 ip address 40.1.1.2 255.255.255.0
 speed auto
!
interface Serial0
 no ip address
 shutdown
!
interface Serial1
 no ip address
 shutdown
!
router ospf 1
 log-adjacency-changes
 network 40.1.1.0 0.0.0.255 area 0
 network 41.1.1.0 0.0.0.255 area 0
                                   //在 ospf 中不通告 42.1.1.0/24 的网段
!
router bgp 300
 bgp log-neighbor-changes
 network 40.1.1.0 mask 255.255.255.0
 network 41.1.1.0 mask 255.255.255.0   //41.1.1.1/24 的 loopback 口没配置好
 network 42.1.1.0 mask 255.255.255.0
 neighbor 30.1.3.1 remote-as 100       //不配 multihop
```

neighbor 30.1.3.1 send-community //禁止 **42.1.1.0/24** 网段发布到 **AS200** 中
neighbor 30.1.3.1 route-map aaa out
!
ip classless
no ip http server
ip pim bidir-enable
!
route-map aaa permit 10
match ip address 1
set community no-export
!
access-list 1 permit 42.1.1.0 0.0.0.255
!
!
line con 0
line aux 0
line vty 0 4
password cisco
login
!
end

AS300-F#

【Completed Configuration】
1． AS200-A的配置及结果 **TOP**

AS200-A#show run
Building configuration...

Current configuration : 960 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS200-A
!
enable password cisco
!
memory-size iomem 15
mmi polling-interval 60
no mmi auto-configure

```
no mmi pvc
mmi snmp-timeout 180
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
!
!
!
!
interface Loopback0
 ip address 21.1.1.1 255.255.255.0
!
interface Loopback1
 ip address 20.1.1.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 no ip address
 shutdown
 speed auto
!
interface Serial0
 ip address 20.1.2.1 255.255.255.0
 clockrate 56000
!
interface Serial1
 no ip address
 shutdown
!
router bgp 200
 no synchronization
 bgp log-neighbor-changes
 network 20.1.1.0 mask 255.255.255.0
 network 21.1.1.0 mask 255.255.255.0
 neighbor 20.1.2.2 remote-as 100
 no auto-summary
!
```

```
ip classless
no ip http server
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
  password cisco
  login
!
no scheduler allocate
end

AS200-A#show ip bgp
BGP table version is 78, local router ID is 21.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
r> 20.1.2.0/24      20.1.2.2                 0             0 100 i
*> 21.1.1.0/24      0.0.0.0                  0         32768 i
*> 30.1.1.0/24      20.1.2.2                 0             0 100 i
*> 30.1.2.0/24      20.1.2.2                               0 100 i
*> 30.1.3.0/24      20.1.2.2                               0 100 i
*> 40.1.1.0/24      20.1.2.2                               0 100 300 i
*> 41.1.1.0/24      20.1.2.2                               0 100 300 i
AS200-A#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     21.0.0.0/24 is subnetted, 1 subnets
C       21.1.1.0 is directly connected, Loopback0
     20.0.0.0/24 is subnetted, 1 subnets
```

```
C            20.1.1.0 is directly connected, Loopback1
C            20.1.2.0 is directly connected, Serial0
        40.0.0.0/24 is subnetted, 1 subnets
B            40.1.1.0 [20/0] via 20.1.2.2, 00:07:37
        41.0.0.0/24 is subnetted, 1 subnets
B            41.1.1.0 [20/0] via 20.1.2.2, 00:07:37
        30.0.0.0/24 is subnetted, 3 subnets
B            30.1.3.0 [20/0] via 20.1.2.2, 00:07:37
B            30.1.2.0 [20/0] via 20.1.2.2, 00:09:09
B            30.1.1.0 [20/0] via 20.1.2.2, 00:09:09
AS200-A#

AS200-A#show ip bgp summary
BGP router identifier 21.1.1.1, local AS number 200
BGP table version is 78, main routing table version 78
7 network entries and 7 paths using 959 bytes of memory
4 BGP path attribute entries using 240 bytes of memory
2 BGP AS-PATH entries using 48 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 44/85 prefixes, 45/38 paths, scan interval 60 secs

Neighbor        V    AS  MsgRcvd  MsgSent   TblVer   InQ  OutQ  Up/Down
State/PfxRcd
20.1.2.2        4   100      535      491       78     0     0  00:21:41
6
AS200-A#
```

2．AS100-B的配置及结果 [TOP]

```
    AS100-b#show run
Building configuration...

Current configuration : 1134 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS100-B
!
enable password cisco
!
memory-size iomem 15
```

```
ip subnet-zero
no ip domain-lookup
no ftp-server write-enable
!
!
!
interface Loopback0
 ip address 30.10.10.1 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
!
interface BRI0/0
 no ip address
 shutdown
!
interface FastEthernet0/1
 ip address 30.1.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/1
 ip address 20.1.2.2 255.255.255.0
!
router rip
 network 20.0.0.0
 network 30.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 20.1.2.0 mask 255.255.255.0
 network 30.1.1.0 mask 255.255.255.0
 network 30.20.20.0 mask 255.255.255.0
 neighbor 20.1.2.1 remote-as 200
 neighbor 30.20.20.1 remote-as 100
 neighbor 30.20.20.1 update-source Loopback0
```

```
  neighbor 30.30.30.1 remote-as 100
  neighbor 30.30.30.1 update-source Loopback0
  no auto-summary
!
ip http server
ip classless
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
  password cisco
  login
!
end
```

AS100-B#show ip bgp   //注：**30.20.20.0** 网段是后来才加的，路由表中没有列出来了，其它路由器亦同

```
BGP table version is 9, local router ID is 30.10.10.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 20.1.2.0/24      0.0.0.0                  0         32768 i
*> 21.1.1.0/24      20.1.2.1                 0             0 200 i
*> 30.1.1.0/24      0.0.0.0                  0         32768 i
*>i30.1.2.0/24      30.20.20.1               0    100      0 i
*>i30.1.3.0/24      30.30.30.1               0    100      0 i
*>i40.1.1.0/24      30.30.30.1               0    100      0 300 i
*>i41.1.1.0/24      30.30.30.1               0    100      0 300 i
AS100-B#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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
```

```
     21.0.0.0/24 is subnetted, 1 subnets
B       21.1.1.0 [20/0] via 20.1.2.1, 00:10:56
     20.0.0.0/24 is subnetted, 1 subnets
C       20.1.2.0 is directly connected, Serial0/1
     40.0.0.0/24 is subnetted, 1 subnets
B       40.1.1.0 [200/0] via 30.30.30.1, 00:10:27
     41.0.0.0/24 is subnetted, 1 subnets
B       41.1.1.0 [200/0] via 30.30.30.1, 00:10:27
     30.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
R       30.1.3.0/24 [120/2] via 30.1.1.2, 00:00:15, FastEthernet0/1
R       30.1.2.0/24 [120/1] via 30.1.1.2, 00:00:15, FastEthernet0/1
R       30.20.20.0/24 [120/1] via 30.1.1.2, 00:00:15, FastEthernet0/1
C       30.1.1.0/24 is directly connected, FastEthernet0/1
R       30.30.30.1/32 [120/2] via 30.1.1.2, 00:00:17, FastEthernet0/1
C       30.10.10.1/32 is directly connected, Loopback0
AS100-B#

AS100-B#show ip bgp summary
BGP router identifier 30.10.10.1, local AS number 100
BGP table version is 9, main routing table version 9
7 network entries and 7 paths using 959 bytes of memory
4 BGP path attribute entries using 240 bytes of memory
2 BGP AS-PATH entries using 48 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 95/224 prefixes, 96/89 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
20.1.2.1        4   200     491     535        9    0    0 00:21:15
1
30.20.20.1      4   100      47      52        9    0    0 00:21:28
1
30.30.30.1      4   100      99      97        9    0    0 00:19:28
3
AS100-B#
```

3．AS100-C的配置及结果 [TOP]

```
AS100-C#show run
Building configuration...

Current configuration : 1012 bytes
```

```
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS100-C
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
no ip domain-lookup
no ftp-server write-enable
!
!
!
interface Loopback1
 ip address 30.20.20.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 30.1.1.2 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
 no fair-queue
!
interface BRI0/0
 no ip address
 shutdown
!
interface FastEthernet0/1
 ip address 30.1.2.1 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
 shutdown
!
router rip
```

```
 network 30.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 30.1.2.0 mask 255.255.255.0
 neighbor 30.1.2.2 remote-as 100
 neighbor 30.10.10.1 remote-as 100
 neighbor 30.10.10.1 update-source Loopback1
 no auto-summary
!
ip http server
ip classless
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
end
```

```
AS100-C#show ip bgp
BGP table version is 26, local router ID is 30.20.20.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i20.1.2.0/24      30.10.10.1               0    100      0 i
*>i21.1.1.0/24      20.1.2.1                 0    100      0 200 i
*>i30.1.1.0/24      30.10.10.1               0    100      0 i
*> 30.1.2.0/24      0.0.0.0                  0         32768 i
*>i30.1.3.0/24      30.1.2.2                 0    100      0 i
*>i40.1.1.0/24      30.1.2.2                 0    100      0 300 i
*>i41.1.1.0/24      30.1.2.2                 0    100      0 300 i
```

```
AS100-C#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
i - IS-IS, 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

```
     21.0.0.0/24 is subnetted, 1 subnets
B       21.1.1.0 [200/0] via 20.1.2.1, 00:13:45
     20.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
R       20.0.0.0/8 [120/1] via 30.1.1.1, 00:00:04, FastEthernet0/0
B       20.1.2.0/24 [200/0] via 30.10.10.1, 00:13:45
     40.0.0.0/24 is subnetted, 1 subnets
B       40.1.1.0 [200/0] via 30.1.2.2, 00:53:38
     41.0.0.0/24 is subnetted, 1 subnets
B       41.1.1.0 [200/0] via 30.1.2.2, 00:53:38
     30.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
R       30.1.3.0/24 [120/1] via 30.1.2.2, 00:00:25, FastEthernet0/1
C       30.1.2.0/24 is directly connected, FastEthernet0/1
C       30.20.20.0/24 is directly connected, Loopback1
C       30.1.1.0/24 is directly connected, FastEthernet0/0
R       30.10.10.1/32 [120/1] via 30.1.1.1, 00:00:06, FastEthernet0/0
R       30.30.30.1/32 [120/1] via 30.1.2.2, 00:00:27, FastEthernet0/1
```

AS100-C#

AS100-C#show ip bgp summary
BGP router identifier 30.20.20.1, local AS number 100
BGP table version is 26, main routing table version 26
7 network entries and 7 paths using 959 bytes of memory
4 BGP path attribute entries using 240 bytes of memory
2 BGP AS-PATH entries using 48 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 89/144 prefixes, 93/86 paths, scan interval 60 secs

```
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
30.1.2.2        4   100     513     438       26    0    0 01:00:44
3
30.10.10.1      4   100      51      46       26    0    0 00:20:51
3
```
AS100-C#

4．AS100-D的配置及结果 TOP

```
AS100-D#show run
Building configuration...

Current configuration : 1165 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname "AS100-D"
!
enable password cisco
!
ip subnet-zero
no ip domain lookup
ip host E 30.1.3.2
!
!
!
!
interface Loopback0
 ip address 30.30.30.1 255.255.255.255
!
interface Ethernet0
 ip address 30.1.2.2 255.255.255.0
 no cdp enable
!
interface Ethernet1
 no ip address
 shutdown
 no cdp enable
!
interface Serial0
 ip address 30.1.3.1 255.255.255.0
 clockrate 56000
 no fair-queue
 no cdp enable
!
interface Serial1
 no ip address
```

```
 shutdown
 no cdp enable
!
router rip
 passive-interface Serial0
 network 30.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 30.1.3.0 mask 255.255.255.0
 neighbor 30.1.2.1 remote-as 100
 neighbor 30.1.2.1 next-hop-self
 neighbor 30.10.10.1 remote-as 100
 neighbor 30.10.10.1 update-source Loopback0
 neighbor 30.10.10.1 next-hop-self
 neighbor 40.1.1.2 remote-as 300
 neighbor 40.1.1.2 ebgp-multihop 2
 no auto-summary
!
ip classless
ip route 40.1.1.0 255.255.255.0 30.1.3.2
ip http server
!
!
no cdp run
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
end

AS100-D#show ip bgp
BGP table version is 173, local router ID is 30.1.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i20.1.2.0/24      30.10.10.1               0    100      0 i
```

```
*>i21.1.1.0/24       20.1.2.1                 0    100      0 200 i
*>i30.1.1.0/24       30.10.10.1               0    100      0 i
*>i30.1.2.0/24       30.1.2.1                 0    100      0 i
*> 30.1.3.0/24       0.0.0.0                  0         32768 i
*> 40.1.1.0/24       40.1.1.2                 0             0 300 i
*> 41.1.1.0/24       40.1.1.2                 0             0 300 i
AS100-D#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, 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

     21.0.0.0/24 is subnetted, 1 subnets
B       21.1.1.0 [200/0] via 20.1.2.1, 00:14:20
     20.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
R       20.0.0.0/8 [120/2] via 30.1.2.1, 00:00:22, Ethernet0
B       20.1.2.0/24 [200/0] via 30.10.10.1, 00:14:20
     40.0.0.0/24 is subnetted, 1 subnets
S       40.1.1.0 [1/0] via 30.1.3.2
     41.0.0.0/24 is subnetted, 1 subnets
B       41.1.1.0 [20/0] via 40.1.1.2, 05:00:49
     30.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C       30.1.3.0/24 is directly connected, Serial0
C       30.1.2.0/24 is directly connected, Ethernet0
R       30.20.20.0/24 [120/1] via 30.1.2.1, 00:00:24, Ethernet0
R       30.1.1.0/24 [120/1] via 30.1.2.1, 00:00:24, Ethernet0
R       30.10.10.1/32 [120/2] via 30.1.2.1, 00:00:24, Ethernet0
C       30.30.30.1/32 is directly connected, Loopback0
AS100-D#

AS100-D#show ip bgp summary
BGP router identifier 30.1.3.1, local AS number 100
BGP table version is 173, main routing table version 173
7 network entries and 7 paths using 1043 bytes of memory
4 BGP path attribute entries using 240 bytes of memory
2 BGP AS-PATH entries using 48 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 26/145 prefixes, 33/26 paths, scan interval 60 secs
```

```
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
State/PfxRcd
30.1.2.1        4   100     464     539      173    0    0 01:00:09
1
30.10.10.1      4   100      96      98      173    0    0 00:18:15
3
40.1.1.2        4   300     412     451      173    0    0 05:05:15
2
AS100-D#
```

5. AS100-E的配置及结果 TOP

```
AS300-E#show run
Building configuration...

Current configuration : 1032 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS300-E
!
boot system flash
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
```

```
interface FastEthernet0
 ip address 40.1.1.1 255.255.255.0
 speed auto
!
interface Serial0
 ip address 30.1.3.2 255.255.255.0
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
!
interface Serial2
 no ip address
 shutdown
!
interface Serial3
 no ip address
 shutdown
!
router ospf 1
 log-adjacency-changes
 passive-interface Serial0
 network 30.1.3.0 0.0.0.255 area 0
 network 40.1.1.0 0.0.0.255 area 0
!
ip classless
ip route 0.0.0.0 0.0.0.0 30.1.3.1
no ip http server
ip pim bidir-enable
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end

AS300-E#show ip bgp
% BGP not active
```

```
AS300-E#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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 30.1.3.1 to network 0.0.0.0

     40.0.0.0/24 is subnetted, 1 subnets
C       40.1.1.0 is directly connected, FastEthernet0
     41.0.0.0/32 is subnetted, 1 subnets
O       41.1.1.1 [110/2] via 40.1.1.2, 02:03:49, FastEthernet0
     30.0.0.0/24 is subnetted, 1 subnets
C       30.1.3.0 is directly connected, Serial0
S*   0.0.0.0/0 [1/0] via 30.1.3.1
AS300-E#
```

6. AS100-F的配置及结果 TOP

```
AS300-F#show run
Building configuration...

Current configuration : 1140 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS300-F
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
```

```
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
interface Loopback0
 ip address 41.1.1.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 ip address 40.1.1.2 255.255.255.0
 speed auto
!
interface Serial0
 no ip address
 shutdown
!
interface Serial1
 no ip address
 shutdown
!
router ospf 1
 log-adjacency-changes
 network 40.1.1.0 0.0.0.255 area 0
 network 41.1.1.0 0.0.0.255 area 0
!
router bgp 300
 bgp log-neighbor-changes
 network 40.1.1.0 mask 255.255.255.0
 network 41.1.1.0 mask 255.255.255.0
 neighbor 30.1.3.1 remote-as 100
 neighbor 30.1.3.1 ebgp-multihop 2
!
ip classless
ip route 30.1.3.0 255.255.255.0 40.1.1.1
no ip http server
ip pim bidir-enable
```

```
!
!
!
line con 0
line aux 0
line vty 0 4
  password cisco
  login
!
end
```

```
AS300-F#show ip bgp
BGP table version is 1040, local router ID is 41.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 20.1.2.0/24      30.1.3.1                               0 100 i
*> 21.1.1.0/24      30.1.3.1                               0 100 200 i
*> 30.1.1.0/24      30.1.3.1                               0 100 i
*> 30.1.2.0/24      30.1.3.1                               0 100 i
*> 30.1.3.0/24      30.1.3.1                 0             0 100 i
*> 40.1.1.0/24      0.0.0.0                  0         32768 i
*> 41.1.1.0/24      0.0.0.0                  0         32768 i
AS300-F#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     21.0.0.0/24 is subnetted, 1 subnets
B       21.1.1.0 [20/0] via 30.1.3.1, 00:16:11
     20.0.0.0/24 is subnetted, 1 subnets
B       20.1.2.0 [20/0] via 30.1.3.1, 00:16:40
     40.0.0.0/24 is subnetted, 1 subnets
C       40.1.1.0 is directly connected, FastEthernet0
     41.0.0.0/24 is subnetted, 1 subnets
C       41.1.1.0 is directly connected, Loopback0
     30.0.0.0/24 is subnetted, 3 subnets
```

S   30.1.3.0 [1/0] via 40.1.1.1
B   30.1.2.0 [20/0] via 30.1.3.1, 00:58:03
B   30.1.1.0 [20/0] via 30.1.3.1, 00:16:40
AS300-F#

AS300-F#show ip bgp summary
BGP router identifier 41.1.1.1, local AS number 300
BGP table version is 1040, main routing table version 1040
7 network entries and 7 paths using 959 bytes of memory
4 BGP path attribute entries using 240 bytes of memory
2 BGP AS-PATH entries using 48 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 22/72 prefixes, 25/18 paths, scan interval 15 secs

Neighbor   V   AS MsgRcvd MsgSent   TblVer InQ OutQ Up/Down State/PfxRcd
30.1.3.1   4   100   333   309   1040   0   0 05:04:32 5
AS300-F#

注：以上的“正确”配置中，没有包括 **20.1.1.0/24**、**30.20.20.0/24** 和 **42.1.1.0/24** 这三个网段，因为这三个网段是在 **copy** 下配置后才配置的；不过总体上不怎么影响错误。

BGP1 实验内容

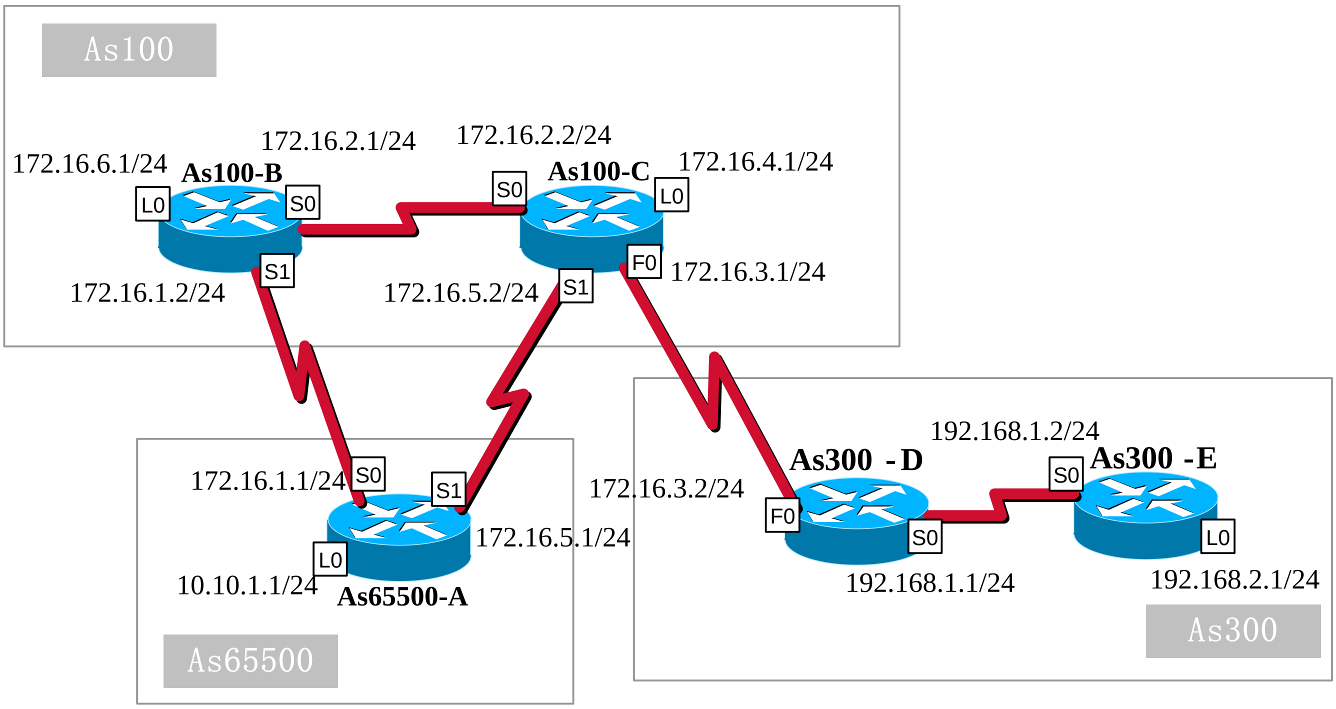
【实验目的】

1. 了解 BGP 的基本配置
2. 了解 multihop,next-hop-self 的配置方法
3. 了解 BGP 中 local preference 和 MED 的概念与配置方法

【实验设备】

cisco1720 ----5 台

实验拓扑：



【实验内容】

一、基本配置路由器,并启动 **BGP** 协议

as65500-A:

```
hostname as65500-a
!
enable password cisco
!
interface Loopback0
 ip address 10.10.1.1 255.255.255.0
!
```

```
interface Serial0
  ip address 172.16.1.1 255.255.255.0
!
interface Serial1
  ip address 172.16.5.1 255.255.255.0
!
router bgp 65500
  no synchronization
  network 10.10.1.0 mask 255.255.255.0
  network 172.16.1.0 mask 255.255.255.0
  network 172.16.5.0 mask 255.255.255.0
  neighbor 172.16.1.2 remote-as 100
  neighbor 172.16.5.2 remote-as 100
  no auto-summary
!
line vty 0 4
  password cisco
  login
```

as100-B:

```
hostname as100-b
!
enable password cisco
!
interface Loopback0
  ip address 172.16.6.1 255.255.255.0
!
interface Serial0
  ip address 172.16.2.1 255.255.255.0
  clockrate 56000
!
interface Serial1
  ip address 172.16.1.2 255.255.255.0
  clockrate 56000
!
router rip
  version 2
  network 172.16.0.0
!
router bgp 100
  no synchronization
  network 172.16.1.0 mask 255.255.255.0
  network 172.16.2.0 mask 255.255.255.0
```

```
  network 172.16.6.0 mask 255.255.255.0
  neighbor 172.16.1.1 remote-as 65500
  neighbor 172.16.2.2 remote-as 100
!
line vty 0 4
  password cisco
  login
!
```

as100-C:

```
hostname AS100-C
!
enable password cisco
!
interface Loopback0
  ip address 172.16.4.1 255.255.255.0
!
interface FastEthernet0/0
  ip address 172.16.3.1 255.255.255.0
!
interface Serial0
  ip address 172.16.2.2 255.255.255.0
!
interface Serial1
  ip address 172.16.5.2 255.255.255.0
!
router rip
  version 2
  network 172.16.0.0
!
router bgp 100
  no synchronization
  network 172.16.2.0 mask 255.255.255.0
  network 172.16.3.0 mask 255.255.255.0
  network 172.16.4.0 mask 255.255.255.0
    network 172.16.5.0 mask 255.255.255.0
  neighbor 172.16.2.1 remote-as 100
    neighbor 192.168.1.2 remote-as 300
  neighbor 172.16.5.1 remote-as 65500
!
line vty 0 4
  password cisco
  login
```

as300-D

```
!
hostname AS300-D
!
enable password cisco
!
interface FastEthernet0/0
  ip address 172.16.3.2 255.255.255.0
!
interface Serial0/0
  ip address 192.168.1.1 255.255.255.0
!
router eigrp 300
    network 192.168.1.0
!
ip route 0.0.0.0 0.0.0.0 172.16.3.1
line vty 0 4
  password cisco
  login
!
```

as300-E

```
hostname AS300-E
!
enable password cisco
!
interface Loopback0
  ip address 192.168.2.1 255.255.255.0
!
interface Serial0/0
  ip address 192.168.1.2 255.255.255.0
!
router eigrp 300
  network 192.168.1.0
  network 192.168.2.0
!
router bgp 300
  network 192.168.1.0
  network 192.168.2.0
  neighbor 172.16.3.1 remote-as 100
!
line vty 0 4
  password cisco
```

login
!

完成了路由器基本配置后，查看路由器运行 BGP 协议的情况。用 show ip bgp 查看 bgp 表，用 show ip route 查看路由表

二、multihop

as100-C 与 as300-E 之间不能成功建立 bgp 邻居关系,是因为 as300 中,as300-D 路由器并不运行 bgp 协议,所以我们需要在 AS300-E 与 AS100-C 两台路由器上附加 multihop 配置.静态路由的添加是为了这两台路由器之间能通过 tcp/ip 协议互相访问,这样 bgp 协议才能正常工作.

具体配置如下:

```
as100-C:
router bgp 100
   neighbor 192.168.1.2 remote-as 300
   neighbor 192.168.1.2 ebgp-multihop 2
!
ip route 192.168.1.0 255.255.255.0 172.16.3.2
!

as300-E
router bgp 300
   neighbor 172.16.3.1 remote-as 100
   neighbor 172.16.3.1 ebgp-multihop 2
!
ip route 172.16.3.0 255.255.255.0 192.168.1.1
!
```

三、理解 next-hop-self

通过以上配置,全部 bgp 邻居都建立起来了.观察 bgp 表,能看到全部网段的信息.但在路由表中,发现 as100-B 路由器并没有 192.168.1.0 和 192.168.2.0 网段的信息.是因为,as100-B 并不知道 192.168.1.2 在哪里,所以不会把通过这个路由学来的 bgp 路由放到路由表中.我们需要通过 next-hop-self 配置,让 as100-B 获得的 192.168.1.0 和 192.168.2.0 网段信息不再是从 192.168.1.2 获得,而是从 172.16.2.2 获得,这样 as100-B 就会把这条 bgp 路由放到路由表中了.

配置 next-hop-self 前请看清楚 bgp 表与路由表,并与配置后的作对比

具体配置为

```
as100-C
router bgp 100
      neighbor 172.16.2.1 next-hop-self
!
```

通过以上配置,我们配通了全部 bgp 协议,请用 ping 命令检查网络全部正常运行.

四、配置 MED

配置 MED 是一个 as 用来控制其他 as 从哪个入口进来本 as 的方法,比如 as100 上,能通过配置 MED,使 as65500 优先选择其中一条路径进入 as100:

在 as100-C 上配置

```
router bgp 100
neighbor 172.16.5.1 remote-as 65500
  neighbor 172.16.5.1 route-map setmed out
!
route-map setmed permit 10
  set metric 100
!
```

配置后,用 clear ip bgp *从起 bgp 协议,并用 show ip bgp 和 show ip route 查看结果

五、配置本地优先

本地优先是指 as 内部路由器控制自己 as 几个出口的优先级.比如 as65500 有两个出口,那么到底选择哪个作为优先呢,我们可以通过配置本地优先来控制.

as65500-a:

```
router bgp 65500
   no synchronization
   network 10.10.1.0 mask 255.255.255.0
   network 172.16.1.0 mask 255.255.255.0
   network 172.16.5.0 mask 255.255.255.0
   neighbor 172.16.1.2 remote-as 100
   neighbor 172.16.5.2 remote-as 100
   neighbor 172.16.5.2 route-map setlocalpre in
!
route-map setlocalpre permit 10
  set local-preference 200
!
!
line vty 0 4
  password cisco
  login
!
```

配置后,用 clear ip bgp *从起 bgp 协议,并用 show ip bgp 和 show ip route 查看结果

六、去掉保留 AS

在 AS 号码中 65001 后面的是保留 AS 部分,一般用作 ISP 内部分配用,所以在广域网上面得去掉保留得 AS 号码.在这里,65500 是保留 AS,所以 as100-C 发送给 as300-E 的时候,应该去掉这个 AS,具体配置为:

as100-C

```
router bgp 100
 neighbor 192.168.1.2 remove-private-as
```

配置后,用 clear ip bgp *从起 bgp 协议,并用 show ip bgp 和 show ip route 查看结果

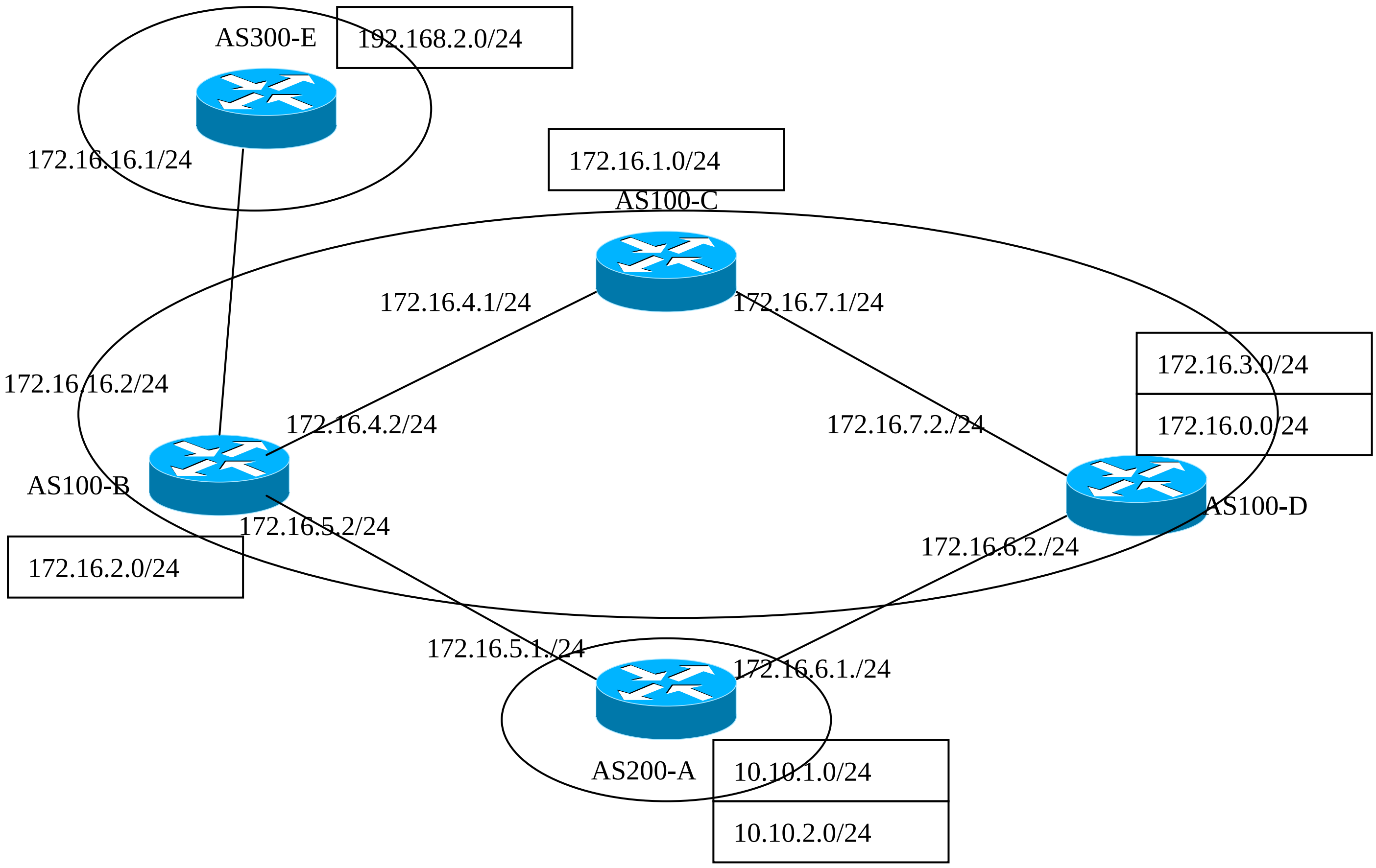
BGP 第二次实验(简化版)

2003-6-13

【实验目的】

1) 了解 BGP 基本配置
2) 了解 BGP 同步与非同步的概念，学会把 BGP 在发布到 IGP，从而克服同步带来的问题
3) 学会配置路由反射器
4) 学会配置汇聚 BGP 路由条目
5) 学会配置前缀列表(prefix list)
6) 学会配置团体字属性
7) 学会配置 peer-group

【实验拓扑】



注意:实线框地内容是路由回环端口地网段地址

【实验内容】

一、BGP 基本配置

1. 在各台路由器上配置 hostname，如上分配。另外，为了在 troubleshooting 时便于检测，最好配置虚拟终端。
2. 在各台路由器上配置基本的 IP 地址，包括回环地址。

3. 在路由器 AS100-B、AS100-C、AS100-D 上配置 RIP version2 协议，相互之间通告 172.16.0.0 网络路由信息；

(config)#router rip

(config-router)#version 2

(config-router)#network 172.16.0.0

4. 在各台路由器上都启动 BGP 协议，各 AS 号如图所示。

(config)#router bgp *as-num*

(config-router)#network x.x.x.x mask x.x.x.x

(config-router)#neighbor x.x.x.x remote-as *as-num*

5. 各台路由器完成配置后，用 show run 命令看自己的配置正确与否

6. 用 show ip route、show ip bgp、show ip bgp neighbors 查看相应的路由信息、bgp 信息

二、 BGP 同步

1. BGP 同步含义

在 BGP 协议中，对于处于同一个自治系统域的 BGP 路由器，如设为 A 和 B，现假设 A 向 B 通告关于某个目的网段的路由信息，B 接收到之后首先在自己的 IGP 表中搜索，看 IGP 路由信息中有无到达该目的网段的路由信息。如果有，B 就会将 A 发给它的 IBGP 路由更新信息通告给 EBGP 邻居；否则，就不会通告给 EBGP。这就是所谓的同步，即是 IBGP 与 IGP 之间必须达到同步。

2. 启用同步

1） 为显示同步的作用，先关闭 AS200-A 上的 172.16.5.1 端口。

因为如果不关闭该端口，AS200-A 可以通过 EBGP 邻居 AS100-B 而通告 10.10.1.0 和 10.10.2.0 网段消息给 AS300-E，而它自己则会通过 AS100-B 而收到 192.168.2.0 网段的信息。

2）在 AS300-E 上。在 AS100-B,AS100-C,AS100-D 三台路由器上启动 BGP 同步，配置为：

(config)#router bgp 100

(config-router)#synchronization

实验结果：

启动同步后，我们可以看到 AS200-A 学不到 192.168.2.0 网段的 BGP 信息，AS300-E 学不到 10.10.1.0，10.10.2.0 网段的信息。用 show ip route、show ip bgp 查看。

3. 同步问题的解决

在启用同步后，可以通过把 BGP 的内容重发布到 IGP 来克服同步带来的问题。

在 AS100-B 与 AS100-D 上配置：

(config)#router rip

(config-router)#redistribute bgp 100 metric 2

实验结果：

配置后可以看到 AS200-A 与 AS300-E 上又学到了对方的路由条目。

三、配置路由反射器

1． 路由反射器原理

在同一个 AS 中，各个 IBGP 邻居默认是不将从一个 IBGP 邻居学来的路由消息转发给另外的 IBGP 邻居，所以通常各个 IBGP 之间要建立全互联关系。那样，随着 IBGP 邻居的增多，路由上的开销就会很大。为了解决这个问题，就采用了路由反射器，这样一部分路由器只要跟路由反射服务器建立 IBGP 关系即可，而没有必要两两建立全互联连接。

2．路由反射器配置

1）先把 AS100-B 和 AS100-D 之间的 bgp 邻居关系去掉

```
AS100-B(config)#router bgp 100
AS100-B(config-router)#no neighbor 172.16.7.2 remote-as 100

AS100-D(config)#Router bgp 100
AS100-D(config-router)#No neighbor 172.16.4.2 remote-as 100
```

实验结果：

配置后，我们能发现，在 AS100-B 上没有 172.16.0.0、172.16.3.0 网段，在 AS100-D 路由器上，没有关于 192.168.2.0、172.16.2.0 网段的信息。

2）在 AS100-C 上配置路由反射器：

```
AS100-C(config)#router bgp 100
AS100-C (config-router)# neighbor 172.16.4.2 route-reflector-client
AS100-C (config-router)# neighbor 172.16.7.2 route-reflector-client
```

实验结果：

通过路由反射器，我们又能在在 AS100-B 上看到有 172.16.0.0、172.16.3.0 网段，在 AS100-D 路由器上，有关于 192.168.2.0、172.16.2.0 网段的信息。

四、配置汇聚路由

1． 在 AS100-B 上，可以汇聚一条路由

配置为：

```
as100-B(config-router)#aggregate-address 172.16.0.0 255.255.248.0
```

实验结果：

可以在 AS300-E 上看到一条 172.16.0.0/21 的条目。

2．在配置的时候，还可以用 summary-only 参数，让 bgp 路由器只发送汇总的路由：

```
as100-B(config-router)#aggregate-address 172.16.0.0 255.255.248.0 summary-only
```

实验结果：

在 AS300-E 上只有相应的一条聚合路由。注意 AS100-B 上的小 s 是指这条路由条目抑制不发送，这个时候 AS300-E 上只有汇总后的路由了

五、 配置前缀列表(prefix list)

1. 前缀列表

在路由信息过滤方面，前缀列表与发布列表(distribute-list)有相同的功效，但前者可以看作是后者的改进，从而具有更好的操控性。

命令格式为：

(config)#**ip prefix-list** list-name **[seq** seq-value] **permit|deny** network/len

[**ge** ge-value][**le** le-value]

2. 在本实验中，为控制 AS100-B 只发送 172.16.0.0/16 到 172.16.0.0/24 网段的路由条目给 AS300-E，就可以采用前缀列表，具体配置为：

AS100-B(config)#router bgp 100

AS100-B(config-router)#neighbor 172.16.16.1 prefix-list aaa out

AS100-B(config-router)#exit

AS100-B(config)#ip prefix-list aaa seq 5 deny 172.16.3.0/24

AS100-B(config)#ip prefix-list aaa seq 10 permit 172.16.0.0/16 le 24

实验结果：

在路由器 AS300-E 上没有 10.10.1.0 与 10.10.2.0 和 172.16.3.0 的路由信息

六、 配置团体字属性

1. Community 属性

Community 属性可以让一组目的网段享用某些相同的路由特性,但这些目的网段不必要求处于同一 AS。它可以用来控制 BGP 信息所经过的路由器怎么对待这条 BGP 信息，比如：NO_EXPORT 为不发布到别的 AS，NO_ADV 为不在发布到别的路由器，Local_AS 为这个信息为内部 AS 信息，应该发布到 AS 内部，但不应该发布到公众网上，internet 为公网信息。这些都是公共 community 属性，当然，还可以用一些如 10～777 的数字来表示。

2. Community 配置

1）配置之前看一下 AS300-E 的 bgp 表，用 show ip bgp。看一下有没有 10.10.1.0/24 的路由信息。

2）为了让发到 AS200 中的关于 10.10.1.0 网段的信息不再发送到 as300 中去，我们可以在 AS200-A 上配置 NO_EXPORT 参数，

在 AS200-A 上配置为：

AS200-A(config)#router bgp 200

AS100-A(config-router)#neighbor 172.16.5.2 send-community

AS100-A(config-router)#neighbor 172.16.5.2 route-map SETCOMMUNITY out

AS100-A(config-router)#neighbor 172.16.6.2 send-community

AS100-A(config-router)#exit

AS200-A(config)#access-list 1 permit 10.10.1.0 0.0.0.255

AS200-A(config)#route-map SETCOMMUNITY permit 10

AS200-A(config-route-map)#match ip address 1

AS200-A(config-route-map)#set community no-export

实验结果：

在 AS300-E 上没有，没有 10.10.1.0 网段的信息。

注意：如果是直接在以上几步的基础上配置 community，则由于已将 BGP 信息导进了 IGP 中，10.10.1.0 网段的信息仍然会通过路由器 AS100-D 传给 AS100-B，之后 AS100-B 再传给 AS300-E，从而 AS300-E 也可以看到 10.10.l.0 网段的信息。此时，AS200-A 发给 AS100-D 关于 10.10.1.0 网段的路由信息也要设置 NO-EXPORT 的 community 属性。

七、 配置 peer-group

1． Peer-group

有时对于某个 BGP 路由，其若干个邻居（IBGP 或 EBGP 邻居）有共同的属性、可以实施共同的路由策略、可以使用相同的过滤列表等。这时，就可以使用 peer-group，一来减少配置量，二来减少路由更新量（同一个 peer-group 的全部 n 个成员只产生一条更新，而不是 n 条相同的更新）。

2． Peer-group 配置

从刚才的配置经历中，我们可以发现在我们的实验拓扑中，AS100-C 的两个邻居 AS100-B 和 AS100-D 的配置属性相同，AS200-A 的两个 EBGP 邻居 AS100-B 和 AS100-D 也具有相同的配置属性，则可以采用 peer-group 来简化配置。

它们的配置如下：

- 路由器 AS100-C

  在 AS100-C 上配置，把 172.16.1.0 网段加入团体属性 NO_ADVERTISE 。另外，AS100-B 和 AS100-D 同为 AS100，同为 AS100-C 的路由反射器客户，配置如下：

  //首先定义 ACL

  AS100-C(config)#access-list 2 permit 172.16.1.0 0.0.0.255

  //定义路由策略 route-map

  AS100-C(config)# route-map NOADV permit 10
  AS100-C(config-route-map)#match ip address 2
  AS100-C(config-route-map)# set community no-advertise
  AS100-C(config-route-map)#exit

  //配置 peer-group

  AS100-C(config)#router bgp 100
  AS100-C(config-router)#neighbor LOCAL peer-group
  AS100-C(config-router)#neighbor LOCAL remote-as 100
  AS100-C(config-router)#neighbor LOCAL route-reflector-client
  AS100-C(config-router)#neighbor LOCAL send-community
  AS100-C(config-router)#neighbor LOCAL route-map NOADV out
  AS100-C(config-router)#neighbor 172.16.4.2 peer-group LOCAL
  AS100-C(config-router)#neighbor 172.16.7.2 peer-group LOCAL

- 路由器 AS200-A

  AS100-B 和AS100-D同是AS200-A的EBGP邻居且都在AS100上，有相同的community属性设置，其配置如下：

  //首先定义 ACL

  AS100-D(config)# access-list 1 permit 10.10.1.0 0.0.0.255

  //定义路由策略 route-map

  AS100-D(config)# route-map NOEXPORT permit 10

  AS100-D(config-route-map)# match ip address 1

  AS100-D(config-route-map)# set community no-export

  //配置 peer-group

  AS100-D(config)#router bgp 100

  AS100-D(config-router)#neighbor REMOTE peer-group

  AS100-D(config-router)#neighbor REMOTE remote-as 100

  AS100-D(config-router)# neighbor REMOTE send-community

  AS100-D(config-router)#neighbor REMOTE route-map NOEXPORT out

  AS100-D(config-router)#neighbor 172.16.5.2 peer-group REMOTE

  AS100-D(config-router)#neighbor 172.16.6.2 peer-group REMOTE

实验结果:

在 AS200－A 和 AS300－E 上没有关于 172.16.1.0 网段的信息，在 AS300-E 上没有10.10.1.0 网段的信息。

BGP 第二次实验(完整版)

2003-6-13

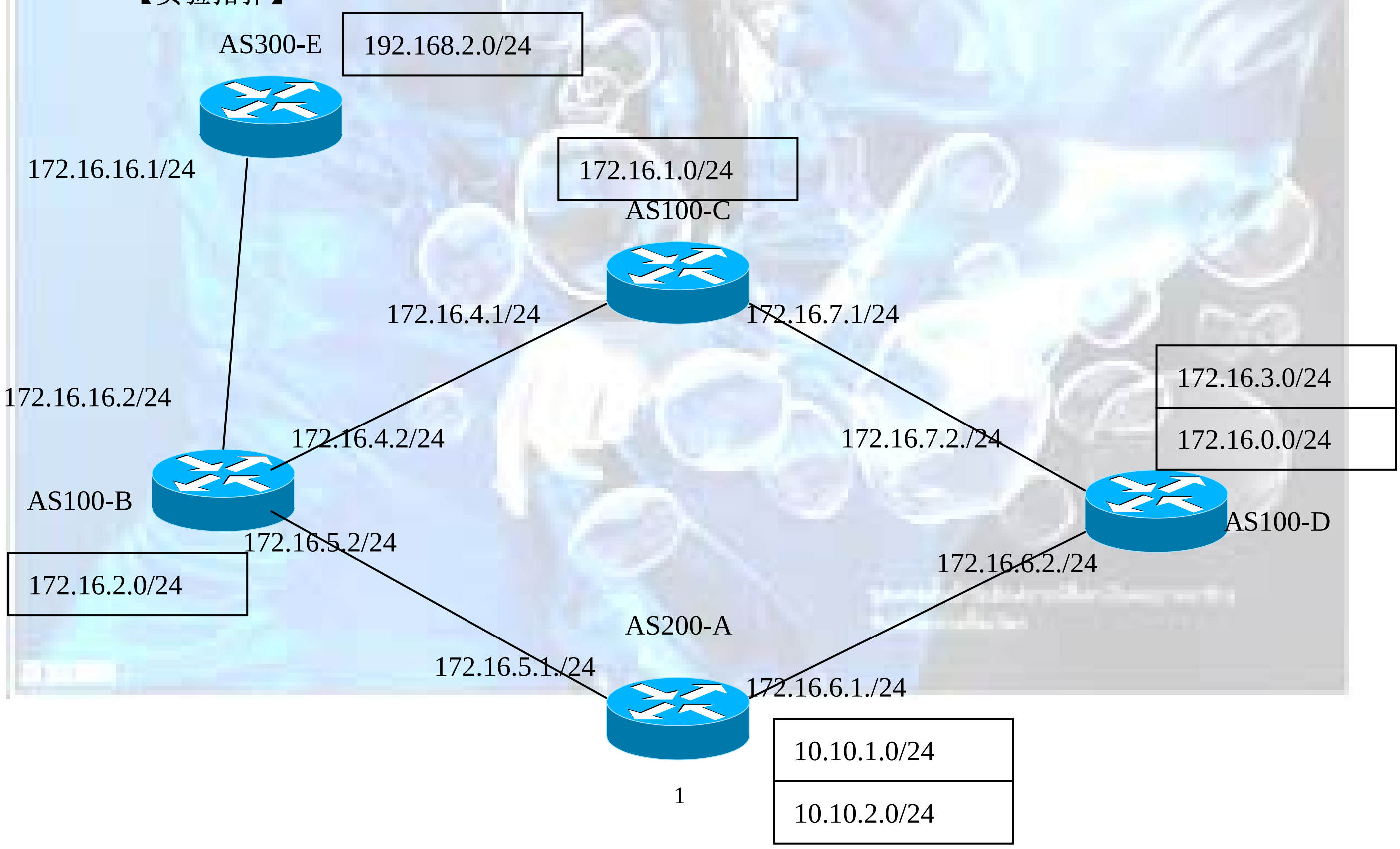
【实验目的】

1. 了解 BGP 基本配置
2. 了解 BGP 同步与非同步的概念，学会把 BGP 在发布到 IGP，从而克服同步带来的问题
3. 学会配置路由反射器
4. 学会配置汇聚 BGP 路由条目
5. 学会配置前缀列表(prefix list)
6. 学会配置团体字属性
7. 学会配置 peer-group

【实验结果链接】

1. 基本配置：AS200-A、AS100-B、AS100-C、AS100-D、AS300-E
   BGP信息：AS200-A、AS100-B、AS100-C、AS100-D、AS300-E
2. 启用同步：AS200-A、AS100-B、AS100-C、AS100-D、AS300-E
   BGP重发布进RIP：AS200-A、AS100-B、AS100-C、AS100-D、AS300-E
3. 去掉B、D之间的IBGP：AS100-B、AS100-D
   配置路由反射器后：AS100-B 、AS100-D
4. 非summary-only聚合：AS300-E
   summary-only聚合：AS100-B、AS300-E
5. 前缀列表：AS300-E
6. 配置团体字前：AS300-E
   配置团体字后：AS300-E
7. 配置peer-group：AS200-A、AS100-C、AS300-E
8. 最终配置结果：AS200-A、AS100-B、AS100-C、AS100-D、AS300-E

【实验拓扑】



注意:实线框地内容是路由回环端口地网段地址

【实验内容】

一、BGP 基本配置

1. 在各台路由器上配置基本的 IP 地址，包括回环地址。另外，为了在 troubleshooting 时便于检测，也配置了虚拟终端。
2. 在路由器 AS100-B、AS100-C、AS100-D 上配置 RIP version2 协议，相互之间通告 172.16.0.0 网络路由信息;
3. 在各台路由器上都启动 BGP 协议，各 AS 号如图所示。
4. 下面是各台路由器完成配置后，用 show run 命令看到的配置结果

1） 路由器AS200-A TOP

```
hostname As200-A
!
enable password cisco
!
interface Loopback1
 ip address 10.10.1.1 255.255.255.0
 no ip directed-broadcast
!
interface Loopback2
 ip address 10.10.2.1 255.255.255.0
 no ip directed-broadcast
!
interface Serial0/0
 ip address 172.16.5.1 255.255.255.0
 no ip directed-broadcast
 clockrate 56000
!
interface Serial0/1
 ip address 172.16.6.1 255.255.255.0
 no ip directed-broadcast
 clockrate 56000
!
router bgp 200
 network 10.10.1.0 mask 255.255.255.0
 network 10.10.2.0 mask 255.255.255.0
 network 172.16.5.0 mask 255.255.255.0
 network 172.16.6.0 mask 255.255.255.0
 neighbor 172.16.5.2 remote-as 100
 neighbor 172.16.6.2 remote-as 100
line vty 0 4
 password cisco
 login
!
```

2）路由器AS100-B TOP

```
hostname AS100-B
!
enable password cisco
!
interface Loopback3
 ip address 172.16.2.1 255.255.255.0
 no ip directed-broadcast
!
interface FastEthernet0/0
 ip address 172.16.16.2 255.255.255.0
 no ip directed-broadcast
!
interface Serial0/0
 ip address 172.16.4.2 255.255.255.0
 no ip directed-broadcast
 no ip mroute-cache
 no fair-queue
!
interface Serial0/1
 ip address 172.16.5.2 255.255.255.0
 no ip directed-broadcast
!
router rip
 version 2
 network 172.16.0.0
!
router bgp 100
 network 172.16.2.0 mask 255.255.255.0
 network 172.16.4.0 mask 255.255.255.0
 network 172.16.5.0 mask 255.255.255.0
 network 172.16.16.0 mask 255.255.255.0
 neighbor 172.16.4.1 remote-as 100
 neighbor 172.16.5.1 remote-as 200
 neighbor 172.16.7.2 remote-as 100
 neighbor 172.16.16.1 remote-as 300
!

line vty 0 4
 password cisco
 login
!
```

3）路由器AS100-C TOP

```
hostname AS100-C
!
enable password cisco
!
interface Loopback0
 ip address 172.16.1.1 255.255.255.0
!
interface Serial0
 ip address 172.16.7.1 255.255.255.0
 no fair-queue
!
interface Serial2
 ip address 172.16.4.1 255.255.255.0
 clockrate 56000
!
router rip
 version 2
 network 172.16.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 172.16.1.0 mask 255.255.255.0
 network 172.16.4.0 mask 255.255.255.0
 network 172.16.7.0 mask 255.255.255.0
 neighbor 172.16.4.2 remote-as 100
 neighbor 172.16.7.2 remote-as 100
 no auto-summary
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
```

4）路由器AS100-D TOP

```
hostname AS100-D
!
enable password cisco
!
interface Loopback0
 ip address 172.16.0.1 255.255.255.0
 no ip directed-broadcast
```

```
!
interface Loopback1
 ip address 172.16.3.1 255.255.255.0
 no ip directed-broadcast
!
interface Serial0/0
 ip address 172.16.7.2 255.255.255.0
 no ip directed-broadcast
 clockrate 56000
!
interface FastEthernet0/1
 no ip address
 no ip directed-broadcast
 shutdown
 duplex auto
 speed auto
!
interface Serial0/1
 ip address 172.16.6.2 255.255.255.0
 no ip directed-broadcast
!
router rip
 version 2
 network 172.16.0.0
!
router bgp 100
 no synchronization
 network 172.16.0.0 mask 255.255.255.0
 network 172.16.3.0 mask 255.255.255.0
 network 172.16.6.0 mask 255.255.255.0
 network 172.16.7.0 mask 255.255.255.0
 neighbor 172.16.4.2 remote-as 100
 neighbor 172.16.6.1 remote-as 200
 neighbor 172.16.7.1 remote-as 100
!
ip classless
no ip http server
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
```

```
!
no scheduler allocate
end
```

5）路由器AS300-E　　**TOP**

```
hostname as300-E
!
enable password cisco
!
interface Loopback1
 ip address 192.168.2.1 255.255.255.0
!
interface Ethernet0
 ip address 172.16.16.1 255.255.255.0
!
router bgp 300
 bgp log-neighbor-changes
 network 172.16.16.0 mask 255.255.255.0
  network 192.168.2.0
 neighbor 172.16.16.2 remote-as 100
!
line vty 0 4
 password cisco
 login
!
```

5．用 show ip route、show ip bgp 以及 show ip bgp neighbors 命令，看到如下结果

1）路由器AS200-A　　**TOP**

- **show ip route**

```
AS200-A#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/24 is subnetted, 9 subnets
B       172.16.16.0 [20/0] via 172.16.5.2, 00:03:51
B       172.16.4.0 [20/0] via 172.16.5.2, 00:03:51
C       172.16.5.0 is directly connected, Serial0/0
```

```
C          172.16.6.0 is directly connected, Serial0/1
B          172.16.7.0 [20/0] via 172.16.6.2, 00:03:51
B          172.16.0.0 [20/0] via 172.16.6.2, 00:03:12
B          172.16.1.0 [20/0] via 172.16.6.2, 00:03:51
B          172.16.2.0 [20/0] via 172.16.5.2, 00:03:51
B          172.16.3.0 [20/0] via 172.16.6.2, 00:03:12
      10.0.0.0/24 is subnetted, 1 subnets
C          10.10.1.0 is directly connected, Loopback1
B      192.168.2.0/24 [20/0] via 172.16.5.2, 00:03:51
```

- **show ip bgp** [TOP](#)

```
AS200-A#show ip bgp
BGP table version is 98, local router ID is 172.16.6.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     0.0.0.0                  0         32768 i
*  172.16.0.0/24    172.16.5.2               0             0 100 i
*>                  172.16.6.2                             0 100 i
*  172.16.1.0/24    172.16.5.2                             0 100 i
*>                  172.16.6.2                             0 100 i
*  172.16.2.0/24    172.16.6.2               0             0 100 i
*>                  172.16.5.2                             0 100 i
*  172.16.3.0/24    172.16.5.2               0             0 100 i
*>                  172.16.6.2                             0 100 i
*  172.16.4.0/24    172.16.6.2               0             0 100 i
*>                  172.16.5.2                             0 100 i
*  172.16.5.0/24    172.16.5.2               0             0 100 i
*                   172.16.6.2                             0 100 i
*>                  0.0.0.0                  0         32768 i
*  172.16.6.0/24    172.16.6.2               0             0 100 i
*                   172.16.5.2                             0 100 i
*>                  0.0.0.0                  0         32768 i
*  172.16.7.0/24    172.16.5.2                             0 100 i
   Network          Next Hop            Metric LocPrf Weight Path
*>                  172.16.6.2               0             0 100 i
*  172.16.16.0/24   172.16.6.2               0             0 100 i
*>                  172.16.5.2                             0 100 i
*  192.168.2.0      172.16.6.2                             0 100 300 i
*>                  172.16.5.2                             0 100 300 i
AS200-A#
```

- **show ip bgp neighbors** [TOP]

```
AS200_A#show ip bgp neighbors

BGP neighbor is 172.16.5.2,  remote AS 100, external link
  BGP version 4, remote router ID 172.16.2.1
  BGP state = Established, up for 01:02:43
  Last read 00:00:43, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 71 messages, 0 notifications, 0 in queue
  Sent 68 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 13, neighbor version 13
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  10 accepted prefixes consume 400 bytes
  Prefix advertised 4, suppressed 0, withdrawn 0
  Connections established 1; dropped 0
  Last reset never

Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.5.1, Local port: 11003
Foreign host: 172.16.5.2, Foreign port: 179
Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)
Event Timers (current time is 0x3F3A68):
Timer          Starts    Wakeups            Next
Retrans            68          0             0x0
TimeWait            0          0             0x0
AckHold            68         24             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
iss: 3576726283  snduna: 3576727671  sndnxt: 3576727671     sndwnd:  14997
irs:   44572312  rcvnxt:   44573854  rcvwnd:      16308  delrcvwnd:     76

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 20 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: higher precedence, nagle
```

```
Datagrams (max data segment is 1460 bytes):
Rcvd: 118 (out of order: 0), with data: 68, total data bytes: 1541
Sent: 94 (retransmit: 0, fastretransmit: 0), with data: 67, total data bytes: 1
387

BGP neighbor is 172.16.6.2,  remote AS 100, external link
  BGP version 4, remote router ID 172.16.3.1
  BGP state = Established, up for 01:01:05
  Last read 00:00:04, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 69 messages, 0 notifications, 0 in queue
  Sent 70 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 13, neighbor version 13
  Index 2, Offset 0, Mask 0x4
  Route refresh request: received 0, sent 0
  10 accepted prefixes consume 400 bytes
  Prefix advertised 11, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.6.1, Local port: 179
Foreign host: 172.16.6.2, Foreign port: 11000

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3F46E0):
Timer          Starts    Wakeups            Next
Retrans            66          0             0x0
TimeWait            0          0             0x0
AckHold            66         46             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 2740737216  snduna: 2740738744  sndnxt: 2740738744     sndwnd:  16327
irs:  180027161  rcvnxt:  180028647  rcvwnd:      16365  delrcvwnd:     19
```

```
SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 0 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 90 (out of order: 0), with data: 66, total data bytes: 1485
Sent: 113 (retransmit: 0, fastretransmit: 0), with data: 65, total data bytes:
1527

BGP neighbor is 172.16.6.2,  remote AS 100, external link
  BGP version 4, remote router ID 172.16.3.1
  BGP state = Established, up for 01:01:05
  Last read 00:00:04, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 69 messages, 0 notifications, 0 in queue
  Sent 70 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 30 seconds


 For address family: IPv4 Unicast
  BGP table version 13, neighbor version 13
  Index 2, Offset 0, Mask 0x4
  Route refresh request: received 0, sent 0
  10 accepted prefixes consume 400 bytes
  Prefix advertised 11, suppressed 0, withdrawn 0


  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.6.1, Local port: 179
Foreign host: 172.16.6.2, Foreign port: 11000


Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)


Event Timers (current time is 0x3F46E0):
Timer          Starts    Wakeups            Next
Retrans            66          0             0x0
TimeWait            0          0             0x0
```

```
AckHold          66        46          0x0
SendWnd           0         0          0x0
KeepAlive         0         0          0x0
GiveUp            0         0          0x0
PmtuAger          0         0          0x0
DeadWait          0         0          0x0

iss: 2740737216  snduna: 2740738744  sndnxt: 2740738744     sndwnd:  16327
irs:  180027161  rcvnxt:  180028647  rcvwnd:      16365  delrcvwnd:     19


SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 0 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 90 (out of order: 0), with data: 66, total data bytes: 1485
Sent: 113 (retransmit: 0, fastretransmit: 0), with data: 65, total data bytes:
1527
```

2）路由器AS100-B **TOP**

- **show ip route**

```
as100-B#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/24 is subnetted, 9 subnets
C       172.16.16.0 is directly connected, FastEthernet0/0
C       172.16.4.0 is directly connected, Serial0/0
C       172.16.5.0 is directly connected, Serial0/1
B       172.16.6.0 [20/0] via 172.16.5.1, 00:59:48
R       172.16.7.0 [120/1] via 172.16.4.1, 00:00:26, Serial0/0
R       172.16.0.0 [120/2] via 172.16.4.1, 00:00:26, Serial0/0
R       172.16.1.0 [120/1] via 172.16.4.1, 00:00:26, Serial0/0
C       172.16.2.0 is directly connected, Loopback3
R       172.16.3.0 [120/2] via 172.16.4.1, 00:00:26, Serial0/0
     10.0.0.0/24 is subnetted, 1 subnets
```

```
B          10.10.1.0 [20/0] via 172.16.5.1, 01:00:14
B          10.10.1.0 [20/0] via 172.16.5.1, 01:00:14
```

- **show ip bgp** [TOP]

```
as100-B#show ip bgp
BGP table version is 21, local router ID is 192.168.1.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i10.10.1.0/24     172.16.6.1               0    100      0 200 i
*>                  172.16.5.1               0             0 200 i
*>i172.16.0.0/24    172.16.7.2               0    100      0 i
*>i172.16.1.0/24    172.16.4.1               0    100      0 i
*> 172.16.2.0/24    0.0.0.0                  0         32768 i
*>i172.16.3.0/24    172.16.7.2               0    100      0 i
* i172.16.4.0/24    172.16.4.1               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*   172.16.5.0/24   172.16.5.1               0             0 200 i
*>                  0.0.0.0                  0         32768 i
* i172.16.6.0/24    172.16.7.2               0    100      0 i
*>                  172.16.5.1               0             0 200 i
* i172.16.7.0/24    172.16.7.2               0    100      0 i
*>i                 172.16.4.1               0    100      0 i
*   172.16.16.0/24  172.16.16.1              0             0 300 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.2.0      172.16.16.1              0             0 300 i
as100-B#
```

- **show ip bgp neighbors** [TOP]

```
RouterB#sh ip bgp neighbors

BGP neighbor is 172.16.4.1,  remote AS 100,  internal link
  BGP version 4,  remote router ID 172.16.1.1
  BGP state = Established,  up for 00:57:09
  Last read 00:00:08,  hold time is 180,  keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 62 messages,  0 notifications,  0 in queue
  Sent 64 messages,  0 notifications,  0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
```

```
  BGP table version 15, neighbor version 15
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  3 accepted prefixes consume 120 bytes
  Prefix advertised 7, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.4.2, Local port: 179
Foreign host: 172.16.4.1, Foreign port: 11001

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3B5D38):
Timer          Starts    Wakeups            Next
Retrans            61          0             0x0
TimeWait            0          0             0x0
AckHold            62         14             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 3399002934  snduna: 3399004309  sndnxt: 3399004309     sndwnd:  15010

irs: 3753617846  rcvnxt: 3753619095  rcvwnd:      15136  delrcvwnd:   1248

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 122 (out of order: 0), with data: 62, total data bytes: 1248
Sent: 75 (retransmit: 0, fastretransmit: 0), with data: 60, total data bytes: 1
374

BGP neighbor is 172.16.5.1,  remote AS 200, external link
  BGP version 4, remote router ID 10.10.2.1
  BGP state = Established, up for 00:58:38
  Last read 00:00:38, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
```

```
    Address family IPv4 Unicast: advertised and received
  Received 64 messages, 0 notifications, 0 in queue
  Sent 67 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 15, neighbor version 15
  Index 2, Offset 0, Mask 0x4
  Route refresh request: received 0, sent 0
  3 accepted prefixes consume 120 bytes
  Prefix advertised 10, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.5.2, Local port: 179
Foreign host: 172.16.5.1, Foreign port: 11003

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3B8224):
Timer          Starts    Wakeups            Next
Retrans            65          0             0x0
TimeWait            0          0             0x0
AckHold            63         46             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss:   44572312  snduna:   44573778  sndnxt:   44573778     sndwnd:  16384
irs: 3576726283  rcvnxt: 3576727595  rcvwnd:      15073  delrcvwnd:   1311

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 20 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 89 (out of order: 0), with data: 63, total data bytes: 1311
Sent: 111 (retransmit: 0, fastretransmit: 0), with data: 64, total data bytes:
1465

BGP neighbor is 172.16.7.2,  remote AS 100, internal link
```

```
  BGP version 4, remote router ID 172.16.3.1
  BGP state = Established, up for 00:57:41
  Last read 00:00:40, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:

    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 64 messages, 0 notifications, 0 in queue
  Sent 64 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 15, neighbor version 15
  Index 3, Offset 0, Mask 0x8
  Route refresh request: received 0, sent 0
  6 accepted prefixes consume 240 bytes
  Prefix advertised 7, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.4.2, Local port: 11006
Foreign host: 172.16.7.2, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3B8F78):
Timer          Starts    Wakeups            Next
Retrans            62          0             0x0
TimeWait            0          0             0x0
AckHold            63         34             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0


iss:  645595783  snduna:  645597158  sndnxt:  645597158     sndwnd:  16099
irs: 1969624055  rcvnxt: 1969625422  rcvwnd:      16118  delrcvwnd:    266


SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 36 ms, maxRTT: 300 ms, ACK hold: 200 ms
```

```
Flags: higher precedence, nagle

Datagrams (max data segment is 536 bytes):
Rcvd: 93 (out of order: 0), with data: 63, total data bytes: 1366

Sent: 99 (retransmit: 0, fastretransmit: 0), with data: 61, total data bytes: 1
374

BGP neighbor is 172.16.16.1,  remote AS 300, external link
  BGP version 4, remote router ID 192.168.2.1
  BGP state = Established, up for 01:04:10
  Last read 00:00:10, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 69 messages, 0 notifications, 0 in queue
  Sent 74 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 15, neighbor version 15
  Index 4, Offset 0, Mask 0x10
  Route refresh request: received 0, sent 0
  1 accepted prefixes consume 40 bytes
  Prefix advertised 12, suppressed 0, withdrawn 1

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.16.2, Local port: 179
Foreign host: 172.16.16.1, Foreign port: 11000

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3B9D24):
Timer          Starts    Wakeups            Next
Retrans            75          0             0x0
TimeWait            0          0             0x0
AckHold            69         23             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
```

```
iss: 4227790013  snduna: 4227791628  sndnxt: 4227791628     sndwnd:  16232
irs: 1142621887  rcvnxt: 1142623258  rcvwnd:      15014  delrcvwnd:   1370

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 124 (out of order: 0), with data: 69, total data bytes: 1370
Sent: 98 (retransmit: 0, fastretransmit: 0), with data: 74, total dat
a bytes: 1614
```

3）路由器AS100-C　　TOP

- **show ip route**

AS100-C#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
i - IS-IS, 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

172.16.0.0/24 is subnetted, 9 subnets
R　172.16.16.0 [120/1] via 172.16.4.2, 00:00:03, Serial2
C　172.16.4.0 is directly connected, Serial2
R　172.16.5.0 [120/1] via 172.16.4.2, 00:00:03, Serial2
R　172.16.6.0 [120/1] via 172.16.7.2, 00:00:08, Serial0
C　172.16.7.0 is directly connected, Serial0
R　172.16.0.0 [120/1] via 172.16.7.2, 00:00:08, Serial0
C　172.16.1.0 is directly connected, Loopback0
R　172.16.2.0 [120/1] via 172.16.4.2, 00:00:03, Serial2
R　172.16.3.0 [120/1] via 172.16.7.2, 00:00:08, Serial0
10.0.0.0/24 is subnetted, 1 subnets
B　10.10.1.0 [200/0] via 172.16.5.1, 00:01:29
B　192.168.2.0/24 [200/0] via 172.16.16.1, 00:01:29

- **show ip bgp**　　TOP

AS100-C#show ip bgp
BGP table version is 15, local router ID is 172.16.1.1

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i10.10.1.0/24     172.16.6.1               0    100      0 200 i
*>i                 172.16.5.1               0    100      0 200 i
*>i172.16.0.0/24    172.16.7.2               0    100      0 i
*> 172.16.1.0/24    0.0.0.0                  0         32768 i
*>i172.16.2.0/24    172.16.4.2               0    100      0 i
*>i172.16.3.0/24    172.16.7.2               0    100      0 i
* i172.16.4.0/24    172.16.4.2               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.5.0/24    172.16.4.2               0    100      0 i
*>i172.16.6.0/24    172.16.7.2               0    100      0 i
* i172.16.7.0/24    172.16.7.2               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.16.0/24   172.16.4.2               0    100      0 i
*>i192.168.2.0      172.16.16.1              0    100      0 300 i
AS100-C#
```

- **show ip bgp neighbors** [TOP]

```
RouterC# sh ip bgp neighbors

BGP neighbor is 172.16.4.2,  remote AS 100, internal link
  BGP version 4, remote router ID 172.16.2.1
  BGP state = Established, up for 00:59:24
  Last read 00:00:24, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 66 messages, 0 notifications, 0 in queue
  Sent 64 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 11, neighbor version 11
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  7 accepted prefixes consume 280 bytes
  Prefix advertised 3, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
```

```
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.4.1, Local port: 11001
Foreign host: 172.16.4.2, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x36F480):
Timer          Starts    Wakeups            Next
Retrans            65          0             0x0
TimeWait            0          0             0x0
AckHold            62         60             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 3753617846  snduna: 3753619133  sndnxt: 3753619133     sndwnd:  15098
irs: 3399002934  rcvnxt: 3399004347  rcvwnd:      14972  delrcvwnd:   1412

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: higher precedence, nagle

Datagrams (max data segment is 1460 bytes):
Rcvd: 77 (out of order: 0), with data: 62, total data bytes: 1412
Sent: 126 (retransmit: 0, fastretransmit: 0), with data: 64, total data bytes:
1286

BGP neighbor is 172.16.7.2,  remote AS 100, internal link
  BGP version 4, remote router ID 172.16.3.1
  BGP state = Established, up for 00:59:27
  Last read 00:00:27, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 66 messages, 0 notifications, 0 in queue
  Sent 64 messages, 0 notifications, 0 in queue

  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 11, neighbor version 11
  Index 2, Offset 0, Mask 0x4
```

```
  Route refresh request: received 0, sent 0
  6 accepted prefixes consume 240 bytes
  Prefix advertised 3, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.7.1, Local port: 11000
Foreign host: 172.16.7.2, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3700D8):
Timer          Starts    Wakeups            Next
Retrans            65          0             0x0
TimeWait            0          0             0x0
AckHold            65         43             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 1895390095  snduna: 1895391382  sndnxt: 1895391382     sndwnd:  15098
irs: 1847910868  rcvnxt: 1847912273  rcvwnd:      14980  delrcvwnd:   1404

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: higher precedence, nagle

Datagrams (max data segment is 1460 bytes):
Rcvd: 89 (out of order: 0), with data: 65, total data bytes: 1404
Sent: 109 (retransmit: 0, fastretransmit: 0), with data: 64, total data bytes:
1286
```

4）路由器AS100-D [TOP]

- **show ip route**

```
AS100-D#sho ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/24 is subnetted, 9 subnets
R        172.16.16.0 [120/2] via 172.16.7.1, 00:00:16, Serial0/0
R        172.16.4.0 [120/1] via 172.16.7.1, 00:00:16, Serial0/0
R        172.16.5.0 [120/2] via 172.16.7.1, 00:00:16, Serial0/0
C        172.16.6.0 is directly connected, Serial0/1
C        172.16.7.0 is directly connected, Serial0/0
C        172.16.0.0 is directly connected, Loopback0
R        172.16.1.0 [120/1] via 172.16.7.1, 00:00:16, Serial0/0
R        172.16.2.0 [120/2] via 172.16.7.1, 00:00:16, Serial0/0
C        172.16.3.0 is directly connected, Loopback1
     10.0.0.0/24 is subnetted, 1 subnets
B        10.10.1.0 [20/0] via 172.16.6.1, 00:02:31
B     192.168.2.0/24 [200/0] via 172.16.16.1, 00:02:36
```

- **show ip bgp** TOP

```
AS100-D#show ip bgp
BGP table version is 14, local router ID is 172.16.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.6.1               0             0 200 i
* i                 172.16.5.1               0    100      0 200 i
*> 172.16.0.0/24    0.0.0.0                  0         32768 i
*>i172.16.1.0/24    172.16.7.1               0    100      0 i
*>i172.16.2.0/24    172.16.4.2               0    100      0 i
*> 172.16.3.0/24    0.0.0.0                  0         32768 i
* i172.16.4.0/24    172.16.4.2               0    100      0 i
*>i                 172.16.7.1               0    100      0 i
*  172.16.5.0/24    172.16.6.1               0             0 200 i
*>i                 172.16.4.2               0    100      0 i
*> 172.16.6.0/24    0.0.0.0                  0         32768 i
*                   172.16.6.1               0             0 200 i
*> 172.16.7.0/24    0.0.0.0                  0         32768 i
* i                 172.16.7.1               0    100      0 i
*>i172.16.16.0/24   172.16.4.2               0    100      0 i
*>i192.168.2.0      172.16.16.1              0    100      0 300 i
AS100-D#
```

- **show ip bgp neighbors** TOP

```
RouterD#sh ip bgp neighbors
BGP neighbor is 172.16.4.2,  remote AS 100, internal link
  BGP version 4, remote router ID 172.16.2.1
  BGP state = Established, up for 01:01:20
  Last read 00:00:20, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 68 messages, 0 notifications, 0 in queue
  Sent 68 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 14, neighbor version 14
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  7 accepted prefixes consume 280 bytes
  Prefix advertised 6, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.7.2, Local port: 179
Foreign host: 172.16.4.2, Foreign port: 11006

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x386BA4):
Timer          Starts    Wakeups            Next
Retrans            68          0             0x0
TimeWait            0          0             0x0
AckHold            65         30             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 1969624055  snduna: 1969625498  sndnxt: 1969625498     sndwnd:  16042
irs:  645595783  rcvnxt:  645597234  rcvwnd:      16023  delrcvwnd:    361

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 32 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs
```

```
Datagrams (max data segment is 536 bytes):
Rcvd: 107 (out of order: 0), with data: 65, total data bytes: 1450
Sent: 100 (retransmit: 0, fastretransmit: 0), with data: 67, total data bytes:
1442

BGP neighbor is 172.16.6.1,  remote AS 200, external link
  BGP version 4, remote router ID 10.10.2.1
  BGP state = Established, up for 01:00:42
  Last read 00:00:42, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 69 messages, 0 notifications, 0 in queue
  Sent 68 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 14, neighbor version 14
  Index 2, Offset 0, Mask 0x4
  Route refresh request: received 0, sent 0
  3 accepted prefixes consume 120 bytes
  Prefix advertised 11, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.6.2, Local port: 11000
Foreign host: 172.16.6.1, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x387744):
Timer          Starts    Wakeups            Next
Retrans            67          1             0x0
TimeWait            0          0             0x0
AckHold            64         21             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss:  180027161  snduna:  180028628  sndnxt:  180028628     sndwnd:  16384
```

```
irs: 2740737216  rcvnxt: 2740738725  rcvwnd:      16346  delrcvwnd:     38

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 0 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: higher precedence, nagle

Datagrams (max data segment is 1460 bytes):
Rcvd: 111 (out of order: 0), with data: 64, total data bytes: 1508
Sent: 89 (retransmit: 1, fastretransmit: 0), with data: 65, total data bytes: 1
466

BGP neighbor is 172.16.7.1,  remote AS 100, internal link
  BGP version 4, remote router ID 172.16.1.1
  BGP state = Established, up for 01:01:09
  Last read 00:00:09, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Address family IPv4 Unicast: advertised and received
  Received 66 messages, 0 notifications, 0 in queue
  Sent 68 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds
 For address family: IPv4 Unicast
  BGP table version 14, neighbor version 14
  Index 3, Offset 0, Mask 0x8
  Route refresh request: received 0, sent 0
  3 accepted prefixes consume 120 bytes
  Prefix advertised 6, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 172.16.7.2, Local port: 179
Foreign host: 172.16.7.1, Foreign port: 11000

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x3884A4):
Timer          Starts    Wakeups            Next
Retrans            68          0             0x0
TimeWait            0          0             0x0
AckHold            66         23             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
```

```
PmtuAger             0          0             0x0
DeadWait             0          0             0x0

iss: 1847910868   snduna: 1847912311   sndnxt: 1847912311     sndwnd:   14942
irs: 1895390095   rcvnxt: 1895391420   rcvwnd:       15060  delrcvwnd:    1324

SRTT: 300 ms, RTTO: 303 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 16 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 1460 bytes):
Rcvd: 113 (out of order: 0), with data: 66, total data bytes: 1324
Sent: 91 (retransmit: 0, fastretransmit: 0), with data: 67, total data bytes: 1
442
```

5）路由器AS300-E TOP

- **show ip bgp**

```
as300-E#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/24 is subnetted, 9 subnets
C       172.16.16.0 is directly connected, Ethernet0
B       172.16.4.0 [20/0] via 172.16.16.2, 00:14:04
B       172.16.5.0 [20/0] via 172.16.16.2, 00:14:04
B       172.16.6.0 [20/0] via 172.16.16.2, 00:14:04
B       172.16.7.0 [20/0] via 172.16.16.2, 00:14:04
B       172.16.0.0 [20/0] via 172.16.16.2, 00:06:05
B       172.16.1.0 [20/0] via 172.16.16.2, 00:14:04
B       172.16.2.0 [20/0] via 172.16.16.2, 00:14:04
B       172.16.3.0 [20/0] via 172.16.16.2, 00:06:06
     10.0.0.0/24 is subnetted, 1 subnets
B       10.10.1.0 [20/0] via 172.16.16.2, 00:14:04
C    192.168.2.0/24 is directly connected, Loopback1
```

- **show ip bgp** TOP

```
as300-E#show ip bgp
```

```
BGP table version is 37, local router ID is 192.168.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.16.2                            0 100 200 i
*> 172.16.0.0/24    172.16.16.2                            0 100 i
*> 172.16.1.0/24    172.16.16.2                            0 100 i
*> 172.16.2.0/24    172.16.16.2              0             0 100 i
*> 172.16.3.0/24    172.16.16.2                            0 100 i
*> 172.16.4.0/24    172.16.16.2              0             0 100 i
*> 172.16.5.0/24    172.16.16.2              0             0 100 i
*> 172.16.6.0/24    172.16.16.2                            0 100 200 i
*> 172.16.7.0/24    172.16.16.2                            0 100 i
*  172.16.16.0/24   172.16.16.2              0             0 100 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.2.0      0.0.0.0                  0         32768 i
as300-E#
```

二、 BGP 同步

1. BGP 同步含义

在 BGP 协议中，对于处于同一个自治系统域的 BGP 路由器，设为 A 和 B。假设 A 向 B 通告关于某个目的网段的路由更新，B 接收到之后首先在自己的 IGP 表中搜索，看 IGP 路由信息中有无到达该目的网段的路由信息。如果有，B 就会将 A 发给它的 IBGP 路由更新信息通告给 EBGP 邻居；否则，就不会通告给 EBGP。这就是所谓的同步，即是 IBGP 与 IGP 之间必须同步。

2. 关闭 AS200-A 上的 172.16.5.1 端口。在 AS100-B,AS100-C,AS100-D 三台路由器上启动 BGP 同步，配置为：

```
AS100-B(config)#router bgp 100
AS100-B(config-router)#synchronization
```

启动同步后，我们可以看到 AS200-A 学不到 192.168.2.0 网段的 BGP 信息，AS300-E 学不到 10.10.1.0，10.10.2.0 网段的信息的 BGP 表为：

1) 路由器AS200-A TOP

- **show ip route**

```
As200-A#show ip bgp
BGP table version is 17, local router ID is 10.10.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     0.0.0.0                  0         32768 i
```

```
*> 10.10.2.0/24       0.0.0.0                  0         32768 i
*> 172.16.0.0/24      172.16.6.2               0             0 100 i
*> 172.16.2.0/24      172.16.6.2                             0 100 i
*> 172.16.3.0/24      172.16.6.2               0             0 100 i
*> 172.16.4.0/24      172.16.6.2                             0 100 i
*  172.16.6.0/24      172.16.6.2               0             0 100 i
*>                    0.0.0.0                  0         32768 i
*> 172.16.7.0/24      172.16.6.2               0             0 100 i
*> 172.16.16.0/24     172.16.6.2                             0 100 i
```

- **show ip bgp** [TOP]

```
AS200_A#show ip bgp
BGP table version is 24, local router ID is 10.10.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     0.0.0.0                  0         32768 i
*> 10.10.2.0/24     0.0.0.0                  0         32768 i
*> 172.16.0.0/24    172.16.6.2               0             0 100 i
*> 172.16.1.0/24    172.16.6.2                             0 100 i
*> 172.16.2.0/24    172.16.6.2                             0 100 i
*> 172.16.3.0/24    172.16.6.2               0             0 100 i
*> 172.16.4.0/24    172.16.6.2                             0 100 i
*> 172.16.6.0/24    172.16.6.2               0             0 100 i
*> 172.16.7.0/24    172.16.6.2               0             0 100 i
*> 172.16.16.0/24   172.16.6.2                             0 100 i
```

2）路由器AS100-B [TOP]

在路由器 AS100-B 上是可以看到 10.10.1.0/24 和 10.10.2.0/24 网段的

- **show ip bgp**

```
as100-B#show ip bgp
BGP table version is 11, local router ID is 172.16.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i10.10.1.0/24     172.16.6.1               0    100      0 200 i
* i10.10.2.0/24     172.16.6.1               0    100      0 200 i
*>i172.16.0.0/24    172.16.7.2               0    100      0 i
*> 172.16.0.0/22    0.0.0.0                            32768 i
*>i172.16.1.0/24    172.16.4.1               0    100      0 i
*> 172.16.2.0/24    0.0.0.0                  0         32768 i
*>i172.16.3.0/24    172.16.7.2               0    100      0 i
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 172.16.4.0/24	0.0.0.0	0		32768	i
*>i172.16.6.0/24	172.16.7.2	0	100	0	i
*>i172.16.7.0/24	172.16.7.2	0	100	0	i
* 172.16.16.0/24	172.16.16.1	0		0	300 i
*>	0.0.0.0	0		32768	i
*> 192.168.2.0	172.16.16.1	0		0	300 i

as100-B#

3）路由器AS100-C TOP

AS100-C#show ip bgp
BGP table version is 70, local router ID is 172.16.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
* i10.10.1.0/24	172.16.6.1	0	100	0	200 i
* i10.10.2.0/24	172.16.6.1	0	100	0	200 i
*>i172.16.0.0/24	172.16.7.2	0	100	0	i
* i172.16.0.0/22	172.16.4.2		100	0	i
*> 172.16.1.0/24	0.0.0.0	0		32768	i
*>i172.16.2.0/24	172.16.4.2	0	100	0	i
*>i172.16.3.0/24	172.16.7.2	0	100	0	i
* i172.16.4.0/24	172.16.4.2	0	100	0	i
*>	0.0.0.0	0		32768	i
*>i172.16.6.0/24	172.16.7.2	0	100	0	i
* i172.16.7.0/24	172.16.7.2	0	100	0	i
*>	0.0.0.0	0		32768	i
*>i172.16.16.0/24	172.16.4.2	0	100	0	i
* i192.168.2.0	172.16.16.1	0	100	0	300 i

4) 路由器AS100-D TOP

AS100-D#show ip bgp
BGP table version is 12, local router ID is 172.16.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 10.10.1.0/24	172.16.6.1	0		0	200 i
*> 10.10.2.0/24	172.16.6.1	0		0	200 i
*> 172.16.0.0/24	0.0.0.0	0		32768	i
* i172.16.0.0/22	172.16.4.2		100	0	i
*>i172.16.1.0/24	172.16.7.1	0	100	0	i
*>i172.16.2.0/24	172.16.4.2	0	100	0	i

```
*> 172.16.3.0/24      0.0.0.0                  0         32768 i
*>i172.16.4.0/24      172.16.4.2               0    100      0 i
*> 172.16.6.0/24      0.0.0.0                  0         32768 i
*                     172.16.6.1               0             0 200 i
*> 172.16.7.0/24      0.0.0.0                  0         32768 i
*>i172.16.16.0/24     172.16.4.2               0    100      0 i
* i192.168.2.0        172.16.16.1              0    100      0 300 i
AS100-D#
```

5）路由器AS300－E [TOP]

在路由器 AS300－E 上看不到 10.10.1.0/24 和 10.10.2.0/24 网段

```
as300-E#show ip bgp
BGP table version is 18, local router ID is 192.168.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 172.16.0.0/24    172.16.16.2                            0 100 i
*> 172.16.0.0/22    172.16.16.2                            0 100 i
*> 172.16.2.0/24    172.16.16.2              0             0 100 i
*> 172.16.3.0/24    172.16.16.2                            0 100 i
*> 172.16.4.0/24    172.16.16.2              0             0 100 i
*> 172.16.6.0/24    172.16.16.2                            0 100 i
*> 172.16.7.0/24    172.16.16.2                            0 100 i
*  172.16.16.0/24   172.16.16.2              0             0 100 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.2.0      0.0.0.0                  0         32768 i
as300-E#
```

3. 同步问题的解决

在启用同步后，可以通过把 BGP 的内容重发布到 IGP 来克服同步带来的问题。

在 AS100-B 与 AS100-D 上配置：

```
router rip
   version 2
   redistribute bgp 100 metric 2
   network 172.16.0.0
```

配置后可以看到 AS200-A 与 AS300-E 上又学到了对方的路由条目，结果为：

- **路由器AS200-A** [TOP]

```
AS200-A#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/16 is variably subnetted, 8 subnets, 2 masks
B       172.16.16.0/24 [20/0] via 172.16.6.2, 00:17:41
B       172.16.4.0/24 [20/0] via 172.16.6.2, 00:17:41
C       172.16.6.0/24 is directly connected, Serial0/1
B       172.16.7.0/24 [20/0] via 172.16.6.2, 00:22:08
B       172.16.0.0/22 [20/0] via 172.16.6.2, 00:09:12
B       172.16.0.0/24 [20/0] via 172.16.6.2, 00:22:08
B       172.16.2.0/24 [20/0] via 172.16.6.2, 00:17:41
B       172.16.3.0/24 [20/0] via 172.16.6.2, 00:22:08
     10.0.0.0/24 is subnetted, 2 subnets
C       10.10.1.0 is directly connected, Loopback1
C       10.10.2.0 is directly connected, Loopback3
B    192.168.2.0/24 [20/0] via 172.16.6.2, 00:09:12

AS200-A#show ip bgp
BGP table version is 19, local router ID is 10.10.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     0.0.0.0                  0         32768 i
*> 10.10.2.0/24     0.0.0.0                  0         32768 i
*> 172.16.0.0/24    172.16.6.2               0             0 100 i
*> 172.16.0.0/22    172.16.6.2                             0 100 i
*> 172.16.2.0/24    172.16.6.2                             0 100 i
*> 172.16.3.0/24    172.16.6.2               0             0 100 i
*> 172.16.4.0/24    172.16.6.2                             0 100 i
*  172.16.6.0/24    172.16.6.2               0             0 100 i
*>                  0.0.0.0                  0         32768 i
*> 172.16.7.0/24    172.16.6.2               0             0 100 i
*> 172.16.16.0/24   172.16.6.2                             0 100 i
*> 192.168.2.0      172.16.6.2                             0 100 300 i
As200-A#
```

- **路由器AS100－B** TOP

```
as100-B#show ip bgp
BGP table version is 11, local router ID is 172.16.2.1
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i10.10.1.0/24     172.16.6.1               0    100      0 200 i
* i10.10.2.0/24     172.16.6.1               0    100      0 200 i
*>i172.16.0.0/24    172.16.7.2               0    100      0 i
*> 172.16.0.0/22    0.0.0.0                            32768 i
*>i172.16.1.0/24    172.16.4.1               0    100      0 i
*> 172.16.2.0/24    0.0.0.0                  0         32768 i
*>i172.16.3.0/24    172.16.7.2               0    100      0 i
*> 172.16.4.0/24    0.0.0.0                  0         32768 i
*>i172.16.6.0/24    172.16.7.2               0    100      0 i
*>i172.16.7.0/24    172.16.7.2               0    100      0 i
*  172.16.16.0/24   172.16.16.1              0             0 300 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.2.0      172.16.16.1              0             0 300 I
```

● 路由器AS100－C TOP

```
AS100-C#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/16 is variably subnetted, 9 subnets, 2 masks
R       172.16.16.0/24 [120/1] via 172.16.4.2, 00:00:10, Serial2
C       172.16.4.0/24 is directly connected, Serial2
R       172.16.6.0/24 [120/1] via 172.16.7.2, 00:00:15, Serial0
C       172.16.7.0/24 is directly connected, Serial0
R       172.16.0.0/22 [120/2] via 172.16.4.2, 00:00:10, Serial2
R       172.16.0.0/24 [120/1] via 172.16.7.2, 00:00:15, Serial0
C       172.16.1.0/24 is directly connected, Loopback0
R       172.16.2.0/24 [120/1] via 172.16.4.2, 00:00:10, Serial2
R       172.16.3.0/24 [120/1] via 172.16.7.2, 00:00:15, Serial0
R    10.0.0.0/8 [120/2] via 172.16.7.2, 00:00:15, Serial0
R    192.168.2.0/24 [120/2] via 172.16.4.2, 00:00:10, Serial2
AS100-C#show ip bgp
BGP table version is 72, local router ID is 172.16.1.1
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i10.10.1.0/24     172.16.6.1               0    100      0 200 i
* i10.10.2.0/24     172.16.6.1               0    100      0 200 i
*>i172.16.0.0/24    172.16.7.2               0    100      0 i
*>i172.16.0.0/22    172.16.4.2                    100      0 i
*> 172.16.1.0/24    0.0.0.0                  0         32768 i
*>i172.16.2.0/24    172.16.4.2               0    100      0 i
*>i172.16.3.0/24    172.16.7.2               0    100      0 i
* i172.16.4.0/24    172.16.4.2               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.6.0/24    172.16.7.2               0    100      0 i
* i172.16.7.0/24    172.16.7.2               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.16.0/24   172.16.4.2               0    100      0 i
*>i192.168.2.0      172.16.16.1              0    100      0 300 i
AS100-C#
```

● 路由器AS100－D TOP

```
AS100-D#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/16 is variably subnetted, 9 subnets, 2 masks
R       172.16.16.0/24 [120/2] via 172.16.7.1, 00:00:07, Serial0/0
R       172.16.4.0/24 [120/1] via 172.16.7.1, 00:00:07, Serial0/0
C       172.16.6.0/24 is directly connected, Serial0/1
C       172.16.7.0/24 is directly connected, Serial0/0
R       172.16.0.0/22 [120/3] via 172.16.7.1, 00:00:07, Serial0/0
C       172.16.0.0/24 is directly connected, Loopback0
R       172.16.1.0/24 [120/1] via 172.16.7.1, 00:00:07, Serial0/0
R       172.16.2.0/24 [120/2] via 172.16.7.1, 00:00:07, Serial0/0
C       172.16.3.0/24 is directly connected, Loopback1
     10.0.0.0/24 is subnetted, 2 subnets
```

```
B         10.10.1.0 [20/0] via 172.16.6.1, 00:22:01
B         10.10.2.0 [20/0] via 172.16.6.1, 00:22:01
R     192.168.2.0/24 [120/3] via 172.16.7.1, 00:00:12, Serial0/0
```

```
AS100-D#show ip bgp
BGP table version is 14, local router ID is 172.16.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.6.1               0             0 200 i
*> 10.10.2.0/24     172.16.6.1               0             0 200 i
*> 172.16.0.0/24    0.0.0.0                  0         32768 i
*>i172.16.0.0/22    172.16.4.2                    100      0 i
*>i172.16.1.0/24    172.16.7.1               0    100      0 i
*>i172.16.2.0/24    172.16.4.2               0    100      0 i
*> 172.16.3.0/24    0.0.0.0                  0         32768 i
*>i172.16.4.0/24    172.16.4.2               0    100      0 i
*> 172.16.6.0/24    0.0.0.0                  0         32768 i
*                       172.16.6.1               0             0 200 i
*> 172.16.7.0/24    0.0.0.0                  0         32768 i
*>i172.16.16.0/24   172.16.4.2               0    100      0 i
*>i192.168.2.0      172.16.16.1              0    100      0 300 i
AS100-D#
```

5）路由器AS300－E <u>**TOP**</u>

```
as300-E#show   ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     172.16.0.0/16 is variably subnetted, 8 subnets, 2 masks
C         172.16.16.0/24 is directly connected, Ethernet0
B         172.16.4.0/24 [20/0] via 172.16.16.2, 00:20:02
B         172.16.6.0/24 [20/0] via 172.16.16.2, 00:15:08
B         172.16.7.0/24 [20/0] via 172.16.16.2, 00:15:08
```

```
B          172.16.0.0/24 [20/0] via 172.16.16.2, 00:15:08
B          172.16.0.0/22 [20/0] via 172.16.16.2, 00:20:02
B          172.16.2.0/24 [20/0] via 172.16.16.2, 00:20:02
B          172.16.3.0/24 [20/0] via 172.16.16.2, 00:15:08
C       192.168.2.0/24 is directly connected, Loopback1
as300-E#show ip bgp
BGP table version is 18, local router ID is 192.168.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 172.16.0.0/24    172.16.16.2                           0 100 i
*> 172.16.0.0/22    172.16.16.2                           0 100 i
*> 172.16.2.0/24    172.16.16.2              0            0 100 i
*> 172.16.3.0/24    172.16.16.2                           0 100 i
*> 172.16.4.0/24    172.16.16.2              0            0 100 i
*> 172.16.6.0/24    172.16.16.2                           0 100 i
*> 172.16.7.0/24    172.16.16.2                           0 100 i
*  172.16.16.0/24   172.16.16.2              0            0 100 i
*>                  0.0.0.0                  0        32768 i
*> 192.168.2.0      0.0.0.0                  0        32768 i
```

三、配置路由反射器

1．路由反射器原理

在同一个 AS 中，各个 IBGP 邻居默认是不将从一个 IBGP 邻居学来的路由消息转发给另外的 IBGP 邻居，所以通常各个 IBGP 之间要建立全互联关系。那样，随着 IBGP 邻居的增多，路由上的开销就会很大。为了解决这个问题，就采用了路由反射器，这样一部分路由器只要跟路由反射服务器建立 IBGP 关系即可，而没有必要两两建立全互联连接。

2．路由反射器配置

1）先把 AS100-B 和 AS100-D 之间的 bgp 邻居关系去掉

```
AS100-B
router bgp 100
      no neighbor 172.16.7.2 remote-as 100

AS100-D
Router bgp 100
      No neighbor 172.16.4.2 remote-as 100
```

配置后，我们能发现，在 AS100-B 上没有 172.16.0.0、172.16.3.0 网段，在 AS100-D 路由器上，没有关于 192.168.2.0、172.16.2.0 网段的信息：

- **路由器AS100-B**   TOP

```
RouterB#sh ip bgp
BGP table version is 7, local router ID is 172.16.2.1
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i172.16.1.0/24    172.16.4.1               0    100      0 i
*> 172.16.2.0/24    0.0.0.0                  0         32768 i
* i172.16.4.0/24    172.16.4.1               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.7.0/24    172.16.4.1               0    100      0 i
*> 172.16.16.0/24   0.0.0.0                  0         32768 i
*> 192.168.2.0      172.16.16.1              0             0 300 i
```

● **路由器AS100-D** TOP

```
AS100-D#show ip bgp
BGP table version is 22, local router ID is 172.16.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.6.1               0             0 200 i
*> 172.16.0.0/24    0.0.0.0                  0         32768 i
*>i172.16.1.0/24    172.16.7.1               0    100      0 i
*> 172.16.3.0/24    0.0.0.0                  0         32768 i
*>i172.16.4.0/24    172.16.7.1               0    100      0 i
*> 172.16.5.0/24    172.16.6.1               0             0 200 i
*> 172.16.6.0/24    0.0.0.0                  0         32768 i
*                   172.16.6.1               0             0 200 i
* i172.16.7.0/24    172.16.7.1               0    100      0 i
*>                  0.0.0.0                  0         32768 i
AS100-D#
```

2）在 **AS100-C** 上配置路由反射器：

```
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 172.16.1.0 mask 255.255.255.0
 network 172.16.4.0 mask 255.255.255.0
 network 172.16.7.0 mask 255.255.255.0
 neighbor 172.16.4.2 remote-as 100
 neighbor 172.16.4.2 route-reflector-client
 neighbor 172.16.7.2 remote-as 100
 neighbor 172.16.7.2 route-reflector-client
 no auto-summary
```

通过路由反射器，我们又能在 AS100-D、AS100-B 可以上看到如下结果：

- **路由器AS100-B** [TOP](#)

```
RouterB#sh ip bgp
BGP table version is 14, local router ID is 172.16.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i172.16.0.0/24    172.16.7.2               0    100      0 i
*>i172.16.1.0/24    172.16.4.1               0    100      0 i
*> 172.16.2.0/24    0.0.0.0                  0         32768 i
*>i172.16.3.0/24    172.16.7.2               0    100      0 i
* i172.16.4.0/24    172.16.4.1               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.6.0/24    172.16.7.2               0    100      0 i
*>i172.16.7.0/24    172.16.4.1               0    100      0 i
*> 172.16.16.0/24   0.0.0.0                  0         32768 i
*> 192.168.2.0      172.16.16.1              0             0 300 i
```

- **路由器AS100-D** [TOP](#)

```
AS100-D#show ip bgp
BGP table version is 30, local router ID is 172.16.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i10.10.1.0/24     172.16.5.1               0    100      0 200 i
*>                  172.16.6.1               0             0 200 i
*> 172.16.0.0/24    0.0.0.0                  0         32768 i
*>i172.16.1.0/24    172.16.7.1               0    100      0 i
*>i172.16.2.0/24    172.16.4.2               0    100      0 i
*> 172.16.3.0/24    0.0.0.0                  0         32768 i
*>i172.16.4.0/24    172.16.7.1               0    100      0 i
*>i172.16.5.0/24    172.16.4.2               0    100      0 i
*                   172.16.6.1               0             0 200 i
*> 172.16.6.0/24    0.0.0.0                  0         32768 i
*                   172.16.6.1               0             0 200 i
* i172.16.7.0/24    172.16.7.1               0    100      0 i
*>                  0.0.0.0                  0         32768 i
*>i172.16.16.0/24   172.16.4.2               0    100      0 i
*>i192.168.2.0      172.16.16.1              0    100      0 300 i
AS100-D#
```

四、配置汇聚路由

1． 在 AS100-B 上，可以汇聚一条路由

配置为：

as100-B(config-router)#aggregate-address 172.16.0.0 255.255.248.0

可以在AS300-E上看到结果： **TOP**

```
as300-E#show ip bgp
BGP table version is 141, local router ID is 192.168.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.16.2                             0 100 200 i
*> 172.16.0.0/24    172.16.16.2                             0 100 i
*> 172.16.0.0/21    172.16.16.2                             0 100 i
*> 172.16.1.0/24    172.16.16.2                             0 100 i
*> 172.16.2.0/24    172.16.16.2              0              0 100 i
*> 172.16.3.0/24    172.16.16.2                             0 100 i
*> 172.16.4.0/24    172.16.16.2              0              0 100 i
*> 172.16.5.0/24    172.16.16.2              0              0 100 i
*> 172.16.6.0/24    172.16.16.2                             0 100 i
*> 172.16.7.0/24    172.16.16.2                             0 100 i
*  172.16.16.0/24   172.16.16.2              0              0 100 i
*>                  0.0.0.0                  0          32768 i
*> 192.168.2.0      0.0.0.0                  0          32768 I
```

2．在配置的时候，还可以用 summary-only 参数，让 bgp 路由器只发送汇总的路由：

as100-B(config-router)#aggregate-address 172.16.0.0 255.255.248.0 summary-only

结果为：(注意 AS100-B 上的小 s 是指这条路由条目抑制不发送，这个时候 AS300-E 上只有汇总后的路由了）

as100-B#show ip bgp **TOP**

```
BGP table version is 25, local router ID is 172.16.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.5.1               0              0 200 i
s>i172.16.0.0/24    172.16.7.2               0    100       0 i
*> 172.16.0.0/21    0.0.0.0                             32768 i
s>i172.16.1.0/24    172.16.4.1               0    100       0 i
s> 172.16.2.0/24    0.0.0.0                  0          32768 i
s>i172.16.3.0/24    172.16.7.2               0    100       0 i
s> 172.16.4.0/24    0.0.0.0                  0          32768 i
s i                 172.16.4.1               0    100       0 i
```

```
s> 172.16.5.0/24     0.0.0.0                  0          32768 i
s                      172.16.5.1               0               0 200 i
s   172.16.6.0/24     172.16.5.1               0               0 200 i
s>i                    172.16.7.2               0     100        0 i
s>i172.16.7.0/24      172.16.4.1               0     100        0 i
*> 172.16.16.0/24     0.0.0.0                  0          32768 i
*                      172.16.16.1              0               0 300 i
*> 192.168.2.0        172.16.16.1              0               0 300 i
as100-B#
```

as300-E#sho ip bgp [**TOP**]

```
BGP table version is 153, local router ID is 192.168.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.1.0/24     172.16.16.2                            0 100 200 i
*> 172.16.0.0/21    172.16.16.2                            0 100 i
*   172.16.16.0/24  172.16.16.2              0             0 100 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.2.0      0.0.0.0                  0         32768 i
as300-E#
```

五、 配置前缀列表(prefix list)

1. 前缀列表

在路由信息过滤方面，前缀列表与发布列表(distribute-list)有相同的功效，但前者可以看作是后者的改进，从而具有更好的操控性。

命令格式为：

(config)#**ip prefix-list** list-name **[seq** seq-value] **permit|deny** network/len
[ge ge-value]**[le** le-value]

2. 在本实验中，为控制 AS100-B 只发送 172.16.0.0/16 到 172.16.0.0/24 网段的路由条目给 AS300-E，就可以采用前缀列表，具体配置为：

```
AS100-B
router bgp 100
no synchronization
network 172.16.2.0 mask 255.255.255.0
network 172.16.4.0 mask 255.255.255.0
network 172.16.5.0 mask 255.255.255.0
network 172.16.16.0 mask 255.255.255.0
aggregate-address 172.16.0.0 255.255.252.0
neighbor 172.16.4.1 remote-as 100
neighbor 172.16.5.1 remote-as 200
neighbor 172.16.16.1 remote-as 300
```

neighbor 172.16.16.1 prefix-list aaa out
!
ip prefix-list aaa seq 5 deny 172.16.3.0/24
ip prefix-list aaa seq 10 permit 172.16.0.0/16 le 24
!

3．在路由器 AS300-E 上的实验结果为：（注意，没有 10.10.1.0 与 10.10.2.0 和 172.16.3.0）

as300-E#show ip bgp　　　**TOP**

BGP table version is 12, local router ID is 192.168.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	172.16.0.0/24	172.16.16.2			0	100 i
*>	172.16.0.0/22	172.16.16.2			0	100 i
*>	172.16.1.0/24	172.16.16.2			0	100 i
*>	172.16.2.0/24	172.16.16.2	0		0	100 i
*>	172.16.4.0/24	172.16.16.2	0		0	100 i
*>	172.16.5.0/24	172.16.16.2	0		0	100 i
*>	172.16.6.0/24	172.16.16.2			0	100 i
*>	172.16.7.0/24	172.16.16.2			0	100 i
*>	172.16.16.0/24	0.0.0.0	0		32768	i
*		172.16.16.2	0		0	100 i
*>	192.168.2.0	0.0.0.0	0		32768	i

as300-E#

六、　配置团体字属性

1．Community 属性

Community 属性可以让一组目的网段享用某些相同的路由特性，但这些目的网段不必要求处于同一 AS。它可以用来控制 BGP 信息所经过的路由器怎么对待这条 BGP 信息，比如：NO_EXPORT 为不发布到别的 AS，NO_ADV 为不在发布到别的路由器，Local_AS 为这个信息为内部 AS 信息，应该发布到 AS 内部，但不应该发布到公众网上，internet 为公网信息。这些都是公共 community 属性，当然，还可以用一些如 10～777 的数字来表示。

2．Community 配置

1）配置之前 AS300-E 的 bgp 表

as300-E#show ip bgp　　　**TOP**

BGP table version is 15, local router ID is 192.168.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	10.10.1.0/24	172.16.16.2			0	100 200 i

*> 10.10.2.0/24	172.16.16.2		0 100 200 i
*> 172.16.0.0/24	172.16.16.2		0 100 i
*> 172.16.0.0/22	172.16.16.2		0 100 i
*> 172.16.1.0/24	172.16.16.2		0 100 i
*> 172.16.2.0/24	172.16.16.2	0	0 100 i
*> 172.16.3.0/24	172.16.16.2		0 100 i
*> 172.16.4.0/24	172.16.16.2	0	0 100 i
*> 172.16.5.0/24	172.16.16.2	0	0 100 i
*> 172.16.6.0/24	172.16.16.2		0 100 i
*> 172.16.7.0/24	172.16.16.2		0 100 i
*> 172.16.16.0/24	0.0.0.0	0	32768 i
*	172.16.16.2	0	0 100 i
*> 192.168.2.0	0.0.0.0	0	32768 i

2）为了让发到 AS200 中的关于 10.10.1.0 网段的信息不再发送到 as300 中去，我们可以在 AS200-A 上配置 NO_EXPORT 参数，

在 AS200-A 上配置为：

```
router bgp 200
neighbor 172.16.5.2 send-community
neighbor 172.16.5.2 route-map SETCOMMUNITY out
neighbor 172.16.6.2 send-community
!
access-list 1 permit 10.10.1.0 0.0.0.255
!
route-map SETCOMMUNITY permit 10
 match ip address 1
 set community no-export
!
route-map SETCOMMUNITY permit 20
!
```

配置后在 AS300-E 上的 bgp 表为：（注意，没有 10.10.1.0 网段）

as300-E#show ip bgp TOP

BGP table version is 13, local router ID is 192.168.2.1

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf Weight Path
*> 10.10.2.0/24	172.16.16.2		0 100 200 i
*> 172.16.0.0/24	172.16.16.2		0 100 i
*> 172.16.0.0/22	172.16.16.2		0 100 i
*> 172.16.1.0/24	172.16.16.2		0 100 i
*> 172.16.2.0/24	172.16.16.2	0	0 100 i
*> 172.16.3.0/24	172.16.16.2		0 100 i

```
*> 172.16.4.0/24      172.16.16.2              0              0 100 i
*> 172.16.5.0/24      172.16.16.2              0              0 100 i
*> 172.16.6.0/24      172.16.16.2                             0 100 i
*> 172.16.7.0/24      172.16.16.2                             0 100 i
*  172.16.16.0/24     172.16.16.2              0              0 100 i
*>                    0.0.0.0                  0          32768 i
*> 192.168.2.0        0.0.0.0                  0          32768 i
as300-E#
```

注意：如果是直接在以上几步的基础上配置 community，则由于已将 BGP 信息导进了 IGP 中，10.10.1.0 网段的信息仍然会通过路由器 AS100-D 传给 AS100-B，之后 AS100-B 再传给 AS300-E，从而 AS300-E 也可以看到 10.10.l.0 网段的信息。此时，AS200-A 发给 AS100-D 关于 10.10.1.0 网段的路由信息也要设置 NO-EXPORT 的 community 属性。

七、 学会配置 peer-group

1． Peer-group

有时对于某个 BGP 路由，其若干个邻居（IBGP 或 EBGP 邻居）有共同的属性、可以实施共同的路由策略、可以使用相同的过滤列表等。这时，就可以使用 peer-group，一来减少配置量，二来减少路由更新量（同一个 peer-group 的全部 n 个成员只产生一条更新，而不是 n 条相同的更新）。

2． Peer-group 配置

从刚才的配置经历中，我们可以发现在我们的实验拓扑中，AS100-C 的两个邻居 AS100-B 和 AS100-D 的配置属性相同，AS200-A 的两个 EBGP 邻居 AS100-B 和 AS100-D 也具有相同的配置属性，则可以采用 peer-group 来简化配置。

它们的配置如下：

- **路由器AS100-C** **TOP**

  在 AS100-C 上配置，把 172.16.1.0 网段加入团体属性 NO_ADVERTISE 。另外，AS100-B 和 AS100-D 同为 AS100，同为 AS100-C 的路由反射器客户，配置如下：

```
router bgp 100
    no synchronization
    bgp log-neighbor-changes
    network 172.16.1.0 mask 255.255.255.0
    network 172.16.4.0 mask 255.255.255.0
    network 172.16.7.0 mask 255.255.255.0
    neighbor LOCAL peer-group
    neighbor LOCAL remote-as 100
    neighbor LOCAL route-reflector-client
    neighbor LOCAL send-community
    neighbor LOCAL route-map NOADV out
    neighbor 172.16.4.2 peer-group LOCAL
    neighbor 172.16.7.2 peer-group LOCAL
    no auto-summary
```

```
!
access-list 2 permit 172.16.1.0 0.0.0.255
!
route-map NOADV permit 10
    match ip address 2
    set community no-advertise
!
```

- **路由器AS200-A** TOP

AS100-B 和 AS100-D 同是 AS200-A 的 EBGP 邻居且都在 AS100 上，有相同的 community 属性设置，其配置如下：

```
router bgp 100
    no synchronization
    bgp log-neighbor-changes
    network 172.16.5.0 mask 255.255.255.0
    network 172.16.6.0 mask 255.255.255.0
    neighbor REMOTE peer-group
    neighbor REMOTE remote-as 100
    neighbor REMOTE send-community
    neighbor REMOTE route-map NOEXPORT out
    neighbor 172.16.5.2 peer-group REMOTE
    neighbor 172.16.6.2 peer-group REMOTE
    no auto-summary
!
access-list 1 permit 10.10.1.0 0.0.0.255
!
route-map NOEXPORT permit 10
    match ip address 1
    set community no-export
!
```

3．实验结果

在 AS200－A 和 AS300－E 上没有关于 172.16.1.0 网段的信息，在 AS300-E 上没有 10.10.1.0 网段的信息。（这里略过 AS200-A 的 bgp 表）

- **路由器AS300-E** TOP

```
as300-E#show ip bgp
BGP table version is 11, local router ID is 192.168.2.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 10.10.2.0/24     172.16.16.2                            0 100 200 i
*> 172.16.0.0/22    172.16.16.2                            0 100 i
```

```
*> 172.16.2.0/24     172.16.16.2              0              0 100 i
*> 172.16.3.0/24     172.16.16.2                             0 100 i
*> 172.16.4.0/24     172.16.16.2              0              0 100 i
*> 172.16.5.0/24     172.16.16.2              0              0 100 i
*> 172.16.6.0/24     172.16.16.2                             0 100 200 i
*> 172.16.16.0/24    0.0.0.0                  0          32768 i
*                    172.16.16.2              0              0 100 i
*> 192.168.2.0       0.0.0.0                  0          32768 i
as300-E#
```

八、 全部实验配置结果

这里给出 5 台路由器最后的实验配置结果，如下所示。

1. 路由器AS200-A TOP

```
AS200_A#show run

Building configuration...


Current configuration : 1531 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS200_A
!
enable secret 5 $1$WB5E$dzaQm4c0Pn/NwgfD4Z0o..
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
```

```
!
!
!
interface Loopback0
 ip address 10.10.1.1 255.255.255.0
!
interface Loopback1
 ip address 10.10.2.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 ip address 172.16.6.1 255.255.255.0
 speed auto
!
interface Serial0
 ip address 172.16.5.1 255.255.255.0
 clockrate 56000
!
interface Serial1

 no ip address
 shutdown
!

router bgp 200
 bgp log-neighbor-changes
 network 10.10.1.0 mask 255.255.255.0
 network 10.10.2.0 mask 255.255.255.0
 network 172.16.5.0 mask 255.255.255.0
 network 172.168.6.0 mask 255.255.255.0
 neighbor REMOTE peer-group
 neighbor REMOTE remote-as 100
 neighbor REMOTE send-community
 neighbor REMOTE route-map NOEXPORT out
 neighbor 172.16.5.2 peer-group REMOTE
 neighbor 172.16.6.2 peer-group REMOTE
!
ip classless
no ip http server
ip pim bidir-enable
!
```

```
access-list 1 permit 10.10.1.0 0.0.0.255
!
route-map NOEXPORT permit 10
 match ip address 1
 set community no-export
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!

no scheduler allocate
end
```

2．路由器AS100-B **TOP**

```
RouterB#show run

Building configuration...

Current configuration : 1317 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname RouterB
!
enable password cisco
!
memory-size iomem 20
ip subnet-zero
!
!
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
```

```
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
interface Loopback0
 ip address 172.16.2.1 255.255.255.0
!
interface FastEthernet0
 no ip address
 shutdown
 speed auto
!
interface Serial0
 ip address 172.16.16.2 255.255.255.0
 clockrate 56000
!
interface Serial1
 ip address 172.16.4.2 255.255.255.0
!
interface Serial2
 ip address 172.16.5.2 255.255.255.0
!
interface Serial3
 no ip address
 shutdown
!
router rip
 version 2
 redistribute bgp 100 metric 2
 network 172.16.0.0
!
router bgp 100
 bgp log-neighbor-changes
 network 172.16.2.0 mask 255.255.255.0
 network 172.16.4.0 mask 255.255.255.0
 network 172.16.5.0 mask 255.255.255.0
 network 172.16.16.0 mask 255.255.255.0
 neighbor 172.16.4.1 remote-as 100
 neighbor 172.16.5.1 remote-as 200
 neighbor 172.16.16.1 remote-as 300
!
ip classless
no ip http server
```

```
ip pim bidir-enable
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end
```

3. 路由器AS100-C TOP

```
   RouterC#sho run
Building configuration...


Current configuration : 1395 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname RouterC
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
!
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
```

```
interface Loopback0
 ip address 172.16.1.1 255.255.255.0
!
interface FastEthernet0
 no ip address
 shutdown
 speed auto
!
interface Serial0
 ip address 172.16.4.1 255.255.255.0
 no fair-queue
 clockrate 56000
!
interface Serial1
 ip address 172.16.7.1 255.255.255.0
 clockrate 56000
!
router rip
 version 2
 network 172.16.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 172.16.1.0 mask 255.255.255.0
 network 172.16.4.0 mask 255.255.255.0
 network 172.16.7.0 mask 255.255.255.0
 neighbor LOCAL peer-group
 neighbor LOCAL remote-as 100
 neighbor LOCAL route-reflector-client
 neighbor LOCAL send-community
 neighbor LOCAL route-map NOADV out
 neighbor 172.16.4.2 peer-group LOCAL
 neighbor 172.16.7.2 peer-group LOCAL
 no auto-summary
!
ip classless
no ip http server
ip pim bidir-enable
!
access-list 2 permit 172.16.1.0 0.0.0.255
!
route-map NOADV permit 10
 match ip address 2
```

```
 set community no-advertise
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end
```

4. 路由器AS100-D **TOP**

```
RouterD#sh run
Building configuration...


Current configuration : 1271 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname RouterD
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
!
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
interface Loopback0
```

```
 ip address 172.16.0.1 255.255.255.0
!
interface Loopback1
 ip address 172.16.3.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 ip address 172.16.6.2 255.255.255.0
 speed auto
!
interface Serial0
 ip address 172.16.7.2 255.255.255.0
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
!
router rip
 version 2
 redistribute bgp 100 metric 2
 network 172.16.0.0
!
router bgp 100
 bgp log-neighbor-changes
 network 172.16.0.0 mask 255.255.255.0
 network 172.16.3.0 mask 255.255.255.0
 network 172.16.6.0 mask 255.255.255.0
 network 172.16.7.0 mask 255.255.255.0
 neighbor 172.16.6.1 remote-as 200
 neighbor 172.16.7.1 remote-as 100
 no auto-summary
!
ip classless
no ip http server
ip pim bidir-enable
!
!
!
line con 0
line aux 0
```

```
line vty 0 4
 password cisco
 login
!
```

5. 路由器AS300-E **TOP**

```
AS300-E#sh run

Building configuration...

Current configuration : 877 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname AS300-E
!
enable password cisco
!
memory-size iomem 15
mmi polling-interval 60
no mmi auto-configure
no mmi pvc
mmi snmp-timeout 180
ip subnet-zero
!
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
!
!
!
!
interface Loopback0
 ip address 192.168.2.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
```

```
!
interface FastEthernet0
 no ip address
 shutdown
 speed auto
!
interface Serial0
 ip address 172.16.16.1 255.255.255.0
!
interface Serial1
 no ip address
 shutdown
!
router bgp 300
 no synchronization

 bgp log-neighbor-changes
 network 192.168.2.0
 neighbor 172.16.16.2 remote-as 100
 no auto-summary
!
ip classless
no ip http server
ip pim bidir-enable
!
!
!
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
end
```

PPP 反向回拨

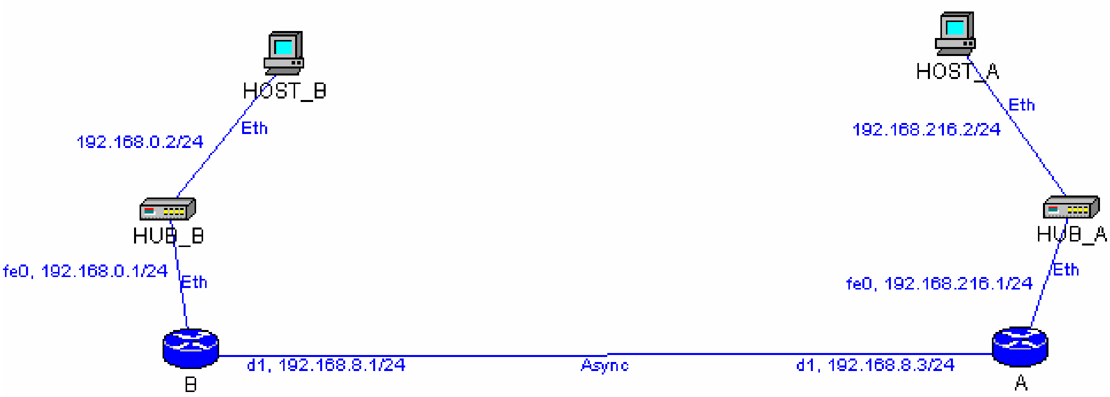
【实验目的】

配置拨号连接，配置和验证反向回拨。

【实验设备】

两台路由器 1700，两个 33.6Kbps Modern，程控交换机一台，两台 PC

【实验拓扑】

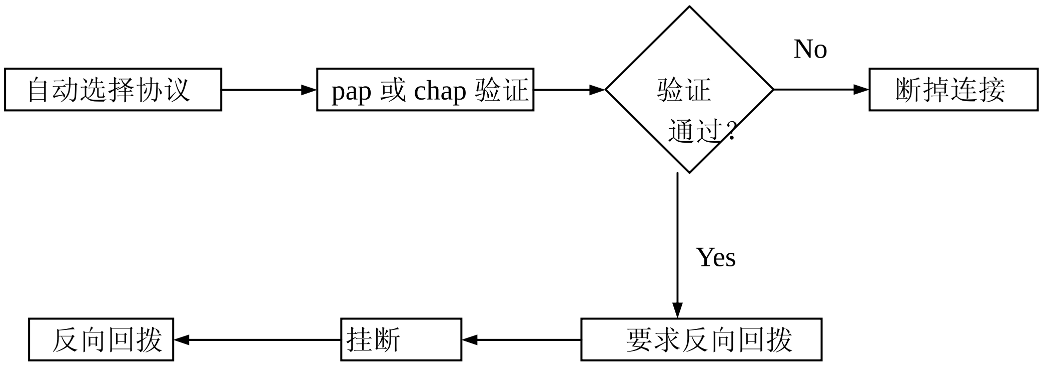


【实验原理】

PPP 反向回拨是 LCP 的一个选项，它采用的模型是 Client/Server 模型。该功能允许发起呼叫的路由器（即客户路由器）请求接收拨号连接的对端路由器（即 Server 路由器）进行回拨。反向回拨的主要目的是利用回拨这种特性来进行访问控制和节省路由器的长途呼叫费用以及统一计费。例如，如果从地区 A 呼叫地区 B 的长途电话费比从地区 B 呼叫地区 A 的费用贵的话，就可以让地区 B 的路由器反向回拨地区 A 的路由器，以节省长途电话费。

实现时，点对点链路两端的路由器都必须配置 PPP 反向回拨功能：其中一台路由器作为反向回拨的客户机，另一台作为反向回拨服务器。反向回拨客户机必须配置为能够发起 PPP 反向回拨请求，而反向回拨服务器必须被配置为能够接收 PPP 反向回拨请求并能发出返回拨叫。

回拨大致过程如下：由客户端发起呼叫并请求回拨，服务器端检查自己的配置，如果允许回拨则进行 pap 或 chap 认证。认证通过后，获得客户端的用户名，然后从自己的配置中识别出回拨号码，接着进行回拨。回拨过程中再进行相应的认证，如果回拨成功则链路 up 起来，如果不成功也不会再继续重试回拨。



【实验内容】

1.配置单向拨叫

（1）Router B（中心路由器）的基本配置为：

```
B(config)# interface Serial0
B(config-if)# physical-layer async
B(config-if)#ip address 192.168.8.1 255.255.255.0
B(config-if)#encapsulation ppp
B(config-if)# async mode dedicated
```

配置 line：

```
B(config)#line 1
B(config-if)#password cisco
B(config-if)#login
B(config-if)#modem InOut
B(config-if)#modem autoconfigure discovery
B(config-if)#transport input all
B(config-if)#stopbits 1
B(config-if)# speed 115200
B(config-if)#flowcontrol hardware
```

（2）Router A（远程节点路由器）的基本配置

```
A(config)#chat-script client ABORT ERROR   ""   "AT Z"   OK   "ATDT\T"   TIMEOUT   30
            CONNECT   \c        //注意空格和大小写

A(config)# interface Serial0
A(config-if)# physical-layer async
A(config-if)#encapsulation ppp
A(config-if)# dialer in-band
A(config-if)#ip address 192.168.8.3 255.255.255.0
A(config-if)# async mode dedicated
A(config-if)#  dialer  hold-queue  50        //定义在连接建立起来以前有多少数据包能进行排
                                             //队等待
A(config-if)# dialer map ip 192.168.8.1 name B modem-script client broadcast 88
                                             //88 为 B 区的电话号码，以实际的为准
A(config-if)# dialer-group 1
A(config)# dialer-list 1 protocol ip permit

A(config)#interface loopback 0
A(config-if)# ip address 192.168.1.1 255.255.255.0     //配置一个 loopback 端口便于反向 telnet
                                                       //到 modern 上便于测试
```

配置 line:

```
A(config)#line 1
A(config-if)#password cisco
A(config-if)#login
A(config-if)#modem InOut
```

A(config-if)#modem autoconfigure discovery
A(config-if)#transport input all
A(config-if)#stopbits 1
A(config-if)# speed 115200
A(config-if)#flowcontrol hardware
验证：
单向拨号成功后，可以用 show line，debug modem 来查看链路信息和拨叫连接过程。

2．配置 pap 或 chap 认证
（1）PAP 认证
B(config)# interface Serial0
B(config-if)#encapsulation ppp
B(config-if)#ppp authentication pap
B(config-if)#ppp pap sent-username B password ciscoB

B(config)#username A password ciscoA

A(config)# interface Serial0
A(config-if)#encapsulation ppp
A(config-if)#ppp authentication pap
A(config-if)#ppp pap sent-username A password ciscoA

A(config)#username B password ciscoB

验证:可以用 debug ppp authentication 看 pap 认证过程。

（2）CHAP 认证
B(config)# interface Serial0
B(config-if)#encapsulation ppp
B(config-if)#ppp authentication chap

B(config)#username A password cisco //username 为对端的 hostname，密码两边都相同

A(config)# interface Serial0
A(config-if)#encapsulation ppp
A(config-if)#ppp authentication chap

A(config)#username B password cisco //username 为对端的 hostname，密码两边都相同

3．配置反向回拨
B(config)#chat-script server ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT \c
B(config)# interface Serial0
B(config-if)# dialer in-band

B(config-if)# dialer hold-queue 50 //定义在连接建立起来以前有多少数据包能进行排队等待

B(config-if)# dialer-group 1

B(config)# dialer-list 1 protocol ip permit // 配置中心路由器 B 拨号的基本配置

在中心路由器上接受回拨请求：

B(config)# interface Serial0

B(config-if)#ppp callback accept

B(config-if)#exit

B(config)#map-class dialer dialback / /这个 dialer 类的名字

B(config-map-class)#dialer callback-server username //表明以根据拨号用户认证名和拨号映射重所规定的主机名来鉴别反向回拨客户的合法性

B(config-map-class)#exit

B(config)#int s0

B(config-if)# dialer map ip 192.168.8.3 name A class dialback modem-script server broadcast 87

//87 为 A 区的电话号码,以实际的为准

//将 dialback 这个反向拨号类绑定在了这个 dialer map 上

远程路由器发出回拨请求

A(config)# interface Serial0

A(config-if)#ppp callback request

A(config-if)#exit

为了保证以太网段的可达性，配置两条静态/默认路由：

B(config)#ip route 192.168.216.0 255.255.255.0 192.168.8.3

A(config)#ip route 0.0.0.0 0.0.0.0 192.168.8.1

验证：用 debug modem 命令。

在远程路由器上和/或主机上 ping 中心路由器或主机，观察拨号过程：routerA 发起呼叫，modern 拨号成功后，链路 up 起来。很快中心路由器就会断掉该链路，然后反向回拨远程路由器 A，建立一条由中心路由器发起的链路。

整个拨号过程的 debug modem 信息：

中心路由器 B:

01:51:01: TTY1: DSR came up
01:51:01: Modem 0/0 Modi: switching to PPP mode
01:51:01: TTY1: no timer type 1 to destroy
01:51:01: TTY1: no timer type 0 to destroy
01:51:01: tty1: Modem: IDLE->(unknown)
01:51:03: Modem 0/0: PPP escape map: Tx map = FFFFFFFF, Rx map = 0
01:51:03: %LINK-3-UPDOWN: Interface Serial0, changed state to up
01:51:03: Modem 0/0: PPP escape map: Tx map = A0000, Rx map = 0
01:51:03: TTY1: Async Int reset: Dropping DTR
01:51:04: TTY1: DSR was dropped
01:51:04: tty1: Modem: READY->(unknown)
01:51:05: TTY1: dropping DTR, hanging up
01:51:05: tty1: Modem: HANGUP->(unknown)
01:51:05: %LINK-5-CHANGED: Interface Serial0, changed state to reset
01:51:06: TTY1: cleanup pending. Delaying DTR
01:51:07: TTY1: cleanup pending. Delaying DTR
01:51:08: TTY1: cleanup pending. Delaying DTR
01:51:08: Modem 0/0 Modi: switching to character mode
01:51:08: TTY1: no timer type 0 to destroy
01:51:08: TTY1: no timer type 1 to destroy
01:51:08: TTY1: no timer type 3 to destroy
01:51:08: TTY1: no timer type 4 to destroy
01:51:08: TTY1: no timer type 2 to destroy
01:51:08: Serial0: allowing modem_process to continue hangup
01:51:09: TTY1: restoring DTR
01:51:10: TTY1: autoconfigure probe started
01:51:10: %LINK-3-UPDOWN: Interface Serial0, changed state to down
01:51:20: CHAT1: Attempting async line dialer script

01:51:20: CHAT1: process started
01:51:20: CHAT1: Asserting DTR
01:51:38: Modem 0/0 Modi: switching to PPP mode
01:51:38: TTY1: no timer type 1 to destroy
01:51:38: TTY1: no timer type 0 to destroy
01:51:40: %LINK-3-UPDOWN: Interface Serial0, changed state to up
01:51:40: Modem 0/0: PPP escape map: Tx map = FFFFFFFF, Rx map = 0
01:51:40: Modem 0/0: PPP escape map: Tx map = A0000, Rx map = 0
01:51:41: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0, changed state to up
B#show dialer interface s 0

Se0 - dialer type = IN-BAND ASYNC NO-PARITY
Idle timer (120 secs), Fast idle timer (20 secs)
Wait for carrier (30 secs), Re-enable (15 secs)
Dialer state is data link layer up
Dial reason: Callback return call
Time until disconnect 43 secs
Connected to 87 (A)

Dial String	Successes	Failures	Last DNIS	Last status
87	8	0	00:01:36	successful

120 秒断掉链路：
01:53:41: TTY1: Async Int reset: Dropping DTR
01:53:41: TTY1: DSR was dropped
01:53:41: tty1: Modem: READY->(unknown)
01:53:42: TTY1: dropping DTR, hanging up
01:53:42: tty1: Modem: HANGUP->(unknown)
01:53:43: %LINK-5-CHANGED: Interface Serial0, changed state to reset
01:53:43: TTY1: cleanup pending. Delaying DTR
01:53:44: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0, changed state to down
01:53:44: TTY1: cleanup pending. Delaying DTR
01:53:45: TTY1: cleanup pending. Delaying DTR
01:53:46: Modem 0/0 Modi: switching to character mode
01:53:46: TTY1: no timer type 0 to destroy
01:53:46: TTY1: no timer type 1 to destroy
01:53:46: TTY1: no timer type 3 to destroy
01:53:46: TTY1: no timer type 4 to destroy
01:53:46: TTY1: no timer type 2 to destroy
01:53:46: Serial0: allowing modem_process to continue hangup
01:53:46: TTY1: restoring DTR
01:53:48: TTY1: autoconfigure probe started
01:53:48: %LINK-3-UPDOWN: Interface Serial0, changed state to down

```
B#show dialer interface    s0

Se0 - dialer type = IN-BAND ASYNC NO-PARITY
Idle timer (120 secs), Fast idle timer (20 secs)
Wait for carrier (30 secs), Re-enable (15 secs)
Dialer state is idle

Dial String          Successes     Failures       Last DNIS      Last status
87                                8                0       00:04:06            successful
```

DHCP 服务器&IP Helper Address 实验讲义

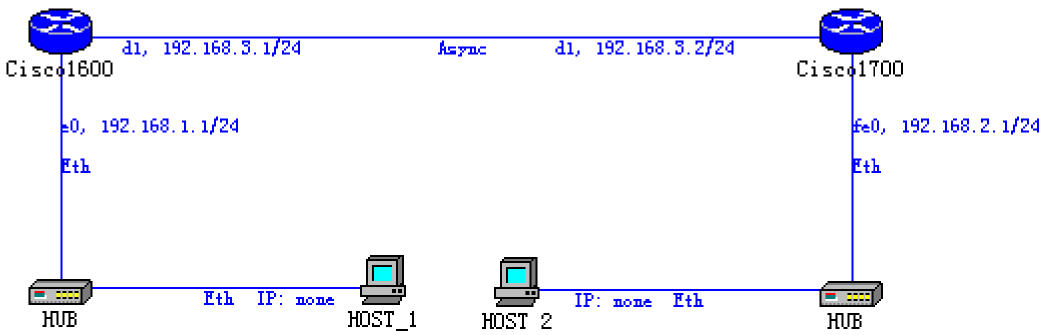
一. 实验目的

本实验的目的是让学员掌握在路由器上配置 DHCP 服务器的方法，并通过配置帮助地址将客户向 DHCP 服务器发出的广播转发成定点广播，以通过路由器到达服务器。

二. 实验设备

Cisco 路由器两部（1600 系列一部，1700 系列一部），带超级终端的 PC 机两台。

三. 实验拓朴



四. 实验步骤

1. 配置路由器端口的 IP 地址：

   1）Cisco1600 的配置：

   Cisco1600#config t

   Cisco1600 (config)#int e0

   Cisco1600 (config-if)#ip address 192.168.1.1 255.255.255.0

   Cisco1600 (config-if)#no shut

   Cisco1600 (config-if)#int s0

Cisco1600 (config-if)#ip address 192.168.3.1　255.255.255.0
Cisco1600 (config-if)#clock rate 56000
Cisco1600(config-if)#no shut

2）Cisco1700 的配置：

Cisco1700#config t
Cisco1700 (config)#int e0
Cisco1700 (config-if)#ip address 192.168.2.1　255.255.255.0
Cisco1700 (config-if)#no shut
Cisco1700 (config-if)#int s0
Cisco1700 (config-if)#ip address 192.168.3.2　255.255.255.0
Cisco1700(config-if)#no shut

2．使用 RIP 协议作为该网络的路由协议，实现网络的动态路由配置。完成配置后使用 show ip route,show interface,show running-configuration 查看路由配置的正确性或者使用 ping 命令验证网络之间是否完全互连。

1）Cisco1600 的配置：

Cisco1600#config t
Cisco1600 (config)#router rip
Cisco1600(config-router)#network 192.168.1.0
Cisco1600(config-router)#network 192.168.3.0

2）Cisco1700 的配置：

Cisco1700#config t
Cisco1700 (config)#router rip
Cisco1700(config-router)#network 192.168.2.0
Cisco1700(config-router)#network 192.168.3.0

3．在 Cisco1700 路由器上配置 DHCP 服务：

1）配置 192.168.1.0 网段的 DHCP 服务：

Cisco1700#config t
Cisco1700(config)#ip dhcp pool Host1
Cisco1700(dhcp-config)#network 192.168.1.0 255.255.255.0
Cisco1700(dhcp-config)#default-router 192.168.1.1
Cisco1700(dhcp-config)#dns-server 202.116.64.1
Cisco1700(config)#ip dhcp excluded-address 192.168.1.1

2）配置 192.168.2.0 网段的 DHCP 服务：

Cisco1700#config t
Cisco1700(config)#ip dhcp pool Host2
Cisco1700(dhcp-config)#network 192.168.2.0 255.255.255.0
Cisco1700(dhcp-config)#default-router 192.168.2.1

Cisco1700(dhcp-config)#dns-server 202.116.64.1
Cisco1700(config)#ip dhcp excluded-address 192.168.2.1

4．在 Cisco1600 路由器上配置 IP helper address：

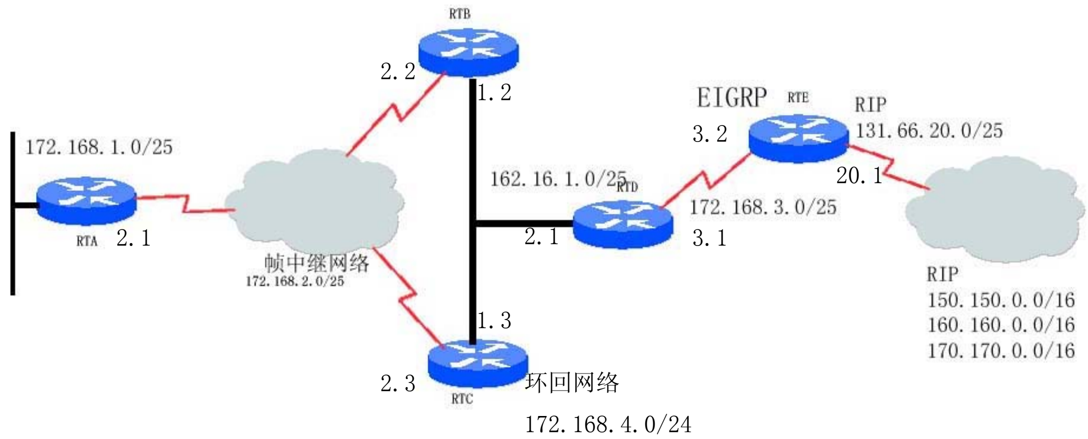
Cisco1600#config t
Cisco1600(config)#int e0
Cisoc1600(config-if)ip helper-address 192.168.3.2

5．验证 DHCP 和 IP helper address:

在 Host1 和 Host2 两台主机的网络 IP/TCP 属性上分别设置为自动获取 IP 地址，然后在主机的 MS-DOS 下执行 ipconfig /all 命令，可以查看到 Host1 和 Host2 自动获取到的 IP 地址，DHCP 服务器地址，DNS 服务器地址等信息。

Eigrp Troubleshooting

【实验拓扑】



说明：以 RTE 为界分为内部网络（左边）和外部网络（右边），内部网络运行 EIGRP 协议，外部网络运行 RIP 协议。

【实验目的】

1. 网络可以正常工作，所有路由器可以看以网络 172.168.1.0/24，172.168.2.0/24，172.168.2.0/24，172.168.4.0/24，162.16.1.0/24，150.150.0.0/16。
2. RTD 上有两条到达网络 172.168.2.0/24 的路径，而只有一条到达网络 172.168.4.0/24 的路径（事先已经配置好让 RTC 不在以太网口发布这个网络）。
3. 外部网络除 150.150.0.0/16 外全部不能被内部网络看到，内部网络只能通过缺省网络访问其它外部网络。

【错误设计】

一、二层出错，帧中继交换机被配成单向链路（即少一条 frame-relay map）

RTA#sh ip route

```
     172.168.0.0/24 is subnetted, 3 subnets
C       172.168.1.0 is directly connected, FastEthernet0
C       172.168.2.0 is directly connected, Serial0.1
D       172.168.3.0 [90/21026560] via 172.168.2.3, 00:34:08, Serial0.1
     162.16.0.0/24 is subnetted, 1 subnets
D       162.16.1.0 [90/20514560] via 172.168.2.3, 00:37:34, Serial0.1
D EX 150.150.0.0/16 [170/21282560] via 172.168.2.3, 00:24:00, Serial0.1
```

RTA#sh ip eigrp neighbors

```
IP-EIGRP neighbors for process 1
H    Address                 Interface        Hold  Uptime      SRTT     RTO    Q    Seq
Type
                                              (sec)             (ms)          Cnt Num
1    172.168.2.3             Se0.1            13 00:38:21    308    1848    0    23
```

RTA#sh frame-relay pvc

PVC Statistics for interface Serial0 (Frame Relay DTE)

	Active	Inactive	Deleted	Static
Local	1	0	1	0
Switched	0	0	0	0
Unused	0	0	0	0

DLCI = 101, DLCI USAGE = LOCAL, PVC STATUS = DELETED, INTERFACE = Serial0.1

input pkts 886 output pkts 97 in bytes 73955
out bytes 7548 dropped pkts 0 in FECN pkts 0
in BECN pkts 0 out FECN pkts 0 out BECN pkts 0
in DE pkts 0 out DE pkts 0
out bcast pkts 40 out bcast bytes 2560
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
pvc create time 01:04:01, last time pvc status changed 00:01:42

DLCI = 201, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0.1

input pkts 874 output pkts 97 in bytes 70019
out bytes 7068 dropped pkts 0 in FECN pkts 0
in BECN pkts 0 out FECN pkts 0 out BECN pkts 0
in DE pkts 0 out DE pkts 0
out bcast pkts 42 out bcast bytes 2688
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
pvc create time 01:03:55, last time pvc status changed 01:00:26

RTB#sh frame-relay pvc

PVC Statistics for interface Serial0 (Frame Relay DTE)

	Active	Inactive	Deleted	Static
Local	0	1	0	0
Switched	0	0	0	0
Unused	0	0	0	0

DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = INACTIVE, INTERFACE = Serial0.1

input pkts 97 output pkts 891 in bytes 7548
out bytes 74544 dropped pkts 0 in FECN pkts 0
in BECN pkts 0 out FECN pkts 0 out BECN pkts 0
in DE pkts 0 out DE pkts 0
out bcast pkts 863 out bcast bytes 72401
5 minute input rate 0 bits/sec, 0 packets/sec

5 minute output rate 0 bits/sec, 0 packets/sec
pvc create time 01:17:38, last time pvc status changed 00:02:43

RTB#sh ip route

172.168.0.0/24 is subnetted, 3 subnets
D   172.168.1.0 [90/20517120] via 162.16.1.3, 00:03:03, FastEthernet0
D   172.168.2.0 [90/20514560] via 162.16.1.3, 00:03:03, FastEthernet0
D   172.168.3.0 [90/2172416] via 162.16.1.1, 00:36:45, FastEthernet0
162.16.0.0/24 is subnetted, 1 subnets
C   162.16.1.0 is directly connected, FastEthernet0
D EX 150.150.0.0/16 [170/2428416] via 162.16.1.1, 00:26:38, FastEthernet0

二、共享链路带宽问题，让 B 和 C 到帧中继网络有不同的带宽，但必须让 D 有两条到 A 的路由。

RTB#conf t
Enter configuration commands, one per line. End with CNTL/Z.
RTB(config)#int s0.1
RTB(config-subif)#bandwidth 2040
RTC(config)#int s0.1
RTC(config-subif)#bandwidth 2048

RTD#sh ip route

172.168.0.0/24 is subnetted, 3 subnets
D   172.168.1.0 [90/1789952] via 162.16.1.3, 00:00:03, FastEthernet0/0
D   172.168.2.0 [90/1787392] via 162.16.1.3, 00:00:03, FastEthernet0/0
C   172.168.3.0 is directly connected, Serial0/0
162.16.0.0/24 is subnetted, 1 subnets
C   162.16.1.0 is directly connected, FastEthernet0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:00:03, Serial0/0

RTD#sh ip eigrp topology 172.168.2.0 255.255.255.0

IP-EIGRP (AS 1): Topology entry for 172.168.2.0/24
State is Passive, Query origin flag is 1, 1 Successor(s), FD is 1787392
Routing Descriptor Blocks:
162.16.1.3 (FastEthernet0/0), from 162.16.1.3, Send flag is 0x0
Composite metric is (1787392/1761792), Route is Internal
Vector metric:
Minimum bandwidth is 2048 Kbit
Total delay is 21000 microseconds
Reliability is 255/255
Load is 1/255
Minimum MTU is 1500
Hop count is 1
162.16.1.2 (FastEthernet0/0), from 162.16.1.2, Send flag is 0x0
Composite metric is (1792256/1766656), Route is Internal
Vector metric:
Minimum bandwidth is 2040 Kbit
Total delay is 21000 microseconds

Reliability is 255/255
Load is 1/255
Minimum MTU is 1500
Hop count is 1

加入 Variance 2

RTD#sh ip route

```
     172.168.0.0/24 is subnetted, 3 subnets
D       172.168.1.0 [90/1789952] via 162.16.1.3, 00:00:03, FastEthernet0/0
D       172.168.2.0 [90/1787392] via 162.16.1.3, 00:00:03, FastEthernet0/0
                    [90/1792256] via 162.16.1.2, 00:00:03, FastEthernet0/0
C       172.168.3.0 is directly connected, Serial0/0
     162.16.0.0/24 is subnetted, 1 subnets
C       162.16.1.0 is directly connected, FastEthernet0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:00:03, Serial0/0
```

三、水平分割问题，A 的多少接口上的水平分割让网络 172.168.4.0/25 只能被 A 收到，当然还要配分发列表。

```
RTC(config)#int loopback 0
RTC(config-if)#ip addr 172.168.4.1 255.255.255.0
RTC(config-if)#exit
RTC(config)#router eigrp 1
RTC(config-router)#distribute-list 1 out fastEthernet 0
RTC(config-router)#exit
RTC(config)#access
RTC(config)#access-list 1 deny 172.168.4.0 0.0.0.255
RTC(config)#access-
RTC(config)#access-list 1 permit any
```

RTA#sh ip rout

```
     172.168.0.0/24 is subnetted, 4 subnets
D       172.168.4.0 [90/20640000] via 172.168.2.3, 00:01:47, Serial0.1
C       172.168.1.0 is directly connected, FastEthernet0
C       172.168.2.0 is directly connected, Serial0.1
D       172.168.3.0 [90/21026560] via 172.168.2.2, 00:01:06, Serial0.1
                    [90/21026560] via 172.168.2.3, 00:01:06, Serial0.1
     162.16.0.0/24 is subnetted, 1 subnets
D       162.16.1.0 [90/20514560] via 172.168.2.3, 00:12:05, Serial0.1
                   [90/20514560] via 172.168.2.2, 00:12:06, Serial0.1
D EX 150.150.0.0/16 [170/21282560] via 172.168.2.2, 00:01:07, Serial0.1
                    [170/21282560] via 172.168.2.3, 00:01:07, Serial0.1
```

RTB#sh ip route

```
     172.168.0.0/24 is subnetted, 3 subnets
D       172.168.1.0 [90/1769216] via 172.168.2.1, 00:02:21, Serial0.1
C       172.168.2.0 is directly connected, Serial0.1
D       172.168.3.0 [90/2172416] via 162.16.1.1, 00:12:38, FastEthernet0
     162.16.0.0/24 is subnetted, 1 subnets
```

C 162.16.1.0 is directly connected, FastEthernet0
D EX 150.150.0.0/16 [170/2428416] via 162.16.1.1, 00:12:38, FastEthernet0
RTA(config-subif)#no ip split-horizon eigrp 1
RTB#sh ip route
172.168.0.0/24 is subnetted, 4 subnets
D 172.168.4.0 [90/21152000] via 172.168.2.1, 00:00:06, Serial0.1
D 172.168.1.0 [90/1769216] via 172.168.2.1, 00:00:06, Serial0.1
C 172.168.2.0 is directly connected, Serial0.1
D 172.168.3.0 [90/2172416] via 162.16.1.1, 00:00:06, FastEthernet0
162.16.0.0/24 is subnetted, 1 subnets
C 162.16.1.0 is directly connected, FastEthernet0
D EX 150.150.0.0/16 [170/2428416] via 162.16.1.1, 00:00:06, FastEthernet0

四、是否允许广播，当在多点接口上不加入关键字 broadcast 时，会出现 hello 包无法发送因为它使用了组播地址。

RTA(config-subif)#no frame-relay map ip 172.168.2.2 101 broadcast
RTA(config-subif)#frame-relay map ip 172.168.2.2 101
RTA(config-subif)#no frame-relay map ip 172.168.2.3 201 broadcast
RTA(config-subif)#frame-relay map ip 172.168.2.3 201
RTA(config-subif)#
RTA#sh ip eigrp nei
IP-EIGRP neighbors for process 1

为空，加入后的输出：

RTA#sh ip eigrp nei
IP-EIGRP neighbors for process 1

H	Address	Interface	Hold Uptime (sec)	SRTT (ms)	RTO	Q Cnt	Seq Num	Type
1	162.16.1.3	Fa0	11 00:00:18	4	200	0	104	
0	162.16.1.1	Fa0	10 00:00:18	8	200	0	106	

五、不连续子网问题，B、C、D 之间的网络把 172.168.0.0/16 分开，如果不在这些路由器中配置 no auto-summary 命令会造成有的网络收不到。

RTD(config)#router eigrp 1
RTD(config-router)#auto-summary
RTB#sh ip route
172.168.0.0/16 is variably subnetted, 4 subnets, 2 masks
D 172.168.4.0/24 [90/21152000] via 172.168.2.1, 00:02:15, Serial0.1
D 172.168.0.0/16 [90/1794816] via 162.16.1.1, 00:00:32, FastEthernet0
D 172.168.1.0/24 [90/1769216] via 172.168.2.1, 00:02:15, Serial0.1
C 172.168.2.0/24 is directly connected, Serial0.1
162.16.0.0/24 is subnetted, 1 subnets
C 162.16.1.0 is directly connected, FastEthernet0
D EX 150.150.0.0/16 [170/2428416] via 162.16.1.1, 00:00:35, FastEthernet0

六、不共同子网，当配错 D 的以太网口时，无法建立邻居关系，而且有错误提示。

RTD(config-if)#ip addr 162.16.11.1 255.255.255.0
RTD(config-if)#

02:32:24: IP-EIGRP: Neighbor 162.16.1.2 not on common subnet for FastEthernet0/0 (162.16.11.1 255.255.255.0

七、K 不同也会造成邻居问题

RTD(config)#router eigrp 1

RTD(config-router)#metric weights 0 1 1 1 1 0

RTD(config)#^Z

RTD#

02:36:36: %SYS-5-CONFIG_I: Configured from console by consoleear

RTD#sh ip eigrp nei

IP-EIGRP neighbors for process 1

RTD(config-router)#metric weights 0 1 0 1 0 0

RTD(config-router)#exit

RTD(config)#exit

RTD#

02:37:57: %SYS-5-CONFIG_I: Configured from console by console

RTD#clear ip eigrp nei

RTD#sh ip eigrp nei

IP-EIGRP neighbors for process 1

H	Address	Interface	Hold Uptime	SRTT	RTO	Q	Seq Type
			(sec)	(ms)		Cnt	Num
2	162.16.1.3	Fa0/0	14 00:00:02	1	3000	2	167
1	162.16.1.2	Fa0/0	13 00:00:03	1	3000	2	191
0	172.168.3.2	Se0/0	14 00:00:05	26	200	0	70

八、发布列表，在 E 上不进行路由发布过滤时会让内部路由器看到所有路由。

RTD#sh ip route

D EX 170.170.0.0/16 [170/2425856] via 172.168.3.2, 00:00:06, Serial0/0
     172.168.0.0/24 is subnetted, 4 subnets
D   172.168.4.0 [90/21177600] via 162.16.1.2, 00:01:33, FastEthernet0/0
D   172.168.1.0 [90/1794816] via 162.16.1.3, 00:01:33, FastEthernet0/0
                    [90/1794816] via 162.16.1.2, 00:01:33, FastEthernet0/0
D   172.168.2.0 [90/1792256] via 162.16.1.3, 00:01:33, FastEthernet0/0
                    [90/1792256] via 162.16.1.2, 00:01:33, FastEthernet0/0
C   172.168.3.0 is directly connected, Serial0/0
     162.16.0.0/24 is subnetted, 1 subnets
C   162.16.1.0 is directly connected, FastEthernet0/0
D EX 160.160.0.0/16 [170/2425856] via 172.168.3.2, 00:00:06, Serial0/0
     131.66.0.0/24 is subnetted, 1 subnets
D EX   131.66.20.0 [170/2425856] via 172.168.3.2, 00:00:07, Serial0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:00:15, Serial0/0

RTE(config)#router eigrp 1

RTE(config-router)#distribute-list 1 out

Access-list 1 permit 150.150.0.0 0.0.255.255

RTD#sh ip route

172.168.0.0/24 is subnetted, 4 subnets
D 172.168.4.0 [90/21177600] via 162.16.1.2, 00:03:26, FastEthernet0/0
D 172.168.1.0 [90/1794816] via 162.16.1.3, 00:03:26, FastEthernet0/0
[90/1794816] via 162.16.1.2, 00:03:26, FastEthernet0/0
D 172.168.2.0 [90/1792256] via 162.16.1.3, 00:03:26, FastEthernet0/0
[90/1792256] via 162.16.1.2, 00:03:26, FastEthernet0/0
C 172.168.3.0 is directly connected, Serial0/0
162.16.0.0/24 is subnetted, 1 subnets
C 162.16.1.0 is directly connected, FastEthernet0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:00:03, Serial0/0

九、重发布，没有 default-metric 命令的话重发布是不会发生。

RTD#sh ip route
172.168.0.0/24 is subnetted, 4 subnets
D 172.168.4.0 [90/21177600] via 162.16.1.2, 00:05:01, FastEthernet0/0
D 172.168.1.0 [90/1794816] via 162.16.1.3, 00:05:01, FastEthernet0/0
[90/1794816] via 162.16.1.2, 00:05:01, FastEthernet0/0
D 172.168.2.0 [90/1792256] via 162.16.1.3, 00:05:01, FastEthernet0/0
[90/1792256] via 162.16.1.2, 00:05:01, FastEthernet0/0
C 172.168.3.0 is directly connected, Serial0/0
162.16.0.0/24 is subnetted, 1 subnets
C 162.16.1.0 is directly connected, FastEthernet0/0
RTE(config)#router eigrp 1
RTE(config-router)#default-metric 10000 1000 255 1 1500
RTD#sh ip route
172.168.0.0/24 is subnetted, 4 subnets
D 172.168.4.0 [90/21177600] via 162.16.1.2, 00:06:45, FastEthernet0/0
D 172.168.1.0 [90/1794816] via 162.16.1.3, 00:06:45, FastEthernet0/0
[90/1794816] via 162.16.1.2, 00:06:45, FastEthernet0/0
D 172.168.2.0 [90/1792256] via 162.16.1.3, 00:06:45, FastEthernet0/0
[90/1792256] via 162.16.1.2, 00:06:45, FastEthernet0/0
C 172.168.3.0 is directly connected, Serial0/0
162.16.0.0/24 is subnetted, 1 subnets
C 162.16.1.0 is directly connected, FastEthernet0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:00:25, Serial0/0

十、从复 ID，A 和 E 都使用环回地址 192.168.1.1，所以 E 重发布的路由 A 不接爱。

RTA#sh ip route
172.168.0.0/24 is subnetted, 4 subnets
D 172.168.4.0 [90/20640000] via 172.168.2.3, 00:00:30, Serial0.1
C 172.168.1.0 is directly connected, FastEthernet0
C 172.168.2.0 is directly connected, Serial0.1
D 172.168.3.0 [90/21026560] via 172.168.2.3, 00:00:30, Serial0.1
[90/21026560] via 172.168.2.2, 00:00:30, Serial0.1
162.16.0.0/24 is subnetted, 1 subnets
D 162.16.1.0 [90/20514560] via 172.168.2.3, 00:00:30, Serial0.1

```
                              [90/20514560] via 172.168.2.2, 00:00:30, Serial0.1
C       192.168.1.0/24 is directly connected, Loopback0
```
RTD#sh ip route
```
        172.168.0.0/24 is subnetted, 4 subnets
D          172.168.4.0 [90/21177600] via 162.16.1.2, 00:01:15, FastEthernet0/0
D          172.168.1.0 [90/1794816] via 162.16.1.3, 00:01:15, FastEthernet0/0
                        [90/1794816] via 162.16.1.2, 00:01:15, FastEthernet0/0
D          172.168.2.0 [90/1792256] via 162.16.1.3, 00:02:15, FastEthernet0/0
                        [90/1792256] via 162.16.1.2, 00:02:15, FastEthernet0/0
C          172.168.3.0 is directly connected, Serial0/0
        162.16.0.0/24 is subnetted, 1 subnets
C          162.16.1.0 is directly connected, FastEthernet0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:02:53, Serial0/0
```
改了 E 的环回地址，重启后就正常了。

RTA#sh ip route
```
        172.168.0.0/24 is subnetted, 4 subnets
D          172.168.4.0 [90/20640000] via 172.168.2.3, 00:09:38, Serial0.1
C          172.168.1.0 is directly connected, FastEthernet0
C          172.168.2.0 is directly connected, Serial0.1
D          172.168.3.0 [90/21026560] via 172.168.2.3, 00:00:41, Serial0.1
                        [90/21026560] via 172.168.2.2, 00:00:41, Serial0.1
        162.16.0.0/24 is subnetted, 1 subnets
D          162.16.1.0 [90/20514560] via 172.168.2.3, 00:09:38, Serial0.1
                      [90/20514560] via 172.168.2.2, 00:09:38, Serial0.1
C       192.168.1.0/24 is directly connected, Loopback0
D EX 150.150.0.0/16 [170/21282560] via 172.168.2.3, 00:00:27, Serial0.1
                        [170/21282560] via 172.168.2.2, 00:00:27, Serial0.1
```
十一、认证问题，当 D 上没有配论证，而 E 上配了时，它们会无法建立邻居关系。

```
RTE(config)#int s0/0
RTE(config-if)#ip authentication mode eigrp 1 md5
RTE(config-if)#ip authentication key-chain eigrp 1 holly
RTE(config-if)#key chain holly
RTE(config-keychain)#key 1
RTE(config-keychain-key)#key-string 123
```
RTE#sh ip eigrp nei
```
IP-EIGRP neighbors for process 1


RTD(config)#int s0/0
RTD(config-if)#ip au
RTD(config-if)#ip authentication mode ei
RTD(config-if)#ip authentication mode eigrp 1 md5
RTD(config-if)#ip au
RTD(config-if)#ip authentication key
```

RTD(config-if)#ip authentication key-chain eig
RTD(config-if)#ip authentication key-chain eigrp 1 mikey
RTD(config-if)#key chain mikey
RTD(config-keychain)#key 1
RTD(config-keychain-key)#key
RTD(config-keychain-key)#key-string 123
RTD(config-keychain-key)#^Z
RTD#
03:22:16: %SYS-5-CONFIG_I: Configured from console by console
RTD#sh ip eigrp nei
IP-EIGRP neighbors for process 1

H	Address	Interface	Hold	Uptime	SRTT	RTO	Q	Seq Type
			(sec)		(ms)		Cnt	Num
2	172.168.3.2	Se0/0	14	00:00:00	1	2000	1	0
1	162.16.1.2	Fa0/0	14	00:00:04	1	3000	3	291
0	162.16.1.3	Fa0/0	14	00:00:05	4	200	0	276

RTD#sh ip route
172.168.0.0/24 is subnetted, 4 subnets
D 172.168.4.0 [90/21177600] via 162.16.1.2, 00:00:10, FastEthernet0/0
D 172.168.1.0 [90/1794816] via 162.16.1.2, 00:00:10, FastEthernet0/0
[90/1794816] via 162.16.1.3, 00:00:10, FastEthernet0/0
D 172.168.2.0 [90/1792256] via 162.16.1.2, 00:00:10, FastEthernet0/0
[90/1792256] via 162.16.1.3, 00:00:10, FastEthernet0/0
C 172.168.3.0 is directly connected, Serial0/0
162.16.0.0/24 is subnetted, 1 subnets
C 162.16.1.0 is directly connected, FastEthernet0/0
D EX 150.150.0.0/16 [170/2425856] via 172.168.3.2, 00:00:06, Serial0/0

十二、默认路由问题

在 EIGRP 中是不能用 ip route 0.0.0.0 0.0.0.0 next-hop 命令来通告默认路由的，只能用 ip default-network 命令来进行配置，比如在 RTE 上使用 ip default-network 150.150.0.0 255.255.0.0，这样将使其它路由器上的 150.150.0.0/16 网络变成缺省网络（有*号）。

2513#show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default

Gateway of last resort is 161.44.192.2 to network 198.10.1.0

161.44.0.0 255.255.255.0 is subnetted, 1 subnets

C 161.44.192.0 is directly connected, Ethernet0

S 161.44.0.0 255.255.0.0 [1/0] via 161.44.192.0

S* 198.10.1.0 [1/0] via 161.44.192.2

131.108.0.0 255.255.255.0 is subnetted, 1 subnets

C 131.108.99.0 is directly connected, TokenRing0

注：上面的输出不是基于本实验拓扑，只作为说明用。在上面的结果的蓝色部分可以看到有最后的网关了。

【路由器上的错误配置】

注：蓝色为正常时要用的，排错时去掉；绿色为在设错时添加的

帧中继交换机

(Config) # frame-relay switching

(Config) # int s0

！ 进入 s0 端口

(config-if) # enacapsulation frame-relay

(config-if) # frame-relay intf-type dce

！ 设置端口类型为 DCE

(config-if) # frame-relay lmi-type cisco

！ 配置 lmi 类型

(config-if) # clock rate 56000

(config-if) # frame-relay route 101 interface s1 102 ！ 建立一条交换记录

(config-if) # frame-relay route 201 interface s2 202 ！ 建立第二条交换记

(config-if) # no shut

(config-if) # exit

(Config) # int s1

！ 进入 s1 端口

(config-if) # encapsulation frame-relay

(config-if) # frame-relay intf-type dce

(config-if) # frame-relay lmi-type cisco

(config-if) # clock rate 56000

(config-if) # frame-relay route 102 interface s0 101

(config-if) # no shut

(config-if) # exit

(Config) # int s2

！ 进入 s2 端口

(config-if) # enacapsulation frame-relay

(config-if) # frame-relay intf-type dce

(config-if) # frame-relay lmi-type cisco
(config-if) # clock rate 56000
(config-if) # frame-relay route 202 interface s0 201
(config-if) # no shut
(config-if) # exit

路由器 RTA 的配置

int e 0
ip addr 172.168.1.1 255.255.255.0
no shut
int s0
encapsulation frame-relay
frame-relay lmi-type cisco
int s0.1 multipoint
ip addr 172.168.2.1 255.255.255.0
frame-relay map ip 172.168.2.2 101 broadcast(frame-relay map ip 172.168.2.2 102)
frame-relay map ip 172.168.2.3 201 broadcast(frame-relay map ip 172.168.2.2 202)
no ip split-horizon eigrp 1
no shut
int loopback 0
ip addr 192.168.1.1 255.255.255.0
exit
router eigrp 1
network 172.168.0.0
exit

路由器 RTB 的配置

int e 0
ip addr 162.16.1.2 255.255.255.0
no shut
int s0
no ip addr
encapsulation frame-relay
frame-relay lmi-type cisco
int s0.1 point-to-point
bandwidth 2048 (bandwidth 2040)
ip addr 172.168.2.2 255.255.255.0
frame-relay interface-dlci 102
exit
no shut
router eigrp 1
network 172.168.0.0
network 162.16.0.0
no auto-summary
exit

路由器 RTC 的配置

int e 0

ip addr 162.16.1.3 255.255.255.0

no shut

RTC(config)#int loopback 0

RTC(config-if)#ip addr 172.168.4.1 255.255.255.0

int s0

encapsulation frame-relay

frame-relay lmi-type cisco

int s0.1 point-to-point

bandwidth 2048

ip addr 172.168.2.3 255.255.255.0

frame-relay interface-dlci 202

exit

no shut

router eigrp 1

distribute-list 1 out fastEthernet 0

network 172.168.0.0

network 162.16.0.0

no auto-summary

Exit

access-list 1 deny 172.168.4.0 0.0.0.255

access-list 1 permit any

路由器 RTD 的配置

int e 0

ip addr 162.16.1.1 255.255.255.0 (ip addr 162.16.11.1 255.255.255.0)

no shut

int s0

RTD(config-if)#ip authentication mode eigrp 1 md5

RTD(config-if)#ip authentication key-chain eigrp 1 mikey

RTD(config-if)#key chain mikey

RTD(config-keychain)#key 1

RTD(config-keychain-key)#key-string 123

ip addr 172.168.3.1 255.255.255.0

clock rate 56000

no shut

router eigrp 1

network 172.168.0.0

network 162.16.0.0

no auto-summary

metric weights 0 1 1 1 1 0
exit

路由器 RTE 的配置
int s 0
RTE(config-if)#ip authentication mode eigrp 1 md5
RTE(config-if)#ip authentication key-chain eigrp 1 holly
RTE(config-if)#key chain holly
RTE(config-keychain)#key 1
RTE(config-keychain-key)#key-string 123

ip addr 172.168.3.2 255.255.255.0
clock rate 56000
no shut
int s1
ip addr 131.66.20.1 255.255.255.0
clock rate 56000
no shut
int loopback 0
ip addr 192.168.6.1 255.255.255.0(ip addr 192.168.1.1 255.255.255.0)
exit

router eigrp 1
network 172.168.0.0
redistribute rip
default-metric 10000 100 255 1 1500
distribute-list 1 out
exit
router rip
network 131.66.0.0
access-list 1 permit 150.150.0.0 0.0.255.255

外部的配置
int s0
ip addr 131.66.20.2
clock rate 56000
no shut
int loopback 0
ip addr 150.150.0.1 255.255.0.0
int loopback 1
ip addr 160.160.0.1 255.255.0.0
int loopback 2
ip addr 170.170.0.1 255.255.0.0
router rip

network 150.150.0.0
network 160.160.0.0
network 170.170.0.0

EIGRP

【实验目的

1、掌握EIGRP的基本配置及如何验证EIGRP的配置；
2、了解EIGRP对VLSM的支持，学会如何配置EIGRP的手工汇总；
3、了解EIGRP与IGRP的自动重分布；
4、学会如何配置EIGRP的带宽利用率；
5、学会如何配置EIGRP的负载均衡；
6、学会如何配置EIGRP的基本参数；

【实验原理】

EIGRP 是 CISCO 专有的路由协议，它是 IGRP 的增强版本，它同样使用距离向量技术，并且作了一些有助于协议汇聚和操作效率的改进。EIGRP 有一些与链路状态协议相似的特性。它的主要特点有：无回路路由表，快速汇聚，减少带宽的使用，使用综合度量（默认情况下是带宽和延迟），可以非均衡负载平衡，后继路由及可行后继路由，支持 VLSM，可以手工汇总，以及与 IGRP 的兼容性。以上这些特点使得 EIGRP 可以使用在一些大规模的网络中，而相对的配置比较简单。

EIGRP 不会使用超过一条链路声明的带宽的 50%.在 Cisco 路由器上允许使用 bandwidth 命令来改变链路的默认设置。这对于串行链路通常是很有必要的，因为默认带宽是 1.544Mb/s。如果链路的实际带宽是 56Kb/s，就很容易发现 EIGRP 使得链路变得饱和。另外，EIGRP 还允许手工配置带宽的利用率（bandwidth-percent）,当在网络中 bandwidth 命令不能反映链路的真实速率时，使用该命令可以使用更多的带宽，使得配置更加灵活。

EIGRP 自动在具有相等开销的链路上负载均衡。使用 variance 命令可以在不等度量路径上实现负载均衡。

EIGRP 的度量计算使用以下的公式：

$$metric = [(K1 \times bandwidth + (K2 \times bandwidth)/(256 - load) \\ + (K3 \times delay)] \times [K5/(reliability + K4)]$$

默认值是 $K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0.$（K5，K4 为 0 时，后一项不起作用）

即 $metric = bandwidth + delay$

另外，
$$\text{bandwidth for eigrp} = (10000000 / bandwidth) \times 256$$
$$\text{delay for eigrp} = (delay / 10) \times 256$$

我们可以通过改变各个系数的值来改变 EIGRP 的度量计算。

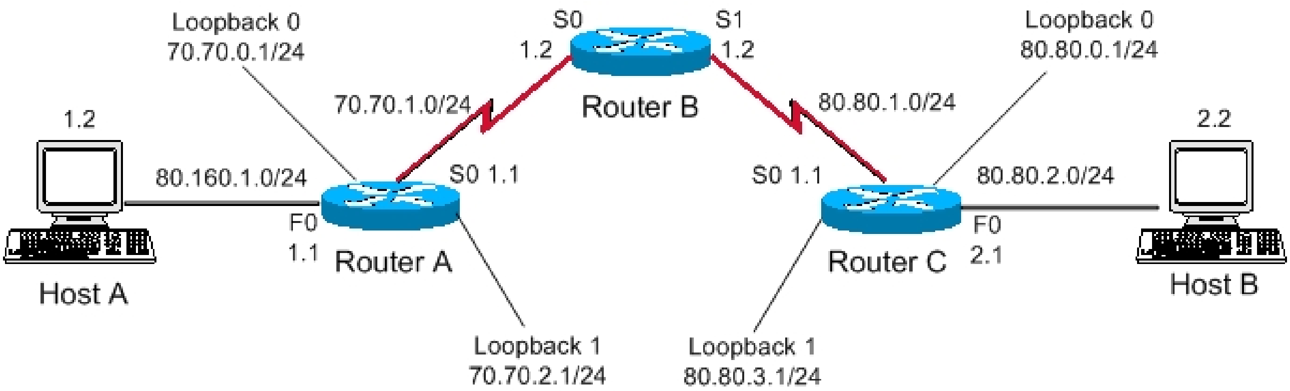
【实验设备】

带有两个串行口的路由器一台，带有一个串行口的路由器两台；

用于配置路由器的主机三台；
串行线、交叉线若干；

【实验内容】

实验一、二采用如下的实验拓扑：



图一

实验一、EIGRP 的基本配置

参照图一配置好主机和路由器各个端口的 IP 地址：

Router A F0=80.160.1.1/24 S0=70.70.1.1/24 S1=shutdown L0=70.70.0.1/24 L1=70.70.2.1/24	Router B F0=shutdown S0=70.70.1.2/24 S1=80.80.1.2/24	Router C F0=80.80.2.1 S0=shutdown S1=80.80.1.1/24 L0=80.80.0.1/24 L1=80.80.3.1/24

Host A IP =80.160.1.2/24 GW=80.160.1.1	Host B IP =80.80.2.2/24 GW=80.80.2.1

然后，在每一台路由器上启用 EIGRP，注意自治系统号要统一。可能需要用到的配置命令格式为：

```
Router(config)# router eigrp autonomous-system-number
Router(config-router)# network network-number
Router(config-if)# bandwidth kilobits
Router(config-router)# eigrp log-neighbor-changes
```

然后，在每一台路由器上使用 show ip route 观察路由表的情况，用 show ip protocol 来观察是否正确的公告定义的网络。

使用 **show ip eigrp neighbors** 来观察路由器发现的邻居；使用 **show ip eigrp topology** 来观察 EIGRP 的拓扑表；使用 **show ip eigrp interfaces** [interface-*type interface-number*] [*as-number*] 显示 EIGRP 的端口信息，使用 **show ip eigrp neighbors** [*interface-type* | *as-number* | static] 显示 EIGRP 发现的邻居的信息。

各个路由器的配置以及输出信息如下：

Router A:

show running-config	show ip route	show ip protocols
show ip eigrp neighbors	show ip eigrp interfaces	show ip eigrp topology

Router B:

show running-config	show ip route	show ip protocols
show ip eigrp neighbors	show ip eigrp interfaces	show ip eigrp topology

Router C:

show running-config	show ip route	show ip protocols
show ip eigrp neighbors	show ip eigrp interfaces	show ip eigrp topology

```
RouterA#sh run
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname RouterA
!
!
ip subnet-zero
!
!
!
interface Loopback0
 ip address 70.70.0.1 255.255.255.0
 no ip directed-broadcast
!
interface Loopback1
 ip address 70.70.2.1 255.255.255.0
 no ip directed-broadcast
!
interface Ethernet0
 ip address 80.160.1.1 255.255.255.0
 no ip directed-broadcast
!
interface Serial0
 bandwidth 64
 ip address 70.70.1.1 255.255.255.0
 no ip directed-broadcast
 no fair-queue
```

```
!
router eigrp 75
 network 70.0.0.0
 network 80.0.0.0
 eigrp log-neighbor-changes
!
ip classless
!
!
line con 0
 exec-timeout 0 0
 transport input none
line vty 0 4
!
end
```

```
RouterA#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR

Gateway of last resort is not set

     70.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C       70.70.0.0/24 is directly connected, Loopback0
C       70.70.1.0/24 is directly connected, Serial0
C       70.70.2.0/24 is directly connected, Loopback1
D       70.0.0.0/8 is a summary, 00:10:01, Null0
     80.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       80.0.0.0/8 is a summary, 00:09:55, Null0
C       80.160.1.0/24 is directly connected, Ethernet0
```

```
RouterA#show ip protocols
Routing Protocol is "eigrp 75"
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  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 75
  Automatic network summarization is in effect
  Automatic address summarization:
    80.0.0.0/8 for Loopback0, Loopback1, Serial0
      Summarizing with metric 281600
    70.0.0.0/8 for Ethernet0
      Summarizing with metric 128256
  Routing for Networks:
    70.0.0.0
    80.0.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)        5        00:11:15
    70.70.1.2            90       00:11:14
  Distance: internal 90 external 170
```

```
RouterA#sh ip eigrp neighbors
IP-EIGRP neighbors for process 75
H   Address              Interface   Hold Uptime   SRTT   RTO  Q  Seq
                                     (sec)         (ms)       Cnt Num
0   70.70.1.2            Se0           11 00:18:52    0   4500  0  9
```

```
RouterA#show ip eigrp interfaces
IP-EIGRP interfaces for process 75

                    Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface   Peers   Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Lo0           0        0/0        0        0/10           0           0
Lo1           0        0/0        0        0/10           0           0
Se0           1        0/0        0       10/380        5084          0
```

```
RouterA#sh ip eigrp topology
IP-EIGRP Topology Table for process 75

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 70.70.0.0/24, 1 successors, FD is 128256
         via Connected, Loopback0
P 70.70.1.0/24, 1 successors, FD is 40512000
         via Connected, Serial0
P 70.70.2.0/24, 1 successors, FD is 128256
         via Connected, Loopback1
P 70.0.0.0/8, 1 successors, FD is 128256
         via Summary (128256/0), Null0
```

```
P 80.0.0.0/8, 1 successors, FD is 281600
        via Summary (281600/0), Null0
P 80.160.1.0/24, 1 successors, FD is 281600
        via Connected, Ethernet0
Et0          0        0/0        0       0/10          0          0
```

```
RouterB#sh run
Building configuration...

Current configuration : 891 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname RouterB
!
!
memory-size iomem 15
ip subnet-zero
!
!
!
ip audit notify log
ip audit po max-events 100
ip ssh time-out 120
ip ssh authentication-retries 3
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
!
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 no ip address
 shutdown
 speed auto
!
interface Serial0
 bandwidth 64
```

```
 ip address 70.70.1.2 255.255.255.0
 no fair-queue
 clockrate 56000
!
interface Serial1
 bandwidth 64
 ip address 80.80.1.2 255.255.255.0
!
router eigrp 75
 network 70.0.0.0
 network 80.0.0.0
 auto-summary
 eigrp log-neighbor-changes
!
ip classless
no ip http server
ip pim bidir-enable
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
!
no scheduler allocate
end
```

```
RouterB#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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
     70.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
D       70.70.0.0/24 [90/20640000] via 70.70.1.1, 00:02:15, Serial2
C       70.70.1.0/24 is directly connected, Serial2
D       70.70.2.0/24 [90/20640000] via 70.70.1.1, 00:02:15, Serial2
D       70.0.0.0/8 is a summary, 00:02:13, Null0
     80.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
D       80.80.0.0/24 [90/20640000] via 80.80.1.1, 00:02:11, Serial0
C       80.80.1.0/24 is directly connected, Serial0
```

```
D       80.80.2.0/24 [90/20514560] via 80.80.1.1, 00:02:12, Serial0
D       80.80.3.0/24 [90/20640000] via 80.80.1.1, 00:02:12, Serial0
D       80.0.0.0/8 is a summary, 00:02:14, Null0
```

```
RouterB#sh ip protocols
Routing Protocol is "eigrp 75"
  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 75
  Automatic network summarization is in effect
  Automatic address summarization:
    80.0.0.0/8 for Serial0
      Summarizing with metric 40512000
    70.0.0.0/8 for Serial1
      Summarizing with metric 40512000
  Maximum path: 4
  Routing for Networks:
    70.0.0.0
    80.0.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    70.70.1.1             90      00:25:55
    (this router)         90      00:25:55
    Gateway         Distance      Last Update
    80.80.1.1             90      00:26:02
  Distance: internal 90 external 170
```

```
RouterB#sh ip eigrp neighbors
IP-EIGRP neighbors for process 75
H   Address          Interface   Hold Uptime    SRTT   RTO   Q    Seq Type
                                 (sec)          (ms)         Cnt  Num
1   80.80.1.1         Se0        12 00:03:23    1432   5000  0    4
0   70.70.1.1         Se2        13 00:03:28    1089   5000  0    3
```

```
RouterB#sh ip eigrp interfaces
IP-EIGRP interfaces for process 75

                    Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface   Peers   Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Se2           1        0/0       1089      5/190         4546         0
Se0           1        0/0       1432      5/190         7326         0
```

```
RouterB#sh ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(80.80.1.2)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 80.80.0.0/24, 1 successors, FD is 20640000
         via 80.80.1.1 (20640000/128256), Serial0
P 70.70.0.0/24, 1 successors, FD is 20640000
         via 70.70.1.1 (20640000/128256), Serial2
P 80.80.1.0/24, 1 successors, FD is 20512000
         via Connected, Serial0
P 70.70.1.0/24, 1 successors, FD is 20512000
         via Connected, Serial2
P 80.80.2.0/24, 1 successors, FD is 20514560
         via 80.80.1.1 (20514560/28160), Serial0
P 70.70.2.0/24, 1 successors, FD is 20640000
         via 70.70.1.1 (20640000/128256), Serial2
P 80.80.3.0/24, 1 successors, FD is 20640000
         via 80.80.1.1 (20640000/128256), Serial0
P 70.0.0.0/8, 1 successors, FD is 20512000
         via Summary (20512000/0), Null0
P 80.0.0.0/8, 1 successors, FD is 20512000
         via Summary (20512000/0), Null0

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

         via 70.70.1.1 (20514560/28160), Serial2
```

```
RouterC#sh run
Building configuration...

Current configuration : 677 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname "RouterC"
!
!
ip subnet-zero
```

```
!
!
!
!
interface Loopback0
 ip address 80.80.0.1 255.255.255.0
!
interface Loopback1
 ip address 80.80.3.1 255.255.255.0
!
interface Ethernet0
 ip address 80.80.2.1 255.255.255.0
!
interface Ethernet1
 no ip address
 shutdown
!
interface Serial0
 bandwidth 64
 ip address 80.80.1.1 255.255.255.0
 clockrate 56000
 no fair-queue
!
interface Serial1
 no ip address
 shutdown
!
router eigrp 75
 network 80.0.0.0
 auto-summary
!
ip classless
ip http server
!
!
no cdp run
!
!
line con 0
line aux 0
line vty 0 4
!
end
```

```
RouterC#sh 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, 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

D    70.0.0.0/8 [90/41024000] via 80.80.1.2, 00:46:37, Serial0
     80.0.0.0/24 is subnetted, 4 subnets
C       80.80.0.0 is directly connected, Loopback0
C       80.80.1.0 is directly connected, Serial0
C       80.80.2.0 is directly connected, Ethernet0
C       80.80.3.0 is directly connected, Loopback1
```

```
RouterC#show ip protocols
Routing Protocol is "eigrp 75"
  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 75
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    80.0.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    80.80.1.2             90      00:40:15
  Distance: internal 90 external 170
```

```
RouterC#show ip eigrp neighbors
IP-EIGRP neighbors for process 75
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq Type
                                            (sec)         (ms)       Cnt Num
0   80.80.1.2               Se0               11 00:48:27   28   2280  0  7
```

```
RouterC#show ip eigrp interfaces
IP-EIGRP interfaces for process 75

                    Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface   Peers   Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Et0           0         0/0         0       0/10           0           0
Se0           1         0/0        28      10/380        380           0
```

Lo0	0	0/0	0	0/10	0	0
Lo1	0	0/0	0	0/10	0	0

RouterC#show ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(80.80.3.1)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
        r - reply Status, s - sia Status

P 80.80.0.0/24, 1 successors, FD is 128256
        via Connected, Loopback0
P 80.80.1.0/24, 1 successors, FD is 40512000
        via Connected, Serial0
P 80.80.2.0/24, 1 successors, FD is 281600
        via Connected, Ethernet0
P 80.80.3.0/24, 1 successors, FD is 128256
        via Connected, Loopback1
P 70.0.0.0/8, 1 successors, FD is 41024000
        via 80.80.1.2 (41024000/40512000), Serial0

问题 1：从 Router C 是否可以 ping 通 Router A 的 Loopback0（70.70.0.1）?
问题 2：从 Router C 是否可以 ping 通 Router A 的 F0 口（80.160.1.1）?

实验二、EIGRP 的接口汇总（Interface Summarization）

在每个路由器上取消自动汇总，命令如下：

```
Router(config-router)# no auto-summary
```

取消自动汇总后，Router 上的输出信息：

RouterB(config-router)#no auto-summary
RouterB(config-router)#
00:55:26: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 70.70.1.1 (Serial2) is down: summary configured
00:55:26: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 80.80.1.1 (Serial0) is down: summary configured
1700B(config-router)#
00:55:30: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 80.80.1.1 (Serial0) is up: new adjacency
00:55:30: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 70.70.1.1 (Serial2) is up: new adjacency

然后，在每个路由器上使用 show ip route，可以发现 Router C 有了到 80.160.1.0 的路由。
取消自动汇总后，各个路由器的路由表如下：

RouterA#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR

Gateway of last resort is not set

     70.0.0.0/24 is subnetted, 3 subnets
C       70.70.0.0 is directly connected, Loopback0
C       70.70.1.0 is directly connected, Serial0
C       70.70.2.0 is directly connected, Loopback1
     80.0.0.0/24 is subnetted, 5 subnets
D       80.80.0.0 [90/41152000] via 70.70.1.2, 00:03:33, Serial0
D       80.80.1.0 [90/41024000] via 70.70.1.2, 00:03:33, Serial0
D       80.80.2.0 [90/41049600] via 70.70.1.2, 00:03:33, Serial0
D       80.80.3.0 [90/41152000] via 70.70.1.2, 00:03:33, Serial0
C       80.160.1.0 is directly connected, Ethernet0
```

```
RouterB#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     70.0.0.0/24 is subnetted, 3 subnets
D       70.70.0.0 [90/40640000] via 70.70.1.1, 00:04:33, Serial0
C       70.70.1.0 is directly connected, Serial0
D       70.70.2.0 [90/40640000] via 70.70.1.1, 00:04:33, Serial0
     80.0.0.0/24 is subnetted, 5 subnets
D       80.80.0.0 [90/40640000] via 80.80.1.1, 00:04:49, Serial1
C       80.80.1.0 is directly connected, Serial1
D       80.80.2.0 [90/40537600] via 80.80.1.1, 00:04:49, Serial1
D       80.80.3.0 [90/40640000] via 80.80.1.1, 00:04:49, Serial1
D       80.160.1.0 [90/40537600] via 70.70.1.1, 00:04:34, Serial0
```

```
RouterC#sh 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, 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

70.0.0.0/24 is subnetted, 3 subnets
D 70.70.0.0 [90/41152000] via 80.80.1.2, 00:05:03, Serial0
D 70.70.1.0 [90/41024000] via 80.80.1.2, 00:05:18, Serial0
D 70.70.2.0 [90/41152000] via 80.80.1.2, 00:05:03, Serial0
80.0.0.0/24 is subnetted, 5 subnets
C 80.80.0.0 is directly connected, Loopback0
C 80.80.1.0 is directly connected, Serial0
C 80.80.2.0 is directly connected, Ethernet0
C 80.80.3.0 is directly connected, Loopback1
D 80.160.1.0 [90/41049600] via 80.80.1.2, 00:05:04, Serial0

然而，这样配置的话，每个路由器的路由表的开销很大。我们可以使用 EIGRP 的接口汇总来减少路由表的数目。具体命令如下：

Router(config-if)# **ip summary-address eigrp** *autonomous-system-number ip-address mask administrative-distance*

在Router B，我们进行如下配置[注]：
interface Serial0
ip address 70.70.1.2 255.255.255.0
ip summary-address eigrp 75 80.80.0.0 255.255.0.0 5
!
interface Serial1
ip address 80.80.1.2 255.255.255.0
ip summary-address eigrp 75 70.0.0.0 255.0.0.0 5
!
然后，使用 show ip route 来观察路由表的变化。

RouterA#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
U - per-user static route, o - ODR

Gateway of last resort is not set

70.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C 70.70.0.0/24 is directly connected, Loopback0

```
    C       70.70.1.0/24 is directly connected, Serial0
    C       70.70.2.0/24 is directly connected, Loopback1
    D       70.0.0.0/8 is a summary, 00:24:58, Null0
         80.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
    D       80.80.0.0/16 [90/41024000] via 70.70.1.2, 00:00:05, Serial0
    C       80.160.1.0/24 is directly connected, Ethernet0
RouterB#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     70.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
D       70.70.0.0/24 [90/40640000] via 70.70.1.1, 00:00:54, Serial0
C       70.70.1.0/24 is directly connected, Serial0
D       70.70.2.0/24 [90/40640000] via 70.70.1.1, 00:00:54, Serial0
D       70.0.0.0/8 is a summary, 00:28:26, Null0
     80.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
D       80.80.0.0/24 [90/40640000] via 80.80.1.1, 00:01:21, Serial1
D       80.80.0.0/16 is a summary, 00:15:23, Null0
C       80.80.1.0/24 is directly connected, Serial1
D       80.80.2.0/24 [90/40537600] via 80.80.1.1, 00:01:23, Serial1
D       80.80.3.0/24 [90/40640000] via 80.80.1.1, 00:01:23, Serial1
D       80.160.1.0/24 [90/40537600] via 70.70.1.1, 00:00:55, Serial0
```

```
    RouterC#sh 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, 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

    D    70.0.0.0/8 [90/41024000] via 80.80.1.2, 00:01:53, Serial0
         80.0.0.0/24 is subnetted, 5 subnets
    C       80.80.0.0 is directly connected, Loopback0
    C       80.80.1.0 is directly connected, Serial0
    C       80.80.2.0 is directly connected, Ethernet0
```

C　　　80.80.3.0 is directly connected, Loopback1
D　　　80.160.1.0 [90/41049600] via 80.80.1.2, 00:01:24, Serial0

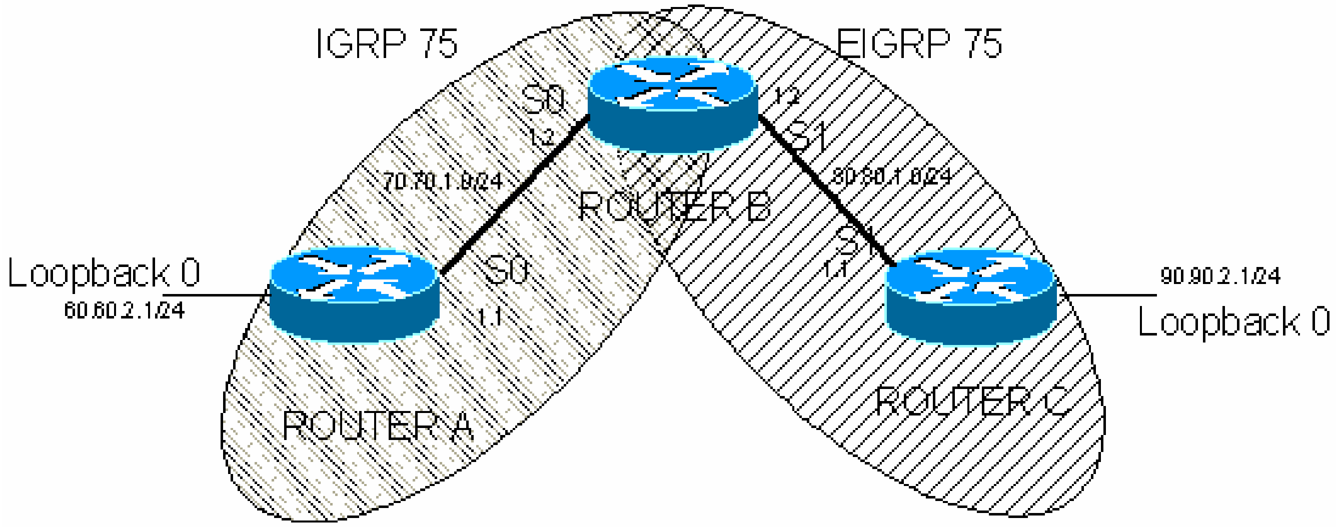
问题 3：Host A，B 之间是否可以互相 ping 通？

※学员可以尝试对 Router A、C 进行路由汇总，并用 show ip router 查看汇总结果。

实验三、IGRP/EIGRP 的自动重分布（Redistribution）

在相同的 AS 号的情况下，IGRP 会自动重分布进去 EIGRP。由于 IGRP 不支持无类别域间路由（CIDR），所以路由器的端口 IP 地址要做一些改变。

将 Router A 和 Router B 的 F0 口都 shutdown，我们暂时不需用到两台主机，只是观察路由器上路由表的情况。



图二

参照图二配置好主机和路由器各个端口的 IP 地址。然后，在 RouterA 上启用 IGRP，在 RouterC 上启用 EIGRP，在 RouterB 上同时启用 IGRP 和 EIGRP。注意自治系统号要统一。可能需要用到的配置命令格式为：

Router(config)# **router eigrp** *autonomous-system-number*
Router(config)# **router igrp** *autonomous-system-number*
Router(config-router)# **network** *network-number*
Router(config-if)# **bandwidth** *kilobits*

在 RouterA 和 C 上使用 show ip route 和 show ip eigrp traffic，记录你的发现。

```
RouterA#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     70.0.0.0/24 is subnetted, 1 subnets
C       70.70.1.0 is directly connected, Serial0
I    80.0.0.0/8 [100/82125] via 70.70.1.2, 00:01:02, Serial0
I    90.0.0.0/8 [100/82625] via 70.70.1.2, 00:01:02, Serial0
     60.0.0.0/24 is subnetted, 1 subnets
C       60.60.2.0 is directly connected, Loopback0
```

```
RouterA#sh ip eigrp traffic
```

（空）

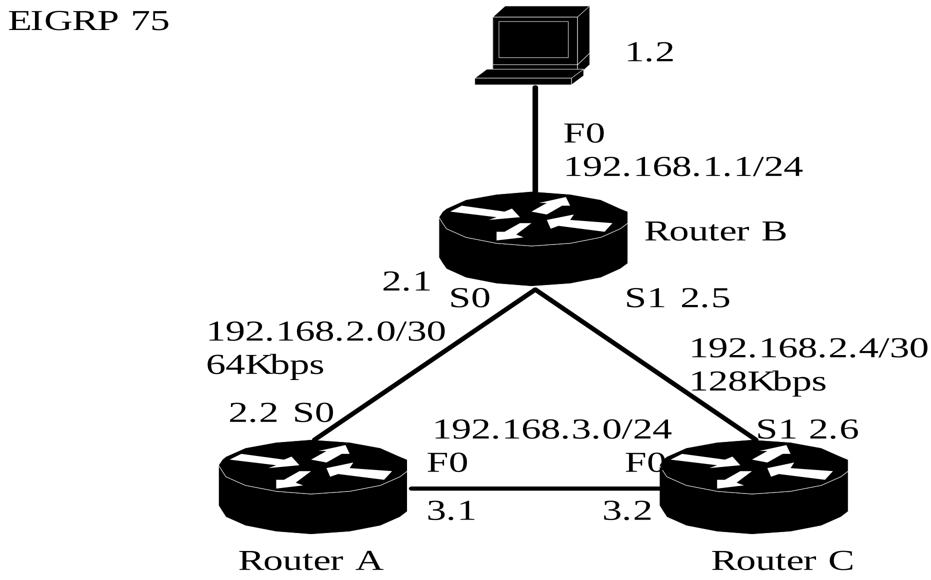
```
RouterC#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS,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

     70.0.0.0/24 is subnetted, 1 subnets
D EX    70.70.1.0 [170/41024000] via 80.80.1.2, 00:02:52, Serial0
     80.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       80.80.1.0/24 is directly connected, Serial0
D       80.0.0.0/8 is a summary, 00:04:06, Null0
     90.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       90.90.2.0/24 is directly connected, Loopback0
D       90.0.0.0/8 is a summary, 00:04:06, Null0
D EX 60.0.0.0/8 [170/41152000] via 80.80.1.2, 00:01:07, Serial0
```

```
RouterC#sh ip eigrp traffic
IP-EIGRP Traffic Statistics for process 75
  Hellos sent/received: 225/210
  Updates sent/received: 4/3
  Queries sent/received: 0/0
  Replies sent/received: 0/0
  Acks sent/received: 2/3
  Input queue high water mark 1, 0 drops
  SIA-Queries sent/received: 0/0
  SIA-Replies sent/received: 0/0
```

实验四、五、六采用如下的实验拓扑



图三

实验四、EIGRP 的带宽控制

按照拓扑图所示设置主机及路由器端口的 IP 地址及线路带宽，对各个网段启用 EIGRP。由于使用了非主类网，记得将自动汇总禁止。

配置好各个路由器，然后使用show ip route来观察路由表，看看网络是否能够正常运作（在主机上使用ping，tracert命令）。

如 Router B 为例，设置如下：

```
 interface Serial0
bandwidth 64
ip address 192.168.2.1 255.255.255.252
 interface Serial1
bandwidth 128
ip address 192.168.2.5 255.255.255.252
 router eigrp 75
network 192.168.2.0
network 192.168.1.0
no auto-summary
```

如此类推，配置好各个路由器，然后使用show ip route来观察路由表，看看网络是否能够正常运作（在主机上使用ping，tracert命令）。

在各个路由器上使用show ip eigrp topology，show ip route，show interfaces观察配置的结果。

Router A:

show ip eigrp topology　show ip route　show interfaces

Router B:

show ip eigrp topology　show ip route　show interfaces

Router C:

show ip eigrp topology　show ip route　show interfaces

```
RouterA#sh ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(192.168.3.1)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 192.168.1.0/24, 1 successors, FD is 20540160
         via 192.168.3.2 (20540160/20514560), Ethernet0
         via 192.168.2.1 (40514560/28160), Serial0
P 192.168.2.0/30, 1 successors, FD is 40512000
         via Connected, Serial0
P 192.168.3.0/24, 1 successors, FD is 281600
         via Connected, Ethernet0
P 192.168.2.4/30, 1 successors, FD is 20537600
         via 192.168.3.2 (20537600/20512000), Ethernet0
         via 192.168.2.1 (41024000/20512000), Serial0
```

```
RouterA#sh 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, 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

D    192.168.1.0/24 [90/20540160] via 192.168.3.2, 00:02:38, Ethernet0
     192.168.2.0/30 is subnetted, 2 subnets
C       192.168.2.0 is directly connected, Serial0
D       192.168.2.4 [90/20537600] via 192.168.3.2, 00:02:40, Ethernet0
C    192.168.3.0/24 is directly connected, Ethernet0
```

```
RouterA#sh int s0
Serial0 is up, line protocol is up
  Hardware is HD64570
  Internet address is 192.168.2.2/30
  MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:01, output 00:00:01, output hang never
  Last clearing of "show interface" counters 00:23:31
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 79
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
```

```
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     125 packets input, 8975 bytes, 0 no buffer
     Received 43 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     124 packets output, 7156 bytes, 0 underruns
     0 output errors, 0 collisions, 10 interface resets
     0 output buffer failures, 0 output buffers swapped out
     2 carrier transitions
     DCD=up   DSR=up   DTR=up   RTS=up   CTS=up

RouterA#sh int e0
Ethernet0 is up, line protocol is up
  Hardware is Lance, address is 00e0.1e60.82b6 (bia 00e0.1e60.82b6)
  Internet address is 192.168.3.1/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:02, output 00:00:00, 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 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     82 packets input, 7602 bytes, 0 no buffer
     Received 77 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     361 packets output, 46120 bytes, 0 underruns
     117 output errors, 0 collisions, 5 interface resets
     0 babbles, 0 late collision, 0 deferred
     117 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

```
     RouterB#show ip eigrp topology
     IP-EIGRP Topology Table for AS(75)/ID(192.168.2.5)

     Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
            r - reply Status, s - sia Status

     P 192.168.1.0/24, 1 successors, FD is 28160
              via Connected, FastEthernet0
     P 192.168.2.0/30, 1 successors, FD is 40512000
```

```
        via Connected, Serial1
P 192.168.3.0/24, 1 successors, FD is 20537600
        via 192.168.2.6 (20537600/281600), Serial0
        via 192.168.2.2 (40537600/281600), Serial1
P 192.168.2.4/30, 1 successors, FD is 20512000
        via Connected, Serial0
```

```
RouterB#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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    192.168.1.0/24 is directly connected, FastEthernet0
     192.168.2.0/30 is subnetted, 2 subnets
C       192.168.2.0 is directly connected, Serial1
C       192.168.2.4 is directly connected, Serial0
D    192.168.3.0/24 [90/20537600] via 192.168.2.6, 00:08:45, Serial0
```

```
RouterB#sh int f0
FastEthernet0 is up, line protocol is up
  Hardware is PQUICC_FEC, address is 0006.d7ee.39b6 (bia 0006.d7ee.39b6)
  Internet address is 192.168.1.1/24
  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 00:05:00, output 00:00:01, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     122 packets input, 17103 bytes
     Received 122 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
     399 packets output, 88998 bytes, 0 underruns
```

```
      37 output errors, 0 collisions, 4 interface resets
      0 babbles, 0 late collision, 0 deferred
      37 lost carrier, 0 no carrier
      0 output buffer failures, 0 output buffers swapped out

RouterB#sh int s0
Serial0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.2.1/30
  MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
      reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:03, output 00:00:00, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 54
  Queueing strategy: weighted fair
  Output queue: 0/1000/64/54 (size/max total/threshold/drops)
      Conversations  0/2/32 (active/max active/max total)
      Reserved Conversations 0/0 (allocated/max allocated)
      Available Bandwidth 48 kilobits/sec
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
      230 packets input, 11820 bytes, 0 no buffer
      Received 69 broadcasts, 0 runts, 0 giants, 0 throttles
      0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
      250 packets output, 17483 bytes, 0 underruns
      0 output errors, 0 collisions, 3 interface resets
      0 output buffer failures, 0 output buffers swapped out
      12 carrier transitions
      DCD=up  DSR=up  DTR=up  RTS=up  CTS=up

RouterB#sh int s1
Serial1 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.2.5/30
  MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec,
      reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:03, output 00:00:00, output hang never
  Last clearing of "show interface" counters 00:28:57
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
```

```
  5 minute output rate 0 bits/sec, 0 packets/sec
     209 packets input, 13584 bytes, 0 no buffer
     Received 76 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     222 packets output, 17280 bytes, 0 underruns
     0 output errors, 0 collisions, 4 interface resets
     0 output buffer failures, 0 output buffers swapped out
     1 carrier transitions
     DCD=up   DSR=up   DTR=up   RTS=up   CTS=up
```

```
RouterC#show ip eigrp topology
IP-EIGRP Topology Table for process 75

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 192.168.1.0/24, 1 successors, FD is 20514560
         via 192.168.2.5 (20514560/28160), Serial0
P 192.168.2.0/30, 1 successors, FD is 40537600
         via 192.168.3.1 (40537600/40512000), Ethernet0
         via 192.168.2.5 (41024000/40512000), Serial0
P 192.168.3.0/24, 1 successors, FD is 281600
         via Connected, Ethernet0
P 192.168.2.4/30, 1 successors, FD is 20512000
         via Connected, Serial0
```

```
RouterC#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR

Gateway of last resort is not set

D    192.168.1.0/24 [90/20514560] via 192.168.2.5, 00:13:22, Serial0
     192.168.2.0/30 is subnetted, 2 subnets
D       192.168.2.0 [90/40537600] via 192.168.3.1, 00:13:22, Ethernet0
C       192.168.2.4 is directly connected, Serial0
C    192.168.3.0/24 is directly connected, Ethernet0
```

```
RouterC#sh int e0
Ethernet0 is up, line protocol is up
  Hardware is QUICC Ethernet, address is 0010.7b2c.e59c (bia 0010.7b2c.e59c)
  Internet address is 192.168.3.2/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec, rely 255/255, load 1/255
```

```
   Encapsulation ARPA, loopback not set, keepalive set (10 sec)
   ARP type: ARPA, ARP Timeout 04:00:00
   Last input 00:00:00, output 00:00:02, output hang never
   Last clearing of "show interface" counters never
   Queueing strategy: fifo
   Output queue 0/40, 0 drops; input queue 0/75, 0 drops
   5 minute input rate 0 bits/sec, 0 packets/sec
   5 minute output rate 0 bits/sec, 0 packets/sec
      194 packets input, 14449 bytes, 0 no buffer
      Received 189 broadcasts, 0 runts, 0 giants, 0 throttles
      0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
      0 input packets with dribble condition detected
      318 packets output, 27905 bytes, 0 underruns
      0 output errors, 0 collisions, 2 interface resets
      0 babbles, 0 late collision, 0 deferred
      0 lost carrier, 0 no carrier
      0 output buffer failures, 0 output buffers swapped out

 RouterC#sh int s0
 Serial0 is up, line protocol is up
   Hardware is QUICC Serial
   Internet address is 192.168.2.6/30
   MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec, rely 255/255, load 1/255
   Encapsulation HDLC, loopback not set, keepalive set (10 sec)
   Last input 00:00:01, output 00:00:00, output hang never
   Last clearing of "show interface" counters never
   Input queue: 0/75/0 (size/max/drops); Total output drops: 0
   Queueing strategy: weighted fair
   Output queue: 0/1000/64/0 (size/max total/threshold/drops)
      Conversations  0/1/256 (active/max active/max total)
      Reserved Conversations 0/0 (allocated/max allocated)
   5 minute input rate 0 bits/sec, 0 packets/sec
   5 minute output rate 0 bits/sec, 0 packets/sec
      317 packets input, 24376 bytes, 0 no buffer
      Received 119 broadcasts, 0 runts, 0 giants, 0 throttles
      0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
      303 packets output, 19509 bytes, 0 underruns
      0 output errors, 0 collisions, 14 interface resets
      0 output buffer failures, 0 output buffers swapped out
      0 carrier transitions
      DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

接着，我们在RouterA的S0和RouterB的S0上设置EIGRP最多使用64Kbps链路带宽的100%。以Router B为例：

```
interface Serial0
```

```
bandwidth 64
ip address 192.168.2.1 255.255.255.252
ip bandwidth-percent eigrp 75 100
 interface Serial1
bandwidth 128
  ip address 192.168.2.5 255.255.255.252
```

在RouterC上使用show ip eigrp topology，show ip route，show interfaces观察配置的结果。

```
RouterC#sh ip eigrp topology
IP-EIGRP Topology Table for process 75

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 192.168.1.0/24, 1 successors, FD is 20514560
         via 192.168.2.5 (20514560/28160), Serial0
P 192.168.2.0/30, 1 successors, FD is 40537600
         via 192.168.3.1 (40537600/40512000), Ethernet0
         via 192.168.2.5 (41024000/40512000), Serial0
P 192.168.3.0/24, 1 successors, FD is 281600
         via Connected, Ethernet0
P 192.168.2.4/30, 1 successors, FD is 20512000
         via Connected, Serial0
```

```
RouterC#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR

Gateway of last resort is not set

D    192.168.1.0/24 [90/20514560] via 192.168.2.5, 00:30:42, Serial0
     192.168.2.0/30 is subnetted, 2 subnets
D       192.168.2.0 [90/40537600] via 192.168.3.1, 00:30:43, Ethernet0
C       192.168.2.4 is directly connected, Serial0
C    192.168.3.0/24 is directly connected, Ethernet0
```

```
RouterC#sh int s0
Serial0 is up, line protocol is up
  Hardware is QUICC Serial
  Internet address is 192.168.2.6/30
```

```
MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec, rely 255/255, load 1/255
Encapsulation HDLC, loopback not set, keepalive set (10 sec)
Last input 00:00:00, output 00:00:01, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0 (size/max/drops); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
   Conversations  0/1/256 (active/max active/max total)
   Reserved Conversations 0/0 (allocated/max allocated)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
   698 packets input, 55064 bytes, 0 no buffer
   Received 252 broadcasts, 0 runts, 0 giants, 0 throttles
   0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
   663 packets output, 43280 bytes, 0 underruns
   0 output errors, 0 collisions, 14 interface resets
   0 output buffer failures, 0 output buffers swapped out
   0 carrier transitions
   DCD=up  DSR=up  DTR=up  RTS=up  CTS=up

   RouterC#sh int e0
   Ethernet0 is up, line protocol is up
     Hardware is QUICC Ethernet, address is 0010.7b2c.e59c (bia 0010.7b2c.e59c)
     Internet address is 192.168.3.2/24
     MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec, rely 255/255, load 1/255
     Encapsulation ARPA, loopback not set, keepalive set (10 sec)
     ARP type: ARPA, ARP Timeout 04:00:00
     Last input 00:00:00, output 00:00:01, output hang never
     Last clearing of "show interface" counters never
     Queueing strategy: fifo
     Output queue 0/40, 0 drops; input queue 0/75, 0 drops
     5 minute input rate 0 bits/sec, 0 packets/sec
     5 minute output rate 0 bits/sec, 0 packets/sec
        421 packets input, 31447 bytes, 0 no buffer
        Received 411 broadcasts, 0 runts, 0 giants, 0 throttles
        0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
        0 input packets with dribble condition detected
        673 packets output, 56992 bytes, 0 underruns
        0 output errors, 0 collisions, 2 interface resets
        0 babbles, 0 late collision, 0 deferred
        0 lost carrier, 0 no carrier
        0 output buffer failures, 0 output buffers swapped out
```

体会EIGRP的增量更新，键入debug eigrp fsm，接着，将Router C Fastethernet口上的网线拔下，

观察这时候的debug信息。

```
RouterC#debug eigrp fsm
EIGRP FSM Events/Actions debugging is on
RouterC#
00:15:20: DUAL: rcvquery: 192.168.3.0/24 via 192.168.2.5 metric 4294967295/4294967295, RD is 41026560
00:15:20: DUAL: Find FS for dest 192.168.3.0/24. FD is 41026560, RD is 41026560
00:15:20: DUAL:       192.168.2.5 metric 4294967295/4294967295 not found Dmin is 4294967295
00:15:20: DUAL: Dest 192.168.3.0/24 (Split Horizon) not entering active state.
00:15:20: DUAL: send REPLY(r1/n1) about 192.168.3.0/24 to 192.168.2.5
00:15:20: DUAL: Removing dest 192.168.3.0/24, nexthop 192.168.2.5
00:15:20: DUAL: No routes.  Flushing dest 192.168.3.0/24
```

重新把网线插上

```
00:15:50: DUAL: dest(192.168.3.0/24) not active
00:15:50: DUAL: rcvupdate: 192.168.3.0/24 via 192.168.2.5 metric 41026560/40514560
00:15:50: DUAL: Find FS for dest 192.168.3.0/24. FD is 4294967295, RD is 4294967295 found
00:15:50: DUAL: RT installed 192.168.3.0/24 via 192.168.2.5
00:15:50: DUAL: Send update about 192.168.3.0/24.  Reason: metric chg
00:15:50: DUAL: Send update about 192.168.3.0/24.  Reason: new if
```

实验五、EIGRP 的不等成本负载平衡（Unequal-Cost Load Balancing with IGRP）

配置负载均衡，在 RouterB 中键入如下命令：

RouterB(config)#router eigrp 75

RouterB(config-router)#variance 10

通过show ip route命令查看RouterB的路由表[注]

启用 variace 命令前的路由表	启用 variace 命令后的路由表
RouterC#sh ip route Codes: C - connected, S - static, I - IGRP, 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, E - EGP i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default U - per-user static route, o - ODR Gateway of last resort is not set D 192.168.1.0/24 [90/20514560] via 192.168.2.5, 00:30:42, Serial0	RouterB#sh ip route Codes: C - connected, S - static, I - IGRP, 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, E - EGP i - IS-IS, 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

192.168.2.0/30 is subnetted, 2 subnets D 192.168.2.0 [90/40537600] via 192.168.3.1, 00:30:43, Ethernet0 C 192.168.2.4 is directly connected, Serial0 C 192.168.3.0/24 is directly connected, Ethernet0	C 192.168.1.0/24 is directly connected, FastEthernet0 192.168.2.0/30 is subnetted, 2 subnets C 192.168.2.0 is directly connected, Serial1 C 192.168.2.4 is directly connected, Serial0 D 192.168.3.0/24 [90/40537600] via 192.168.2.2, 00:00:08, Serial1 [90/20537600] via 192.168.2.6, 00:00:08, Serial0

※如果观察不到以上结果，可以先保存配置，然后重启一遍路由器

接着，在 Host 上通过 ping 192.168.3.1 -t -r 3 命令验证 variance 命令

```
C:\>ping 192.168.3.1 -t -r 3

Pinging 192.168.3.1 with 32 bytes of data:

Reply from 192.168.3.1: bytes=32 time=21ms TTL=253
    Route: 192.168.2.1 ->
           192.168.3.1 ->
           192.168.3.1
Reply from 192.168.3.1: bytes=32 time=20ms TTL=253
    Route: 192.168.2.5 ->
           192.168.3.2 ->
           192.168.3.1
Reply from 192.168.3.1: bytes=32 time=20ms TTL=253
    Route: 192.168.2.5 ->
           192.168.3.2 ->
           192.168.3.1
Reply from 192.168.3.1: bytes=32 time=20ms TTL=253
    Route: 192.168.2.1 ->
           192.168.3.1 ->
           192.168.3.1
Reply from 192.168.3.1: bytes=32 time=20ms TTL=253
    Route: 192.168.2.5 ->
           192.168.3.2 ->
           192.168.3.1
Reply from 192.168.3.1: bytes=32 time=20ms TTL=253
    Route: 192.168.2.5 ->
           192.168.3.2 ->
           192.168.3.1


Ping statistics for 192.168.3.1:
    Packets: Sent = 6, Received = 6, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 20ms, Maximum =  21ms, Average =  20ms
Control-C
^C
```

可见，没 3 个数据包中，有两个经 192.168.2.5 走，另一个经 192.168.2.1 走，证明不等成本负载平衡生效。

实验六、EIGRP 的参数修改

◆ **修改hello-interval和hold-time**

根据Cisco公司关于EIGRP的白皮书，默认情况下，在高带宽链路上，EIGRP每5秒发送一次hello包，在低带宽多点链路上，EIGRP每60秒发送一次hello包。而hold time的默认时间是hello包发送时间的3倍[注]。即高带宽链路上的hold time是15秒，低带宽链路上的hold time是180秒。我们可以用ip hello-interval eigrp和ip hold-time eigrp命令更改hello包发送时间和hold time。

在没有更改前，先用show ip eigrp neighbor命令查看一下两个timer。

RouterB#sh ip eigrp nei

IP-EIGRP neighbors for process 75

H	Address	Interface	Hold Uptime (sec)	SRTT (ms)	RTO	Q Cnt	Seq Num	Type
0	192.168.2.6	Se0	12 00:17:17	20	1140	0	38	
1	192.168.2.2	Se2	14 00:36:56	21	1140	0	53	

然后我们在RouterB上，把hello interval改成10秒，holdtime改成30秒。再在RouterC上用show ip eigrp neighbor命令查看：

RouterC#sh ip eigrp nei

IP-EIGRP neighbors for process 75

H	Address	Interface	Hold Uptime (sec)	SRTT (ms)	RTO	Q Cnt	Seq Num	Type
1	192.168.3.1	Fa0	12 00:05:53	4	200	0	52	
0	192.168.2.5	Se0	21 00:17:42	27	200	0	20	

我们也可以通过debug eigrp packets命令查看：

```
01:38:55: EIGRP: Received HELLO on FastEthernet0 nbr 192.168.3.1
01:38:55:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
01:38:55: EIGRP: Sending HELLO on Serial0
01:38:55:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
01:38:55: EIGRP: Sending HELLO on FastEthernet0
01:38:55:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
01:38:57: EIGRP: Received HELLO on Serial0 nbr 192.168.2.5
01:38:57:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
01:38:59: EIGRP: Received HELLO on FastEthernet0 nbr 192.168.3.1
01:38:59:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
01:39:00: EIGRP: Sending HELLO on Serial0
01:39:00:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
01:39:00: EIGRP: Sending HELLO on FastEthernet0
01:39:00:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
01:39:04: EIGRP: Received HELLO on FastEthernet0 nbr 192.168.3.1
01:39:04:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
01:39:04: EIGRP: Sending HELLO on Serial0
01:39:04:     AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
```

01:39:05: EIGRP: Sending HELLO on FastEthernet0
01:39:05:   AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
01:39:07: EIGRP: Received HELLO on Serial0 nbr 192.168.2.5
01:39:07:   AS 75, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0

※ "EIGRP sends hello packets every 5 seconds on high bandwidth links and every 60 seconds on low bandwidth multipoint links.

- 5-second hello:
  - broadcast media, such as Ethernet, Token Ring, and FDDI ♦
  - point-to-point serial links, such as PPP or HDLC leased circuits, Frame Relay point-to-point subinterfaces, and ATM point-to-point subinterfaces ♦
  - high bandwidth (greater than T1) multipoint circuits, such as ISDN PRI and Frame Relay ♦
- 60-second hello: •
  - multipoint circuits T1 bandwidth or slower, such as Frame Relay multipoint interfaces, ATM multipoint interfaces, ATM
  - switched virtual circuits, and ISDN BRIs ♦

The rate at which EIGRP sends hello packets is called the hello interval, and you can adjust it per interface with the **ip hello-interval eigrp** command. The hold time is the amount of time that a router will consider a neighbor alive without receiving a hello packet. The hold time is typically three times the hello interval, by default, 15 seconds and 180 seconds. You can adjust the hold time with the **ip hold-time eigrp** command. Note that if you change the hello interval, the hold time is not automatically adjusted to account for this change - you must manually adjust the hold time to reflect the configured hello interval. It is possible for two routers to become EIGRP neighbors even though the hello and hold timers don't match. The hold time is included in the hello packets so each neighbor should stay alive even though the hello interval and hold timers don't match."

——Cisco - White Paper: EIGRP

◆ 五个 **K** 值的修改（选做）

在 RouterB 上先用 show ip route，show ip eigrp topology，观察到 192.168.3.0 网络的度量。
分别在 RouterA 和 RouterC 上改变 eigrp 的参数，使用如下的命令：
RouterA(config-router)#metric weights 0 *K1 K2 K3 K4 K5*
再次在 RouterB 上 show ip route, show ip eigrp topology，观察是否已经修改了 eigrp 的度量。

<table>
<tr><th>K1=1,K2=0,K3=1,K4=0,K5=0（默认）</th><th>K1=K2=K3=K4=K5=1</th></tr>
<tr><td><pre>RouterA#sh 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, 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

D   192.168.1.0/24 [90/20540160] via 192.168.3.2, 00:09:56, Ethernet0
     192.168.2.0/30 is subnetted, 2 subnets
C   192.168.2.0 is directly connected, Serial0
D   192.168.2.4 [90/20537600] via 192.168.3.2, 00:09:56, Ethernet0
C   192.168.3.0/24 is directly connected, Ethernet0</pre></td><td><pre>RouterA#sh 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, 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

D   192.168.1.0/24 [90/80541] via 192.168.3.2, 00:03:12, Ethernet0
     192.168.2.0/30 is subnetted, 2 subnets
C   192.168.2.0 is directly connected, Serial0
D   192.168.2.4 [90/80531] via 192.168.3.2, 00:03:12, Ethernet0
C   192.168.3.0/24 is directly connected, Ethernet0</pre></td></tr>
</table>

```
RouterA#sh ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(192.168.3.1)

Codes: P - Passive, A - Active, U - Update, Q - Query,
R - Reply,
      r - reply Status, s - sia Status

P 192.168.1.0/24, 1 successors, FD is 20540160
        via 192.168.3.2 (20540160/20514560), Ethernet0
        via 192.168.2.1 (40514560/28160), Serial0
P 192.168.2.0/30, 1 successors, FD is 40512000
        via Connected, Serial0
P 192.168.3.0/24, 1 successors, FD is 281600
        via Connected, Ethernet0
P 192.168.2.4/30, 1 successors, FD is 20537600
        via 192.168.3.2 (20537600/20512000), Ethernet0
        via 192.168.2.1 (41024000/20512000), Serial0
```

```
RouterA#sh ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(192.168.3.1)

Codes: P - Passive, A - Active, U - Update, Q - Query,
R - Reply,
      r - reply Status, s - sia Status

P 192.168.1.0/24, 1 successors, FD is 80541
        via 192.168.3.2 (80541/80441), Ethernet0
        via 192.168.2.1 (158872/110), Serial0
P 192.168.2.0/30, 1 successors, FD is 158862
        via Connected, Serial0
P 192.168.3.0/24, 1 successors, FD is 1103
        via Connected, Ethernet0
P 192.168.2.4/30, 1 successors, FD is 80531
        via 192.168.3.2 (80531/80431), Ethernet0
        via 192.168.2.1 (160862/80431), Serial0
```

```
RouterB#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
      i - IS-IS, 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        192.168.1.0/24  is  directly  connected,
FastEthernet0
    192.168.2.0/30 is subnetted, 2 subnets
C      192.168.2.0 is directly connected, Serial1
C      192.168.2.4 is directly connected, Serial0
D    192.168.3.0/24 [90/20537600] via 192.168.2.6,
00:11:47, Serial0
                 [90/40537600]   via   192.168.2.2,
00:11:47, Serial1
```

```
RouterB#sh ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(192.168.2.5)

Codes: P - Passive, A - Active, U - Update, Q - Query,
R - Reply,
      r - reply Status, s - sia Status

P 192.168.1.0/24, 1 successors, FD is 28160
        via Connected, FastEthernet0
P 192.168.2.0/30, 1 successors, FD is 40512000
        via Connected, Serial1
P 192.168.3.0/24, 1 successors, FD is 20537600
        via 192.168.2.6 (20537600/281600), Serial0
        via 192.168.2.2 (40537600/281600), Serial1
P 192.168.2.4/30, 1 successors, FD is 20512000
        via Connected, Serial0
```

```
RouterB#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
      i - IS-IS, 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   192.168.1.0/24 is directly connected, FastEthernet0
    192.168.2.0/30 is subnetted, 2 subnets
C      192.168.2.0 is directly connected, Serial1
C      192.168.2.4 is directly connected, Serial0
D       192.168.3.0/24  [90/80531]  via  192.168.2.6,
00:04:28, Serial0
                [90/158962] via 192.168.2.2, 00:04:28,
Serial1
```

```
RouterB#sh ip eigrp topology
IP-EIGRP Topology Table for AS(75)/ID(192.168.2.5)

Codes: P - Passive, A - Active, U - Update, Q - Query,
R - Reply,
      r - reply Status, s - sia Status

P 192.168.1.0/24, 1 successors, FD is 28160
        via Connected, FastEthernet0
P 192.168.2.0/30, 1 successors, FD is 40512000
        via Connected, Serial1
        via 192.168.2.6 (160962/158962), Serial0
P 192.168.3.0/24, 1 successors, FD is 80531
        via 192.168.2.6 (80531/1103), Serial0
        via 192.168.2.2 (158962/1103), Serial1
P 192.168.2.4/30, 1 successors, FD is 20512000
        via Connected, Serial0
        via 192.168.2.2 (160962/80531), Serial1
```

```
RouterC#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
      i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
* - candidate default
      U - per-user static route, o - ODR

Gateway of last resort is not set

D    192.168.1.0/24 [90/20514560] via 192.168.2.5,
00:13:37, Serial0
```

```
RouterC#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
      i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
* - candidate default
      U - per-user static route, o - ODR

Gateway of last resort is not set

D       192.168.1.0/24  [90/80441]  via  192.168.2.5,
00:06:14, Serial0
```

<pre>   192.168.2.0/30 is subnetted, 2 subnets
D   192.168.2.0 [90/40537600] via 192.168.3.1,
00:13:17, Ethernet0
C   192.168.2.4 is directly connected, Serial0
C   192.168.3.0/24 is directly connected, Ethernet0
RouterC#sh ip eigrp topology
IP-EIGRP Topology Table for process 75
 	
Codes: P - Passive, A - Active, U - Update, Q - Query,
R - Reply,
      r - Reply status
 	
P 192.168.1.0/24, 1 successors, FD is 20514560
        via 192.168.2.5 (20514560/28160), Serial0
P 192.168.2.0/30, 1 successors, FD is 40537600
        via 192.168.3.1 (40537600/40512000), Ethernet0
        via 192.168.2.5 (41024000/40512000), Serial0
P 192.168.3.0/24, 1 successors, FD is 281600
        via Connected, Ethernet0
P 192.168.2.4/30, 1 successors, FD is 20512000
        via Connected, Serial0</pre>
	<pre> 192.168.2.0/30 is subnetted, 2 subnets
	D 192.168.2.0 [90/158962] via 192.168.3.1,
	00:05:34, Ethernet0
	C 192.168.2.4 is directly connected, Serial0
	C 192.168.3.0/24 is directly connected, Ethernet0
	RouterC#sh ip eigrp topology
	IP-EIGRP Topology Table for process 75
	
	Codes: P - Passive, A - Active, U - Update, Q - Query,
	R - Reply,
	      r - Reply status
	
	P 192.168.1.0/24, 1 successors, FD is 80441
	        via 192.168.2.5 (80441/110), Serial0
	P 192.168.2.0/30, 1 successors, FD is 158962
	        via 192.168.3.1 (158962/158862), Ethernet0
	        via 192.168.2.5 (160862/158862), Serial0
	P 192.168.3.0/24, 1 successors, FD is 281600
	        via Connected, Ethernet0
	P 192.168.2.4/30, 1 successors, FD is 20512000
	        via Connected, Serial0</pre>

修改 K 值过程中屏幕显示的信息：

```
*Mar  1 00:18:37.655: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:18:37.923: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
*Mar  1 00:18:42.539: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
*Mar  1 00:18:42.575: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:18:46.883: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:18:47.487: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
*Mar  1 00:18:51.255: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:18:51.947: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
*Mar  1 00:18:55.531: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:18:56.407: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
*Mar  1 00:19:00.131: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:19:01.195: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
*Mar  1 00:19:04.911: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is down: K-value mismatch
*Mar  1 00:19:05.739: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is down: K-value mismatch
RouterA(config-router)# metric weights 0 1 1 1 1 1
*Mar  1 00:19:09.559: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.2.1
(Serial0) is up: new adjacency
```

```
*Mar  1 00:19:10.407: %DUAL-5-NBRCHANGE: IP-EIGRP 75: Neighbor 192.168.3.2
(Ethernet0) is up: new adjacency
```

通过 show ip protocols 命令查看 K 值:

```
RouterC#sh ip protocols
Routing Protocol is "eigrp 75"
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=1, K3=1, K4=1, K5=1
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 75
  Automatic network summarization is not in effect
  Routing for Networks:
    192.168.2.0
    192.168.3.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.3.1           90      00:06:27
    192.168.2.5           90      00:06:29
  Distance: internal 90 external 170
```

Frame-relay 实验

【实验目的】

1. 掌握全网格型帧中继的配置；
2. 掌握帧中继子端口的配置；
3. 掌握帧中继的流量整形。

【实验原理】

一、 帧中继技术概述

1. 帧中继网简述——帧中继封装方式：cisco 和 ietf
   注意：帧中继只工作在 OSI 的物理层和数据链路层。
2. DLCI、LMI 的意义和类型
   DLCI—用来标识 VC（通常是 PVC）的数字，在 0～1023 之间。DLCI 只具有局部意义，即不同帧中继交换机接口的 DLCI 可以相同。
   LMI—本地管理接口，是 FR 网络中的信令。LMI 有三种类型：ANSI、Q933a 和 cisco。
3. 帧格式：

标志	地址包含DLCI,FECN,BECN 位	数据	帧校验序列	标志
1 Byte	2 Bytes	n Bytes	2 Bytes	1 Bytes

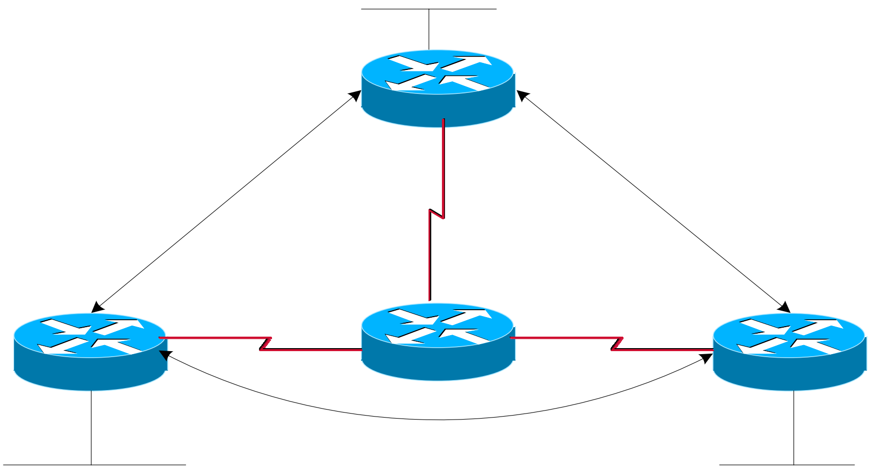
二、帧中继原理

1. 帧中继映射表－－将下一跳的 IP 地址映射成该接口上的 DLCI 号
2. 帧中继交换表－－将入口的 DLCI 映射到出口的 DLCI，实现寻路和交换。由于 FR 一般都采用了 PVC，所以这些映射表是静态指定的。
3. 逆向 ARP(Inverse-ARP)原理－－类似于 Ethernet 中的 RARP，主要作用是可以自动生成帧中继映射表。但是，有一点要注意的是，在用子接口时，Inverse-ARP 会失效，此时要在子接口中显示的指定 DLCI 号或者是手动配置映射表。

【实验步骤】

一、配置全网格型帧中继

实验拓扑如下：(连接时注意串行线的 DCE 端必须接到中间的由 router 模拟而成的交换机接口上。看标签或看线的构造决定（公的一端为 DTE，母的一端为 DCE）。



1．完成 Frswitch 的配置，命令如下：

```
hostname FR-switch
enable password cisco
frame-relay switching   !路由器用作帧中继交换机
interface Serial0
 encapsulation frame-relay   ！配置帧中继封装（默认为cisco封装方式）
 clockrate 56000   ！dce配置时钟
 frame-relay lmi-type cisco   ！帧中继lmi类型(IOS11.2后可以自动发现，可
                                以不配置)
 frame-relay intf-type dce    ！端口类型为dce
 frame-relay route 17 interface Serial1 16  ！配置帧中继交换表
 frame-relay route 18 interface Serial2 16
interface Serial1
encapsulation frame-relay
 clockrate 56000
 frame-relay intf-type dce
 frame-relay route 16 interface Serial0 17
 frame-relay route 18 interface Serial2 17
interface Serial2
 encapsulation frame-relay
 clockrate 56000
 frame-relay intf-type dce
 frame-relay route 16 interface Serial0 18
 frame-relay route 17 interface Serial1 18
```

2．完成各个用户路由器的配置，以 RouterA 为例（其它跟 RouterA 的类似）：

```
RouterA(config)#int s0
RouterA(config-if)#ip address 192.168.4.1 255.255.255.0
RouterA(config-if)#encapsulation frame-relay
！以下三条可以由FR的机制和IOS功能，可以自动实现，可以不配。
RouterA(config-if)#frame-relay lmi-type cisco
RouterA(config-if)#frame-relay map ip 192.168.4.2 17 broadcast
！broadcast有两功能：（1）组播没启动时，转发广播；（2）简化FR中ospf的配置
RouterA(config-if)#frame-relay map ip 192.168.4.3 18 broadcast
```

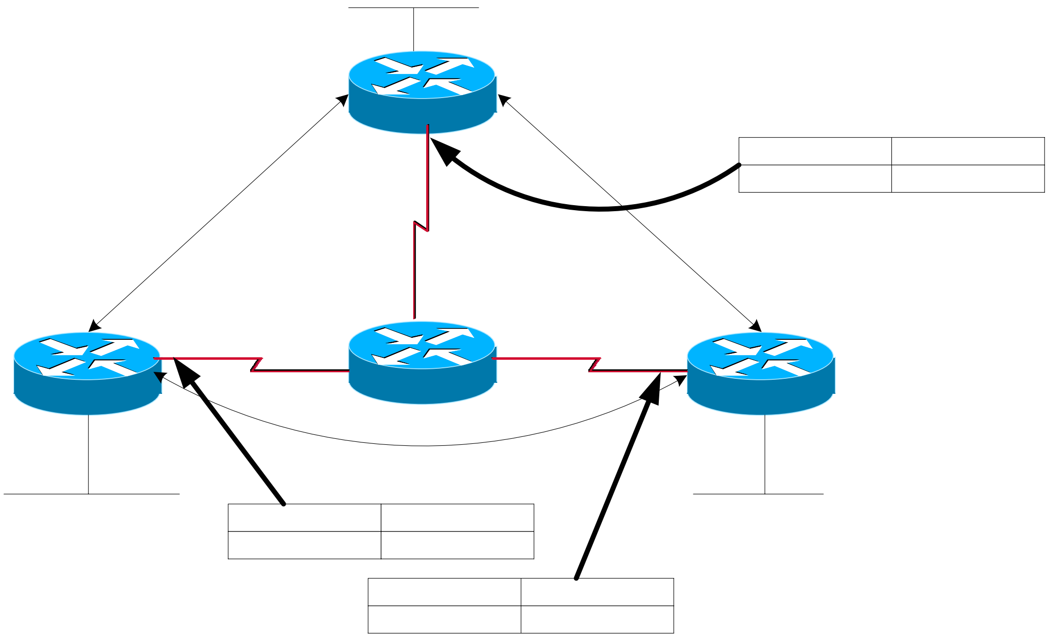
3．检查各个pvc是否处于active状态，命令show frame-relay pvc；
4．启动igrp路由协议，自治号为100；
5．使用ping命令检查各个用于路由器是否联通；
6．用show frame-relay lmi看lmi信息；
7．用show frame-relay map看帧中继映射表；
8．用show ip route看路由表是否正确？

二、配置子端口

划分子端口，主要是为了解决帧中继环境中路由更新时水平分割所带来的问题。所谓划

分子端口，就是指对物理端口进行逻辑划分，使每个子端口都是一条逻辑上独立的端口，从而在功能上看相当于独立的物理端口。子端口有两种模式： point-to-point 和 multipoint。前者一个子端口只能配一条 PVC，对方 Router 可以是物理也可以是子端口，两端处于同一子网中；后者一个端口可以配置多条 PVC，对方 Router 可以是物理也可以是子端口，但它们都必须处于同一子网中。

拓扑如下：



1. Frswitch的配置不需修改；
2. 用户路由器，以RouterA为例，先将原来物理端口上的ip地址去掉(因为如果不删除，子接口将不起作用)，如果配置过frame-relay map则也要删除，并加上子端口：

```
RouterA(config)#int s0
RouterA(config-if)#no ip address
RouterA(config-if)#encapsulation frame-relay
RouterA(config-if)#frame-relay lmi-type cisco
RouterA(config-if)#no frame-relay map ip 192.168.4.2 17 broadcast
RouterA(config-if)#no frame-relay map ip 192.168.4.3 18 broadcast
RouterA(config-if)#int s0.17 point-to-point ！配置为点到点类型的子端口
RouterA(config-subif)#ip address 192.168.101.1 255.255.255.0
RouterA(config-subif)#frame-relay interface-dlci 17
RouterA(config-if)#int s0.18 point-to-point ！配置为点到点类型的子端口
RouterA(config-subif)#ip address 192.168.102.1 255.255.255.0
RouterA(config-subif)#frame-relay interface-dlci 18
```

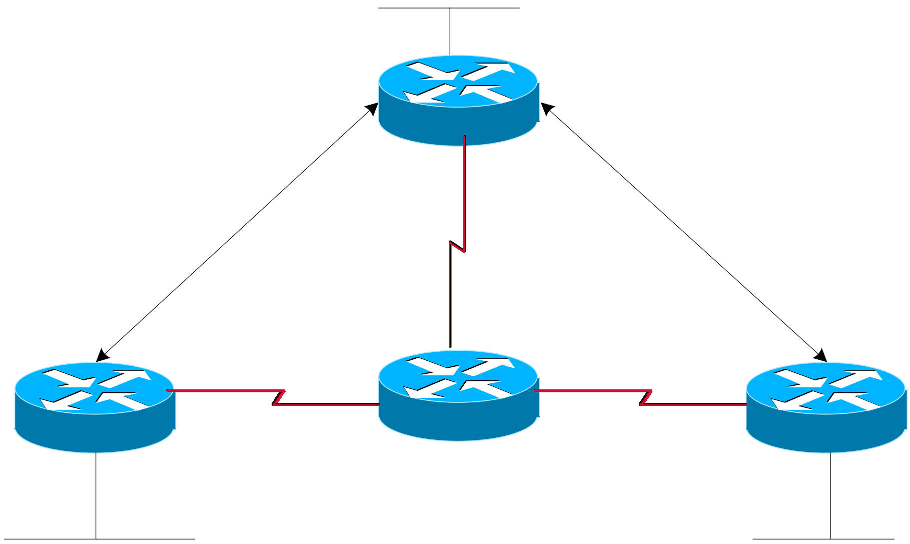
3. Show frame—relay pvc，检查链路是否处于active状态；

RouterB -

4. 修改原来的igrp的配置，将各个子端口的网络加上；
5. Show frame—relay map，检查帧中继映射表；
6. Show frame—relay lmi，看lmi信息；
7. Show ip route 看路由表是否正确？

三、配置hub－and－spoke型帧中继网络

hub-and-spoke主要是为了解决full-mesh时DLCI大量消耗的问题。拓扑如下：



1. 在Frswitch上删除RouterB←→RouterC间的pvc
2. 修改用户路由器的配置，对于hub路由器（RouterA），由于其子端口需要多个dlci，所以其子端口类型为multipoint。命令如下：

```
RouterA(config)#int s0
RouterA(config-if)#no ip address
RouterA(config-if)#encapsulation frame-relay
RouterA(config-if)#frame-relay lmi-type cisco
RouterA(config-if)#int s0.1 multipoint ! 配置为点到点类型的子端口
RouterA(config-subif)#ip address 192.168.4.1 255.255.255.0
RouterA(config-subif)#frame-relay interface-dlci 17
RouterA(config-subif)#frame-relay interface-dlci 18
```

RouterB

对于spoke路由器（RouterB和RouterC），由于其子端口只需一个dlci，其子端口类型可以配置为点对点，也可以配置在物理接口上，其配置如前全网格型的配置。

3. 同样启动igrp路由协议，自治号为100；
4. 由RouterA上ping RouterB及RouterC，测试联通性；
5. 再试试RouterB和RouterC之间互ping；
6. 在用扩展ping命令，在RouterB上以192.168.2.1的ip地址ping RouterC的loopback地址192.168.3.1,看看能否成功？（想想为什么？）
7. Show ip route，看看各个路由表的信息；
8. 去掉RouterA上的水平分割：

```
RouterA(config-if)#int s0.1 multipoint
RouterA(config-subif)#no ip split-horizon
```

RouterA - DLCI 16

9. 然后show ip int s0.1看是否已经将水平分割disable了。
10. 再看看各个路由器的路由表，看看是否正确？

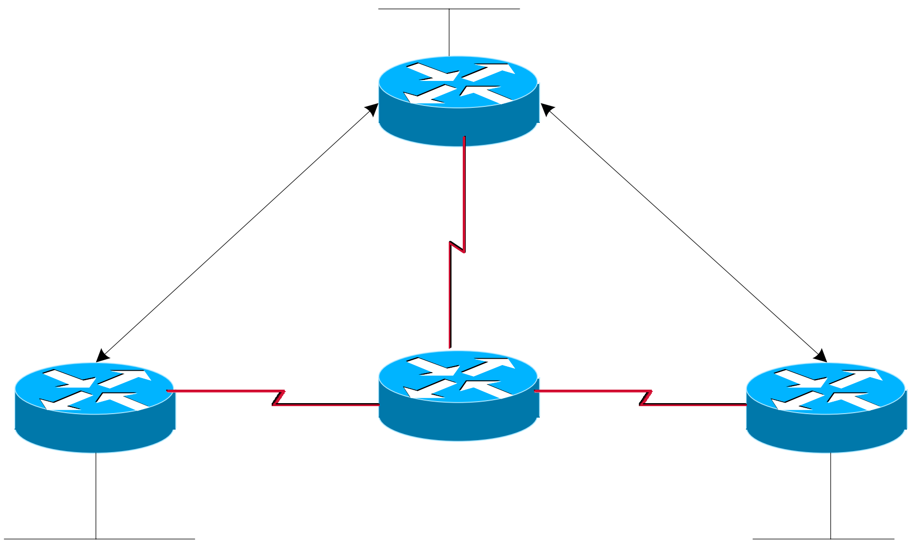
S0.16 1

11.　　在RouterB上用扩展ping，看能否联通？

四、帧中继的流量整形

流量整型主要包括三个方面：（1） 限定平均速率和峰值速率；（2） 用becn实现拥塞控制；3）采用优先队列或可定制队列实施控制。

实验拓扑：



在还没进行下面的实验以前，先用扩展ping命令，记录下他们的返回时间；

RouterA#**ping**

Protocol [ip]:

Target IP address: **192.168.2.1**

Repeat count [5]: **55**

Datagram size [100]: **1111**

Timeout in seconds [2]:

Extended commands [n]: **y**

Source address or interface: **192.168.1.1**

Type of service [0]:

Set DF bit in IP header? [no]:

Validate reply data? [no]:

Data pattern [0xABCD]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Sweep range of sizes [n]:

Type escape sequence to abort.

Sending 55, 1111-byte ICMP Echoes to 192.168.2.1, timeout is 2 seconds:

!!!

Success rate is 100 percent (55/55), round-trip min/avg/max = **176/179/192 ms**

1. 在同一条pvc之间（如RouterA←→RouterB）创建一个map-class，定义pvc的CIR（committed information rate）命令如下：

RouterA(config)#map-class frame-relay CIRA
RouterA(config-map-class)#**frame-relay traffic-rate 48000 96000**
RouterA(config-map-class)#frame-relay adaptive-shaping becn
RouterB(config)#map-class frame-relay CIRB
RouterB(config-map-class)#**frame-relay traffic-rate 9600 192000**
RouterC(config)#map-class frame-relay CIRC
RouterC(config-map-class)#**frame-relay traffic-rate 1000 2000**

2. 将该map-class应用到端口上：
RouterA(config)#interface serial 0
RouterA(config-if)#**frame-relay traffic-shaping**
RouterA(config-subif)#**frame-relay class CIRA**

RouterB(config)#interface serial 0
RouterB(config-if)#**frame-relay traffic-shaping**
RouterB(config-if)#**interface serial 0.16 point-to-point**
RouterB(config-subif)#**frame-relay class CIRB**
！RouterC的于RouterB的相似。

3. 用show frame-relay pvc验证CIR的配置；
4. 再一次用扩展ping命令，验证返回的时间是否比原来的要长？
5. 实验结果

```
RouterA#pin        //ping RouterB的回环口地址
Protocol [ip]:
Target IP address: 192.168.2.1
Repeat count [5]: 10
Datagram size [100]: 1111    //包大小不变
Timeout in seconds [2]: 5
Extended commands [n]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 10, 1111-byte ICMP Echos to 192.168.2.1, timeout is 5 seconds:
!!!!!!!!!!
Success rate is 100 percent (10/10), round-trip min/avg/max =
640/4010/4608 ms

RouterA#ping              //ping RouterC的回环口地址,将
Timeout in seconds [2]: 10 //timeout设为10 second
Sending 10, 1111-byte ICMP Echos to 192.168.3.1, timeout is 10 seconds:
!..!!!!!..
Success rate is 60 percent (6/10), round-trip min/avg/max =
644/7887/9568 ms
```

IP unnumbered 实验讲义

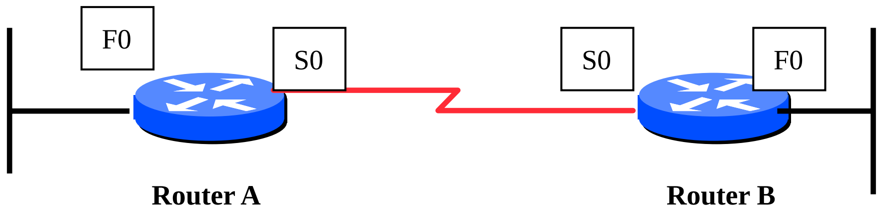
一. 实验目的:

掌握 ip unnumbered 命令以及命令适用范围。

二. 实验设备:

2600 router*2,serial 相连
IOS (tm) C2600 Software (C2600-DO3S-M), Version 12.0(5)T1

三. 实验拓扑:



四. 实验内容:

基本配置:

Router A#config t
Router A(config)#interface Serial0/0
Router A(config-if)#ip unnumbered FastEthernet0/0
Router A(config-if)#clockrate 56000
Router A(config-if)#no shut
Router A(config)#router rip
Router A(config-router)#network 172.16.0.0
Router A(config-router)#network 172.17.0.0

Router B#config t
Router B(config)#interface Serial0/0
Router B(config-if)#ip unnumbered FastEthernet0/0
Router B(config-if)#no shut
Router B(config)#router rip
Router B(config-router)#network 172.16.0.0
Router B(config-router)#network 172.17.0.0

1、相同网络号，无子网划分（无法工作）

Router A#config t

Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.65 255.255.0.0
Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router B(config-if)# ip address 172.16.10.1 255.255.0.0
Router B(config-if)#no shut

验证：
Router A#sh ip route
C 172.16.0.0/16 is directly connected, FastEthernet0/0
Router B#sh ip route
172.16.0.0/16 is subnetted, 1 subnets
C 172.16.0.0 is directly connected, FastEthernet0/0

2、同一网络号的等长子网掩码
Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.65 255.255.255.192
Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router Bonfig-if)# ip address 172.16.17.17 255.255.255.192
Router Bconfig-if)#no shut

验证：
Router A#show ip route
172.16.0.0/26 is subnetted, 3 subnets
C 172.16.16.64 is directly connected, FastEthernet0/0
R 172.16.17.0 [120/1] via 172.16.17.17, 00:00:16, Serial0/0
R 172.16.0.0 [120/1] via 172.16.17.17, 00:00:16, Serial0/0

Router B#show ip route
172.16.0.0/26 is subnetted, 3 subnets
C 172.16.17.0 is directly connected, FastEthernet0/0
R 172.16.0.0 [120/1] via 172.16.16.65, 00:00:25, Serial0/0
R 172.16.16.64 [120/1] via 172.16.16.65, 00:00:25, Serial0/0

3．不同网络号，默认子网掩码
Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.65 255.255.0.0

Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router B(config-if)# ip address 172.17.17.129 255.255.0.0
Router B(config-if)#no shut

验证：
Router A#sh ip route
R 172.17.0.0/16 [120/1] via 172.17.17.129, 00:00:00, Serial0/0
C 172.16.0.0/16 is directly connected, FastEthernet0/0

Router B#sh ip route
C 172.17.0.0/16 is directly connected, FastEthernet0/0
172.16.0.0/16 is subnetted, 1 subnets(???)
R 172.16.0.0 [120/1] via 172.16.16.65, 00:00:03, Serial0/0

4、不同网络号，等长子网掩码
Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.1 255.255.255.0
Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router B(config-if)# ip address 172.17.17.1 255.255.255.0
Router B(config-if)#no shut

验证：
Router A#sh ip route
172.17.0.0/16 is variably subnetted, 2 subnets, 2 masks
R 172.17.17.0/32 [120/1] via 172.17.17.1, 00:00:08, Serial0/0
R 172.17.0.0/16 [120/1] via 172.17.17.1, 00:00:08, Serial0/0
172.16.0.0/24 is subnetted, 1 subnets
C 172.16.16.0 is directly connected, FastEthernet0/0

Router B#sh ip route
172.17.0.0/24 is subnetted, 1 subnets
C 172.17.17.0 is directly connected, FastEthernet0/0
172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
R 172.16.16.0/32 [120/1] via 172.16.16.1, 00:00:01, Serial0/0
R 172.16.0.0/16 [120/1] via 172.16.16.1, 00:00:01, Serial0/0

5、同一网络号，不等长子网掩码(无法工作)

1）

Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.65 255.255.0.0
Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router B(config-if)# ip address 172.16.10.65 255.255.255.192
Router B(config-if)#no shut

验证：

Router A#sh ip route
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C   172.16.0.0/16 is directly connected, FastEthernet0/0
R   172.16.10.64/32 [120/1] via 172.16.10.65, 00:00:22, Serial0/0

Router B#sh ip route
    172.16.0.0/26 is subnetted, 2 subnets
R   172.16.0.0 [120/1] via 172.16.16.65, 00:00:23, Serial0/0
C   172.16.10.64 is directly connected, FastEthernet0/0

2）

Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.1 255.255.0.0
Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router B(config-if)# ip address 172.16.10.65 255.255.255.192
Router B(config-if)#no shut

验证：

Router A#
    172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C   172.16.16.0/24 is directly connected, FastEthernet0/0
R   172.16.0.0/24 [120/1] via 172.16.10.65, 00:00:17, Serial0/0
R   172.16.10.64/32 [120/1] via 172.16.10.65, 00:00:17, Serial0/0

Router B#show ip route
    172.16.0.0/26 is subnetted, 3 subnets
R   172.16.16.0 [120/1] via 172.16.16.1, 00:00:10, Serial0/0
R   172.16.0.0 [120/1] via 172.16.16.1, 00:00:10, Serial0/0

C   172.16.10.64 is directly connected, FastEthernet0/0

不通原因：皆缺少去 172.16.10.65 的路由(处于子网 172.16.10.64/26)，
如若刚好处于子网 172.16.10.0/26,则应无问题。

6、两不同网络号，不同子网掩码长度

Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.16.66 255.255.255.192
Router A(config-if)#no shut

Router B#config t
Router B(config)# interface FastEthernet0/0
Router B(config-if)# ip address 172.17.17.1 255.255.255.0
Router B(config-if)#no shut

验证：

```
Router A#
      172.17.0.0/16 is variably subnetted, 2 subnets, 2 masks
R         172.17.17.0/32 [120/1] via 172.17.17.1, 00:00:03, Serial0/0
R         172.17.0.0/16 [120/1] via 172.17.17.1, 00:00:03, Serial0/0
      172.16.0.0/26 is subnetted, 1 subnets
C         172.16.16.64 is directly connected, FastEthernet0/0

Router B#
      172.17.0.0/24 is subnetted, 1 subnets
C         172.17.17.0 is directly connected, FastEthernet0/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
R         172.16.0.0/16 [120/1] via 172.16.16.66, 00:00:07, Serial0/0
R         172.16.16.64/32 [120/1] via 172.16.16.66, 00:00:07, Serial0/0
```

%IOS version 11.0(2) and higher，通过发送一聚合 route 解决问题%

ISDN 实验

【实验目的】

1. 掌握 ISDN 原理，掌握 ISDN 的 BRI 和 PRI 的特性。
2. 掌握 ISDN BRI 接口的配置，并用 DDR 实现按需拨号。
3. 掌握 PPP multilink 的意义和配置。
4. 掌握 ISDN PRI 接口的配置。

【实验原理】

1. ISDN 模型

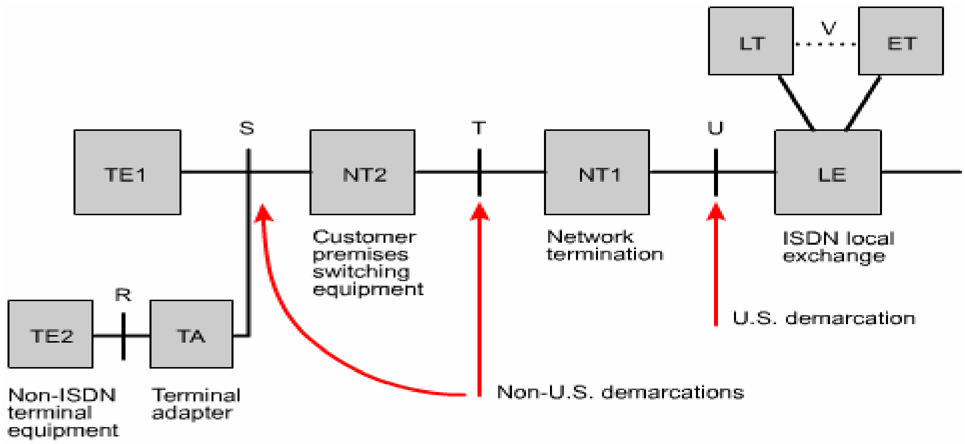


图 2　ISDN 参考模型

2. ISDN 的 BRI 和 PRI 接口

ISDN 的接口按速率分为两类：基本速率接口(BRI)和基群速率接口(PRI)。前者由 2B+D 信道方式组成，有效数据速率最高达到 128kbps，总速率达到 192kbps；后者基于 T1（23B+D）或者 E1（30B+D），总速率分别为 1.544Mbps 或 2.048Mbps。

3. ISDN 协议栈

	D Channel	B Channel
Layer 3	DSS1 (Q.931)	IP/IPX
Layer 2	LAPD (Q.921)	HDLC/PPP/FR/LAPB
Layer 1	I.430/I.431/ANSI T1.601	

图 3　ISDN 协议栈

其中要注意的一点是 LAPD 和 DSS1 都只是与 ISDN 服务提供接入交换机之间的信令协议，在服务提供商的 PSTN 网络里或者这些网络之间一般是采用 SS7 信令。

对于 BRI 接口，常用的信令标准有 AT&T 的 5ESS、Nortel 的 DMS-100、National ISDN 和 ETSI 的 net3 这几种；对于 PRI 而言，也是上面几个相对应的应用在 PRI 接口的信令，其中 ETSI 的为 net5。中国和欧洲在 BRI 接口上采用了 net3，在 PRI 接口上采用了 net5。

4． SPID(Service Profile Identification)

用数字表示，它由服务提供商提供，用来标识客户所使用的链路的配置情况。通过它，就可以使得多台 ISDN 设备共享一条 ISDN 本地环路。DMS-100 和 National ISDN-1 标准需要使用 SPIDs。取决于软件的实施，有些 AT&T 5ESS 的交换机也可能会需要 SPIDs。

5． Multilink

Multilink 即是将两条或两条以上链路绑在一起形成一条逻辑链路的方法，以提供负责均衡的能力。在 multilink 的多条物理链路之间采用 MLP(Multil-Link Protocol)进行管理。对于要传送的一帧，MLP 会对该帧进行分成若干个“片”，同时在各条物理链路上进行传输，然后在 multilink 的对端进行重组。

对 BRI 接口而言，提供了两条都是 64kbps 的 B 信道。为了增加传输速率，可以将这两条 B 信道绑在一起形成 multilink。

Multilink 不仅仅可以在同一物理接口的不同 B 信道上实现，还可以在不同的物理接口上实现。

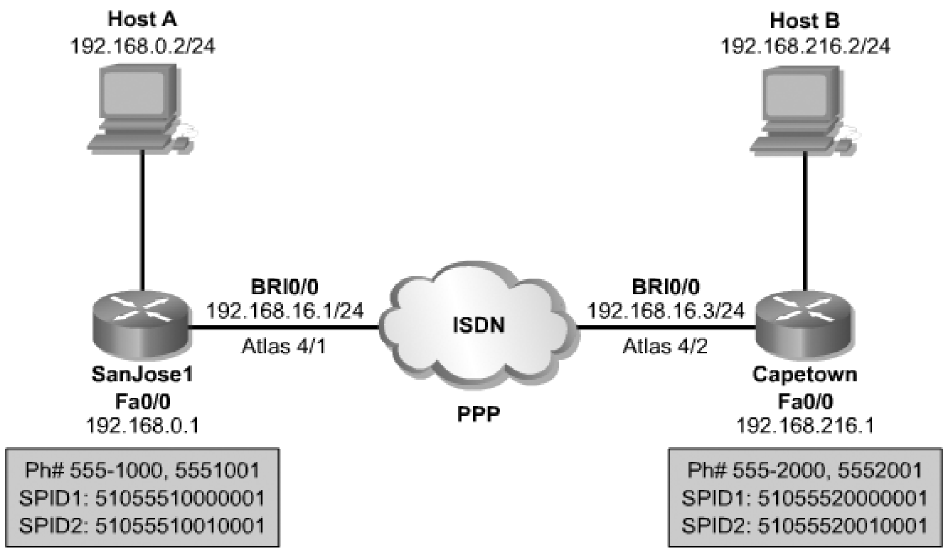
【实验设备】

带 S/T 接口或 U 接口的 Cisco 路由器三部，带 E1 controller 的路由器一台，带超级终端的 PC 机三台，Atlas550 一台，相应的连接线若干。

【实验内容】

一、　　配置 ISDN BRI 接口

1．实验拓扑图如下：



上图中，如果采用的是 net3 信令，则不用配置 SPID。

2．BRI 接口配置

（1）配置任务如下：

- 在全局配置模式下配置交换机类型
- 配置 BRI 接口的 IP/mask，配置封装方式为 PPP，并配置 CHAP 认证方式
- 配置 DDR

- 如果有需要相应的路由信息的话，一般情况下为了节省动态更新带来的额外开销，常常配置静态或默认路由。
- 配置可选参数，如 dialer idle-timeout, dialer fast-idle timeout 等。

（2）具体配置如下：

下面以 SanJose1 的为例，Capetown 的与 SanJose1 的类似。

SanJose1(config)#username Capetown password cisco //为 CHAP 配置用户名和密码

SanJose1(config)#isdn switch-type basic-net3 //配置接入方交换机类型

SanJose1(config)#interface bri0/0

SanJose1(config-if)#ip address 192.168.16.1 255.255.255.0

SanJose1(config-if)#encapsulation ppp

SanJose1(config-if)#ppp authentication chap

SanJose1(config-if)#dialer map ip 192.168.16.3 name Capetown broadcast 5552000

//DDR 配置，其中 5552000 为对端号码

SanJose1(config-if)#dialer-group 1 //绑定触发性列表

SanJose1(config)#dialer-list 1 protocol ip permit //定义触发性列表

SanJose1(config)#ip route 192.168.216.0 255.255.255.0 192.168.16.3

SanJose1(config-if)#dialer idle-timeout 60 //配置空闲时间值

如果是配置 National ISDN 或 DMS-100，则还需配置 SPID，配置方式如下：

（config-if）#**isdn spid** *spid_num* 【*ldn*】

其中 ldn 为本地呼叫号码。例如对 SanJose1 而言，配置如下：

SanJose1 (config-if)#isdn spid1 51055520000001 5552000

SanJose1 (config-if)#isdn spid2 51055520010001 5552001

Capetown 的配置可以仿照 SanJose1 的进行。

（3）检验

可以使用下列命令来观察相关信息：

show isdn status //显示 ISDN 接口的相关状态信息

show isdn active //显示 ISDN 接口已经激活的信道及其状态

show dialer //显示有关拨号的信息

debug dialer

debug ppp negotiation

clear int bri0 //断开 BRI 接口上的连接，或重新刷新状态

测试方法如下：

- 在 SanJose1 上 ping Capetown 的以太网口，看能否 ping 通，可以启动相应的 debug 命令查看信息。
- 用 clear int bri0 命令断开连接，再在 Capetown 上 ping SanJose1 上的 BRI 接口，看能

否 ping 通。

- 观察在没有数据流量的时候相隔多长时间会自动断开连接，改变 idle-timeout 的时间再次观察。此时开启 debug dialer 和 debug ppp negotiation 来看时间标记。

3．用 PPP multilink 实现 ISDN B 信道聚合

(3)　配置任务

- 在接口配置模式下启动 ppp multilink。
- 配置启动第 2 条 B 信道的阈值，阈值为 1 时则表示无论如何都会强迫第 2 条 B 信道拨起来。此阈值反映的是占一条 64kbps 的 B 信道的带宽的百分比。
- 配置重拨的时间间隔和次数。可选参数。

注：只有配置了前面两点，则一个 dialer map 就可以同时拨通两个 B 信道，亦即一个电话号码就可以拨通两路 B 信道。

(3)　具体配置

SanJose1(config)#interface bri0/0

SanJose1(config-if)#ppp multilink

SanJose1(config-if)#dialer load-threshold 1 either

//配置阈值为 1，方向为 inbound 或 outbound 都行，即不管是 inbound 还是 outbound 的数据流，只要达到阈值就拨通第 2 条 B 信道。

SanJose1(config-if)#dialer redialer interval 5 attemps 5 //可选参数，重拨的间隔和次数

在 Capetown 上：

Capetown(config-if)#ppp multilink

这里只是启动 multilink，它不配置阈值，只是接收对端的呼叫。这条命令是必须配置的，因为在 PPP 的认证完成之后，两端都要进行 multilink 的协商，如果协商通不过则 multilink 无法建立起来。可以用 debug ppp multilink 查看。

(3)　检验

除了上面的检验命令外，还可以用 show ppp multilink 和 debug ppp multilink events 查看相应的信息。

在 SanJose1 上 ping Capetown 的 BRI 接口，看 BRI 接口上的两个 B 信道的灯是否都变绿；另外用上面提到的命令查看相关的信息。

反过来，在 Capetown 上 ping SanJose1 的 BRI 接口，看能否 ping 通。

二．　配置 ISDN PRI

1．拓扑如下图所示

2．PRI 接口的基本配置

（1）配置任务

- 配置 ISDN PRI 接口的交换机类型为 primary-net5,因为我们使用的是 E1 controller，所以要使用 ETSI 的 net5 类型的信令；
- 配置路由器上的 e1 controller，配置它们的 framing 方式、linecode 方式以及时隙范围。对于 e1 而言，它们默认是 CRC-4、HDB3，时隙最大范围为 1~31。

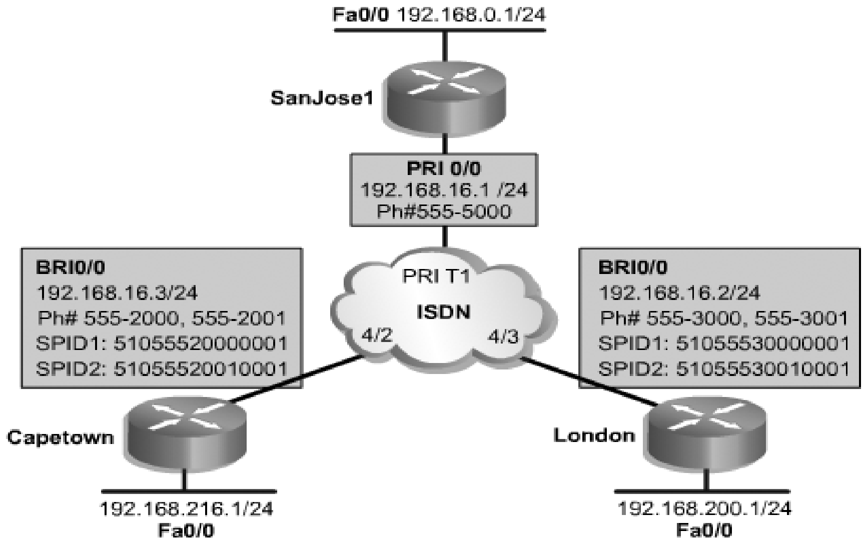


图 5　PRI 配置

- 配置信令接口，对 E1 链路而言，是采用第 16 路时隙作为信令时隙。由于 cisco 路由器是从 0 开始算的，因此其编号应该是 15。该信令接口为逻辑接口，用“接口号:15”方式表示。此接口中的配置跟上边 BRI 接口的配置类似。
- 配置一些可选参数，如 clock source 等。

（2）具体配置

■　这一部分的拓扑中，Capetown 和 Lodon 的配置同 BRI 的配置。SanJose1 的配置为：

```
SanJose1(config)#username Capetown password cisco    //for CHAP
SanJose1(config)#username London password cisco

SanJose1(config)#isdn switch-type primary-net5      //配置 ISDN 交换机类型

SanJose1(config)#controller e1 1/0                  //配置 E1 controller
SanJose1(config-controller)#framing crc-4
SanJose1(config-controller)#linecode hdb3
SanJose1(config-controller)#pri-group timeslots 1-31

SanJose1(config)#interface serial 1/0:15         //配置信令逻辑接口
SanJose1(config-if)#ip address 192.168.16.1 255.255.255.0
SanJose1(config-if)#encapsulation ppp
SanJose1(config-if)#ppp authentication chap
SanJose1(config-if)#ppp multilink
SanJose1(config-if)#dialer load-threshold 30 outbound

SanJose1(config-if)#dialer map ip 192.168.16.3 name Capetown 5552000    //DDR
SanJose1(config-if)#dialer map ip 192.168.16.2 name London 5553000
SanJose1(config-if)#dialer-group 1

SanJose1(config)#dialer-list 1 protocol ip permit
```

```
SanJose1(config)#ip route 192.168.200.0 255.255.255.0 192.168.16.2
SanJose1(config)#ip route 192.168.216.0 255.255.255.0 192.168.16.3
```

- 对于 Capetown 和 London 这两台路由器的配置，根据这一部分所分配的 IP 地址，并参照前一部分的配置方法进行配置。两台路由器都配置成 multilink 方式，但阈值改为 5，方向都改为 outbound。

(3)　检验

相关的命令跟前面 BRI 接口的配置和 multilink 配置时的检验方法相同。

进行如下测试：

- 只在中心路由器 SanJose1 上分别用扩展 ping 命令(count=100, size=10000) ping 路由器 Capetown 和 London，看可以启用多少条 B 信道？用 show isdn active 命令看是谁发起拨叫的？

  注：此时，其它两台路由器不 ping。
- 先在 Capetown 上用扩展 ping 命令 ping SanJose1 的 S1/0:15 的 IP 地址，看 multilink 是否起作用？然后在 London 上也用类似的方法 ping，看是否可以 ping 通？multilink 呢？
- 在 Capetown 和 Lodon 上台路由器上几乎同时 ping SanJose1 时又如何？

3．Multilink 时，两条 B 信道的分解

(1) 对于 multilink 来说，当两条 B 信道一起使用时，可以提高速率。但是如果这时候，有电话进来或有另外一路数据请求的时候，它会自动释放出一条 B 信道进行应答。

(2)　配置

在 London 上配置拨向 Capetown 的 DDR，以使得 London 能拨通 Capetown。

(3)　测试

首先，在 SanJose1 上 ping Capetown 的 BRI 口，启动 multilink。然后在 Lodon 上 ping Capetown 的 BRI 口，看能否 ping 通。这时应该是 ping 不通的，因为 Capetown 的其中一个号码已经给到 SanJose1 的连接使用着，但还无法释放此连接，而此时 Lodon 又去拨该号码，所以就无法拨通，显示的信息是”wait for isdn carrier timeout”。

(4)　配置多条 dialer map

解决办法是让 London 拨 Capetown 的另外一个号码。最简单的配置就是多加一台拨 Capetown 的另一个号码的 dialer map，这样一来就有两条 dialer map。在拨号的时候，路由器会自动搜索，某一条不行时自动使用另一条进行。

配置完后，继续采用(3)的测试方法，看能否令 multilink 的两条 B 信道让出一条给 Lodon 使用。可以用 show isdn active 查看，也可以启动相关的 debug 信息查看。

IS-IS 实验讲义

【实验目的】：掌握 IS-IS 路由协议的基本配置，理解在 CLNS 和 IP 两种不同的第三层协议下，IS-IS 配置的不同；理解 DIS 选举过程；熟悉 IS-IS 相关的配置命令与监视命令，并懂得在同一 router 上配置 Multiarea。

【实验设备】：2500 系列路由器两台，2600 路由器 3 台，要求 IOS 为支持 IS-IS 协议的电信级版本

【实验拓扑】：拓扑结构如下：其中图一是用于第一部分实验，图二是用于第二部分实验；图三是用于第三部分实验；

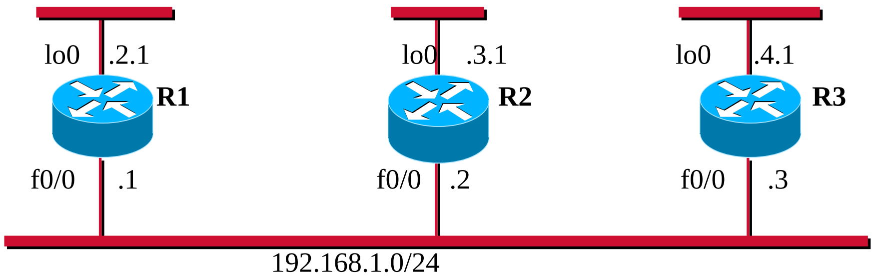


图 1：DIS 选举及 single area 配置

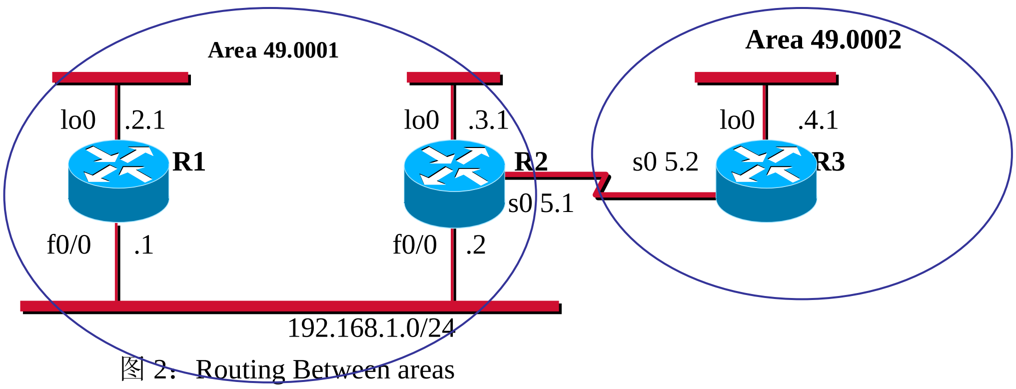


图 2：Routing Between areas

192.168.*.*

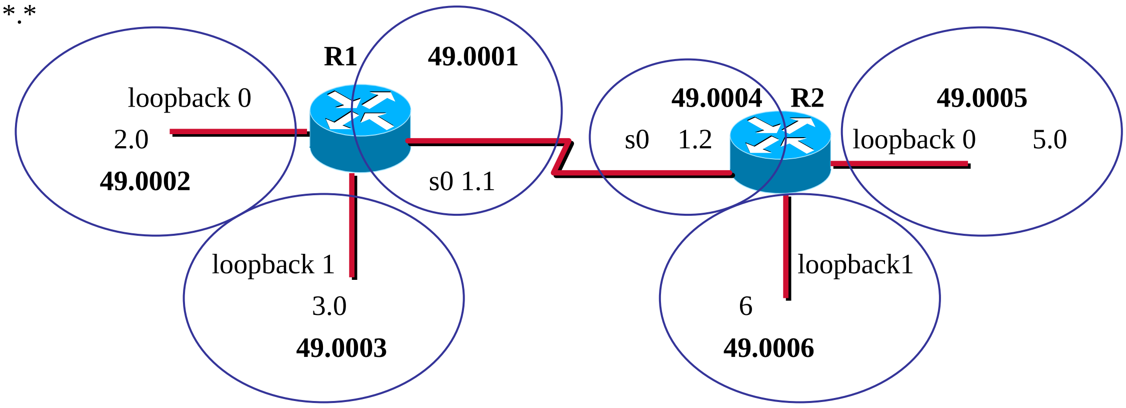


图 3：enable the multiarea feature

【实验步骤】：

第一部份：DIS 选举过程与 single area 配置；

1　按图 1 连接好 3 台 2600 系列路由器，并按图上标出的地址配置好各个端口；检查各个配置端口是否出于正常状态；

2　启动 IS-IS 路由进程：在各个路由器的全局配置模式下按如下步骤启动路由进程：

R1:

```
router isis                              //configuration of is-is process
        is-type level-1
        net 49.0001.1111.1111.1111.00
```

R2:

```
router isis                              //configuration of is-is process
        is-type level-1
        net 49.0001.2222.2222.2222.00
```

R3:

```
router isis                              //configuration of is-is process
        is-type level-1
        net 49.0001.3333.3333.3333.00
```

3　将 IS-IS 进程应用到端口上：在各个路由器中，分别对于 f0/0 和 lo0，运行 IS-IS 路由。在接口模式下，配置如下命令：

ip router isis　　　　//在某一接口上运行 IS-IS

4　观察 DIS：要查看 IS-IS 的数据库信息，可以用 show isis database 命令来查看 LSP 包的情况。通过该命令可查看出在 LAN 中哪一台路由器作为 DIS。

5　改变接口优先级以便人为干涉 DIS 选举过程：由于 DIS 选举是首先基于优先级的,因此我们可以通过改变接口优先级来控制 DIS 的选举，所用到的命令如下：

```
Router(config-if)#isis priority 100    //change priority to 100
```

6　此时可以再用 show isis database 来查看 DIS 的变化；

7　另外几个重要的观察 IS-IS 的命令是:

show isis topology　　//查看 IS-IS 所生成的拓扑结构

show ip route, show clns route,　　　//查看 IP 路由和 CLNS 路由

show clns neighbors　　　　　　//查看邻居情况

第二部份：区域间路由（FOR IP and CLNS）

For IP 协议

1　按图 2 连接好设备并配置好 IP 地址；

2　类似于第一部分那样给各个路由器启动 IS-IS 进程，但 NET 有所不同，差别如下：

R1:

```
router isis                              //configuration of is-is process
        is-type level-1
        net 49.0001.1111.1111.1111.00
```

R2:

```
router isis                              //configuration of is-is process
        is-type level-1-2
        net 49.0001.2222.2222.2222.00
```

R3:

```
router isis                              //configuration of is-is process
        is-type level-1-2
```

net 49.0002.3333.3333.3333.00

3　在接口上运行 IS-IS：在 R1 的 f0/0，lo0，R2 的 f0/0,lo0,s0 上以及 R3 的 lo0,s0 上分别运行 IS-IS

4　用上面介绍的观察命令检查数据库和路由表，并尝试是否能在不同网段间互相通信（ping 测试）。

5　观察 IS-IS database 中 level-1 和 level-2 的信息，比较他们之间的不同，据此理解 level-1 和 level-2 他们之间的功能差别。

For CLNS 协议

6　用 no 命令将上面第 3 步中对端口所设的 ip router isis 命令取消，并改为 clns router isis,此时 IS-IS 所支持的第三层协议为 CLNS，此时我们可以用 show clns route 和 show isis route 来查看 clns 的路由信息。比较这两个命令所显示的路由信息与 IP 路由信息的不同。

7　检查 CLNS 网络的连通性：有几种途径：一个可行的方法是用 show clns route 看路由，也可以在特权模式下用 which-route 命令来查看到某一个 NSAP 是否能找到相应的路由，请在路由器上试运行该命令查看。但最直接的方法当然用 ping 命令和 traceroute 命令，如下：

ping clns <CLNS 地址>

traceroute clns <CLNS 地址>

第三部份：CISCO 路由器的对 multiarea 特性的支持：在此部分实验中，我们将在其中一台路由器上启动多个 IS-IS 路由进程，并将不同的进程应用到相应的接口上，使一个路由器可以支持多个 area。

1　按图 3 连接好设备并配置好 IP 地址；

2　在 R1 上启动三个路由进程：

```
router isis A1                          //configuration of is-is process A1
      is-type level-1-2
      net 49.0001.1111.1111.1111.00
router isis A2                          //configuration of is-is process A2
      is-type level-1
      net 49.0002.1111.1111.1111.00
router isis A3                          //configuration of is-is process A3
      is-type level-1
      net 49.0003.1111.1111.1111.00
```

3　在 R1 的 loopback0，loopback1，s0 上分别运行不同的路由进程，配置如下：

```
interface s0
      ip router isis A1
interface loopback 0
      ip router isis A2
interface loopback 1
      ip router isis A3
```

4　与 R1 的配置方法相似，按图 3 在 R2 上配置 IS-IS 进程。

5　检查路由表及 IS-IS 数据库，并用 ping 测试网络是否能连通。

6　去掉 for IP 协议的配置，将其改为 for CLNS 协议，以与上面类似的方法配置 IS-IS routing for CLNS

【注意事项】:

1　IS-IS 路由协议在 CISCO 路由器中只在电信级的 IOS 中支持；

2　要看到 DIS 选举过程的变化，可先通过 debug isis updatepackets 命令打开 debug 功能；

3　对于 CLNS 和 IP 协议，IS-IS 的配置有所不同，要主要他们配置的不同主要在于端口模式下的启动形

式，对于 IP 协议是 ip router isis,而对于 CLNS 则是 clns router isis。比较这两种设置不同所造成的路由表的差别。

4 DIS 只存在在 LAN 里面，点对点连接中不存在 DIS，这可以在 IS-IS database 里面看出来。

Modem 基本配置

实验目的：

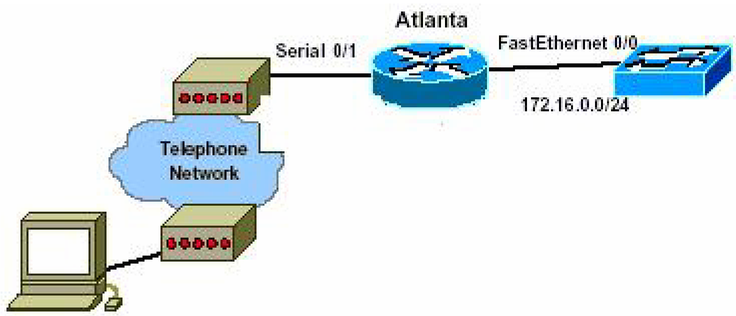
1) 了解 modem 的基本配置
2) 通过 modem 登陆到路由器上配置路由器（用 serial 口和 aux 口两种）
3) 两台路由器通过 modem 连接

实验设备：

两台路由器（带 serial<—>com 口连线），两台 modem，一台程控交换机

实验内容：

1、 通过 serial 口和 modem 连接，并且能登陆到路由上配置路由，如图



enable password cisco

!

interface Serial1——配置 serial 为异步线路（配置 modem 连接必要的第一步）

  physical-layer async

  no ip address

!

line 2——serial 上 modem 的物理层配置（line 模式下为物理配置、int 模式下为逻辑配置）

  password cisco

  login　　　　　　　　　　//以上两步配置和 line vty 中配置原理相同

  modem InOut　　　　　　　//modem 既可被拨入，又可以拨出

  modem autoconfigure discovery　　//modem 自动检测

  transport input all　　　　//允许所有的协议都可以通过该线路送入访问服务器

  stopbits 1　　　　　　　　//设置每个字节的停止位数

  speed 115200　　　　　　//设置 modem 和路由器之间的最大数据传输速率

  flowcontrol hardware　　　//使用 RTS/CTS 信号进行硬件流控

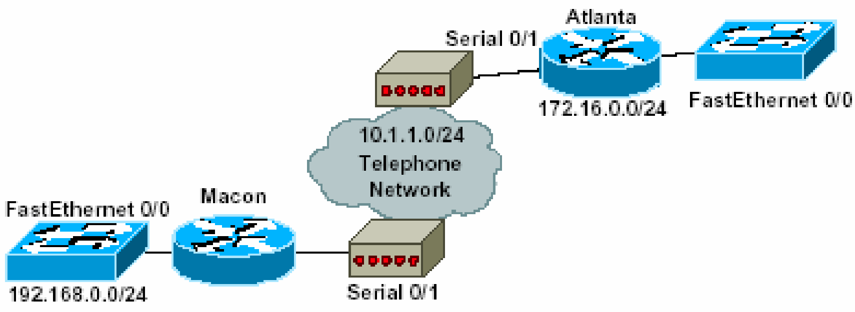
配置好后，配置主机的拨号设置为"连接后显示终端"，然后用超级终端或者拨号连接就能登陆到路由器上，对路由器进行配置：

```
User Access Verification
Password:
```

为 Serial 配置一个 ip 地址，用 show line 命令确定端口后（line 号＋2000），反向 telnet

到 modem 上（telnet host_ip port）试用一下 modem 上 AT 指令（由于标准和指令的不统一，所以不作实验要求）。用 ctrl-shift-6 x 或 disconnect 退出。

2、配置广域网拨号连接，如图



line 号（例如 1720：con 0 为 line 0、serial 0－3 为 line 1-4、aux 0 为 serial 的数目+1＝5、vty 0 4 为 line 6-9。）用 show line 来确定，注意的是，不同端口的最高传输速率是不同的。

中心路由配置如下：

```
enable password cisco
!
interface loopback 0
  ip address 172.16.0.1 255.255.255.0
!
interface Serial1
  physical-layer async
  ip address 10.20.1.1 255.255.255.0
  encapsulation ppp
  keepalive 10              //规定发送 keepalive 包到其他路由器的时间
  async mode dedicated    //访问端口为 dedicated，用户不能执行任何命令和改变任何配置
  no cdp enable
line 2
  password cisco
  login
  modem InOut
  modem autoconfigure discovery
  transport input all
  stopbits 1
  speed 115200
  flowcontrol hardware
!
ip route 0.0.0.0 0.0.0.0 10.20.1.2
```

配置远程节点路由器

```
!
enable password cisco
!
```

```
interface loopback 0
  ip address 192.168.0.1 255.255.255.0
!
interface Serial3
     physical-layer async
     ip address 10.20.1.2 255.255.255.0
     encapsulation ppp
     keepalive 10
     dialer in-band                    //启用 DDR 和 V.25bis（一个带内信令标准）拨号
     dialer idle-timeout 300           //如果空闲 5 分钟则关闭连接
     dialer wait-for-carrier-time 60   //连接发生等待最多一分钟
     dialer map ip 10.10.1.1 name as200-e broadcast 84－－84 为对方号码
     dialer hold-queue 50
     dialer-group 1                    //类似 ip access-group
     async mode dedicated
     no cdp enable
!
line 4
     password cisco
     login
     modem InOut
     stopbits 1
     speed 115200
     flowcontrol hardware
!
dialer-list 1 protocol ip permit      //类似 access-list
!
ip route 0.0.0.0 0.0.0.0 10.20.1.1
!
```

由于异步 modem 不是完全标准化，用户必须写出定制的 chat-scripts 以执行下列任务：modem 配置、拨号和远程登陆命令、失败检测。其基本形式如下：

Router(config)#**chat-script** script-name expect-string send-string

其中 expect-string 为本地系统期望从远端系统收到的字符串，send-string 为本地系统应发送的字符串。一句话，就是告诉路由器当收到某些信号时采取什么行动（例如断开连接，或者向 modem 发出 AT 指令等）。例如 ABORT ERROR 就是收到 ERROR 信号就停止执行该 chat-script、”” “ATZ”就是不必收到什么信号都发送”ATZ”复位指令、OK “ATDT\T”为收到 OK 信号就发送”ATDT\T”指令、TIMEOUT 30 CONNECT 表示最多为收到”CONNECT”字符串等待 30 秒、\c 表示不再发送的字符串后加回车符。

网络管理实验

【实验目的】

了解网络管理的几种方式：console 配置，远程登录配置，http 登录配置以及使用 cisco works2000 管理（snmp 监控软件）

【实验设备】

cisco19xx、 cisco29xx 交换机，cisco2600 路由器，带虚拟终端的 pc，终端控制数据线、网线。

【实验原理】

常见的配置网络的方式有：

1. 使用 console 进行配制
2. 使用 telnet，ssh 等远程登录进行配置
3. 使用 http 登录进行配置
4. 使用 snmp 监控软件进行管理以及配置（cisco works2000 管理软件）

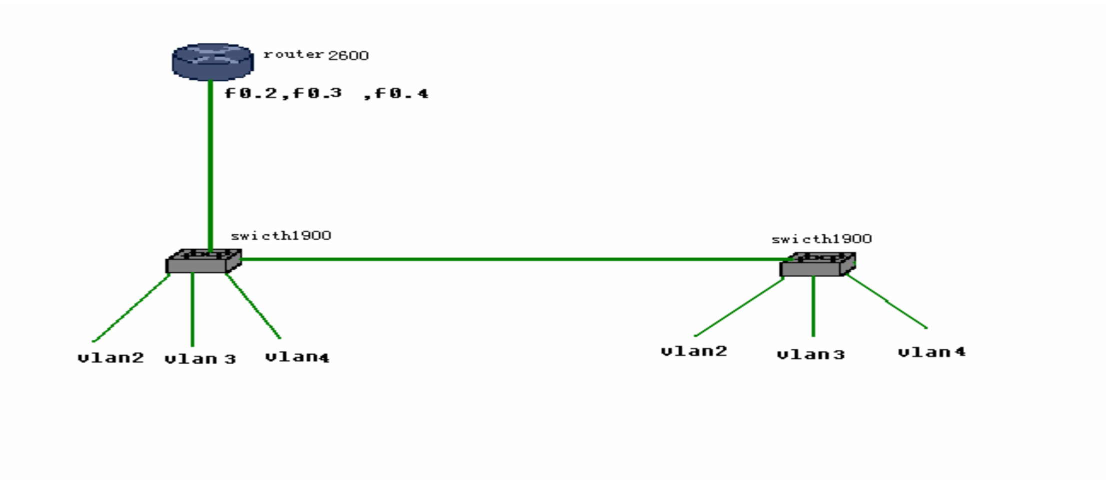
Ciscoworks2000 是 Cisco 公司开发的网络管理工具，包括多个管理模块，而这些管理模块几乎全部以 CiscoWorks2000 Server 为平台进行应用。 它并不具有网络管理的功能，只是为其他应用模块提供了一些管理服务。

Cisco Works 是 Cisco 公司开发的网络管理工具，主要用于 Cisco 设备的管理，它包括多个管理模块，目前，我们只介绍其中的几个，分别是：

- ✓ Cisco View：
  属于网元级别的管理模块。即：它只对单独一个设备进行管理。
- ✓ Traffic Director：
  属于网络流量管理模块。即：它负责对网络中各种数据流量进行管理。
- ✓ Campus Manager：
  属于网络级别的管理模块。即：它负责对于整个网络的拓扑，路由协议，ACL 等等进行管理。

【实验内容】

一．基本拓朴：



二. 试验步骤:

【使用 console 对设备进行配置】

1. 未对交换机配置之前，因为目前所有的主机都位于同一 VLAN(缺省为 VLAN1)，交换机不能隔离广播，交换机上的各个端口之间可以进行通信。

2. 现在我们要在两个处于不同物理位置的交换机上分别配上 vlan：vlan2,vlan3,vlan4。使得相同交换机上的同一个 vlan 上主机可以互相通信，同一交换机上不同 vlan 上主机不能通信。

- 清除交换机的初始配置:

  #delete nvram　　防止以前配过的 VLAN 影响本次实验

- 一些基本的 show 命令的使用:

  #show running-config　查看当前的配置，注意缺省设置
  #show version　　查看交换机的 IOS 版本
  #show vlan　　查看交换机当前的 VLAN 配置情况
  #show mac-address-table　查看交换机当前的 mac 地址表，
  　用这条命令可以查看当前有接设备的交换机端口是哪些
  #config t
  (config)#hostname WORD

- **19xx 系列 switch 的配置**

19xx 系列 swicth 有菜单模式和命令行模式两种。开交换机电源,登录交换机，进入命令行界面

```
User Interface Menu
 [M] Menus
 [K] Command Line
 [I] IP Configuration
 [P] Console Password
Enter Selection: K
```
输入字母 K 进入 Command-Line Interface(CLI)

在 19xx 系列的 switch 上定义 vlan2、vlan3 和 vlan4，把它其中的端口 1 与 2 配置为 VLAN2，端口 3 与 4 配置为 VLAN3，端口 5 与 6 配置为 vlan4。

```
>enable
#config t
(config)#vlan <vlan 号> name <vlan 名称>
```

(config)#vlan <vlan 号> name <vlan 名称>

(config)#vlan <vlan 号> name <vlan 名称>   /定义 vlan2、vlan3，vlan4

(config)#int e0/<端口号>

(config-if)#vlan-membership static <vlan 号> /重复以上两条命令

/分配各端口到各 vlan 上

(config-fi)#ctrl^z

#show vlan-membership

#show vlan

- **29xx 系列 switch 的配置**

switch#vlan database

switch(vlan)#vlan 2 name vlan2

switch(vlan)#vlan 3 name vlan3

switch(vlan)#vlan 4 name vlan4

switch(vlan)#exit

switch#config t

switch(config)#int f0/1

switch(config-if)#switchport access vlan 2   //将 f0/1 划入 vlan2

switch(config)#int f0/2

switch(config-if)#switchport access vlan 2 //将 f0/2 划入 vlan2

switch(config-if)#int f0/3

switch(config-if)# switchport access vlan 3   //将 f0/3 划入 vlan3

switch(config-if)#int f0/4

switch(config-if)# switchport access vlan 3   //将 f0/4 划入 vlan3

switch(config-if)#int f0/5

switch(config-if)# switchport access vlan 4   //将 f0/5 划入 vlan4

switch(config-if)#int f0/6

switch(config-if)# switchport access vlan 4   //将 f0/6 划入 vlan4

switch(config-if)#exit

switch#show vlan

完成这一步配置后，同一台交换机上不同 vlan 之间的主机不能通信，同一 vlan 上的主机能够通信，这样防止了广播造成不必要的流量。

3.使用干道链路将两台交换机连起来，使得不同交换机的相同 vlan 间可以通信，不同 vlan 间不可以通信。

用交叉线把两台交换机的快速以太网口相连，然后用下面的命令配置交换机。

- **19xx 系列 switch 的配置**

#config t

(config)#int f0/<端口号> (A 口为 26,B 口为 27)

(config-if)#trunk on

(config-if)# ctrl+Z

#show trunk <trunk 口>

#show trunk <trunk 口> allowed-vlans ->查看在干道上允许的 vlan

- **29xx 系列 switch 的配置**

```
switch(config)#int f0/7
switch(config-if)#switchport trunk encapsulation dot1q  //设置 trunk 口的封装
switch(config-if)#switch mode trunk                   //启动 trunk 口
switch2950(config-if)#switchport mode trunk             //switch2950 默认封装为 802.1q
```

完成这一步后不同交换机上同一 vlan 上的主机能够通信，按以下步骤测试。

在两个交换机上：

同一 vlan 主机互 ping

不同 vlan 主机互 ping

4. 利用路由器在第三层实现不同 vlan 间的互连

我们运用 vlan 的技术成功隔离了广播，但是现在要求在隔离广播的基础上实现 vlan 间的通信，这一步必须上到第三层：路由层。

将路由器的快速以太网口和交换机（两台已经连好的交换机的其中任何一台）的快速以太网口连起来，并分别配置成 trunk 模式：

（1）在交换机的快速以太网口上启动 trunk 模式（方法如前）

（2）在路由器上所连 trunk 口上

```
config#interface f0/0
(config-if)#no ip address
(config-if)#int f0/0.2
(config-subif)#encapsulation isl 2                    //或者封装 dot1q
(config-subif)#ip address 10.1.1.1 255.255.255.0
(config-if)#int f0/0.3
(config-subif)#encapsulation isl 3
(config-subif)#ip address 192.168.3.1 255.255.255.0
(config-if)#int f0/0.4
(config-subif)#encapsulation isl 4
(config-subif)#ip address 192.168.4.1 255.255.255.0
(config-subif)#exit
(config-if)#no shut
```

路由器如此配置之后，就在 trunk 上配置了三个子端口，分别属于 2.0、3.0、4.0 网段，这三个网段是与路由器直连的，所以不用配路由选择协议。这样三个不同的 vlan 间就可以通信了。

为交换机配置管理 ip 和管理 vlan，以及 default gateway。

设置 vlan 2 为管理 vlan。

交换机管理 ip 为：10.1.1.0/24 网段内。

Default Gateway:10.1.1.1

- **19xx 系列 switch 的配置**

```
(config)#ip address 10.1.1.x 255.255.255.0
(config)#ip default-gateway 10.1.1.1
(config)#ip mgmt-vlan 2
```

- **29xx 系列 switch 的配置**

```
switch(config)#interface vlan 10
switch(config-subif)#ip address 10.1.1.x 255.255.255.0
switch(config-subif)#management
switch(config)#ip default-gateway 10.1.1.1
```

测试：

ping 同一 vlan 和不同 vlan 之间的主机，是否可以 ping 得通；

【使用 telnet 对设备进行配置】

使用命令：

设置 enable password

```
enable password cisco
```

配置远程登陆服务器：

```
line vty 0 4
 password cisco
 login
```

测试：

在 windows 命令行使用 telnet 进行登录。

【使用 http 对设备进行配置】

使用命令：

启动 http server：

```
ip http server
```

测试：

在 windows 下，打开 ie，在地址栏上直接填需要管理的设备的 ip。便可以通过 ie 对该设备进行管理了。

【使用 snmp 对设备进行配置】

使用命令：

- **19xx 系列 switch 的配置**

```
(config)#snmp-server community cisco rw
```

- **29xx 系列 switch 的配置**

```
(config)#snmp-server community cisco rw
(config)#snmp-server enable informs
```

- **26xx 系列 router 的配置**

```
Router(config)#snmp-server community cisco rw
Router(config)#snmp-server enable informs
```

为了让我们的实验网络可以访问到 cisco works2000 的 server，我们需要在 router 添加一条静态路由：

```
Router(config)#ip route 202.116.78.0 255.255.255.0 10.10.0.1
```

Cisco works2000 server：202.116.78.253

在 windows 下，打开 ie，在地址栏:http://202.116.78.253:1741

熟悉 cisco works 2000 管理模块:cisco view 的使用方法。(请参考附录的《cisco works 2000 使用手册》)

OSPF MutiArea

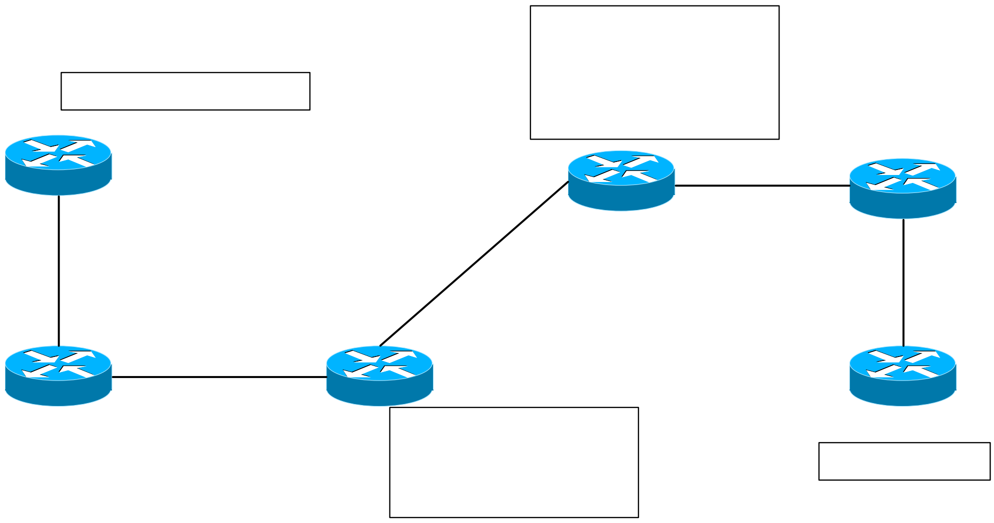
【实验目的】

了解和掌握 ospf 的原理，熟悉 ospf 多域配置步骤。懂得如何配置 Vitrul links,Transit area, Stub Area ,Totally Stubby Area, Not-so-stubby area(nssa)。

【实验原理】

了解 Internal router，Backbone router，Area Border Router (ABR)， Autonomous System Boundary Router (ASBR) 以及各种类型链路通告的不同之处，优化 ospf 网络。

【实验拓扑】



【实验设备】

路由器五台，
串行线，用于配置路由的主机

【实验内容】

1、 按图示配置端口，用 ping 检查各端口间连通性
（A/B，E/F 用于 virtul links 实验;
C 的 lo 地址在用于验证 external route summarization
D 的 lo 地址加入 area 8，为验证 interarea summarization;
A/F 的 lo 地址在 nssa 时才加入）
建议配置好各个 neighber 的 vty，可以用一台终端观察整个拓扑。
(config)#enable password cisco
(config)#line vty 0 4
(config-line)#Login
(config-line)#Password cisco
利用**terminal monitor**可在telnet上看到debug输出

2、 在各个路由器启动 ospf 进程，注意 area 的分布

Router(config)#router ospf *

Router(config-router)#network *.*.*.* *.*.*.* area *

查看 ABR/ASBR/DR/BDR。

show ip ospf

show ip ospf interface

show ip ospf neighbor

show ip ospf neighbor detail

3、 show ip route 查看各 router 路由表，注意 area 10,area 11 没出现在别的 router。

(loopback 地址当主机路由发布)

4、配置 Vitrul links,使 area 10,area 11 可以正常工作。

观察路由表项：

(原来没有连接到 backbone area 的 area 的具体情况:

可观察到：area 运行和工作状态正常， 但是就是没有收到其他 area 的链路状态通告)

C#show ip route

配置在 ABR 上进行（B/C）,(D/E)：

(config-router)#area 5 virtual-link (router-id)

(router id 可通过 show ip ospf neighbor 查看，互指对端)

观察配置前后不同之处：

A/F#show ip route

(show neighbor 与 debug 的话输出和以前一样很正常)

C/E#show ip route

B/C,E/F#show ip ospf virtual-links

此时 area 5,area 1 为 transit area。

5、 在 D 配置 interarea route summarization，观察配置结果

观察未配置时的路由表：

Router#show ip route

配置 summarization：

D(config-router)#area 8 range 192.168.64.0 255.255.252.0

观察配置结果：

D#show ip route

C 192.168.64.0/24 is directly connected, Loopback0

C 192.168.65.0/24 is directly connected, Loopback1

C 192.168.66.0/24 is directly connected, Loopback4

C   192.168.67.0/24 is directly connected, Loopback8
O   192.168.64.0/22 is a summary, 00:00:02, Null0

E#show ip route
O IA 192.168.64.0/22 [110/129] via 192.168.1.9, 00:00:45, Serial1
原为 4 项主机路由，变为一项。
或者是用命令：
Router#show ip route supernets-only

6、在 C 添加外部路由，配置重分布并观察
配置:
C(config)#ip route 172.16.0.0 255.255.0.0 null 0

Router(config-router)#redistribute static subnets metric-type ?
1 Set OSPF External Type 1 metrics
2 Set OSPF External Type 2 metrics

C(config-router)#redistribute static subnets (E2,static metrics)
(不加上 subnets 只重发布 classful 路由:
% Only classful networks will be redistributed)
观察配置结果：
Router# show ip route

更改配置：
C(config-router)#redistribute static subnets metric-type 1 (E1)
在各个 router 比较输出的不同(metric 值)
router>show ip route

7、验证 external route summarization
配置：
C(config)#ip route 172.17.0.0 255.255.0.0 null 0
C(config)#ip route 172.18.0.0 255.255.0.0 null 0
C(config)#ip route 172.19.0.0 255.255.0.0 null 0
C(config-router)#summary-address 172.16.0.0 255.252.0.0
观察配置结果：
C#show ip route
S   172.17.0.0/16 is directly connected, Null0
S   172.16.0.0/16 is directly connected, Null0
S   172.19.0.0/16 is directly connected, Null0
S   172.18.0.0/16 is directly connected, Null0
O   172.16.0.0/14 is a summary, 00:00:02, Null0
或者可以使用命令：
Router#show ip route supernets-only

8、传播默认路由

C 配置一个 loopback 端口，用于验证默认路由起作用。

C(config)#interface lo 0

C(config-if)#ip address 172.16.0.1 255.255.255.0

配置：

C(config-router)#default-information originate always

always 使 C 强行通告默认路由,即使 C 本身没有默认路由。

观察配置结果：

Show 发现本机路由表不发生变化，但对别的 router 起作用

C#show ip route

Gateway of last resort is not set

router>show ip route

Gateway of last resort is 192.168.1.* to network 0.0.0.0

ping C loopback 端口(172.16.0.1)，验证默认路由起作用

去掉 C loopback 端口，再 ping

假设 C 的 loopback 端口为 internet 地址，重新加入。A/F 的 loopback 端口暂未要配置。去掉第 8 中配置的默认路由发布。loopback 地址参考拓扑图。

9、配置 Stub Area ,Totally Stubby Area

router 路由表原只有 IA 项,C 做了静态重分布后多了 E*项。

亦即有 type-5 的 LSA 到达

C(config)#interface lo 0

C(config-if)#ip address 172.16.0.1 255.255.255.0

C(config)#interface lo 1

C(config-if)#ip address 172.16.1.1 255.255.255.0

C(config)#interface lo 2

C(config-if)#ip address 172.16.2.1 255.255.255.0

C(config)#interface lo 3

C(config-if)#ip address 172.16.3.1 255.255.255.0

C(config-router)#redistribute conneted subnets

(无 subnets 时，% Only classful networks will be redistributed)

观察重分布结果:

router#show ip route

分别在 A/B 和 E/F 配置 Stub Area：

A(config-router)#area 10 stub

B(config-router)#area 10 stub

E(config-router)#area 11 stub
F(config-router)#area 11 stub
如果配置时间差较大，可观察到邻接关系断开

router#show ip ospf (观察 area 变化)
…………
It is a stub area
…………
router#show ip route (观察路由表)
没了 E2 项，多了默认路由
(不接受 Type 5 LSAs)

配置 Totally Stubby Area：
B(config-router)#no area 10 stub
B(config-router)#area 10 stub no-summary

E(config-router)#no area 11 stub
E(config-router)#area 11 stub no-summary
如果同时配置 stub 和 stub no-summary，no-summary 起作用

router#show ip route (观察 default 路由)
只剩下 C 项和 O*IA 项
(不接受 Type 3/4 LSAs，只需在 ABR 上配置)

10、配置 Not-so-stubby area(nssa)
配置 A 和 F 的 loopback 端口，模拟非 ospf 域，使 A 和 E 成为 ASBR；
清除第 9 步中 router ospf stub area 的配置。
用于 nssa 配置前后比较路由表变化

A(config)#interface lo 0
A(config-if)#ip address 172.16.16.1 255.255.255.0

F(config)#interface lo 0
F(config-if)#ip address 10.0.0.1 255.255.255.0

router#show ip route (观察路由表)
此时还没有重发布路由，见不到新添的 Loopback 路由。

A(config-router)#redistribute connected subnets
F(config-router)#redistribute connected subnets

比较配置前后路由表变化

router#show ip route (观察路由表)
见到 E2 型路由条目

此时不能在 A/F 执行 (config-router)#area 1 stub 建立 stub area，
OSPF: Stub command is invalid when it is ASBR

因为有 type 5 LSA， show ip ospf database 可看到。
A/F#show ip ospf database
Type-5 AS External Link States

配置成为 nssa，使得 area 1 和 10 里面只有类型 7：
A (config-router)#area 10 nssa
B(config-router)#area 10 nssa

E(config-router)#area 11 nssa
F(config-router)#area 11 nssa

观察配置结果：
A/F#show ip ospf database
Type-7 AS External Link States (Area 1)
(可观察到 type 5 → type 7)

B/E# show ip ospf database
Type-7 AS External Link States (Area 1)

Type-5 AS External Link States

观察到 type 7→type5

A/F#show ip route (观察路由表,只有 IA 项)
没有象 stub area 一样产生默认路由。所以不能到达 C 的 loopback.

B/E(config-router)#area 11 nssa ?
default-information-originate Originate Type 7 default into NSSA area
no-redistribution No redistribution into this NSSA area
no-summary Do not send summary LSA into NSSA
<cr>

配置使 NSSA 产生默认路由：
The following configuration generates a type 7 default route. You can configure this command on any NSSA ASBR or NSSA ABR with the following rules:

- NSSA ASBR can generate a default only when it has a default route in its routing table.
- NSSA ABR can generate a default route with or without a default route in its own routing

table.

E(config-router)#area 11 nssa default-information-originate
B(config-router)#area 1 nssa default-information-originate

观察配置结果：
A/F#show ip route (观察路由表，有 N2 项出现)
O*N2 0.0.0.0/0 [110/1] via 192.168.1.9, 00:00:29, Serial1

B/E#show ip route
Gateway of last resort is not set
对本身路由表无影响

配置 NSSA Totally Stub Area：
B(config-router)#no area 10 nssa default-information-originate
B(config-router)#area 10 nssa no-summary

E(config-router)#no area 11 nssa default-information-originate
E(config-router)#area 11 nssa no-summary

观察配置结果：
A/F#show ip route (观察 default 路由)
O*IA 0.0.0.0/0 [110/65] via 192.168.1.9, 00:00:21, Serial1
(不接受 Type 3/4 LSAs，只需在 ABR 上配置,生成默认路由)

B/E#show ip route (观察路由表,N*项)
Gateway of last resort is not set
对本身路由表无影响

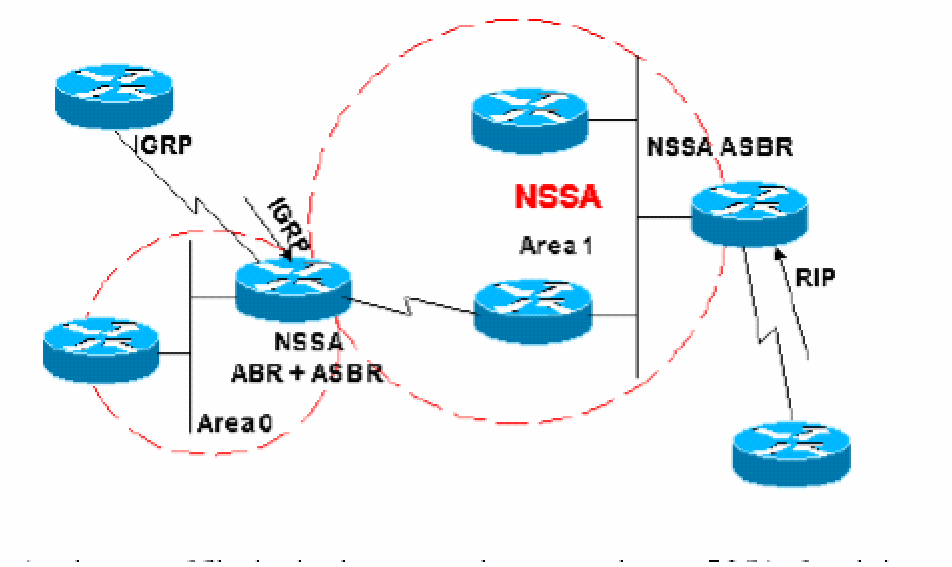
router#show ip ospf database (Type 5)
router#show ip route (观察路由表,E*项)
Gateway of last resort is not set
在 nssa 以外，有 E2 型 route，无 N2 型。
经过 ABR 后，又剩下 type5 的 LSA，只有 NSSA 中有 type-7 的 LSA

选做内容：
1、两台 Router，配置相同的 RouterID，在启动进程时候，会发现重复 id，无法建立邻接关系。
2、两个不同的路由器进程，之间不共享路由信息。假如一个 area 在两个进程中都存在，则先加入的那个进程有此 area 的条目。要使得条目共享，要进行路由的重发布。即将一个 OSPF 进程的路由发布入另外一个进程中。要两端都互相发布才可以互通。

[注意事项]

**IOS 版本对 OSPF 运行的影响:
http://www.cisco.com/warp/public/104/redist-conn.html
This document demonstrates the different behavior of redistributing connected routes into OSPF. The change in behavior began in Cisco IOS version 12.1(3).

**NSSARouter(config-router)#area 1 nssa no-redistribution
Only configure this command on an NSSA ASBR that's also an ABR
不需要把外部路由转换成 type-7 的 LSA 的时候使用，如下图：



使 IGRP 路由不向 NSSA 域发布。。

也可利用
NSSA(config-router)#summary-address X.X.X.X X.X.X.X not-advertise
使某些路由不从 type-7→type-5。

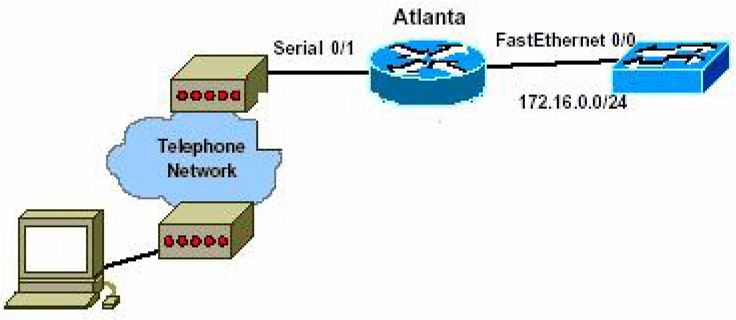
PPP 实验

实验目的

1） 了解拨号上网的基本配置，了解地址分配的几种方法

2） 了解认证协议的配置

实验拓扑：



实验步骤：

1） 配置静态接入地址

在路由器上配置为：

RTA#show run

!

hostname RTA

!

enable password cisco

!

no ip domain-lookup

!

chat-script aa56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT \c

!

interface Serial0

physical-layer async ——串口设置为异步模式

ip address 10.1.1.2 255.255.255.0 ——分配串口地址

encapsulation ppp ——启动 PPP 协议

keepalive 10 ——规定发送 keepalive 包到其他路由器的时间

async mode interactive ——相应 PPP 连接与 EXEC 连接

peer default ip address 10.1.1.3 ——配置接入地址为固定 IP

!

ip classless

ip route 0.0.0.0 0.0.0.0 10.1.1.1 ——定义最后默认路由

!

line 1

password cisco

login

modem InOut

```
modem autoconfigure discovery
transport input all
autoselect ppp                    ——判断，选择 PPP 协议
stopbits 1
speed 115200
flowcontrol hardware
line vty 0 4
password cisco
!
```

启动 PPP：配置好路由器后，在主机上连接 modem，然后启动拨号连接，只需要填写接入号码，不需要填写任何其他信息。拨号后，在主机上运行 winipcfg 可以看到拨号所获得的 IP 地址，在主机上可以 ping 通网关。证明主机自动发出 PPP 连接请求，路由器能响应 PPP 连接

2） 配置动态地址分配

修改配置为：

```
interface Serial0
 physical-layer async
 ip address 10.1.1.2 255.255.255.0
 encapsulation ppp
 keepalive 10
 async mode interactive
 peer default ip address pool ippool
!
ip local pool ippool 10.1.1.5 10.1.1.15
```

配置好后，在主机上进行同样的拨号，应该可以获得 10.1.1.5 的 IP 地址。断开后再进行拨号，可以获得下一个 IP。

启动 EXEC：在拨号属性里选择“拨号后出现终端窗口”属性，再次拨号。拨号后提示输入密码，输入 cisco 就可以进入路由配置 EXEC 模式（即路由用户配置模式）。这里的 cisco 是 line 1 的 login password。如果输入 cisco 后输入 ppp 的话，路由将启动 PPP 协议。

3） 自动地址分配（由用户手动定义 IP 地址）

配置为：

```
interface Serial0
 physical-layer async
 ip address 10.1.1.2 255.255.255.0
 encapsulation ppp
 keepalive 10
 async dynamic address
 async mode interactive
 no peer default ip address
!
```

可以在拨号属性的 TCP/IP 配置里面填写 IP 地址，或者在“终端窗口”的用户提示

模式下输入 ppp，然后输入你所需要的 IP 地址。在主机上运行 winipcfg 查看所获得的 IP 地址。

4） 配置密码认证

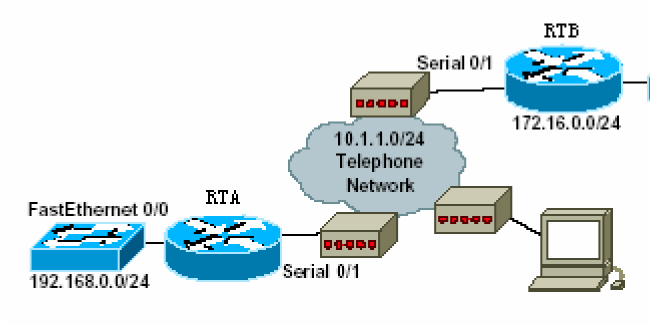
在路由器上配置：

```
interface Serial0
 physical-layer async
 ip address 10.1.1.2 255.255.255.0
 encapsulation ppp
 keepalive 10
 async dynamic address
 async mode interactive
 peer default ip address pool ippool
 ppp authentication chap
!
username abc password cisco
!
```

在拨号的时候要加上用户名与密码。检验一下用户名，密码有错的时候能否接入。

5） 通过拨号认证连接两台路由器

实验拓扑如下：



为两台路由器之间的拨号连接加上密码认证

路由器 RTA 的配置为：

```
hostname RTA
username RTB password ciscob
!
chat-script aa56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT
\c
!
interface Serial0
 physical-layer async
 ip address 10.1.1.2 255.255.255.0
 encapsulation ppp
 keepalive 10
 async mode dedicated
 ppp authentication pap
```

```
   ppp pap sent-username RTA password ciscoa
!
```

路由器 RTB 的配置为：

```
hostname RTB
!
username RTA password ciscoa
chat-script abc56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT
\c
!
interface Serial0
 physical-layer async
 ip address 10.1.1.1 255.255.255.0
 encapsulation ppp
 keepalive 10
 dialer in-band                                //让路由器发起拨号连接
 dialer map ip 10.1.1.2 name RTA modem-script abc56k broadcast 88
                                               //88 为对端的电话号码，以实际的为准
 dialer-group 1
 async mode dedicated
 ppp authentication pap                        //认证方式为 pap 方式
 ppp pap sent-username RTB password ciscob     //发送认证用户名、密码
!
ip route 0.0.0.0 0.0.0.0 10.1.1.2
!
dialer-list 1 protocol ip permit
!
line 1
 password cisco
 login
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
```

然后在 RTB 上通过 ping 来连接 RTA。通过 debug ppp authentication 与 debug ppp negotiation。在两台路由器上用 show line 来看线路的情况，如果线路忙，要发连接的话先用 clear line 1 来清除原来的连接。若速率不匹配（即不为 115200）请重启 modem，再用 show line 来观测，直到两端的异步端口速率都为 115200。

若认证方式改为 chap，则要在端口模式下输入 ppp authentication chap 删除 ppp pap sent-username *** password *****，而且输入对方的主机名，且使用相同的密码

如在 RTA 上输入 username RTB password cisco ；在 RTB 上输入 username RTA password cisco

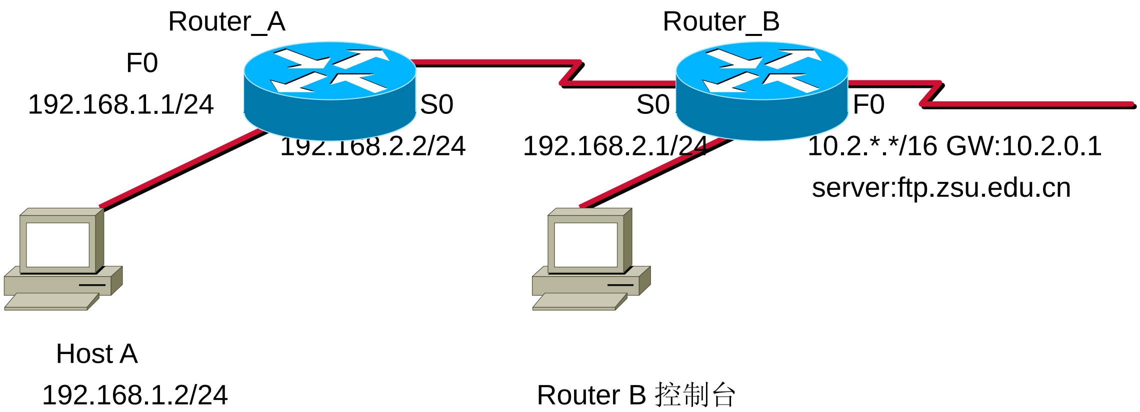
队列实验

[实验目的]
配置验证加权公平队列，优先级队列和可定制队列，
观察比较各自的特点。

[知识概述]

在 router 上，数据包传输的经典算法是先进先出(FIFO)算法。采用 FIFO,数据包的传输与其被接收的顺序一致。当在 WAN 上由于突发性流量和相对低速流量的同时存在，可能引起暂时性的拥塞，这时候可以采用对数据流进行优先级划分的方法来解决拥塞，保证为用户提供适当的服务质量。CISCO IOS 提供了另外 3 种队列技术：加权公平队列(WFQ)，优先级队列(PQ)，可定制队列(CQ)。

[实验拓扑]



本实验由 Host A 触发数据流，观察实验现象；在 RouterB 配置并观察队列。
Router B 的以太口接至实验室内部网，默认路由指向内部网关：10.2.0.1
由服务器 ftp.zsu.edu.cn 提供 FTP 服务。
因为网关没有 192.168.*.*网段的正确路由，所以需要设置 NAT。

[实验过程]

基本配置：

RouterA:

interface FastEthernet0
    ip address 192.168.1.1 255.255.255.0 //配置 IP 地址
    no shutdown
interface Serial 0
    ip address 192.168.2.2 255.255.255.0
    clock rate 56000
    no shutdown
router rip //配置路由
    network 192.168.1.0

network 192.168.2.0
ip route 0.0.0.0 0.0.0.0 10.2.0.1

RouterB
ip route 0.0.0.0 0.0.0.0 10.2.0.1 //配置默认路由
ip nat inside source static 192.168.1.2 10.2.*.* //配置 NAT
interface FastEthernet0
ip address 10.2.*.* 255.255.0.0
ip nat outside
no shutdown
interface Serial 0
ip address 192.168.2.1 255.255.255.0
clock rate 56000
ip nat inside
no shutdown
router rip
network 10.0.0.0
network 192.168.2.0
passive-interface FastEthernet0 //使 RIP 不在内部网交换信息

一. 加权公平队列（WFQ）

加权公平队列是一种为所有数据流提供公平带宽分配的自动方式。该算法将数据流分成对话(conversation)信息，在传输数据之前将各个对话的数据包放到公平队列(fair queue)中进行排序，将数据包从 WFQ 中提取出来的次序是由每个到达的 packet 的最后一个 bit 的虚拟发送时间决定的，小数据量对话的 packet 优先级高于大数据量对话的 packet。当小数据量的数据包被发送之后，其他各个大数据量对话的数据包将公平地分享剩下的带宽。

将数据流划为对话(conversation)的方法是根据数据包头的信息，例如源/目的网络地址、MAC 地址、端口号、socket 号、frame relay 的 DLCI 值……WFQ 在 E1 速率（2.048Mb/s）或 E1 以下速率的物理接口上是被默认启用的。

!
queque 绑定在 RouterB 的 Serial0 端口上
interface Serial0
fair-queue
(fair-queue 128) //128 是拥塞丢弃门限值，默认为 64
//在这个实验中没有配置门限值，采用默认值 64
!
验证 **fair queue**：
正常状态（无流量）：
#show queueing int s0
Interface Serial0 queueing strategy: fair
Input queue: 0/75/0 (size/max/drops); Total output drops: 0
Queueing strategy: weighted fair

Output queue: 0/1000/64/0 (size/max total/threshold/drops)
  Conversations 0/1/256 (active/max active/max total) //会话序号
  Reserved Conversations 0/0 (allocated/max allocated)

#sh queueing fair
Current fair queue configuration:

Interface	Discard threshold	Dynamic queues	Reserved queues	Link queues	Priority queues
Serial0	64	16	0	8	1

观察 WFQ：在 host A 上 Ping ftp.zsu.edu.cn，同时拉 ftp.zsu.edu.cn 的文件
show queueing int s0/0

与 FIFO 比较：

```
interface Serial0
 no fair-queue
 clockrate 56000
!
#show queueing int s0
```

结论：WFQ 确保了低数据量的数据流(例如 telnet，ping)能被及时传输。
ps ,也可以利用 http 触发多个数据流观察.

二. 优先级队列（**PQ**）

有 4 个队列：high，medium，normal，low。高优先级队列中的数据包总是在优先级别低于它的队列之前被发送出去。好处：管理员可以设置关键型的数据流总是优先于其他数据被传输。弊端：高优先级队列中的数据包有可能会占用所有可以获得的带宽，在低优先级队列中的数据包有可能不能被及时发送或者根本就没机会被发送了。

在 RouterB 上配置

```
interface Serial0
 ip access-group 103 out
 priority-group 1
 clockrate 56000
!
access-list 101 permit icmp any host 192.168.1.2
access-list 103 permit ip any any log    //记录数据包数量
priority-list 1 protocol ip high tcp ftp
priority-list 1 protocol ip medium list 101
priority-list 1 interface Serial1 normal
priority-list 1 default low    //默认队列的优先级默认为 normal，这里改为 low
priority-list 1 queue-limit 5 10 15 20    //每个队列的数据包默认容量为 20 40 60 80
```

!

#sh queueing priority
Current DLCI priority queue configuration:
Current priority queue configuration:

List	Queue	Args	
1	**low**	**default**	
1	**high**	**protocol ip**	**tcp port ftp**
1	**medium**	**protocol ip**	**list 101**
1	**normal**	**interface Serial1**	
1	**high**	**limit 5**	
1	**medium**	**limit 10**	
1	**normal**	**limit 15**	
1	**low**	**limit 20**	

为较好的观察优先对列对数据优先级的影响，
建议通过同时触发多条数据流并更改优先级队列观察比较。
注：telnet 可以用 **telnet bbs.zsu.edu.cn**
如：ftp-data 为 high 时，ping 与 telnet 等完全无法工作，显示为 time out；
ftp-data 为 medium 时，设 ping 为 high,则 telnet 无法工作，
ping 正常，但延迟大于正常状态。
ftp-data 为 low 时,telnet 设 normal，则虽有延迟，但可工作。
同时可观察 队列缓冲看统计

三． **可定制队列（CQ）**

最多有 16 个队列可用。避免了优先级队列可能出现的独占带宽的弊端。用户可以采用命令 queue-list *list-No* queue *queue-No* byte-count *limit-num* 为每个队列分配一定比例的带宽，路由器采用循环机制依次为每个队列服务。这样，没有一种类型的数据流有独占全部带宽的可能性。(使用 Round-robin 算法，达到队列门限值或者队列为空后转入下一队列工作)
注：若无定制 default 队列，则数据流并入队列 1.

在 RouterB 上配置

```
interface Serial0
 ip access-group 103 out
 custom-queue-list 1
 clockrate 56000
!
access-list 101 permit icmp any host 192.168.1.2
access-list 103 permit ip any any log
queue-list 1 protocol ip 1 tcp ftp
queue-list 1 protocol ip 2 list 101
queue-list 1 protocol cdp 3
```

queue-list 1 interface Serial1 4
queue-list 1 default 5
queue-list 1 queue 1 byte-count 1400
! // 规定了这个队列在一个循环周期中可以传
// 输的最小字节数。默认为 **1500** 字节。

#sh queueing custom
Current custom queue configuration:

List	Queue	Args	
1	5	default	
1	1	protocol ip	tcp port ftp
1	2	protocol ip	list 101
1	3	protocol cdp	
1	4	interface Serial1	
1	1	limit 4500	

#sh queueing int s0
Interface Serial0 queueing strategy: custom
Output queue utilization (queue/count)
0/33 1/0 2/294 3/8 4/0 5/0 6/0 7/0 8/0
9/0 10/0 11/0 12/0 13/0 14/0 15/0 16/0

同 PQ，建议通过同时触发多条数据流观察比较。
观察到的现象：同时 ftp 与 ping，ping 的延迟较 PQ 大，但比 FIFO 好。

Rotary group and dialer profiles

一．实验目的

1．熟悉 DDR 的基本配置；
2．练习循环组（rotary group）和拨号原型（dialer profiles）的配置步骤；
3．掌握循环组（rotary group）和拨号原型（dialer profiles）的区别。

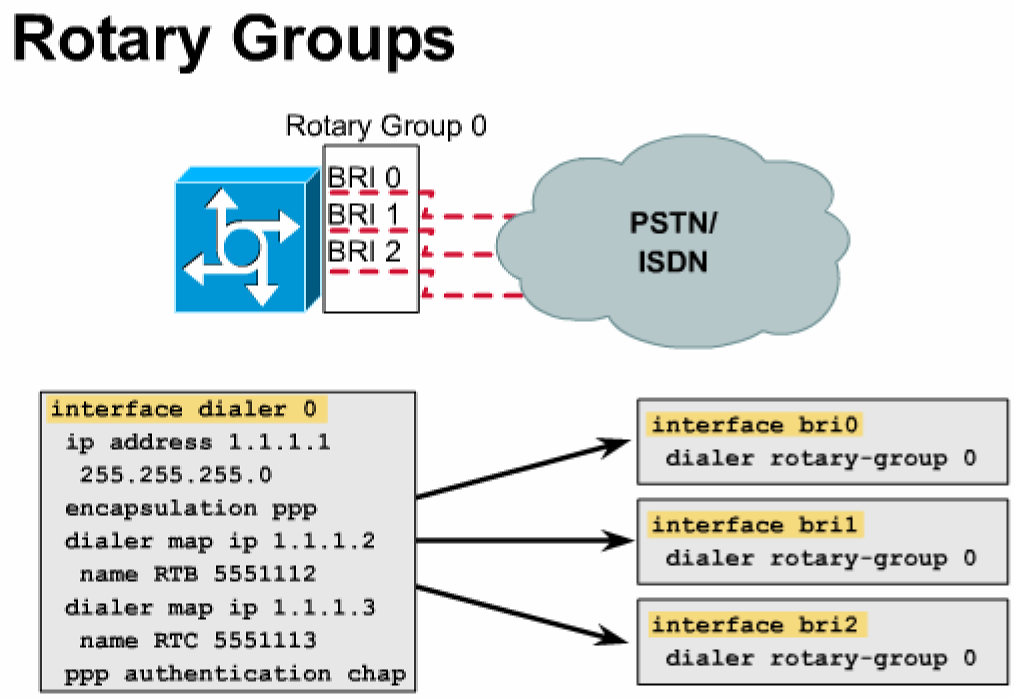
二．实验设备

路由器四台，设备自带数据线若干，网线若干，电源。

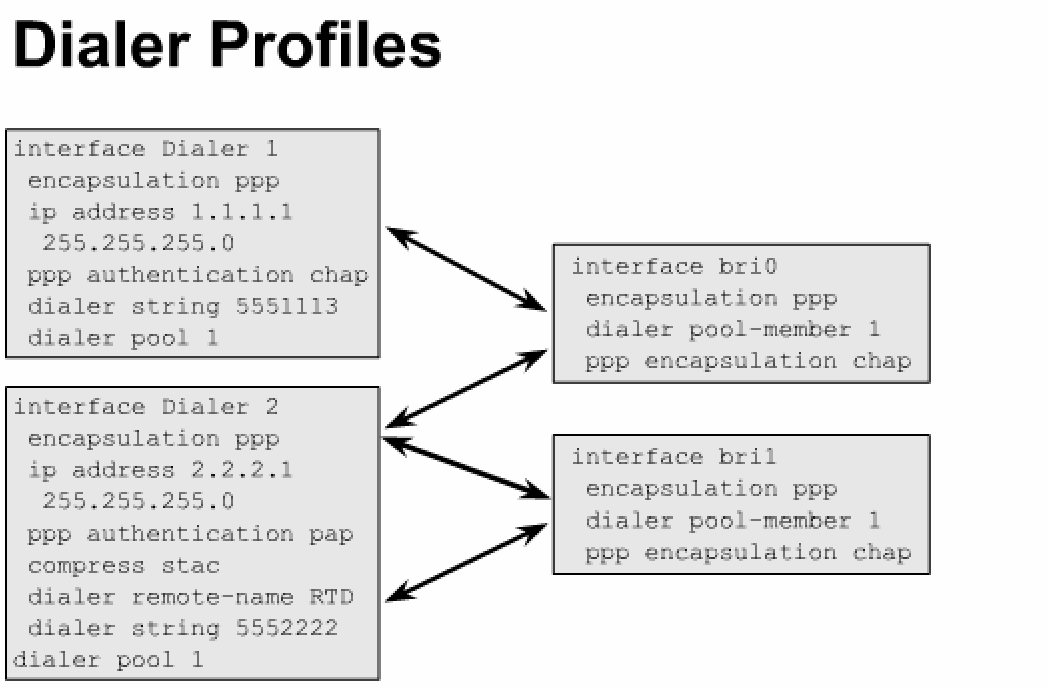
三．实验原理

传统的 DDR 的缺点是把一个物理接口固定一个配置。它是用 dialer map 命令来指定到目的地的拨号的，如果只是要拨一个目的地来说，传统的 DDR 是能够胜任的。但是，如果要拨号的目的地不止一个，而且拨号的配置参数也要求不同，那就显示出传统的 DDR 的弱点了。如果用传统的 DDR，那么要路由器有多个拨号端口，每个端口对应一个目的地，这就浪费了资源和金钱。

解决的方法是使用拨号原型（dialer profiles）或者旋转组（rotary group）。使用旋转组时，我们可以用在传统 DDR 中配置物理接口的方法配一个或多个 dialer 接口。Dialer 接口的好处是，我们将有同样 dialer 接口号码的物理接口分配给同一个旋转组。一个物理接口只能在一个旋转组中，每一个 dialer 接口也只和一个旋转组对应。



Dialer profile 是一种更新的配置 DDR 的方法。它允许我们创建物理接口池，每一个池可以包含很多物理接口，每一个物理接口可以位于一个以上的池中。配置 dialer 接口使用 dialer 池，允许多个带 per-user（基于用户）或 per-destination（基于目的地）配置的 dialer 接口共享同样物理接口的 dialer 池。

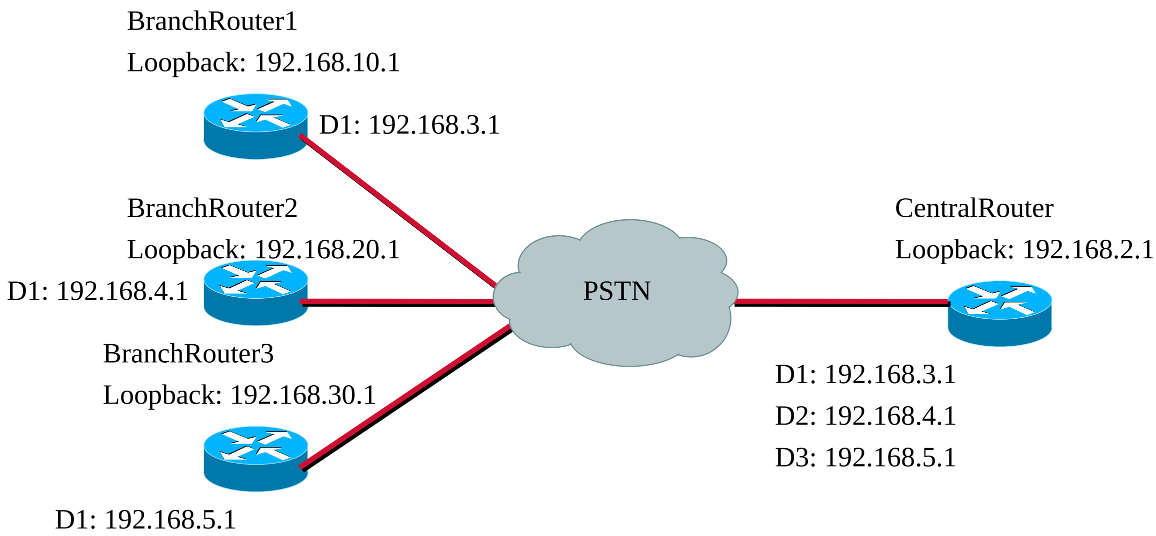


四．实验内容

1．Dialer profiles 的配置

在 CentralRouter 上配置三个 dialer interface，当 BranchRouter1 拨号时，用 dialer interface 1，当 BranchRouter2 拨号时，用 dialer interface 2。当 BranchRouter3 拨号时，用 dialer interface 3

实验拓扑图



①CentralRouter 的配置

```
CentralRouter#show run
(some of the output is omitted)
hostname CentralRouter
!
username BranchRouter1 password 0 cisco
username BranchRouter2 password 0 cisco
username BranchRouter3 password 0 cisco

interface Loopback0
 ip address 192.168.2.1 255.255.255.0
```

```
 no ip directed-broadcast
!
interface Serial0/1
 physical-layer async
 no ip address
 no ip directed-broadcast
 encapsulation ppp
 dialer in-band
 dialer pool-member 1    //把逻辑接口绑定在物理端口上
 async mode dedicated
ppp authentication chap
!
interface Dialer1
 ip address 192.168.3.2 255.255.255.0   //指定 ip 地址
 no ip directed-broadcast
 encapsulation ppp
 dialer remote-name BranchRouter1        //远端路由器的名字
 dialer string 82                       //远端路由器的电话号码
 dialer pool 1                          //拨号池一
 dialer-group 1
 ppp authentication chap
!
 interface Dialer2
 ip address 192.168.4.2 255.255.255.0  //指定 ip 地址（与上面一个不同，以便验证）
 no ip directed-broadcast
 encapsulation ppp
 dialer remote-name BranchRouter2
 dialer string 83
 dialer pool 1
 dialer-group 1
 ppp authentication chap
!
 interface Dialer3
 ip address 192.168.5.2 255.255.255.0
 no ip directed-broadcast
 encapsulation ppp
 dialer remote-name BranchRouter3
 dialer string 84
 dialer pool 1
 dialer-group 1
 ppp authentication chap
!
ip route 192.168.10.1 255.255.255.255 192.168.3.1
ip route 192.168.20.1 255.255.255.255 192.168.4.1
ip route 192.168.30.1 255.255.255.255 192.168.5.1
!
dialer-list 1 protocol ip permit
!
line con 0
```

```
 transport input none
line 1
 password cisco
 login
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
line aux 0
line vty 0 4
 password cisco
 login
!
!
end
```

②BranchRouter1 的配置

```
BranchRouter1#show run
(some of the output is omitted)

hostname BranchRouter1
!
username CentralRouter password 0 cisco
!
interface Loopback0
 ip address 192.168.10.1 255.255.255.0
!
interface Serial0
 physical-layer async
 no ip address
 encapsulation ppp
 dialer in-band
 dialer pool-member 1
 async mode dedicated
 ppp authentication chap
!
interface Dialer1
 ip address 192.168.3.1 255.255.255.0
 encapsulation ppp
 dialer pool 1
 dialer remote-name CentralRouter
 dialer string 85
 dialer-group 1
 ppp authentication chap
!
ip classless
ip route 192.168.2.0 255.255.255.0 192.168.3.2
```

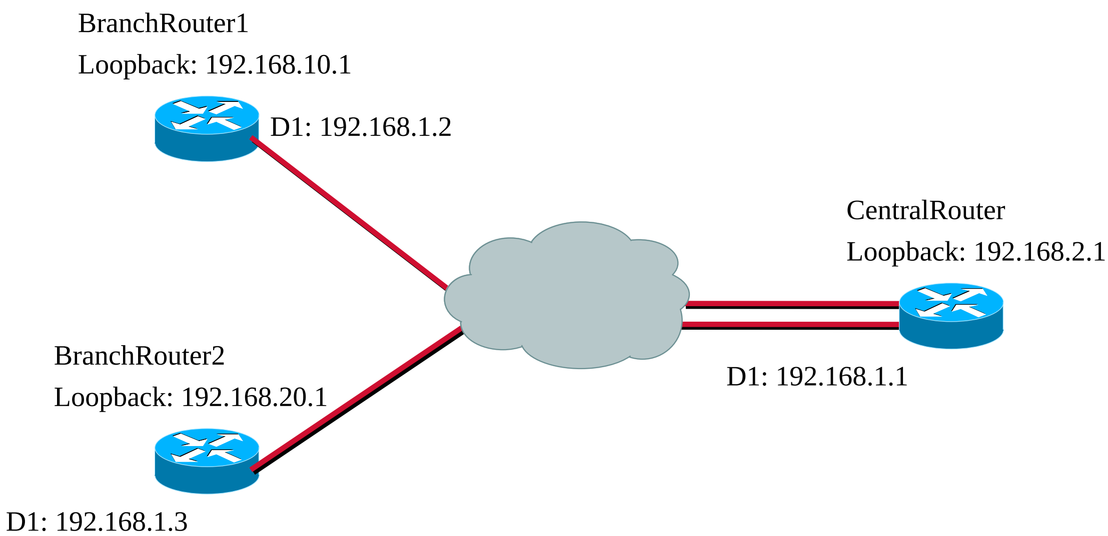
```
no ip http server
ip pim bidir-enable
!
!
dialer-list 1 protocol ip permit
!
!
line con 0
line 1
 password cisco
 login
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end
```

BranchRouter2 和 BranchRouter3 的配置和 BranchRouter1 的配置相似。

配置完后，尝试从 BranchRouter1、2、3 分别 ping CentralRouter。

2．Rotary group 的配置

实验拓扑图



①CentralRouter 的配置

```
hostname CentralRuoter
!
enable password cisco
!
```

```
username BranchRouter1 password 0 cisco
username BranchRouter2 password 0 cisco
interface Loopback0
  ip address 192.168.2.1 255.255.255.0
  no ip directed-broadcast
!
interface Serial0/0
  physical-layer async
  no ip address
  no ip directed-broadcast
  encapsulation ppp
  dialer in-band
  dialer rotary-group 1
  async mode dedicated
!!
interface Serial0/1
  physical-layer async
  no ip address
  no ip directed-broadcast
  encapsulation ppp
  dialer in-band
  dialer rotary-group 1
  async mode dedicated
!
interface Dialer1
  ip address 192.168.1.1 255.255.255.0
  no ip directed-broadcast
  encapsulation ppp
  dialer in-band
  dialer map ip 192.168.1.2 name BranchRouter1 82                    //拨号目的地
  dialer map ip 192.168.1.3 name BranchRouter2 83
  dialer-group 1
  ppp authentication chap
!
ip classless
ip route 192.168.10.1 255.255.255.255 192.168.1.2
ip route 192.168.20.1 255.255.255.255 192.168.1.3
no ip http server
!
dialer-list 1 protocol ip permit
!
line con 0
  transport input none
line 1 2
  password cisco
  login
  modem InOut
  modem autoconfigure discovery
  transport input all
  stopbits 1
```

```
  speed 115200
  flowcontrol hardware
line aux 0
line vty 0 4
!
!
end
```

②BranchRouter1，2 的配置

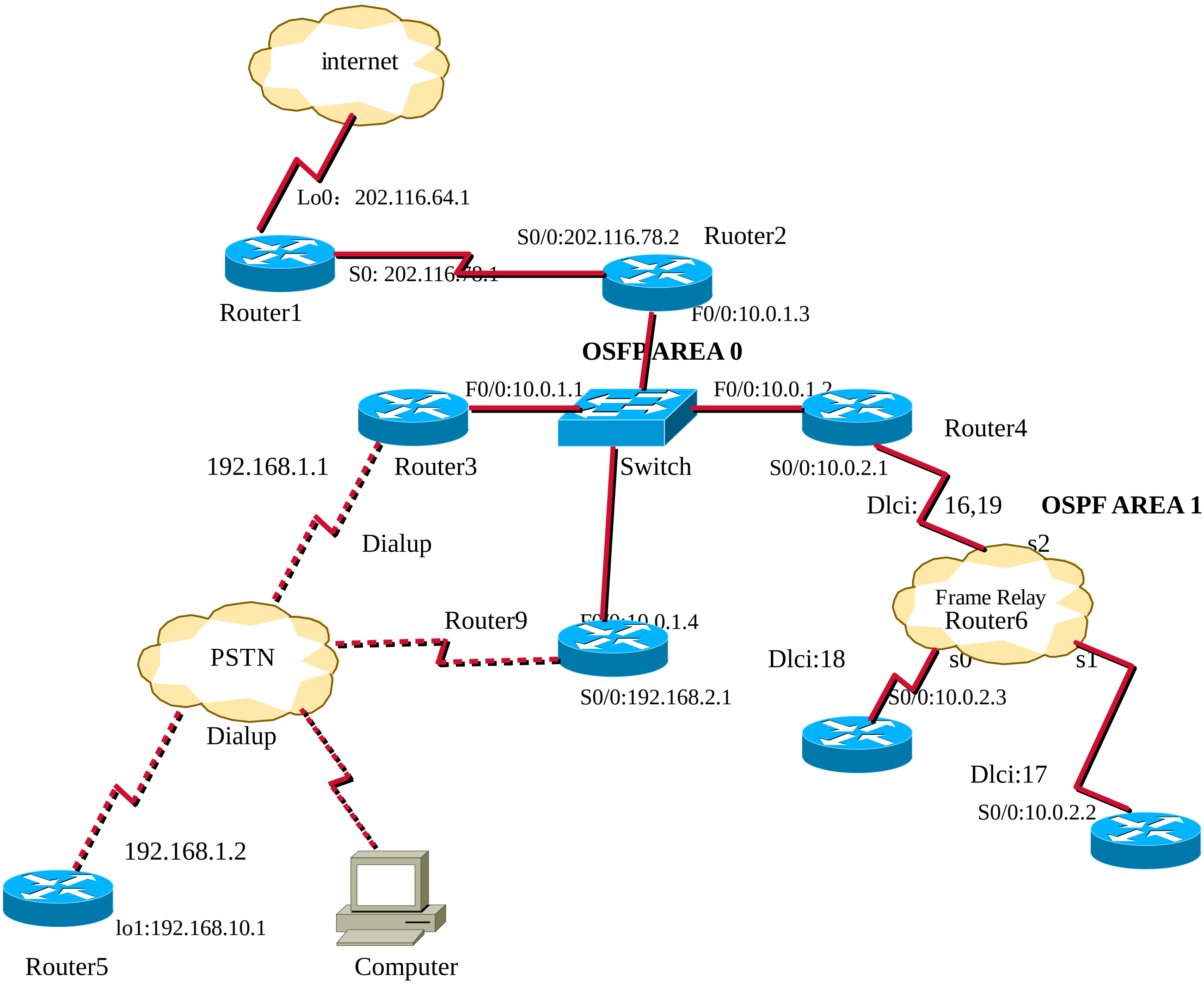
```
BranchRouter1#show run
hostname BranchRouter1
!
enable password cisco
!
username CentralRouter password 0 cisco
interface Loopback0
  ip address 192.168.10.1 255.255.255.0
!
interface Serial0
  physical-layer async
  ip address 192.168.1.2 255.255.255.0
  encapsulation ppp
  async mode dedicated
  ppp authentication chap
!
ip classless
ip route 192.168.2.1 255.255.255.0 192.168.1.1
!
line con 0
line 1
  password cisco
  login
  modem InOut
  modem autoconfigure discovery
  transport input all
  stopbits 1
  speed 115200
  flowcontrol hardware
line aux 0
line vty 0 4
  password cisco
  login
!no scheduler allocate
end
```

BranchRouter2 的配置跟 BranchRouter1 的配置基本一样，只是 s0 的 ip 地址不一样。这里不再重复。

配置完毕后，分别在 BranchRouter1 和 BranchRouter2 上 ping CentralRouter 验证配置结果。

SEMESTER 6 FANAL CASE

[实验拓扑]



[实验内容]

1． 配置各个路由器，实现以上拓扑

hostname R?

enable password

vty

各个端口（包括 Loop back 口）的 IP 及 DCE 时钟(注意 Router6 作为 FR switch 相连的都为 DCE)

2． 以 Router6 作为帧中继交换机，并配置 FR cloud 边界各个路由端口。

参考命令：

#(config)frame-relay switching

#(config-if)encapsulation frame-relay

frame-relay lmi-type cisco

frame-relay intf-type dce

frame-relay route [local dlci No] interface [remote intface] [remote dlci No]

3. 配置两种远程接入 ospf 中心网络：管理员单机接入 Router9 和远程路由接入 Router3，Router3 并反向回拨

参考命令：

- chat-script hayes56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT \c
- 物理端口：

```
line 1
 password cisco
 login
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
```

- 异步线路 serial：

```
interface Serial0
 physical-layer async
 no ip address
 encapsulation ppp
 dialer in-band
 dialer rotary-group 0
 async mode dedicated
```

- 配置 chap 验证
- 配置 callback

```
  ppp callback request
  ppp callback accept
```

4. 启动路由协议，使得路由信息完整，各网段能够通信

[参考配置结果]

```
R1#show run
Building configuration...

Current configuration : 844 bytes
!
。。。
!
hostname R1
!
enable password cisco
!
。。。
!
```

```
。。。
!
interface Serial0
  ip address 202.116.78.1 255.255.255.0
  clockrate 56000
!
interface Serial1
  no ip address
  shutdown
!
router ospf 1
  log-adjacency-changes
network 202.116.78.0 0.0.0.255 area 0
network 202.116.64.0 0.0.0.255 area 0
!
ip classless
no ip http server
ip pim bidir-enable
!
line con 0
line aux 0
line vty 0 4
  password cisco
  login
!
no scheduler allocate
end

R2#show run
Current configuration : 797 bytes
!
version 12.2
。。。
hostname R2
!
enable password cisco
!
。。。
!
interface FastEthernet0/0
  ip address 10.0.1.3 255.255.255.0
  duplex auto
  speed auto
!
```

```
interface Serial0/0
  ip address 202.116.78.2 255.255.255.0
  no fair-queue
!
interface FastEthernet0/1
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface Serial0/1
  no ip address
  shutdown
!
router ospf 1
  log-adjacency-changes
  network 10.0.1.0 0.0.0.255 area 0
  network 202.116.78.0 0.0.0.255 area 0
!
ip http server
ip classless
ip pim bidir-enable
 !
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  password cisco
  login
!
end

R3#show run
Building configuration...
…
hostname R3
!
enable password cisco
!
username R5 password 0 cisco
!
no ip domain-lookup
ip host modem 2002 192.168.168.1
!
```

```
…
chat-script modem56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT \c
!
!
interface Loopback0
 ip address 192.168.168.1 255.255.255.0
!
interface BRI0
 no ip address
 shutdown
!
interface FastEthernet0
 ip address 10.0.1.1 255.255.255.0
 speed auto
!
interface Serial0
 no ip address
 shutdown
 no fair-queue
!
interface Serial1
 physical-layer async
 ip address 192.168.1.1 255.255.255.0
 encapsulation ppp
 dialer in-band
 dialer map ip 192.168.1.2 name R5 class dialback modem-script modem56k broadcast
81
 async default routing
 async mode dedicated
 ppp callback accept
 ppp authentication chap
  dialer-group 1
!
router ospf 1
 log-adjacency-changes
 redistribute static subnets
 redistribute igrp 100 metric 100 subnets
 network 10.0.1.0 0.0.0.255 area 0
!
router igrp 100
 network 192.168.1.0
!
ip classless
ip route 192.168.10.0 255.255.255.0 192.168.1.2
```

```
no ip http server
ip pim bidir-enable
!
!
map-class dialer dialback
 dialer callback-server username
dialer-list 1 protocol ip permit
!
line con 0
line 2
 password cisco
 modem InOut
 modem autoconfigure discovery
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end
```

```
R4#show run
Building configuration...

Current configuration : 803 bytes
!
。。。
!
hostname R4
!
enable password cisco
!
。。。
!
interface FastEthernet0/0
 ip address 10.0.1.2 255.255.255.0
 duplex auto
 speed auto
!
```

```
interface Serial0/0
  ip address 10.0.2.1 255.255.255.0
  encapsulation frame-relay
  ip ospf network point-to-multipoint
  no fair-queue
!
interface FastEthernet0/1
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface Serial0/1
  no ip address
  clockrate 56000
!
router ospf 1
  log-adjacency-changes
  network 10.0.1.0 0.0.0.255 area 0
  network 10.0.2.0 0.0.0.255 area 1
!
ip http server
ip classless
ip pim bidir-enable
!
line con 0
line aux 0
line vty 0 4
  password cisco
  login
!
end

R5#show run
Building configuration...

Current configuration : 1699 bytes
!
。。。
hostname R5
!
enable password cisco
!
username R3 password 0 cisco
```

```
。。。
!
no ip domain-lookup
!
ip audit notify log
ip audit po max-events 100
chat-script hayes56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT 30 CONNECT \c
!
interface Loopback0
 ip address 10.1.1.1 255.255.255.0
!
interface Loopback1
 ip address 192.168.10.1 255.255.255.0
!
。。。
!
interface Serial0
 physical-layer async
  ip address 192.168.1.2 255.255.255.0
 encapsulation ppp
 dialer in-band
 async default routing
  dialer map ip 192.168.1.1 name R3 modem-script hayes56k broadcast 83
  dialer-group 1
 async mode dedicated
 ppp callback request
 ppp authentication chap
!
interface Serial1
 no ip address
 shutdown
!
interface Serial2
 no ip address
 shutdown
!
interface Serial3
 no ip address
 shutdown
!
router igrp 100
 network 192.168.1.0
 network 192.168.10.0
!
```

```
ip classless
ip route 0.0.0.0 0.0.0.0 192.168.1.1
no ip http server
ip pim bidir-enable
!
dialer-list 1 protocol ip permit
!
line con 0
line 1
  password cisco
  login
  modem InOut
  modem autoconfigure discovery
  transport input all
  stopbits 1
  speed 115200
  flowcontrol hardware
line aux 0
line vty 0 4
  password cisco
  login
!
no scheduler allocate
end

R6#show run
Building configuration...

Current configuration : 1199 bytes
。。。
!
hostname R6
!
。。。
frame-relay switching
!
crypto mib ipsec flowmib history tunnel size 200
crypto mib ipsec flowmib history failure size 200
!
interface FastEthernet0
  no ip address
  shutdown
  speed auto
!
```

```
interface Serial0
  no ip address
  encapsulation frame-relay
  clockrate 56000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 18 interface Serial2 16
!
interface Serial1
  no ip address
  encapsulation frame-relay
  clockrate 56000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 17 interface Serial2 19
!
interface Serial2
  no ip address
  encapsulation frame-relay
  clockrate 56000
  frame-relay lmi-type cisco
  frame-relay intf-type dce
  frame-relay route 16 interface Serial0 18
  frame-relay route 19 interface Serial1 17
!
interface Serial3
  no ip address
  shutdown
!
ip classless
no ip http server
ip pim bidir-enable
!
line con 0
line aux 0
line vty 0 4
!
no scheduler allocate
end

router7#show run
Building configuration...

。。。
```

```
!
hostname router7
!
enable password cisco
!
memory-size iomem 15
ip subnet-zero
!
。。。
!
interface Serial0
  ip address 10.0.2.2 255.255.255.0
  encapsulation frame-relay
  ip ospf network point-to-multipoint
  no fair-queue
!
interface Serial1
  no ip address
  shutdown
!
router ospf 1
  log-adjacency-changes
  network 10.0.2.0 0.0.0.255 area 1
!
ip classless
no ip http server
ip pim bidir-enable
!
line con 0
line aux 0
line vty 0 4
  password cisco
  login
!
no scheduler allocate
end


R8#show run
Building configuration...
。。。
!
hostname Router8
!
```

```
enable password cisco
!
。。。
!
interface Serial0
 ip address 10.0.2.3 255.255.255.0
 encapsulation frame-relay
 ip ospf network point-to-multipoint
 frame-relay lmi-type cisco
!
interface Serial1
 no ip address
 shutdown
!
router ospf 1
 log-adjacency-changes
 network 10.0.2.0 0.0.0.255 area 1
!
ip classless
no ip http server
ip pim bidir-enable
!
line con 0
line aux 0
line vty 0 4
 password cisco
 login
!
no scheduler allocate
end
```

```
R9#show run
Building configuration...

Current configuration : 1157 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R9
!
enable password cisco
```

```
!
memory-size iomem 15
ip subnet-zero
no ftp-server write-enable
chat-script aa56k ABORT ERROR "" "AT Z" OK "ATDT\T" TIMEOUT CONNECT\c
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.0
!
!
interface FastEthernet0/0
ip address 10.0.1.4 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0
 physical-layer async
 ip address 192.168.2.1 255.255.255.0
 encapsulation ppp
 async mode interactive
 peer default ip address pool ippool
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/1
 no ip address
 shutdown
!
router ospf 1
 log-adjacency-changes
network 10.0.1.0 0.0.0.255 area 0
 network 192.168.2.0 0.0.0.255 area 0
!
ip local pool ippool 192.168.2.2 192.168.2.15
ip http server
ip classless
ip pim bidir-enable
!
```

```
!
!
!
line con 0
line 1
 password cisco
 login
 modem InOut
 modem autoconfigure discovery
 transport input all
 autoselect ppp
 stopbits 1
 speed 115200
 flowcontrol hardware
line aux 0
 line vty 0 4
 password cisco
 login
!
end
```

Single Area OSPF

【实验目的】

了解和掌握 OSPF 的原理，熟悉 OSPF 配置步骤。懂得如何配置 OSPF router ID，update timers, authentication,了解 DR/BDR 选举过程，以及在 multi-access 网络和帧中继网络上点到多点的 OSPF 配置。

【基本概念及实验原理】

◆ OSPF 数据包的五种类型：

Type 1- Hello	用于建立和维持与邻居的连接信息
Type 2- Database description packet(DBD)	用于描述一个路由器的链路状态数据库的内容
Type 3- Link-state request(LSR)	用于请求一个路由器链路状态数据库的一些特定的条目
Type 4- Link-state update(LSU)	用于把“链路状态更新”(LSAs)传输给其它路由器
Type 5- Link-state acknowledgment (LSAck)	用于确认自己收到了一个从邻居发过来的 LSA

◆ OSPF 的各种状态（OSPF 邻居关系建立的过程）

Down.→ Init. → Two-Way. → ExStart. → Exchange. → Loading. → Full Adjacency

hello→ 发现邻居→确定主从关系→比较数据库→交换数据→确立邻接关系

◆ Designated Router (DR) / Backup Designated Router(BDR)选举过程

(存在于 multiaccess 网络，点对点和点对多点网络中无此选举过程)

选举过程：

依次比较 hello 包中的端口优先级(priority)，路由 id。选举结束后，只有 DR/BDR fail 才会引起新的选举过程；如果发生 DR 故障，则 BDR 替补上去；次高优先级 router 选为 BDR。

新加入的 router 只接受现有的 DR/BDR，即使拥有更高优先级，亦不会引起新的选举过程。

优先级默认值 1，范围 0 到 255，应用于 OSPF 端口。路由 id 为 loopback 接口（或者 up 起来的端口）的最高 ip 地址值。建议使用优先级操纵 DR/BDR 选举过程。

◆ NBMA 网络 ospf 邻接关系的解决方法

全网状拓扑：一是使用 **neighbor** 命令，指定 neighbor；

二是配置点到点的子端口（point-to-point sub-interfaces）

hub-and-spoke 拓扑（部分网状的一种）：

使用不了 neighbor 命令，hello 包只能 send 到中心点。

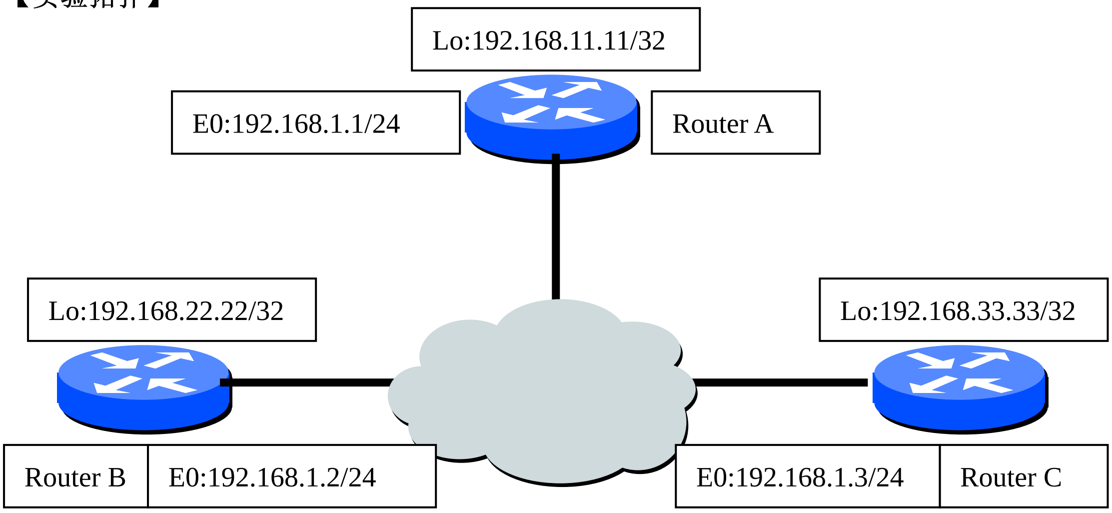
一是配置端口优先级，使 spoke-router 的端口优先级为 0，不加入选举。

二是划分子网，利用子端口配置点到点网络。

三是配置点到多点，无 DR/BDR 选举。逻辑上形成全网状关系。

可利用反向地址解析或者 neighbor 命令找到邻居。

【实验拓扑】



说明：网络云开始可用 hub 或者普通 switch 替代，建立 multi-access 网络，以太口连接。
做点对多点实验时替换成配置好的帧中继交换机（至少三个串口的 router 模拟）
串口连接。

【实验设备】

起码带有一个串口的路由器 3 台（可以是 1600、1700、2500 或 2600）；
集线器或交换机 1 个；
起码带有三个串口的 1720 路由器一台；
用于配置路由器的主机 3 台；
串行线、以太网线若干；

【实验内容】

◆ multi-access 网络的 OSPF 配置

1、配置各台路由器的端口地址，并利用 ping 命令检查连通性

Router(config)#Interface Ethernet 0
Router(config-if)#ip address 192.168.1.* 255.255.255.*
Router(config-if)#no shutdown

2、配置 loopback 端口作为 OSPF router ID，确保 router ID 的稳定性。

Router(config)#Interface loopback 0
Router(config-if)#ip address 192.168.*.* 255.255.255.255

3、启动 router 上 OSPF 进程并观察

Router(config)#router ospf 1
Router(config-router)#network 192.168.1.0 0.0.0.255 area 0

配置完毕打开 switch/hub

Router C#show ip ospf neighbor
Router C#show ip protocols
Router C#show ip ospf

Router C#show ip ospf neighbor detail

4、更改 timer

Router C(config-if)#ip ospf hello-interval *

RouterC (config-if)#ip ospf dead-interval *

由于 hello 时间间隔有相等的要求，

所以在先改动了一台 router 参数后可观察到握手不成功。

Router C#debug ip ospf events

Router#undebug all

RouterB#show ip ospf neighbor

(空)

若一个个 router 改 interval，无论顺序如何，结果还是先前的 DR/BDR。

ps.当先修改 DR 的 interval 后，会导致 DR/BDR 的选举发生；

若此时改回原 DR 的 interval，会再次引发选举，DR 恢复原状。(中途无 shut 端口)

5、配置认证

```
Router(config-if)# ip ospf authentication-key password
Router(config-router)# area number authentication [message-digest]
```

查看信息

Router C#debug ip ospf events

取消认证后，会重新引发选举

或者

```
Router(config-if)# ip ospf message-digest-key key-id md5 [encryption-type] password
Router(config-router)# area number authentication [message-digest]
```

查看信息

Router C#debug ip ospf events

6、更改端口优先级指定网段内 DR

（可使 router 在不同网段处于不同角色，不同于 router id 的指定）

观察默认优先级:

Router C#show ip ospf interface

更改优先级：

Router A(config)#Interface FastEthernet 0

Router A(config-if)#ip ospf priority 250

Router B(config)#Interface FastEthernet 0

Router B(config-if)#ip ospf priority 200

Router C(config)#Interface FastEthernet 0

Router C(config-if)#ip ospf priority 100

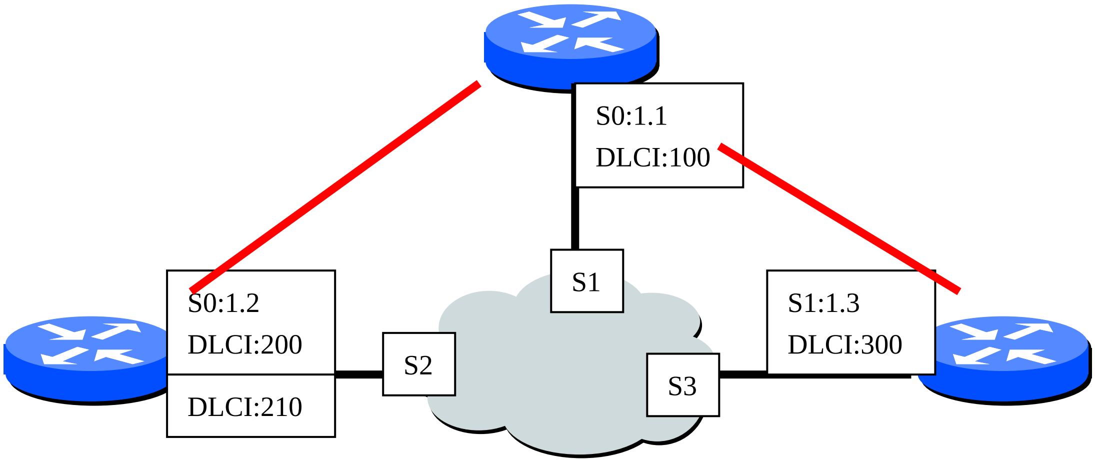
重新开始 DR/BDR 选举进程（需 shutdown 所有端口，同时开）

Router C#debug ip ospf events

在路由器 A 上查看选举结果

Router A#show ip ospf neighbor

◆ 帧中继网络的 OSPF 配置（点到多点）



(1) 配置 router 串口：

Router(config)#Interface Serial 0

Router(config-if)#encapsulation frame-relay [ietf|cisco]

Router(config-if)# ip address 192.168.1.* 255.255.255.0

Router(config-if)#no shutdown

Router(config-if)#frame-relay map ip 192.168.1.* [dlci number] broadcast

Router(config-if)#frame-relay map ip 192.168.1.* [dlci number] broadcast。

Router(config-if)#ip ospf network point-to-multipoint

另有选项：broadcast|non-broadcast|point-to-point

(2) 检查 Frame Relay 配置

Router#show frame-relay map

(3) 添加串口的 ip 段到 ospf 区域

Router(config)#router ospf *

Router(config-router)#network 192.168.1.0 0.0.0.255 area 0

(4) 检查 ospf 配置

Router#show ip route

应具有到对端的主机路由

(5) 检查邻接状态(无 DR/BDR 存在)

Router#show ip ospf neighbor

Router as Frame Relay Switch Configurationshow run

Building configuration...

version 12.2

hostname FRswitch

!

frame-relay switching

!

interface Serial1

no ip address

encapsulation frame-relay

no fair-queue

```
clockrate 56000
 frame-relay intf-type dce
 frame-relay route 100 interface Serial2 200
!
interface Serial2
 no ip address
 encapsulation frame-relay
 clockrate 56000
 frame-relay intf-type dce
 frame-relay route 200 interface Serial1 100
 frame-relay route 210 interface Serial3 300

!
interface Serial3
 no ip address
 encapsulation frame-relay
 clockrate 56000
 frame-relay intf-type dce
 frame-relay route 300 interface Serial2 210
!
```

Frame-relay ODR
&
Snapshot Routing

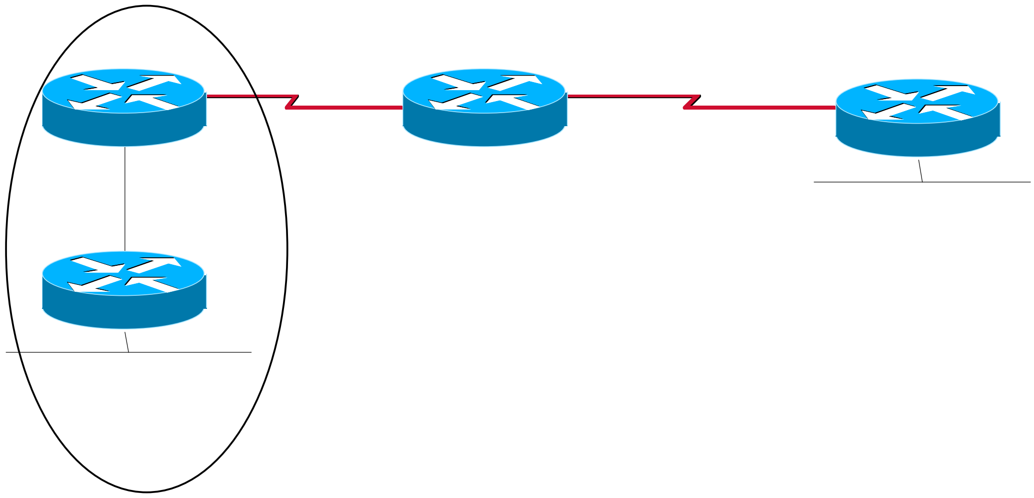
[实验目的]

1. 掌握 Snapshot routing 的配置；
2. 掌握基本的 frame-relay 配置；
3. 掌握 frame-relay 网络中的 ODR 的配置

[实验步骤]

Task 1：配置基于的frame-relay的ODR(ON DEMAND ROUTING)网络

网络拓扑结构如下：



请仔细对照拓扑结构，将路由器接好。值得注意的是Fr—switch（用路由器来模拟实现）所接的serial线必须是DCE端（请对照线上的标签。如果没标签，将串行线连接处拆开，公的那头对应DTE，母的那头对应DCE。

1. 以RouterB为例，其命令为：

```
RouterB(config)#int s0
RouterB(config-if)#ip address 192.168.4.1 255.255.255.0
RouterB(config-if)#encapsulation frame-relay
RouterB(config-if)#frame-relay lmi-type cisco     //IOS11.2之后可以自
RotuerB(config-if)#frame-relay interface-dlci 16 //动发现，可以不配
```

类似的，完成RouterC的帧中继配置。

2. 配置帧中继交换机，命令为：

```
Router(config)#hostname Fr-switch
Fr-switch(config)#frame-relay switching   //将路由器模拟成帧中继交换机
Fr-switch(config)#interface Serial0
Fr-switch(config-if)#encapsulation frame-relay  //配置帧中继封装
Fr-switch(config-if)#frame-relay intf-type dce  //FR交换机的端口为DCE
Fr-switch(config-if)#clockrate 56000            //配置DCE时钟
Fr-switch(config-if)#frame-relay lmi-type cisco  //帧中继lmi类
                                        //型,IOS11.2之后可以自动发现
```

RouterB S0 192

```
Fr-switch(config-if)#frame-relay route 17 interface Serial1 16
                                                    // 配置帧中继交换表
Fr-switch(config-if)#exit
Fr-switch(config-if)#interface Serial1
Fr-switch(config-if)#encapsulation frame-relay
Fr-switch(config-if)#frame-relay intf-type dce
Fr-switch(config-if)#clockrate 56000
Fr-switch(config-if)#frame-relay lmi-type cisco
Fr-switch(config-if)#frame-relay route 16 interface Serial0 17
```

3. 验证帧中继网络的连通性

在 FR－switch 上可以用 show frame-relay pvc 和 show frame-relay route 查看

在 RouterB、RouterC 上可以用下列的命令测试：

测试联通性：ping 命令

查看虚电路：show frame-relay pvc

查看映射表：show frame-relay map //帧中继映射表

查看 lmi 信息：show int s0

4. 在RouterA和RouterB之间启动ospf动态路由协议，area号为0。

命令为：RouterA（config）#router ospf 1

```
RouterA(config-router)#network 192.168.1.0  0.0.0.255 area 0
RouterA(config-router)#network 192.168.2.0  0.0.0.255 area 0

RouterB(config)#router ospf 1
RouterB(config-router)#network 192.168.1.0  0.0.0.255 area 0
RouterB(config-router)#network 192.168.4.0  0.0.0.255 area 0
```

5. 在RouterC上配置下一跳为192.168.4.1的默认路由。(学员自己配置)

6. 查看RouterB的IP路由表，看是否有到192.168.3.0的路由？

7. 在路由器B上show cdp neighbor，看是否能看到RouterC的信息，没有则检查是否启动了cdp协议。如果没有启动，可以用下列命令启动：

```
（config）#cdp run         //全局启动
(config-if)#cdp enable   //某个接口启动
```

8. 在路由器B上启动ODR，命令为：

```
RouterB(config)#router odr
```

9. 再一次查看路由器B的IP路由表，看是否有192.168.3.0的路由？

10. 查看RouterA的IP路由表，是否有192.168.3.0的路由？

11. 将从ODR得到的路由重分布进ospf，命令为：

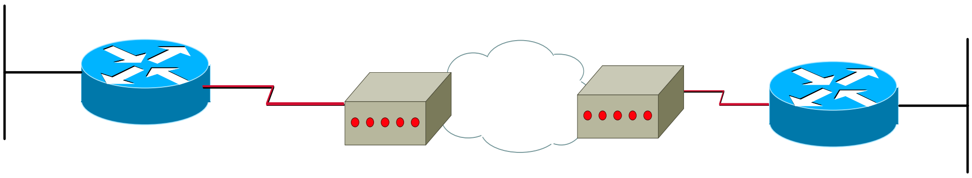
```
RouterB(config)#router ospf 1
RouterB(config-router)# default-metric 20
```

```
RouterB(config-router)# redistribute odr
```

12. 再次查看路由器A的IP路由表，看是否有192.168.3.0的路由？此时应该可以看到该条路由条目了。

TASK 2：配置 dialer rotary-group

1．拓扑如下所示（电话号码以实际的拓扑为准）



2．配置好两边的路由器，使得 Remote 能成功的拨叫 Central 路由器

Remote 路由器的配置：

```
Router(config)#hostname Remote
Remote(config)# no ip domain-lookup
Remote(config)#username Central password 0 cisco

Remote(config)#interface Loopback0
Remote(config-if)#ip address 192.168.1.1 255.255.255.0     //配置 loopback 端口 ip 地址

Remote(config)#interface Serial0
Remote(config-if)#physical-layer async            //serial 口设置为工作在异步模式
Remote(config-if)#encapsulation ppp               //ppp 封装
Remote(config-if)#dialer in-band
Remote(config-if)#dialer rotary-group 0           //逻辑配置为 interface dialer0
Remote(config-if)#async default routing           //允许异步端口发送路由更新信息,必须配置
Remote(config-if)#async mode dedicated
```

Loopback 0

192.168.1.1/24

```
Remote(config)#interface Dialer0                  //配置逻辑拨号接口0
Remote(config-if)#ip address 10.1.1.2   255.255.255.0
Remote(config-if)#encapsulation ppp               //ppp 封装
Remote(config-if)#dialer in-band                  //启动 DDR
Remote(config-if)#dialer map ip 10.1.1.1 name Central broadcast 87     //配置 dialer map
Remote(config-if)#dialer-group 1                  //绑定 dialer-list 1
Remote(config-if)#ppp authentication chap         //ppp 认证

Remote(config)#dialer-list 1 protocol ip permit      //配置 dialer-list，定义触发性数据流

Remote(config)#line 1                             //配置物理线路
Remote(config-line)#login local
Remote(config-line)#modem InOut
```

S

10

Remote

Remote(config-line)#modem autoconfigure discovery
Remote(config-line)#transport input all
Remote(config-line)#stopbits 1
Remote(config-line)#speed 115200
Remote(config-line)#flowcontrol hardware

Central 路由器的配置：(Central 只配置成接受远端拨号，如果要让它拨号，学员自己配置)
Router(config)#hostname Central
Central(config)# no ip domain-lookup
Central(config)#username Remote password 0 cisco

Central(config)#interface Loopback0
Central(config-if)#ip address 192.168.2.1 255.255.255.0 //配置 loopback 端口 ip 地址

Central(config)#interface Serial0
Central(config-if)#physical-layer async //serial 口设置为工作在异步模式
Central(config-if)#ip address 10.1.1.1 255.255.255.0
Central(config-if)#encapsulation ppp //ppp 封装
Central(config-if)#async mode dedicated
Central(config-if)#ppp authentication chap

Central(config)#line 1 //配置物理线路
Central(config-line)#login local
Central(config-line)#modem InOut
Central(config-line)#modem autoconfigure discovery
Central(config-line)#transport input all
Central(config-line)#stopbits 1
Central(config-line)#speed 115200
Central(config-line)#flowcontrol hardware

验证：从 Remote 路由器 ping Central 路由器，看是否能够互通。

3．Snapshot Routing 配置

1）在两台路由器上配置 igrp 动态路由协议（as 为 100）
以 Central 为例：
router igrp 100
network 10.0.0.0
network 192.168.2.0

2）将 Central 设置为 snapshot server（active 时间为 5 分钟）
Central（config）#int s0
Central（config-if）#snapshot server 5
Central（config-if）#dialer idle-timeout 300 //为了较好的观察到效果，将 idle 超时时间设为 5 分钟

3）将 Remote 设置为 snapshot client（active 时间 5 分钟，quiet 时间为 8 分钟）

Remote(config)#int dialer 0

Remote (config-if)#snapshot client 5 8 suppress-statechange-update Dialer

注：suppress-statechange-update防止路由器在接口状态在up/down之间变化时，影响snapshot。即是由用户的数据流（up/down状态变化）引起的链路变化与snapshot两者之间独立。

dialer是允许client路由器在没有数据流（此时链路是down的）的时候也可以对server路由器拨号以进行路由信息交互。

如果配置了suppress-statechange-update，dialer关键字是必须的。

Remote(config-if)#dialer map snapshot 1 name Central broadcast 88

注：指定某个snapshot Server的电话号码，当snapshot由quiet进入active状态，而此时链路又是down时，用此号码拨号；1是一个序号，当client对多个snapshot server拨号时，此序号作为唯一标识，然后拨号时从序号低的开始拨。

Remote(config-if)#dialer idle-timeout 300

4） Show ip route观察路由表，然后Remote用ping连接到Central，再查看路由表。

5） Show snapshot。

6）启动debug dialer packets，查看snapshot的过程。等待8分钟，看Remote路由器是否会对Central路由器拨号。

7)由于idle timeout时间为5分钟，则5分钟后拨号链路down掉。在拨通之后，两边都是可以看到各自的loopback的网段；但当链路down掉后，只有snapshot client可以看到192.168.2.0/24的网段，而snapshot server看不到192.168.1.0/24的网段，这就是snapshot的效果。再过3分钟（可能有一定的误差，并不是非常精确的），client开始snapshot的拨号（debug信息中可以看到cause snapshot）。

要注意的是quiet time的8分钟是包括active的5分钟在内的，即真正的quiet时间是3分钟。

4. 注意事项

1）工作在异步模式的serial，必须配置async default routing，否则，路由协议不会对serial端口发送update信息。

2）如果路由器正在quiet状态，可以通过在client端用命令clear snapshot quiet-time s0强制使路由器进入active状态。

3）观察路由器在各个状态下的动作，理解snapshot的工作原理。

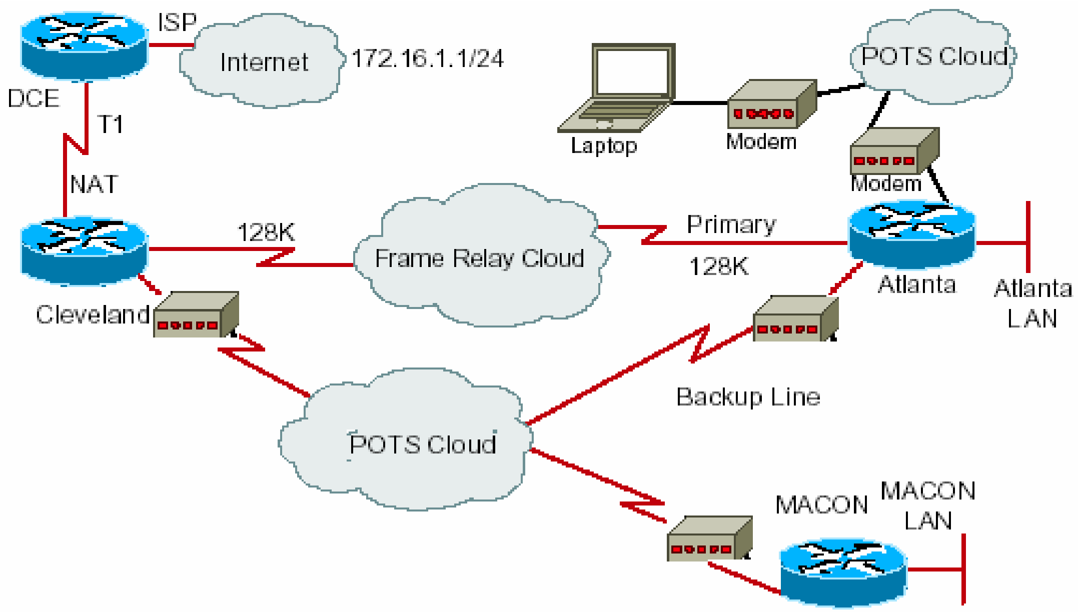
4）本实验必须使用rotary-group等使端口配置与逻辑配置相分离的配置方法，如果直接在serial端口上配置snapshot，由于serial端口在断开连接的瞬间会被路由器认为进入down状态而将与serial口相连的路由删除，导致snapshot routing 不起作用，而使用interface dialer则不会进入down状态。

5)当active时间比idle timeout大时，在active还没到时之前，即使链路由于超过idle timeout时间，client仍会继续拨叫server路由器以进行路由信息交换。所以为了更好的观察效果而将idle timeout设为5分钟。

Sem6 Case Study (I)

Student Skills Assessment (Version 2)

Topology:



Scenario:

The Cleveland Pie Works of Cleveland, Ohio has bought out the Atlanta Bread Company. You are the new network administrator for the Cleveland Pie Works. You must configure the network above. You will use static routes between all company sites. You must configure a Frame Relay connection between the Cleveland headquarters site and Atlanta Bread Company site. Atlanta must have connectivity at all times to Cleveland, so you have decided to install a backup asynchronous line. There is a branch office in Macon that will utilize the asynchronous port on the Atlanta router when it is not being used as a backup connection to the Cleveland headquarters. Configure the Atlanta router as a dial-in access server. Verify end-to-end reachability. All passwords will be "cisco" for this exam.

Instructions:

IP Addressing

1. You must be able to support 230 users on each LAN segment at all the sites. You have been allocated the 192.168.2.84/30 address by your ISP. This will require you to implement NAT at the Cleveland headquarters site.

Cleveland Company Headquarters

1. Configure static routes to the Atlanta and Macon sites.
2. Configure the connection to your ISP. Your address will be 192.168.2.82/30. The ISP interface is 192.168.2.81/30. Internet connections will be done via a default static route with PPP and CHAP authentication

3. Configure the Frame Relay connection to Atlanta. Your local DLCI number is 16 and your LMI-type is **ANSI**. The bandwidth of the link is 128Kbs.
4. Configure the asynchronous interface to Atlanta. This connection should use CHAP authentication.
5. Configure NAT overload on the appropriate router.

Atlanta

1. Configure a 128 kbs. Frame Relay connection to the Cleveland Headquarters. Your local dlci is 18 and your lmi-type is **ANSI**.
2. Configure an asynchronous backup connection to the Cleveland Headquarters site. The backup line will use a floating static route. This connection should use CHAP authentication.
3. Configure the async interface to either dial or receive calls from Macon.
4. *Enable Stac compression to the Macon router. (optional)*
5. Use static routes for outside connectivity.
6. Configure an asynchronous connection for the CTO in Atlanta. The remote user should be able to access all LANs in the network and also reach the Internet. This connection should use PPP

Macon

1. Configure the asynchronous connection to Atlanta. This connection should use Multilink PPP and CHAP authentication
2. Enable Stac compression to the Atlanta router.
3. Use static default routes for outside connectivity.
4. Verify end-to-end reachability.

Atlanta CTO

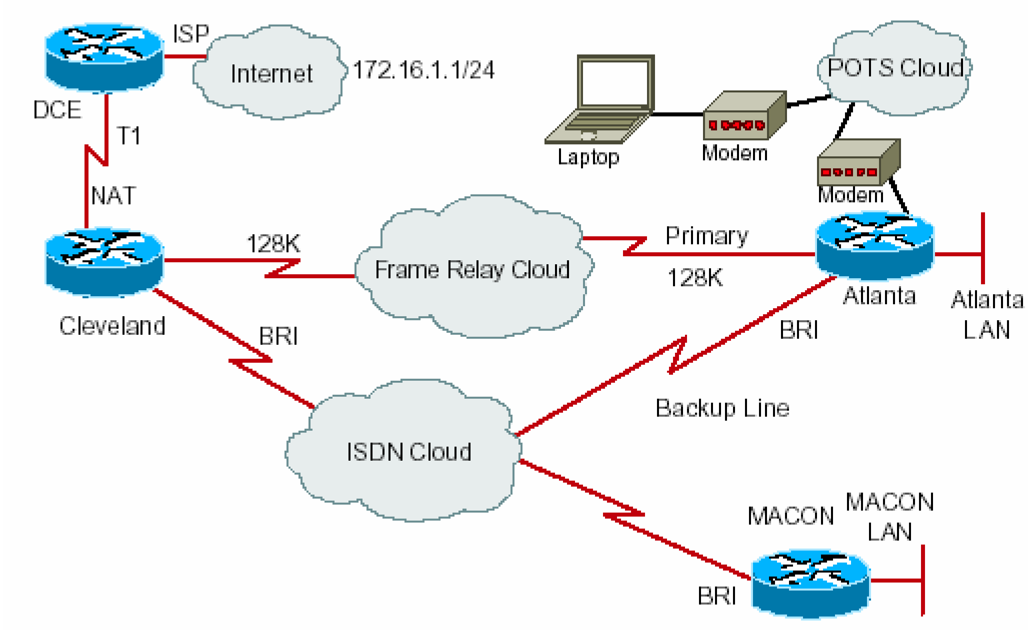
1. Configure your laptop for dialup access to the Atlanta router's asynchronous port. Use PPP as your WAN protocol. (Note:Maybe AUX port is a good choice.)
2. You should assign an IP address for dial-in that is on the Atlanta LAN. (The CTO is considered part of the Atlanta LAN.)
3. Verify end-to-end reachability.

ISP provider:

1. Using a router to simulate the ISP provider. Configure its serial with IP address(reference to the Cleveland router).
2. Using a loopback interface to simulate the Internet.
3. *Configure the ISP provider router to act as an AAA server, and implement the login authentication, exec authorization, and accounting for exec, connection, commands level 15, and so on.. (optional)*

Note: when you configure your network, you'd better configure step by step. It means that once you configure one of the issues, you are strongly recommended to test your network's reachability.

Student Skills Assessment
Version 2



Scenario:
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Instructions:
IP Addressing
1. You must be able to support 230 users on each LAN segment at all the sites. You have been allocated the 192.168.2.84/30 address by your ISP. This will require you to implement NAT at the Cleveland headquarters site.

Cleveland Company Headquarters
1. Configure static routes to the Atlanta and Macon sites.
2. Configure the connection to your ISP. Your address will be 192.168.2.82/30. The ISP interface is 192.168.2.81/30. Internet connections will be done via a default static route with PPP and CHAP authentication
3. Configure the Frame Relay connection to Atlanta. Your local DLCI number is 16 and your LMI-type is ANSI. The bandwidth of the link is 128Kbs.
4. Configure the ISDN interface to Atlanta. This connection should use Multilink PPP and CHAP authentication.
5. Configure NAT overload on the appropriate router.

Atlanta
1. Configure a 128 kbs. Frame Relay connection to the Cleveland Headquarters. Your local dlci is 18 and your lmi-type is ANSI.
2. Configure an ISDN backup connection to the Cleveland Headquarters site. The backup line will use a floating static route. This connection should use Multilink PPP and CHAP authentication.
3. Configure the ISDN interface to either dial or receive calls from Macon.

4. Enable Stac compression to the Macon router.
5. Use static routes for outside connectivity.
6. Configure an asynchronous connection for the CTO in Atlanta. The remote user should be able to access all LANs in the network and also reach the Internet. This connection should use PPP

Macon

1. Configure the ISDN connection to Atlanta. This connection should use Multilink PPP and CHAP authentication
2. Enable Stac compression to the Atlanta router.
3. Use static default routes for outside connectivity.
4. Verify end-to-end reachability.

Atlanta CTO

1. Configure your laptop for dialup access to the Atlanta router's AUX port. Use PPP as your WAN protocol
2. You should assign an IP address for dial-in that is on the Atlanta LAN. (The CTO is considered part of the Atlanta LAN.)
3. Verify end-to-end reachability.

CHECKLIST:

1. NAT working correctly at Cleveland ______________
2. Static routes on Cleveland _________________
3. Frame Relay connection between Cleveland and Atlanta_________________
4. ISDN backup connection between Atlanta and Cleveland _______________
5. ISDN connection to Macon____________________
6. Stac compression between Macon and Atlanta _______________
7. Dialup server connection prepared on Atlanta _______________
8. T1 PPP connection from Cleveland to ISP _______________
9. All users can reach Internet and ISP Web Server ______________
10. All users can reach the Macon LAN _____________

Student Exam 2-ISP Configuration

```
hostname isp
!
enable password cisco
!
username cleveland password 0 cisco
!
!
interface Loopback0
ip address 172.16.1.1 255.255.255.0
!
interface Ethernet0
no ip address
shutdown
!
interface Serial0
ip address 192.168.2.81 255.255.255.252
encapsulation ppp
clockrate 56000
ppp authentication chap
!
interface Serial1
no ip address
shutdown
!
ip http server
no ip classless
ip route 192.168.2.84 255.255.255.252 192.168.2.82
!
line con 0
line aux 0
line vty 0 4
```

```
password cisco
login
!
end
```

Student Exam 2-Cleveland Configuration

```
hostname cleveland
!
enable password cisco
!
username isp password 0 cisco
username atlanta password 0 cisco
ip nat pool bread-pool 192.168.2.85 192.168.2.86 netmask 255.255.255.252
ip nat inside source list 1 pool bread-pool overload
isdn switch-type basic-ni1
!
!
interface Ethernet0
ip address 10.1.10.1 255.255.255.0
ip nat inside
no keepalive
fair-queue 64 256 0
!
interface Serial0
ip address 192.168.2.82 255.255.255.252
ip nat outside
encapsulation ppp
no ip mroute-cache
ppp authentication chap
!
interface Serial1
ip address 10.1.20.1 255.255.255.0
ip nat inside
encapsulation frame-relay
bandwidth 128
frame-relay interface-dlci 16
frame-relay lmi-type ansi
!
interface BRI0
ip address 10.1.50.1 255.255.255.0
no ip directed-broadcast
ip nat inside
encapsulation ppp
dialer map ip 10.1.50.2 name atlanta broadcast 5554000
dialer map ip 10.1.50.2 name atlanta broadcast 5554001
dialer load-threshold 1 either
dialer-group 1
isdn spid1 51055512340001 5551234
isdn spid2 51055512350001 5551235
ppp authentication chap
ppp multilink
!
ip classless
ip route 0.0.0.0 0.0.0.0 192.168.2.81
ip route 10.0.0.0 255.0.0.0 10.1.20.2
ip route 10.0.0.0 255.0.0.0 10.1.50.2 200
!
access-list 1 permit 10.0.0.0 0.255.255.255
dialer-list 1 protocol ip permit
!
line con 0
line aux 0
line vty 0 4
password cisco
login
!
end
```

Student Exam 2-Atlanta Configuration

```
hostname atlanta
!
enable password cisco
```

```
!
username macon password 0 cisco
username cleveland password 0 cisco
username cto password 0 cisco
!
memory-size iomem 20
ip subnet-zero
!
isdn switch-type basic-ni
!
process-max-time 200
!
interface Serial0
bandwidth 128
ip address 10.1.20.2 255.255.255.0
no ip directed-broadcast
encapsulation frame-relay
fair-queue 64 256 0
cdp enable
frame-relay interface-dlci 18
frame-relay lmi-type ansi
!
interface BRI0
no ip address
no ip directed-broadcast
encapsulation ppp
dialer pool-member 1
isdn switch-type basic-ni
isdn spid1 51055540000001 5554000
isdn spid2 51055540010001 5554001
ppp authentication chap
!
interface FastEthernet0
ip address 10.2.1.1 255.255.255.0
no ip directed-broadcast
no keepalive
!
interface Async5
ip unnumbered FastEthernet0
no ip directed-broadcast
encapsulation ppp
async mode dedicated
peer default ip address 10.2.1.200
fair-queue 64 16 0
no cdp enable
ppp authentication pap
!
interface Dialer1
description dialer to Cleveland
ip address 10.1.50.2 255.255.255.0
no ip directed-broadcast
encapsulation ppp
dialer remote-name cleveland
dialer idle-timeout 300
dialer string 5551234
dialer string 5551235
dialer load-threshold 1 either
dialer pool 1
dialer-group 1
ppp authentication chap
ppp multilink
!
interface Dialer2
description dialer to macon
```

```
ip address 10.2.2.1 255.255.255.0
no ip directed-broadcast
encapsulation ppp
dialer remote-name macon
dialer idle-timeout 60
dialer fast-idle 10
dialer string 5557000
dialer string 5557001
dialer load-threshold 1 either
dialer pool 1
dialer-group 1
compress stac
ppp authentication chap
ppp multilink
!
ip classless
ip route 0.0.0.0 0.0.0.0 10.1.20.1
ip route 0.0.0.0 0.0.0.0 10.1.50.1 200
ip route 10.2.0.0 255.255.0.0 10.2.2.2
no ip http server
!
dialer-list 1 protocol ip permit
!
line con 0
transport input none
line aux 0
password cisco
modem InOut
modem autoconfigure discovery
transport input all
stopbits 1
speed 2400
flowcontrol hardware
line vty 0 4
login
!
end
```

Student Exam 2-Macon Configuration

```
hostname macon
!
enable password cisco
!
username atlanta password 0 cisco
!
ip subnet-zero
!
isdn switch-type basic-ni
isdn voice-call-failure 0
!
interface Ethernet0
ip address 10.2.3.1 255.255.255.0
no ip directed-broadcast
no keepalive
!
interface Serial0
no ip address
no ip directed-broadcast
shutdown
!
interface BRI0
ip address 10.2.2.2 255.255.255.0
no ip directed-broadcast
encapsulation ppp
dialer map ip 10.2.2.1 name atlanta 5554000
```

```
dialer map ip 10.2.2.1 name atlanta 5554001
dialer load-threshold 1 outbound
dialer-group 1
isdn switch-type basic-ni
isdn spid1 51055570000001 5557000
isdn spid2 51055570010001 5557001
compress stac
ppp authentication chap
ppp multilink
!
ip classless
ip route 0.0.0.0 0.0.0.0 10.2.2.1
no ip http server
!
dialer-list 1 protocol ip permit
!
line con 0
transport input none
line vty 0 4
password cisco
login
!
end
```

Switching 综合实验

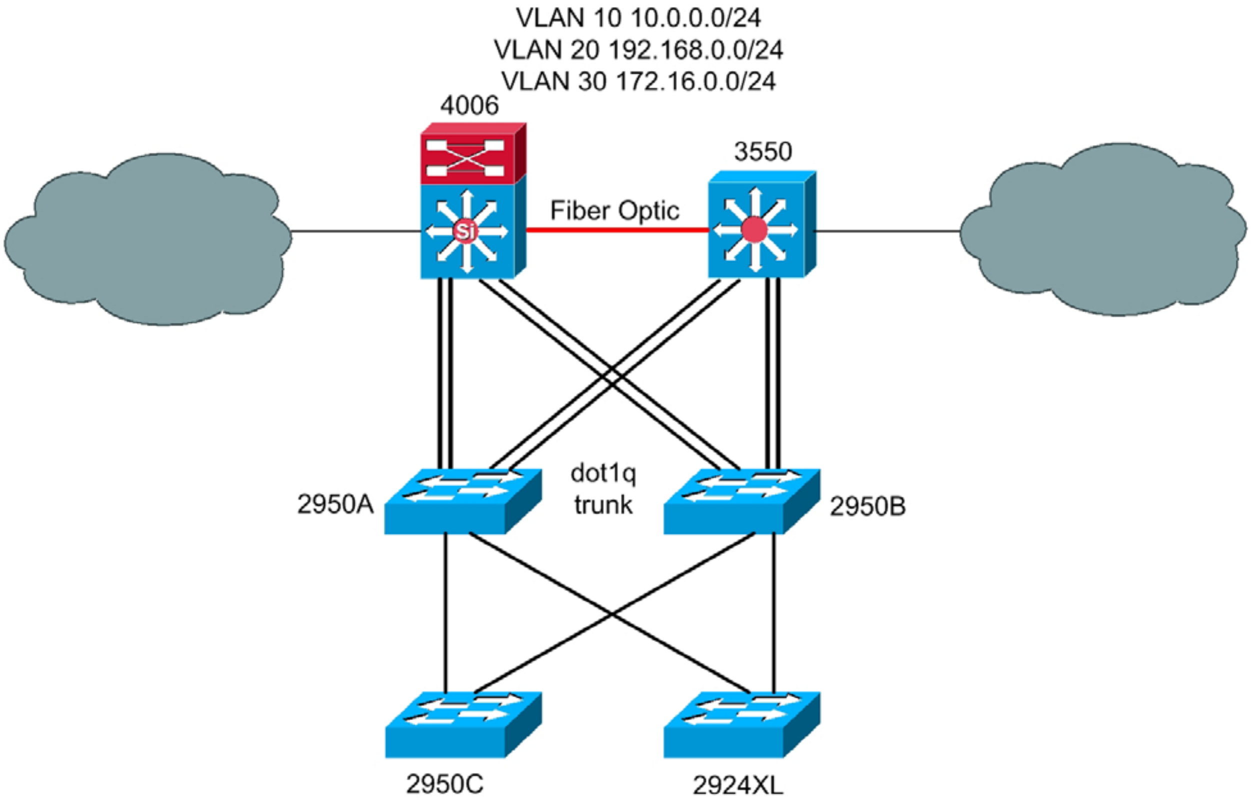
【实验目的】

综合使用冗余链路、VTP、STP、Fash EtherChannel、热备份路由、VLAN 间路由等技术。

【实验设备】

4006×1 3550×1 2950×3 2924XL×1 光纤×2 双绞线若干

【实验拓扑】



【实验内容】

- ◆ 配置各个 switch 的管理 VLAN 为 VLAN10：10.0.0.0/24
- ◆ 配置各个 switch 的 vty 属性，以便远程查看和管理。
- ◆ 各交换机的配置要求：
  - ➢ 4006：
    - ● VTP server。VLAN 10 和 VLAN 20 的 STP 根交换机，VLAN 30 的 STP 待命交换机。
    - ● 利用三层模块的子端口做 VLAN 间路由。
    - ● 二层模块与 3550 用光纤相连，并且通过 Fash EtherChannel 与 2950A 和 2950B 相连。
    - ● 启用 backbone fast。
  - ➢ 3550：
    - ● VTP client。VLAN 10 和 VLAN20 的 STP 的待命交换机。VLAN 30 的 STP 根交换机。
    - ● 做 VLAN 间路由，与 4006 的三层模块做 HSRP。
    - ● 通过光纤与 4006 的二层模块相连，并且通过 Fash EtherChannel 与 2950A 和 2950B 相连
    - ● 启用 backbone fast。
  - ➢ 2950A、2950B：

- VTP client。
- 每台交换机通过 Fash EtherChannel 与 4006、3550 相连。每条 Fash EtherChannel 由两条交叉线组成。
- 通过 trunk 与 2950C、2924XL 相连。
- 启用 backbone fast>

➢ 2950C、2924XL
- VTP client
- 提供 VLAN10、VLAN 20 和 VLAN 30 接入
- 通过 trunk 与 2950A、2950B 相连。
- 启用 backbone fast。在与 2950A、2950B 相连的端口启用 uplink fast，并在与主机相连的端口启用 port fast。

【实验说明】

◆ 交换机之间的连接的封装格式均为 dot1q。

◆ VLAN 10 为管理 VLAN，可命名为 Management，VLAN 20 和 VLAN 30 为用户 VLAN，可分别命名为 user1 和 user2。

◆ 在 3550 中配完 vtp 各项参数后，不必在它与 4006 相连的光口上设置 trunk 属性，3550 能通过与 4006 协商，自动把光口封装格式改成 n-dot1q，并且端口模式也能自动改为 trunk。同样地，在 2950 中配完 vtp 各项参数后，也不必设置它们与 3550 或其他 2950 相连的端口的 trunk 属性，2950 能自动完成设置。

◆ 若搭好拓扑后，先在 4006 上配置它与 2950 相连的端口的 Fash EtherChannel，然后才在 2950A 和 2950B 上配置它们与 4006 相连的端口的 Fash EtherChannel 的话，必须再次激活 4006 上的相应端口，否则不能建立 Fash EtherChannel。但 3550 和 2950 上则没有这个限制：若先在 3550 上配置好 Fash EtherChannel，2950A 和 2950B 上的相应端口甚至不需要配置 Fash EtherChannel 也能与 3550 建立起 200MbPS 的连接。但建议最好仍然在 2950A 和 2950B 的相应端口上配置 Fash EtherChannel。

◆ 2924XL 配置完 vtp 属性后，要手工配置它与 2950A、2950B 相连的端口的 trunk 属性。

◆ 当 STP 检测到有 loop 后，会 block 掉某些端口。在 2924XL 上，被 block 的端口指示灯会变成黄色，但在 2950 上却不会，必须通过 show spanning-tree 命令才能看出哪些端口处于 block 状态。

【实验配置】

➢ **===4006_L2===**

```
4006_L2> (enable) sh run
This command shows non-default configurations only.
Use 'show config all' to show both default and non-default configurations.
..............
.......................
.......................





..


begin
!
# ***** NON-DEFAULT CONFIGURATION *****
!
```

```
!
#time: Wed Dec 18 2002, 07:14:23
!
#version 7.1(2)
!
!
#system web interface version(s)
!
!
#test
!
#frame distribution method
set port channel all distribution mac both
!
#vtp
set vtp domain stu
set vtp passwd cisco
set vlan 1 name default type ethernet mtu 1500 said 100001 state active
set vlan 10 name management type ethernet mtu 1500 said 100010 state active
set vlan 20 name user1 type ethernet mtu 1500 said 100020 state active
set vlan 30 name user2 type ethernet mtu 1500 said 100030 state active
set vlan 1002 name fddi-default type fddi mtu 1500 said 101002 state active
set vlan 1004 name fddinet-default type fddinet mtu 1500 said 101004 state activ
e stp ieee
set vlan 1005 name trnet-default type trbrf mtu 1500 said 101005 state active st
p ibm
set vlan 1003 name token-ring-default type trcrf mtu 1500 said 101003 state acti
ve mode srb aremaxhop 7 stemaxhop 7 backupcrf off
!
#ip
set interface sc0 10 10.0.0.1/255.255.255.0 10.0.0.255

set interface sl0 down
set interface me1 down
!
#spantree
#backbonefast
set spantree backbonefast enable
#vlan                          <VlanId>
set spantree priority 8192     10
set spantree priority 8192     20
!
#syslog
set logging level cops 2 default
```

```
!
#set boot command
set boot config-register 0x2
set boot system flash bootflash:cat4000-k8.7-1-2.bin
set boot system flash bootflash:cat4000.6-1-2.bin
!
#port channel
set port channel 2/1-4 2
set port channel 2/5-8 3
!
#multicast filter
set igmp filter disable
!
#module 1 : 2-port 1000BaseX Supervisor
set trunk 1/1   on dot1q 1-1005
!
#module 2 : 34-port Router Switch Card
set trunk 2/1   on dot1q 1-1005
set spantree portinstancecost 2/3   cost 19999 mst
set spantree portinstancecost 2/4   cost 19999 mst
set spantree portinstancecost 2/5   cost 19999 mst
set spantree portinstancecost 2/6   cost 19999 mst
set spantree portinstancecost 2/7   cost 19999 mst
set spantree portinstancecost 2/8   cost 19999 mst
set spantree portinstancecost 2/9   cost 19999 mst
set spantree portinstancecost 2/10 cost 19999 mst
set spantree portinstancecost 2/11 cost 19999 mst
set spantree portinstancecost 2/12 cost 19999 mst
set spantree portinstancecost 2/13 cost 19999 mst
set spantree portinstancecost 2/14 cost 19999 mst
set spantree portinstancecost 2/15 cost 19999 mst
set spantree portinstancecost 2/16 cost 19999 mst
set spantree portinstancecost 2/17 cost 19999 mst
set spantree portinstancecost 2/18 cost 19999 mst
set spantree portinstancecost 2/19 cost 19999 mst
set spantree portinstancecost 2/20 cost 19999 mst
set spantree portinstancecost 2/21 cost 19999 mst
set spantree portinstancecost 2/22 cost 19999 mst
set spantree portinstancecost 2/23 cost 19999 mst
set spantree portinstancecost 2/24 cost 19999 mst
set spantree portinstancecost 2/25 cost 19999 mst
set spantree portinstancecost 2/26 cost 19999 mst
set spantree portinstancecost 2/27 cost 19999 mst
set spantree portinstancecost 2/28 cost 19999 mst
```

```
set spantree portinstancecost 2/29 cost 19999 mst
set spantree portinstancecost 2/30 cost 19999 mst
set spantree portinstancecost 2/31 cost 19999 mst
set spantree portinstancecost 2/32 cost 19999 mst
set spantree portinstancecost 2/33 cost 19999 mst
set spantree portinstancecost 2/34 cost 19999 mst
set port channel 2/3-6 mode on
!
#module 3 empty
!
#module 4 empty
!
#module 5 empty
!
#module 6 empty
end
```

- **===4006_L3===**

```
4006_L3#sh run
Building configuration...

Current configuration:
!
version 12.0
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname 4006_L3
!
!
ip subnet-zero
!
!
!
interface FastEthernet1
 no ip address
 no ip directed-broadcast
 shutdown
!
```

```
interface GigabitEthernet1
 no ip address
 no ip directed-broadcast
 shutdown
!
interface GigabitEthernet2
 no ip address
 no ip directed-broadcast
 shutdown
!
interface GigabitEthernet3
 no ip address
 no ip directed-broadcast
 no negotiation auto
!
interface GigabitEthernet3.10
 encapsulation dot1Q 10
 ip address 10.0.0.7 255.255.255.0
 no ip directed-broadcast
!
interface GigabitEthernet3.20
 encapsulation dot1Q 20
 ip address 192.168.0.7 255.255.255.0
 no ip redirects
 no ip directed-broadcast
 standby 20 priority 200 preempt
 standby 20 ip 192.168.0.254
!
interface GigabitEthernet3.30
 encapsulation dot1Q 30
 ip address 172.16.0.7 255.255.255.0
 no ip redirects
 no ip directed-broadcast
 standby 30 preempt
 standby 30 ip 172.16.0.254
!
interface GigabitEthernet4
 no ip address
 no ip directed-broadcast
 no negotiation auto
!
ip classless
!
!
```

```
line con 0
  transport input none
line aux 0
line vty 0 4
  privilege level 0
  password cisco
  login
!
end
```

- **===3550===**

```
3550#sh run
Building configuration...

Current configuration : 2075 bytes
!
version 12.1
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname 3550
!
!
ip subnet-zero
!
!
!
spanning-tree portfast default
spanning-tree extend system-id
spanning-tree backbonefast
spanning-tree vlan 30 priority 24576
!
!
!
interface Port-channel1
  no ip address
!
interface Port-channel2
  no ip address
!
interface FastEthernet0/1
```

```
 no ip address
 channel-group 1 mode on
!
interface FastEthernet0/2
 no ip address
 channel-group 1 mode on
!
interface FastEthernet0/3
 no ip address
!
interface FastEthernet0/4
 no ip address
!
interface FastEthernet0/5
 no ip address
!
interface FastEthernet0/6
 no ip address
!
interface FastEthernet0/7
 no ip address
!
interface FastEthernet0/8
 no ip address
!
interface FastEthernet0/9
 no ip address
!
interface FastEthernet0/10
 no ip address
!
interface FastEthernet0/11
 no ip address
!
interface FastEthernet0/12
 no ip address
!
interface FastEthernet0/13
 no ip address
 channel-group 2 mode on
!
interface FastEthernet0/14
 no ip address
 channel-group 2 mode on
```

```
!
interface FastEthernet0/15
 no ip address
!
interface FastEthernet0/16
 no ip address
!
interface FastEthernet0/17
 no ip address
!
interface FastEthernet0/18
 no ip address
!
interface FastEthernet0/19
 no ip address
!
interface FastEthernet0/20
 no ip address
 channel-group 2 mode on
!
interface FastEthernet0/14
 no ip address
 channel-group 2 mode on
!
interface FastEthernet0/15
 no ip address
!
interface FastEthernet0/16
 no ip address
!
interface FastEthernet0/17
 no ip address
!
interface FastEthernet0/18
 no ip address
!
interface FastEthernet0/19
 no ip address
!
interface FastEthernet0/20
 no ip address
!
interface FastEthernet0/21
 no ip address
```

```
!
interface FastEthernet0/22
 no ip address
!
interface FastEthernet0/23
 no ip address
!
interface FastEthernet0/24
 no ip address
!
interface GigabitEthernet0/1
 no ip address
!
interface GigabitEthernet0/2
 no ip address
!
interface Vlan1
 no ip address
 shutdown
!
interface Vlan10
 ip address 10.0.0.2 255.255.255.0
!
interface Vlan20
 ip address 192.168.0.2 255.255.255.0
 no ip redirects
 standby preempt
 standby 20 ip 192.168.0.254
!
interface Vlan30
 ip address 172.16.0.2 255.255.255.0
 no ip redirects
 standby 30 ip 172.16.0.254
 standby 30 priority 200
 standby 30 preempt
!
ip classless
ip http server
!
!
!
!
line con 0
line vty 0 4
```

```
  privilege level 0
  password cisco
  login
line vty 5 15
  login
!
end
```

- **===2950A 和 2950B===**

```
2950A#sh run
Building configuration...

Current configuration : 1762 bytes
!
version 12.1
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname 2950A
!
!
ip subnet-zero
!
!
spanning-tree extend system-id
spanning-tree backbonefast
!
!
interface Port-channel1
  no ip address
  flowcontrol send off
!
!
interface Port-channel2
  no ip address
  flowcontrol send off
!
interface FastEthernet0/1
  no ip address
  channel-group 1 mode on
!
```

```
interface FastEthernet0/2
 no ip address
 channel-group 1 mode on
!
interface FastEthernet0/3
 no ip address
 channel-group 2 mode on
!
interface FastEthernet0/4
 no ip address
 channel-group 2 mode on
!
interface FastEthernet0/5
 no ip address
!
interface FastEthernet0/6
 no ip address
!
interface FastEthernet0/7
 no ip address
!
interface FastEthernet0/8
 no ip address
!
interface FastEthernet0/9
 switchport mode trunk
 no ip address
!
interface FastEthernet0/10
 no ip address
!
interface FastEthernet0/11
 no ip address
!
interface FastEthernet0/12
 no ip address
!
interface FastEthernet0/13
 no ip address
!
interface FastEthernet0/14
 no ip address
!
interface FastEthernet0/15
```

```
 no ip address
!
interface FastEthernet0/16
 no ip address
!
interface FastEthernet0/17
 no ip address
!
interface FastEthernet0/18
 no ip address
!
interface FastEthernet0/19
 no ip address
!
interface FastEthernet0/20
 no ip address
!
interface FastEthernet0/21
 no ip address
!
interface FastEthernet0/22
 no ip address
!
interface FastEthernet0/23
 no ip address
!
interface FastEthernet0/24
 no ip address
!
interface Vlan1
 no ip address
 no ip route-cache
 shutdown
!
interface Vlan10
 ip address 10.0.0.3 255.255.255.0
 no ip route-cache
!
ip default-gateway 10.0.0.1
ip http server
!
!
line con 0
line vty 0 4
```

```
  privilege level 0
  password cisco
  login
line vty 5 15
  login
!
end
```

- **===2950C===**

```
2950C(config)#spanning-tree uplinkfast
00:33:31: %SPANTREE_FAST-7-PORT_FWD_UPLINK: VLAN0001 FastEthernet0/9 moved to Forwarding (UplinkFast).

2950C(config-if)#ip address 10.0.0.6 255.255.255.0

2950C(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 FastEthernet0/2 but will only
  have effect when the interface is in a non-trunking mode.
```

- **===2924XL===**

```
2924XL#sh run
Building configuration...

Current configuration:
!
version 12.0
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname 2924XL
!!
!
!
!
!
```

```
spanning-tree uplinkfast
!
spanning-tree portfast bpduguard
ip subnet-zero
!
!
!
interface FastEthernet0/1
 switchport trunk encapsulation dot1q
 switchport mode trunk
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
 switchport trunk encapsulation dot1q
 switchport mode trunk
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
```

```
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface VLAN1
 no ip directed-broadcast
 no ip route-cache
 shutdown
!
interface VLAN10
 ip address 10.0.0.5 255.255.255.0
 no ip directed-broadcast
 no ip route-cache
!
ip default-gateway 10.0.0.7
!
line con 0
 transport input none
 stopbits 1
line vty 0 4
 privilege level 0
 password cisco
 login
line vty 5 15
 login
!
end
```

【结果观察】

- HSRP
  - ＝＝＝**4006**＝＝＝

```
4006_L3#sh standby
GigabitEthernet3.20 - Group 20
  Local state is Active, priority 200, may preempt
```

Hellotime 3 holdtime 10
Next hello sent in 00:00:01.278
Hot standby IP address is 192.168.0.254 configured
Active router is local
Standby router is 192.168.0.2 expires in 00:00:09
Standby virtual mac address is 0000.0c07.ac14
5 state changes, last state change 00:53:05
GigabitEthernet3.30 - Group 30
Local state is Standby, priority 100, may preempt
Hellotime 3 holdtime 10
Next hello sent in 00:00:00.184
Hot standby IP address is 172.16.0.254 configured
Active router is 172.16.0.2 expires in 00:00:07
Standby router is local
Standby virtual mac address is 0000.0c07.ac1e
10 state changes, last state change 00:35:24

- **====3550===**

3550#sh standby
Vlan20 - Group 20
Local state is Standby, priority 100
Hellotime 3 sec, holdtime 10 sec
Next hello sent in 1.202
Virtual IP address is 192.168.0.254 configured
Active router is 192.168.0.7, priority 200 expires in 7.772
Standby router is local
4 state changes, last state change 00:13:08
Vlan30 - Group 30
Local state is Active, priority 200, may preempt
Hellotime 3 sec, holdtime 10 sec
Next hello sent in 0.958
Virtual IP address is 172.16.0.254 configured
Active router is local
Standby router is 172.16.0.7 expires in 9.276
Virtual mac address is 0000.0c07.ac1e
2 state changes, last state change 00:13:27

- STP
  - **===4006===**

4006_L2> (enable) sh spantree
VLAN 1
Spanning tree mode PVST+
Spanning tree type ieee
Spanning tree enabled

Designated Root 00-07-0e-cd-4a-00

Designated Root Priority 8192
Designated Root Cost 0
Designated Root Port 1/0
Root Max Age 20 sec Hello Time 2 sec Forward Delay 15 sec

Bridge ID MAC ADDR 00-07-0e-cd-4a-00
Bridge ID Priority 8192
Bridge Max Age 20 sec Hello Time 2 sec Forward Delay 15 sec

Port	Vlan	Port-State	Cost	Prio	Portfast	Channel_id
1/1	1	forwarding	4	32	disabled	0
1/2	1	not-connected	4	32	disabled	0
2/1	1	forwarding	4	32	disabled	0
2/2	1	forwarding	4	32	disabled	0
2/3-4	1	forwarding	12	32	disabled	802
2/5-6	1	forwarding	12	32	disabled	803
2/7	1	not-connected	100	32	disabled	0
2/8	1	not-connected	100	32	disabled	0
2/9	1	not-connected	100	32	disabled	0
2/10	1	not-connected	100	32	disabled	0
2/11	1	not-connected	100	32	disabled	0
2/12	1	not-connected	100	32	disabled	0
2/13	1	not-connected	100	32	disabled	0
2/14	1	not-connected	100	32	disabled	0
2/15	1	not-connected	100	32	disabled	0
2/16	1	not-connected	100	32	disabled	0
2/17	1	not-connected	100	32	disabled	0
2/18	1	not-connected	100	32	disabled	0
2/19	1	not-connected	100	32	disabled	0
2/20	1	not-connected	100	32	disabled	0
2/21	1	not-connected	100	32	disabled	0
2/22	1	not-connected	100	32	disabled	0
2/23	1	not-connected	100	32	disabled	0
2/24	1	not-connected	100	32	disabled	0
2/25	1	not-connected	100	32	disabled	0
2/26	1	not-connected	100	32	disabled	0
2/27	1	not-connected	100	32	disabled	0
2/28	1	not-connected	100	32	disabled	0
2/29	1	not-connected	100	32	disabled	0
2/30	1	not-connected	100	32	disabled	0
2/31	1	not-connected	100	32	disabled	0
2/32	1	not-connected	100	32	disabled	0
2/33	1	not-connected	100	32	disabled	0

```
 2/34                    1    not-connected       100    32 disabled 0


4006_L2e> (enable) sh spantree 10
VLAN 10
Spanning tree mode              PVST+
Spanning tree type              ieee
Spanning tree enabled

Designated Root                 00-07-0e-cd-4a-09
Designated Root Priority        8192
Designated Root Cost            0
Designated Root Port            1/0
Root Max Age    20 sec    Hello Time 2   sec    Forward Delay 15 sec

Bridge ID MAC ADDR              00-07-0e-cd-4a-09
Bridge ID Priority              8192
Bridge Max Age 20 sec    Hello Time 2   sec    Forward Delay 15 sec

Port                     Vlan Port-State    Cost      Prio Portfast Channel_id
------------------------ ---- ------------- --------- ---- -------- ----------
 1/1                     10    forwarding            4    32 disabled 0
 2/1                     10    forwarding            4    32 disabled 0
2/3-4                    10    forwarding           12    32 disabled 802
2/5-6                    10    forwarding           12    32 disabled 803


4006_L2> (enable) sh spantree 20
VLAN 20
Spanning tree mode              PVST+
Spanning tree type              ieee
Spanning tree enabled

Designated Root                 00-07-0e-cd-4a-13
Designated Root Priority        8192
Designated Root Cost            0
Designated Root Port            1/0
Root Max Age    20 sec    Hello Time 2   sec    Forward Delay 15 sec

Bridge ID MAC ADDR              00-07-0e-cd-4a-13
Bridge ID Priority              8192
Bridge Max Age 20 sec    Hello Time 2   sec    Forward Delay 15 sec

Port                     Vlan Port-State    Cost      Prio Portfast Channel_id
```

```
----------------------- ---- ------------- --------- ---- -------- ----------
 1/1                     20   forwarding          4   32 disabled 0
 2/1                     20   forwarding          4   32 disabled 0
2/3-4                    20   forwarding         12   32 disabled 802
2/5-6                    20   forwarding         12   32 disabled 803


4006_L2> (enable) sh spantree 30
VLAN 30
Spanning tree mode              PVST+
Spanning tree type              ieee
Spanning tree enabled

Designated Root                 00-0a-b7-8d-31-00          //3550 的 MAC 地址
Designated Root Priority        24606
Designated Root Cost            4
Designated Root Port            1/1
Root Max Age    20 sec    Hello Time 2   sec    Forward Delay 15 sec

Bridge ID MAC ADDR              00-07-0e-cd-4a-1d
Bridge ID Priority              32768
Bridge Max Age 20 sec    Hello Time 2   sec    Forward Delay 15 sec

Port                     Vlan Port-State    Cost      Prio Portfast Channel_id
----------------------- ---- ------------- --------- ---- -------- ----------
 1/1                     30   forwarding          4   32 disabled 0
 2/1                     30   forwarding          4   32 disabled 0
2/3-4                    30   forwarding         12   32 disabled 802
2/5-6                    30   forwarding         12   32 disabled 803
```

- ＝＝＝＝**3550**＝＝＝

```
3550#sh spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    8192
             Address     0007.0ecd.4a00
             Cost        4
             Port        25 (GigabitEthernet0/1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     000a.b78d.3100
```

```
             Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface        Port ID                    Designated                 Port ID
Name                  Prio.Nbr      Cost Sts      Cost Bridge ID              Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Gi0/1            128.25          4 FWD           0    8192 0007.0ecd.4a00 128.1
Po1              128.65         12 FWD           4 32769 000a.b78d.3100 128.65
Po2              128.66         12 FWD           4 32769 000a.b78d.3100 128.66


VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    8192
             Address     0007.0ecd.4a09        //4006 的 MAC 地址
             Cost        4
             Port        25 (GigabitEthernet0/1)
             Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
             Address     000a.b78d.3100
             Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface        Port ID                    Designated                 Port ID
Name                  Prio.Nbr      Cost Sts      Cost Bridge ID              Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Gi0/1            128.25          4 FWD           0    8192 0007.0ecd.4a09 128.1
Po1              128.65         12 FWD           4 32778 000a.b78d.3100 128.65
Po2              128.66         12 FWD           4 32778 000a.b78d.3100 128.66


VLAN0020
  Spanning tree enabled protocol ieee
  Root ID    Priority    8192
             Address     0007.0ecd.4a13      //4006 的 MAC 地址
             Cost        4
             Port        25 (GigabitEthernet0/1)
             Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32788  (priority 32768 sys-id-ext 20)
             Address     000a.b78d.3100
             Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300
```

```
Interface          Port ID                          Designated               Port ID
Name                  Prio.Nbr       Cost Sts        Cost Bridge ID               Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Gi0/1              128.25            4 FWD            0    8192 0007.0ecd.4a13 128.1
Po1                 128.65           12 FWD            4 32788 000a.b78d.3100 128.65
Po2                 128.66           12 FWD            4 32788 000a.b78d.3100 128.66


VLAN0030
  Spanning tree enabled protocol ieee
  Root ID       Priority       24606
                Address        000a.b78d.3100
                This bridge is the root
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID    Priority       24606    (priority 24576 sys-id-ext 30)
                Address        000a.b78d.3100
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec
                Aging Time 300

Interface          Port ID                          Designated               Port ID
Name                  Prio.Nbr       Cost Sts        Cost Bridge ID               Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Gi0/1              128.25            4 FWD            0 24606 000a.b78d.3100 128.25
Po1                 128.65           12 FWD            0 24606 000a.b78d.3100 128.65
Po2                 128.66           12 FWD            0 24606 000a.b78d.3100 128.66
```

- **===2950A、2950B===**

```
2950A#sh spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID       Priority       8192
                Address        0007.0ecd.4a00
                Cost           12
                Port           66 (Port-channel2)
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID    Priority       32769    (priority 32768 sys-id-ext 1)
                Address        000a.f456.3b40
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec
                Aging Time 300
```

```
Interface          Port ID                          Designated                  Port ID
Name                   Prio.Nbr        Cost Sts        Cost Bridge ID                 Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/9               128.9            19 FWD          12 32769 000a.f456.3b40 128.9
Fa0/17              128.17           19 FWD          12 32769 000a.f456.3b40 128.17
Po1                  128.65           12 BLK           4 32769 000a.b78d.3100 128.65
Po2                  128.66           12 FWD           0    8192 0007.0ecd.4a00 131.34


VLAN0010
  Spanning tree enabled protocol ieee
  Root ID       Priority       8192
                Address        0007.0ecd.4a09             //4006 的 MAC 地址
                Cost           12
                Port           66 (Port-channel2)
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID    Priority       32778    (priority 32768 sys-id-ext 10)
                Address        000a.f456.3b40             //3550 的 MAC 地址
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec
                Aging Time 300

Interface          Port ID                          Designated                  Port ID
Name                   Prio.Nbr        Cost Sts        Cost Bridge ID                 Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/9               128.9            19 FWD          12 32778 000a.f456.3b40 128.9
Fa0/17              128.17           19 FWD          12 32778 000a.f456.3b40 128.17
Po1                  128.65           12 BLK           4 32778 000a.b78d.3100 128.65
Po2                  128.66           12 FWD           0    8192 0007.0ecd.4a09 131.34


VLAN0020
  Spanning tree enabled protocol ieee
  Root ID       Priority       8192
                Address        0007.0ecd.4a13
                Cost           12
                Port           66 (Port-channel2)
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID    Priority       32788    (priority 32768 sys-id-ext 20)
                Address        000a.f456.3b40
                Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec
                Aging Time 300
```

```
Interface          Port ID                    Designated               Port ID
Name                   Prio.Nbr       Cost Sts      Cost Bridge ID              Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/9              128.9            19 FWD          12 32788 000a.f456.3b40 128.9
Fa0/17             128.17           19 FWD          12 32788 000a.f456.3b40 128.17
Po1                 128.65           12 BLK           4 32788 000a.b78d.3100 128.65
Po2                 128.66           12 FWD           0    8192 0007.0ecd.4a13 131.34

VLAN0030
  Spanning tree enabled protocol ieee
  Root ID       Priority       24606
                   Address         000a.b78d.3100
                   Cost              12
                   Port              65 (Port-channel1)
                   Hello Time      2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID    Priority       32798    (priority 32768 sys-id-ext 30)
                   Address         000a.f456.3b40
                   Hello Time      2 sec    Max Age 20 sec    Forward Delay 15 sec
                   Aging Time 300

Interface          Port ID                    Designated               Port ID
Name                   Prio.Nbr       Cost Sts      Cost Bridge ID              Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/9              128.9            19 FWD          12 32798 000a.f456.3b40 128.9
Fa0/17             128.17           19 FWD          12 32798 000a.f456.3b40 128.17
Po1                 128.65           12 FWD           0 24606 000a.b78d.3100 128.65
Po2                 128.66           12 BLK           4 32768 0007.0ecd.4a1d 131.34
```

- **===2924XL===**

```
2924XL#sh spanning-tree brief

VLAN1
  Spanning tree enabled protocol IEEE
  ROOT ID       Priority 8192
                   Address 0007.0ecd.4a00
                   Hello Time      2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID    Priority       49152
                   Address         0007.0ef8.01c0
                   Hello Time      2 sec    Max Age 20 sec    Forward Delay 15 sec
```

```
Port                              Designated
Name      Port ID Prio Cost Sts   Cost   Bridge ID        Port ID
------- ------- ---- ---- ---   ----   -------------- -------
Fa0/1     128.13   128   3019 FWD   12     000a.f456.3b40 128.9
Fa0/2     128.14   128   3019 BLK   3031   0007.0ef8.01c0 128.14
Fa0/3     128.15   128   3019 BLK   3031   0007.0ef8.01c0 128.15
Fa0/4     128.16   128   3019 BLK   3031   0007.0ef8.01c0 128.16
Fa0/5     128.17   128   3019 BLK   3031   0007.0ef8.01c0 128.17
Fa0/6     128.18   128   3019 BLK   3031   0007.0ef8.01c0 128.18
Fa0/7     128.19   128   3019 BLK   3031   0007.0ef8.01c0 128.19
Fa0/8     128.20   128   3019 BLK   3031   0007.0ef8.01c0 128.20
Fa0/9     128.22   128   3019 BLK   12     000a.f456.cf00 128.9
Fa0/10    128.23   128   3019 BLK   3031   0007.0ef8.01c0 128.23
Port                              Designated
Name      Port ID Prio Cost Sts   Cost   Bridge ID        Port ID
------- ------- ---- ---- ---   ----   -------------- -------
Fa0/11    128.24   128   3019 BLK   3031   0007.0ef8.01c0 128.24
Fa0/12    128.25   128   3019 BLK   3031   0007.0ef8.01c0 128.25
Fa0/13    128.26   128   3019 BLK   3031   0007.0ef8.01c0 128.26
Fa0/14    128.27   128   3019 BLK   3031   0007.0ef8.01c0 128.27
Fa0/15    128.28   128   3019 BLK   3031   0007.0ef8.01c0 128.28
Fa0/16    128.29   128   3019 BLK   3031   0007.0ef8.01c0 128.29
Fa0/17    128.31   128   3019 BLK   3031   0007.0ef8.01c0 128.31
Fa0/18    128.32   128   3019 BLK   3031   0007.0ef8.01c0 128.32
Fa0/19    128.33   128   3019 BLK   3031   0007.0ef8.01c0 128.33
Fa0/20    128.34   128   3019 BLK   3031   0007.0ef8.01c0 128.34
Fa0/21    128.35   128   3019 BLK   3031   0007.0ef8.01c0 128.35
Port                              Designated
Name      Port ID Prio Cost Sts   Cost   Bridge ID        Port ID
------- ------- ---- ---- ---   ----   -------------- -------
Fa0/22    128.36   128   3019 BLK   3031   0007.0ef8.01c0 128.36
Fa0/23    128.37   128   3019 BLK   3031   0007.0ef8.01c0 128.37
Fa0/24    128.38   128   3019 BLK   3031   0007.0ef8.01c0 128.38
VLAN10
  Spanning tree enabled protocol IEEE
  ROOT ID      Priority 8192
               Address 0007.0ecd.4a09
               Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

  Bridge ID   Priority      49152
               Address        0007.0ef8.01c1
               Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec
Port                              Designated
```

```
Name       Port ID Prio Cost Sts    Cost    Bridge ID          Port ID
------- ------- ---- ---- ---    ----    -------------- -------
Fa0/1      128.13    128    3019 FWD    12       000a.f456.3b40 128.9
Fa0/9      128.22    128    3019 FWD    3031    0007.0ef8.01c1 128.22

VLAN20
   Spanning tree enabled protocol IEEE
   ROOT ID       Priority 8192
                 Address 0007.0ecd.4a13
                 Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec

   Bridge ID    Priority       49152
                 Address        0007.0ef8.01c2
                 Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec
Port                                       Designated
Name       Port ID Prio Cost Sts    Cost    Bridge ID          Port ID
------- ------- ---- ---- ---    ----    -------------- -------
Fa0/1      128.13    128    3019 FWD    12       000a.f456.3b40 128.9
Fa0/9      128.22    128    3019 FWD    3031    0007.0ef8.01c2 128.22

VLAN30
   Spanning tree enabled protocol IEEE
   ROOT ID       Priority 24606
                 Address 000a.b78d.3100
                 Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec

   Bridge ID    Priority       49152
                 Address        0007.0ef8.01c3
                 Hello Time     2 sec    Max Age 20 sec    Forward Delay 15 sec
Port                                       Designated
Name       Port ID Prio Cost Sts    Cost    Bridge ID          Port ID
------- ------- ---- ---- ---    ----    -------------- -------
Fa0/1      128.13    128    3019 FWD    12       000a.f456.3b40 128.9
Fa0/9      128.22    128    3019 FWD    3031    0007.0ef8.01c3 128.22
```

- VTP
  - ＝＝＝**4006**＝＝＝

```
4006_L3> (enable) sh vtp statistics
VTP statistics:
summary advts received                25
subset    advts received              0
request advts received               0
summary advts transmitted           13
```

```
subset    advts transmitted            5
request advts transmitted           0
No of config revision errors       0
No of config digest errors          0


VTP pruning statistics:

Trunk       Join Transmitted Join Received Summary advts received from GVRP PDU
                                                   non-pruning-capable device    Received
-------- ---------------- ------------- -------------------------- ----------
 1/1         0                     0                  0                                        0
 2/1         0                     0                  0                                        0
 2/3         0                     0                  0                                        0
 2/4         0                     0                  0                                        0
 2/5         0                     0                  0                                        0
 2/6         0                     0                  0                                        0


4006_L3> (enable) sh vtp domain
Domain Name                                     Domain Index VTP Version Local Mode    Password
-------------------------------- ------------ ----------- ----------- ----------

stu                                           1                  2                server          configured


Vlan-count Max-vlan-storage Config Revision Notifications
---------- ---------------- --------------- -------------
8                  1023                     3                        disabled

Last Updater       V2 Mode    Pruning    PruneEligible on Vlans
--------------- -------- -------- -------------------------
0.0.0.0                 disabled disabled 2-1000
```

- **===3550===**

```
3550#sh vtp status
VTP Version                               : 2
Configuration Revision                : 3
Maximum VLANs supported locally : 1005
Number of existing VLANs             : 8
VTP Operating Mode                     : Client
VTP Domain Name                          : stu
VTP Pruning Mode                        : Disabled
```

VTP V2 Mode : Disabled
VTP Traps Generation : Disabled
MD5 digest : 0x26 0x79 0x59 0x5F 0x86 0x5C 0x4D 0x6C
Configuration last modified by 0.0.0.0 at 12-16-02 05:26:03

```
3550#debug sw-vlan vtp event
vtp events debugging is on
3550#
00:21:06: VTP LOG RUNTIME: Summary packet received, domain = stu, rev = 3, followers = 0

00:21:06: VTP LOG RUNTIME: Summary packet rev 3 equal to domain stu rev 3

00:21:07: VTP LOG RUNTIME: Transmit vtp summary, domain stu, rev 3, followers 0
     MD5 digest calculated = 26 79 59 5F 86 5C 4D 6C 86 EC ED B1 9F DF AD 79

00:21:37: VTP LOG RUNTIME: Transmit vtp summary, domain stu, rev 3, followers 0
     MD5 digest calculated = 26 79 59 5F 86 5C 4D 6C 86 EC ED B1 9F DF AD 79

3550#
00:26:12: VTP LOG RUNTIME: Summary packet received, domain = stu, rev = 3, followers = 0

00:26:12: VTP LOG RUNTIME: Summary packet rev 3 equal to domain stu rev 3

00:26:12: VTP LOG RUNTIME: Summary packet received, domain = stu, rev = 3, followers = 0

00:26:12: VTP LOG RUNTIME: Summary packet rev 3 equal to domain stu rev 3
```

- **＝＝＝2950A、2950B＝＝＝**

2950A#sh vtp status
VTP Version : 2
Configuration Revision : 3
Maximum VLANs supported locally : 64
Number of existing VLANs : 8
VTP Operating Mode : Client
VTP Domain Name : stu
VTP Pruning Mode : Disabled
VTP V2 Mode : Disabled
VTP Traps Generation : Disabled
MD5 digest : 0x26 0x79 0x59 0x5F 0x86 0x5C 0x4D 0x6C
Configuration last modified by 0.0.0.0 at 12-16-02 05:26:03

- **＝＝＝2924XL＝＝＝**

2924XL#sh vtp status

```
VTP Version                        : 2
Configuration Revision             : 3
Maximum VLANs supported locally : 68
Number of existing VLANs           : 8
VTP Operating Mode                 : Client
VTP Domain Name                    : stu
VTP Pruning Mode                   : Disabled
VTP V2 Mode                        : Disabled
VTP Traps Generation               : Disabled
MD5 digest                         : 0x26 0x79 0x59 0x5F 0x86 0x5C 0x4D 0x6C
Configuration last modified by 0.0.0.0 at 12-16-02 05:26:03
```

- Fash EtherChannel
  - ＝＝＝**4006**＝＝＝

```
4006_L2> (enable) sh port channel
Port  Status     Channel              Admin Ch
                 Mode                 Group Id
----- ---------- -------------------- ----- -----
 2/3  connected  on                     2    802
 2/4  connected  on                     2    802
----- ---------- -------------------- ----- -----
 2/5  connected  on                     3    803
 2/6  connected  on                     3    803

Port  Device-ID                       Port-ID                   Platform
----- ------------------------------- ------------------------- ----------------

 2/3  2950A                           FastEthernet0/3           cisco WS-C2950-24
 2/4  2950A                           FastEthernet0/4           cisco WS-C2950-24
----- ------------------------------- ------------------------- ----------------

 2/5  2950B                           FastEthernet0/3           cisco WS-C2950-24
 2/6  2950B                           FastEthernet0/4           cisco WS-C2950-24
```

  - ＝＝＝**3550**＝＝＝

```
3550#sh int port-channel 1
Port-channel1 is up, line protocol is up
  Hardware is EtherChannel, address is 000a.b78d.3101 (bia 000a.b78d.3101)
  MTU 1500 bytes, BW 200000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Full-duplex, 100Mb/s
```

```
   input flow-control is off, output flow-control is off
   Members in this channel: Fa0/1 Fa0/2
   ARP type: ARPA, ARP Timeout 04:00:00
   Last input 00:04:39, output 00:00:01, 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 0 bits/sec, 0 packets/sec
   5 minute output rate 0 bits/sec, 0 packets/sec
      338 packets input, 34324 bytes, 0 no buffer
      Received 160 broadcasts, 0 runts, 0 giants, 0 throttles
      0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
      0 watchdog, 160 multicast, 0 pause input
      0 input packets with dribble condition detected
      3664 packets output, 266323 bytes, 0 underruns
      0 output errors, 0 collisions, 1 interface resets
      0 babbles, 0 late collision, 0 deferred
      0 lost carrier, 0 no carrier, 0 PAUSE output
      0 output buffer failures, 0 output buffers swapped out

3550#sh int port-channel 2 trunk

Port        Mode             Encapsulation  Status        Native vlan
Po2         desirable      n-802.1q         trunking        1

Port        Vlans allowed on trunk
Po2         1-4094

Port        Vlans allowed and active in management domain
Po2         1,10,20,30

Port        Vlans in spanning tree forwarding state and not pruned
Po2         1,10,20,30
```

- **===2950A、2950B===**

```
2950A#sh int port-channel 1
Port-channel1 is up, line protocol is up
   Hardware is EtherChannel, address is 000a.f456.3b42 (bia 000a.f456.3b42)
   MTU 1500 bytes, BW 200000 Kbit, DLY 1000 usec,
      reliability 255/255, txload 1/255, rxload 1/255
   Encapsulation ARPA, loopback not set
   Full-duplex, 100Mb/s
```

input flow-control is off, output flow-control is off
Members in this channel: Fa0/1 Fa0/2
ARP type: ARPA, ARP Timeout 04:00:00
Last input 00:00:00, output 00:14:27, 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 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    11233 packets input, 810759 bytes, 0 no buffer
    Received 10693 broadcasts, 0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    0 watchdog, 10681 multicast, 0 pause input
    0 input packets with dribble condition detected
    888 packets output, 91596 bytes, 0 underruns
    0 output errors, 0 collisions, 1 interface resets
    0 babbles, 0 late collision, 0 deferred
    0 lost carrier, 0 no carrier, 0 PAUSE output
    0 output buffer failures, 0 output buffers swapped out

2950A#sh int port-channel 2 trunk

Port	Mode	Encapsulation	Status	Native vlan
Po2	desirable	802.1q	trunking	1

Port	Vlans allowed on trunk
Po2	1-4094

Port	Vlans allowed and active in management domain
Po2	1,10,20,30

Port	Vlans in spanning tree forwarding state and not pruned
Po2	1,10,20

【命令格式】

- STP:

CLI-Based Commands

Enable Spanning Tree (Enabled by default)

`Switch> (enable)` **`set spantree enable`** `[all| ` *`mod/num`*`]`

Other Configuration Commands

Root Bridge

Switch> (enable) **set spantree root** [**secondary**] [*vlan-list*] [**dia** *diameter*] [**hello** *hellotime*] (Reduces default priority of 32,768 to 8,192)

Bridge Priority

Switch> (enable) **set spantree priority** *priority vlan* (Lower wins, Priority default = 32,768)

Port Cost

Switch> (enable) **set spantree portcost** *mod/num cost* (Lower wins)
Switch> (enable) **set spantree portvlancost** *mod/num* [**cost** *cost*] [*vlanlist*]

Port Priority

Switch> (enable) **set spantree portpri** *mod/num cost* (Lower wins, Priority default = 32, range 0-63)
Switch> (enable) **set spantree portvlanpri** *mod/num priority vlan-list*

Backbone Fast

Switch>(enable) **set spantree backbonefast** [enable | disable]

IOS-Based Commands CLI-Based Commands

Enable Spanning Tree (Enabled by default)

Switch(config)#**spantree** *vlan-list* (Enabled by default)

Other Configuration Commands

Root Bridge

Switch(config)#**spanning-tree vlan** *vlan-id* **root** [primary|secondary]

Bridge Priority

Switch(config)#**spanning-tree** [**vlan** *vlanlist*] **priority** *prty*

Port Cost

c**spanning-tree** [**vlan** *vlan-list*] **cost** *cost*

Port Priority

Switch(config-if)#**spanning-tree** [**vlan** *vlan-list*] **port-priority** *port-priority*

Backbone Fast

Switch(config)#spanning-tree backbonefast

Uplink Fast

Switch(config)#**spanning-tree uplinkfast** [**max-update-rate** *pkts- per-second*]

Port Fast

Switch(config-if)# **spanning-tree portfast** [trunk]

- VTP：

CLI-Based Commands

Switch> (enable) set vtp [domain <name>] [mode <mode>] [passwd <passwd>] [pruning <enable|disable>] [v2 <enable|disable>]

(mode = client|server|transparent|off

Use passwd '0' to clear vtp password)

Switch> (enable)set vtp pruneeligible <vlans>

(vlans = 2..1000

An example of vlans is 2-10,1000)

IOS-Based Commands CLI-Based Commands

Switch(vlan)#vtp [domain <name>] [mode <mode>] [password <password>] [pruning] [v2]

- Fash EtherChannel:

CLI-Based Commands

Switch> (enable) set port channel <mod/port> [admin_group]

Switch> (enable) set port channel <mod/port> mode <on|off|desirable|auto> [silent|non-silent]

IOS-Based Commands CLI-Based Commands

Switch(config-if)#channel-group <channel-group-number> mode <auto | desirable | on>

- HSRP:

Switch(config)#standby [*group-number*] ip [*ip-address* [secondary]]

Switch(config)#standby [*group-number*] priority *priority* [preempt [delay *delay*]]

Switch(config)#standby [*group-number*] authentication *string*

- 4006 上设管理 VLAN 及管理 IP

Switch<enable>#set interface sc0 [vlan] [ip_addr [netmask [broadcast]]]

Switch<enable>#set interface sc0 [vlan] [ip_addr/netmask [broadcast]]

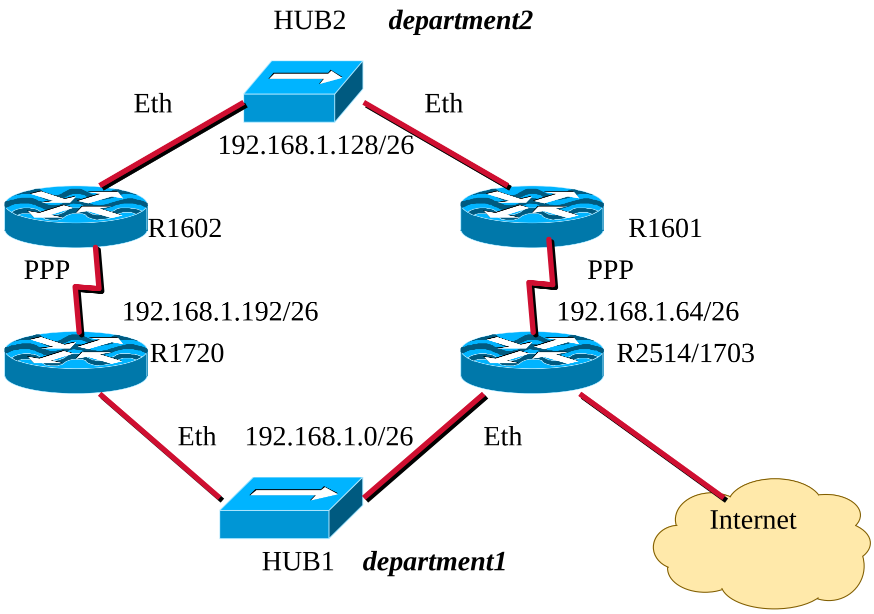
VLSM AND IP unnumbered 实验讲义

Part1:VLSM

实验目的：

使用两种不同的路由选择协议，RIPv1 和 RIPv2 来配置 VLSM，并测试其功能。

实验拓扑：



实验内容：

一）配置不支持 VLSM 的协议 RIP version 1

在早期的路由协议中，如 RIPv1。一般可以把网络划分子网，来满足网络中网段的需求。比如一个公司得到一个 C 类网络 192.168.1.0，一共有 254 个可用地址。公司内部有 2 个部门，分别在 HUB1 和 HUB2 下。

因为 RIP version 1 不支持 VLSM，在发送路由表的时候，网段信息中没有子网掩码，所以我们分配的网络大小应该等长，这样 RIP 协议才能通过自己的子网掩码判断发送过来路由更新信息中网段的子网掩码。我们需要把 192.168.1.0 分成 4 段，分别是

192.168.1.0/26—192.168.1.1-192.168.1.62(供 department1 使用）

192.168.1.64/26—192.168.1.65-192.168.1.126（作为串口网段）

192.168.1.128/26—192.168.1.129-192.168.1.190 （供 department2 使用）

192.168.1.192/26—192.168.1.193-192.168.1.254（作为串口网段）

分配好端口 ip 地址和子网掩码，并启动 rip 协议

配置 rip 协议命令为：

```
router#config t
router(config)#router rip
router(config-router)#network 192.168.1.0
```

配置好后的，用 show ip protocol 查看运行的协议细节内容。再用 show ip route 查看路由表：

```
R1602#show ip route
     192.168.1.0/26 is subnetted, 4 subnets
```

R 192.168.1.64 [120/1] via 192.168.1.129, 00:00:07, Serial0
R 192.168.1.0 [120/1] via 192.168.1.254, 00:00:01, Ethernet0
C 192.168.1.192 is directly connected, Ethernet0
C 192.168.1.128 is directly connected, Serial0

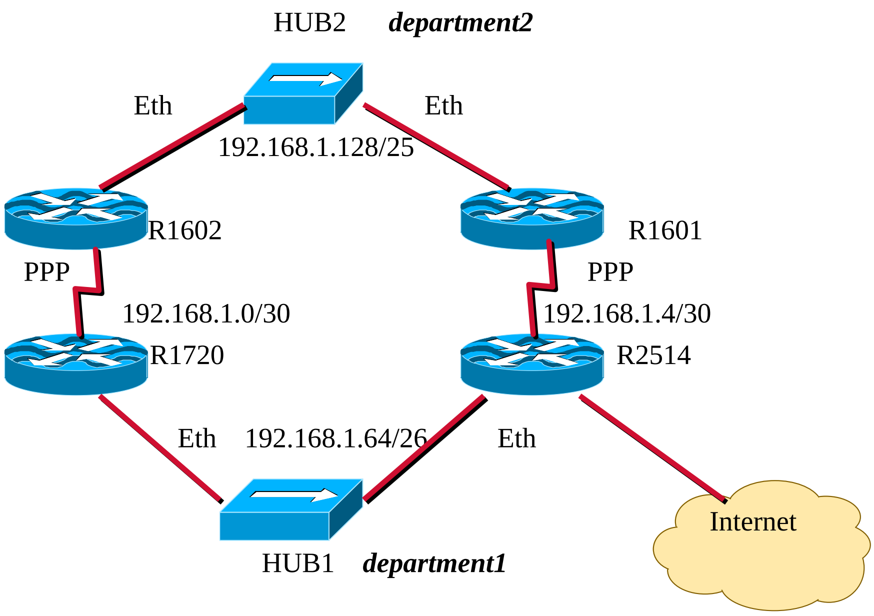
用 debug ip rip 查看路由更新信息。
用 u all（undebug all）命令关掉 debug。

- 总结：

整个网络运行正常，但是对于两条点对点链路网段 192.168.1.64/26 和 192.168.1.192/26 将分别只使用到两个 IP 地址，那么也就是说将有近 60 个 IP 地址被浪费了。

二）配置支持 VLSM 的协议 RIP version 2

在拓扑中所用到的串行口只需要两个 ip 地址，但配置中分配了 62 个地址，用了头尾两个，浪费了 60 个地址。那么我们可以通过配置端口的 ip/mask 调整每段的 ip 数量。分配如：
192.168.1.0/30—192.168.1.1-192.168.1.2（作为串口网段）
192.168.1.4/30—192.168.1.5-192.168.1.6（作为串口网段）
192.168.1.64/26—192.168.1.65-192.168.1.126（共有 62 个 IP 供 department2 使用）
192.168.1.128/25—192.168.1.129-192.168.1.254（共有 126 个 IP 供 department1 使用）
实验拓扑：



当配置好 IP/MASK 后，用 debug ip rip 查看路由更新信息：
00:50:09: RIP: sending v1 update to 255.255.255.255 via Ethernet0 (192.168.1.129
) - suppressing null update
00:50:09: RIP: sending v1 update to 255.255.255.255 via Serial0 (192.168.1.5) -
suppressing null update
这是因为 rip version1 只能通过自己的 MASK 来判断接收到的路由更新信息的子网大小，如果发现自己有不等大小的网段，它就抑制更新信息发布。所以各个路由器都会收不到路由更新报文。
配置路由器 RIPv2 协议支持 VLSM。具体配置为

router#config t
router(config)#router rip
router(config)#version 2

配置好后的，用 show ip protocol 查看运行的协议细节内容。再用 show ip route 查看路由表：

R1602#show ip route

192.168.1.0/24 is variably subnetted, 4 subnets, 3 masks
R 192.168.1.64/**26** [120/1] via 192.168.1.6, 00:00:22, Serial0
R 192.168.1.0/**30** [120/1] via 192.168.1.254, 00:00:17, Ethernet0
C 192.168.1.4/**30** is directly connected, Serial0
C 192.168.1.128/**25** is directly connected, Ethernet0
R1602#

注意路由表中，网段信息后面有子网掩码信息。用 debug ip rip 查看路由更新信息。

- 总结：

整个网络运行正常，由于对两条点对点链路网段进行了可变长度子网划分，两个网段 192.168.1.0/30 和 192.168.1.4/30 的 IP 地址一个都没有被浪费，这样就使紧张的 IP 资源得到了有效的利用。

三）配置路由归纳

RIPv2 协议能自动归纳路由，如果在 2514/1703 的串行口连接一台路由器 RouterISP，配置串行线的网段为 192.168.8.0/24，那么在 RouterISP 上能看到路由表为：

R 192.168.1.0/24 [120/1] via 192.168.3.1, 00:00:01, Serial0
C 192.168.8.0/24 is directly connected, Serial0

路由归纳在路由器上是可以去掉的，具体配置为：

router(config)#router rip
router(config)#no auto-summary

可以查看路由表为：

192.168.1.0/24 is variably subnetted, 5 subnets, 4 masks
R 192.168.1.64/26 [120/2] via 192.168.8.1, 00:00:04, Serial0
R 192.168.1.0/30 [120/2] via 192.168.8.1, 00:00:04, Serial0
R 192.168.1.4/30 [120/2] via 192.168.8.1, 00:00:04, Serial0
R 192.168.1.128/25 [120/1] via 192.168.8.1, 00:00:04, Serial0

我们可以在端口上手动的聚合一条路由，具体配置为：

router(config)#int s0
router(config-if)#ip summary-address rip 192.168.1.0 255.255.255.248

把 192.168.1.0/30 和 192.168.1.4/30 两个网段聚合为 192.168.1.0/29 网段。最后结果为：

RouterISP#show ip route
192.168.1.0/24 is variably subnetted, 3 subnets, 3 masks

R 192.168.1.64/26 [120/2] via 192.168.8.1, 00:00:00, Serial0
R 192.168.1.0/29 [120/2] via 192.168.8.1, 00:00:00, Serial0
R 192.168.1.128/25 [120/1] via 192.168.8.1, 00:00:00, Serial0
C 192.168.8.0/24 is directly connected, Serial0

Part2:IP unnumbered

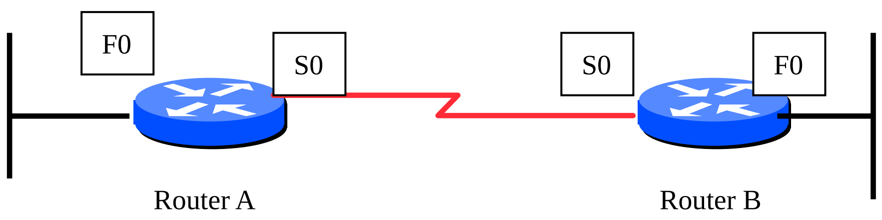
实验目的：

掌握 ip unnumbered 命令以及命令适用范围。

在接口上配置无编号 IP 地址讲义上给出了两条原则：

1. 接口必须都是串行接口，并且是被一条点到点链路连接着；
2. 在该广域网链路两端“借给”它们 IP 地址的局域网接口地址应属于同一个主类网络，并有相同长度的子网掩码。或者，在该广域网链路两端的局域网接口地址属于没有被划分子网的不同主类网络。

实验拓扑：



实验内容：

为了验证讲义中两条规则，我们将分几种情况配置 IP unnumbered。首先，我们先对路由器进行一些基本配置：

Router A#config t
Router A(config)#interface Serial0/0
Router A(config-if)#ip unnumbered FastEthernet0/0
Router A(config-if)#clockrate 56000
Router A(config-if)#no shut
Router A(config)#router rip

Router B#config t
Router B(config)#interface Serial0/0
Router B(config-if)#ip unnumbered FastEthernet0/0
Router B(config-if)#clock rate 56000
Router B(config-if)#no shut
Router B(config)#router rip

规则 1：同一个主类网络，并有相同长度的子网掩码

Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.1.1 255.255.255.0
Router A(config-if)#no shut
Router A(config)#router rip

Router A(config)#network 172.16.0.0

Router B#config t
Router B(config)# interface FastEthernet0/0
Router Bonfig-if)# ip address 172.16.2.1 255.255.255.0
Router Bconfig-if)#no shut
Router A(config)#router rip
Router A(config)#network 172.16.0.0

规则 2：没有被划分子网的不同主类网络
Router A#config t
Router A(config)# interface FastEthernet0/0
Router A(config-if)# ip address 172.16.1.1 255.255.0.0
Router A(config-if)#no shut
Router A(config)#router rip
Router A(config)#network 172.16.0.0

Router B#config t
Router B(config)# interface FastEthernet0/0
Router Bonfig-if)# ip address 192.168.1.1 255.255.255.0
Router Bconfig-if)#no shut
Router A(config)#router rip
Router A(config)#network 192.168.1.0

使用 **show ip route** 查看路由表
debug ip rip events 查看路由的更新信息
用 **ping** 命令检查网络的连通性
debug ip icmp 查看数据包的转发情况

NAT 实验二

一. 实验目的

本实验的目的是通过配置负载均衡 NAT 以及使用 NAT 转换交叉地址空间，让学员对 NAT 的工作原理有更深的认识，掌握 NAT 在路由器上的配置方法，对 NAT 在网络上的应用有更深的了解。

二. 原理知识

NAT 配置中的常用命令：

ip nat {inside|outside}：接口配置命令。以在至少一个内部和一个外部接口上启用 NAT。

ip nat inside source static *local-ip global-ip*：全局配置命令。在对内部局部地址使用静态地址转换时，用该命令进行地址定义。

access-list *access-list-number* **{permit|deny}** *local-ip-address*：使用该命令为内部网络定义一个标准的 IP 访问控制列表。

ip nat pool *pool-name start-ip end-ip* **netmask** *netmask* **[type rotary]**：使用该命令为内部网络定义一个 NAT 地址池。

ip nat inside source list *access-list-number* **pool** *pool-name* **[overload]**：使用该命令定义访问控制列表与 NAT 内部全局地址池之间的映射。

ip nat outside source list *access-list-number* **pool** *pool-name* **[overload]**：使用该命令定义访问控制列表与 NAT 外部局部地址池之间的映射。

ip nat inside destination list *access-list-number* **pool** *pool-name*：使用该命令定义访问控制列表与终端 NAT 地址池之间的映射。

show ip nat translations：显示当前存在的 NAT 转换信息。

show ip nat statistics：查看 NAT 的统计信息。

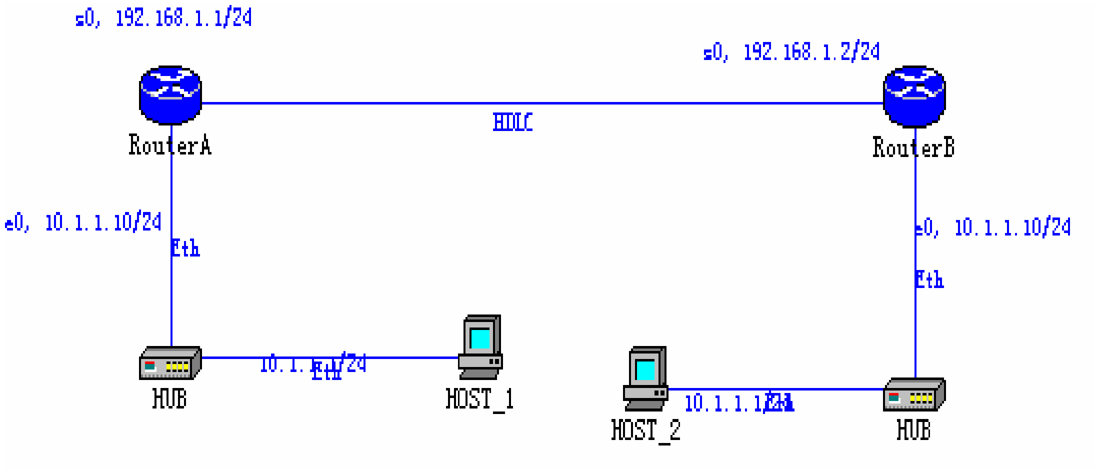
show ip nat translations verbose：显示当前存在的 NAT 转换的详细信息。

debug ip nat：跟踪 NAT 操作，显示出每个被转换的数据包。

Clear ip nat translations *：删除 NAT 映射表中的所有内容.

三. 实验步骤

（一） 用 **NAT** 转换交叉地址空间：



内部局部地址	内部全局地址	外部局部地址	外部全局地址
10.1.1.1	202.116.78.1	202.116.64.1	10.1.1.1

1．配置两条静态路路由，RouterA 上配置到达外部局部地址的路由，RouterB 上配置到达内部全局地址的路由，只两条路由是非常重要的。

1) RouterA 的配置：

Router-A#config t

Router-A(config)#ip route 202.116.64.0 255.255.255.0 192.168.1.2

2) RouterB 的配置：

Router-B#config

Router-B(config)#ip route 202.116.78.0 255.255.255.0 192.168.1.1

2．用 NAT 转换交叉地址空间：

1）基本配置：。

Router-A#config t

Router-A(config)# ip nat pool *CISCO* 202.116.78.1 202.116.78.254 netmask 255.255.255.0

Router-A(config)# ip nat pool *ZSU* 202.116.64.1 202.116.64.254 netmask 255.255.255.0

Router-A(config)# access-list 1 permit 10.1.1.0 0.0.0.255

Router-A(config)#ip nat inside source list 1 pool CISCO

Router-A(config)#ip nat outside source list 1 pool ZSU

Router-A(config)#int e0

Router-A(config-if)#ip nat inside

Router-A(config-if)#int s0

Router-A(config-if)#ip nat outside

2）查看 NAT 转换交叉地址空间的配置：

Router-A#show ip nat translations

Router-A#show ip nat statistics

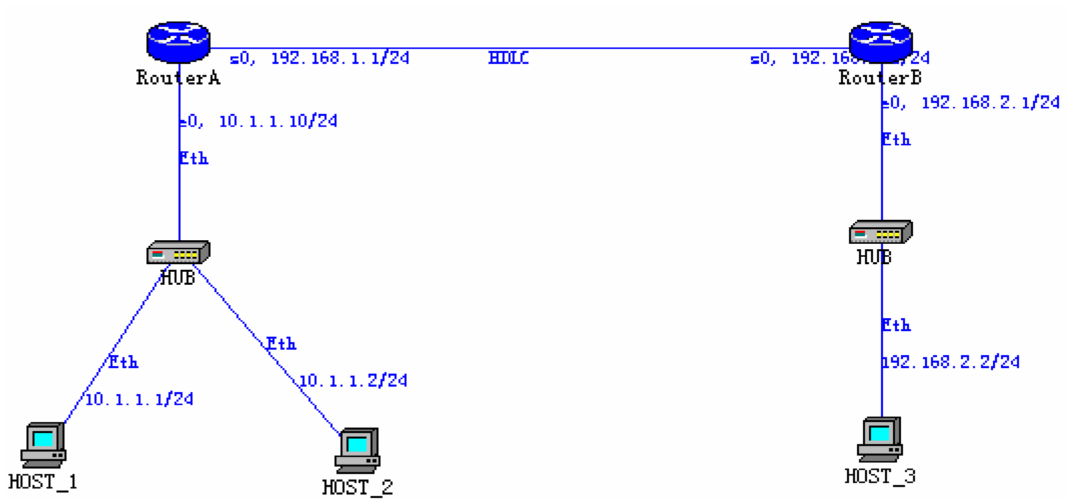
Router-A#show ip nat translations verbose

Router-A#debug ip nat

3）检验 NAT 转换交叉地址空间：

1. 在 Host_1 上 ping RouterB 的 s0,建立内部局部地址 10.1.1.1 与内部全局地址 202.116.78.1 之间的映射,可使用 show ip nat translations 查看映射关系,可使用 debug ip nat 查看映射过程.
2. 在 Host_2 上 ping 内部全局地址 202.116.78.1,可建立外部全局地址 10.1.1.1,外部局部地址 202.116.64.1 和内部全局地址 202.116.78.1 之间的映射，可使用 show ip nat translations 查看映射关系,可使用 debug ip nat 查看映射过程.

（二） TCP 负载均衡:

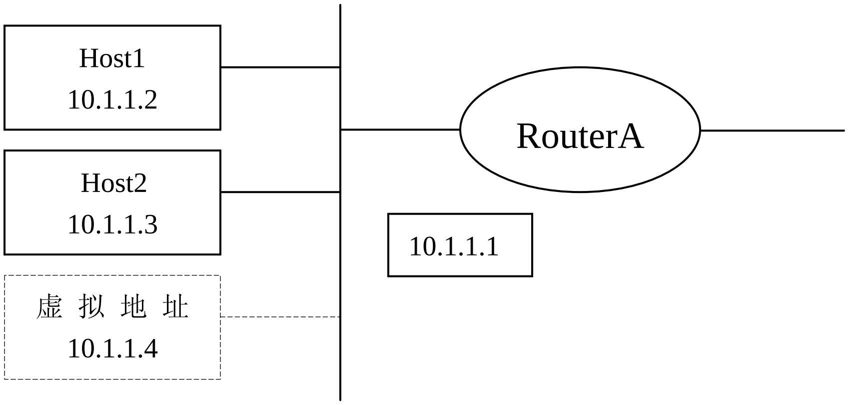


1. 在 RouterB 上配置一条到达内部全局地址的静态路由。这是非常重要的。完成配置后使用 show ip route,show interface,show running-configuration 查看路由配置的正确性。:

   Router-B(config)#ip route 10.1.1.0 255.255.255.0 192.168.1.1

   Router-A(config) #ip route 192.168.2.0 255.255.255.0 192.168.1.2

2．TCP 负载均衡：



将 10.1.1.1 和 10.1.1.2 分别作为两台相同的 WWW 服务器，它们有共同的虚拟地址 10.1.1.4。

1）在 RouterA 上配置 TCP 负载均衡：。

参数“type rotaty”使该地址池成为一个循环型的，否则将不能进行负载均衡。

基本命令：

Router-A#config t

Router-A(config)# ip nat pool *CISCO* 10.1.1.2 10.1.1.3 netmask 255.255.255.0 type rotary

Router-A(config)# access-list 1 permit 10.1.1.4 0.0.0.0

Router-A(config)#ip nat inside destination list 1 pool CISCO

Router-A(config)#int e0

Router-A(config-if)#ip nat inside

Router-A(config-if)#int s0

Router-A(config-if)#ip nat outside

3)检验 TCP 负载均衡：

在 10.1.1.1 和 10.1.1.2 两台服务器上利用 PWS 发布不同的网页，在外部网络的一台主机上访问它们共有的虚拟地址 http://10.1.1.4，NAT 路由器将会把数据包负载均衡到每一台服务器，我们可以看到，主机将轮流访问两台服务器上的主页。

Router-A#show ip nat tra

Pro Inside global	Inside local	Outside local	Outside global
tcp 10.1.2.4:80	10.1.2.2:80	192.168.2.2:1038	192.168.2.2:1038
tcp 10.1.2.4:80	10.1.2.3:80	192.168.2.2:1039	192.168.2.2:1039

热待机路由协议(HSRP)实验

【实验目的】

熟悉和掌握 HSRP 基本配置，观察 HSRP 状态信息，在此基础上理解 HSRP 的用途。

【实验原理】

1． 背景

有时，为了获得可靠性在某一子网内可能会通过两个以上的路由器与外界网络相连，这时作为子网内的主机来说，可以选择不同的网关(路由器)作为出口。在 Windows 系统中，允许主机配置多个缺省网关，以供机器按顺序选择。主机启动后通过 ARP 协议获得某一网关的 MAC 地址，然后以其作为缺省网关。但是，若在某些情况下该路由器失效，主机并没有能力知道这情况，更不会自动地去选择另一个网关作为自己的缺省网关，直到我们人为的运行 ARP 请求或者主机重新启动。正是由于这种原因，造成了在本来有其它出口的情况下，主机却在一段时间内找不到适当的出口的问题。基于这个问题，我们希望能通过某种策略，使得子网内的主机只需要通过某一特定的网关(一个虚拟的路由器)出去，而把担当该虚拟路由器的磋商工作交给路由器之间去完成。这时对于主机来说，网关始终是固定的，从而简化了用户端的配置。HSRP 正是基于这样的思想而设计出来的一种解决上述问题的方法。

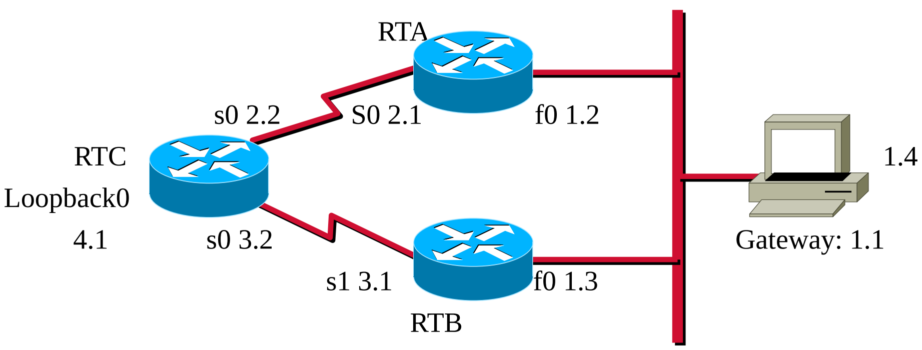
2． HSRP 概述

热待机路由协议的目的就是希望能在网络内提供趋于 100％的数据转发能力，尽量保证在路由器出现故障的情况下，继续发往该路由器的数据包不会丢失，能够自动由其它路由器发送出去。

这是通过一个虚拟的路由器来实现的。子网内的主机以该虚拟路由器作为缺省网关并向其发送数据，而各个启动了 HSRP 的路由器通过竞争来担当该虚拟路由器的角色并负责这些数据的转发。负责转发发向虚拟路由器的数据包的那台路由器为 Active 状态，其它一个或多个路由器作为 Standby 状态。当 Active 路由器失效时，Standby 路由器通过与 Active 路由器的信息交互和计时器来自动取缔原来的路由器，将自身变为 Active，继续负责发往虚拟路由器的数据转发工作。然而，对用户来说，这种网络的变化是透明的，亦即可以达到一种。

【实验拓扑】

实验图如下，子网前缀均为 192.168.:



1700 系列以上的路由器 3 台，主机一台,装有 Windows 操作系统，网线及串行线若干。

【实验步骤】

1. 按上图搭好网络拓扑，配置好相应的 IP 地址及相关东西，同时在三个路由器中都启动 RIP 协议。
   在主机上配置两个网关，分别为 192.168.1.2 和 192.168.1.3。在主机上 ping RTC 的 loopback0 地址，确认能 ping 通，否则检查网络。
2. 检查主机是通过哪个网关出去(例如可以通过 tracert)。不失一般性，假设从 RTA 上出去，
   1）在主机上持续 ping 192.168.4.1，然后把 RTA 的 f0 口拔掉，看看主机上的 ping 信息；
   2) 在主机上持续 ping 192.168.4.1，然后把 RTB 的 f0 口拔掉，看 ping 信息
   观察以上两种情况的 ping 信息，并从选路角度解释该现象。
3. 在主机上将 ARP 表清空，重新 ping RTC 的 loopback0 口，检查此时的发送路径。
   从上面实验可知：
   1）在主机上配置了多个网关时，只有第一个网关可以起作用；
   2）由于在 RTC 上有两条对等路径返回主机，所以返回时会采用均衡负载策略，如果把与 192.168.1.3 的连线拔掉，在一小段时间内会看到一个 ping 得通，一个 ping 不通的现象；再过一会又全部可以 ping 通。原因在于前者 RIP 路由信息条目还有效，后者则是该条经过 192.168.1.3 的路由于没有再更新而是失效了。
   注意：以上是对 windows 操作系统而言，其它操作系统尚未测试过。

为解决这问题，可以使用 HSRP 协议，下面开始 HSRP 协议的配置。

4. 在 RTA 上的配置：
   ```
   RTA#config t
   RTA(config)#int f0
   RTA(config-if)#standby 1 ip 192.168.1.1
   ```
   在 RTB 上作同样的配置。
5. 将主机上原来的两个网关删除，添加一个地址为 192.168.1.1 的网关。
6. 在特权模式下用 show standby 命令查看两个路由器，看看哪个路由器状态属 Active。
   通过 priority 和路由器端口 IP 地址来决定谁是 active：priority 高者胜出；若 priority 相同，则高 IP 地址的路由器胜出。
7. 以 ping 192.168.4.1 –r 9 –t 命令查看机器通过哪个路由器出去，该命令记录了数据报所通过的路由器的各个出口端口 IP。
8. 这时在主机上持续地同时 ping 192.168.1.1 和 192.168.4.1，然后将属于 Active 的路由器 f0 口拔下，观察主机上的 ping 信息是否有变化。
9. 此时再以 ping 192.168.4.1 –r 9 –t 观察，看看路径是否有变化。
10. 观察路由器的状态变化：在各路由器上用 debug standby 命令启动 debug，然后在 Active 状态的路由器上将 f0 口 shutdown，观察其 debug 输出。然后再 no shut 该端口，观察其状态变化的输出。
11. 改变 Standby 优先级：在处于 standby 状态的路由器上，用以下命令改变其优先级，设置为 150，并设置为抢占模式，然后观察其状态是否出现转变。

    ```
    Router#(config-if)standby group-number priority
    priority-value
    Router#(config-if)standby group-number preempt
    ```

12. 改变 HSRP Hello Timer

默认情况下 HSRP Hello 信息的发送间隔为 3 秒，超过 9 秒则 hold down，我们可以用下面命令改变这两个参数：

```
Router(config-if)#standby group-number timers hellotime holdtime
```

在 Active 路由器上运行该命令设置你所需的参数，用 debug 观察 Hello 信息的发送间隔是否改变；再尝试在 standby 路由器上改变参数，观察是否能改变当前的时间间隔。 如果不能，可以得出什么结论? （只有 active 的参数有效，因它们之间会通过 HSRP hello 消息交换和协商具体的参数，最终就由 active 决定。）

13. Enable HSRP Interface Tracking

缺省情况下，处于 Active 状态的路由器，它的其它接口上的 up/down 并不影响到运行 HSRP 接口的优先级变化，因此有可能造成其外部通路已经失效的情况下它依然担当 active 路由器的问题。为解决这个问题，需要启动 interface tracking。在上面实验中，首先人为 shutdown active 网关的 s0 口，观察 ping 信息的变化，同时观察路由器状态是否改变，数据包发送路径呢？然后用下面命令启动接口状态检查:

```
Router(config-if)#standby 1 track s0 60
```

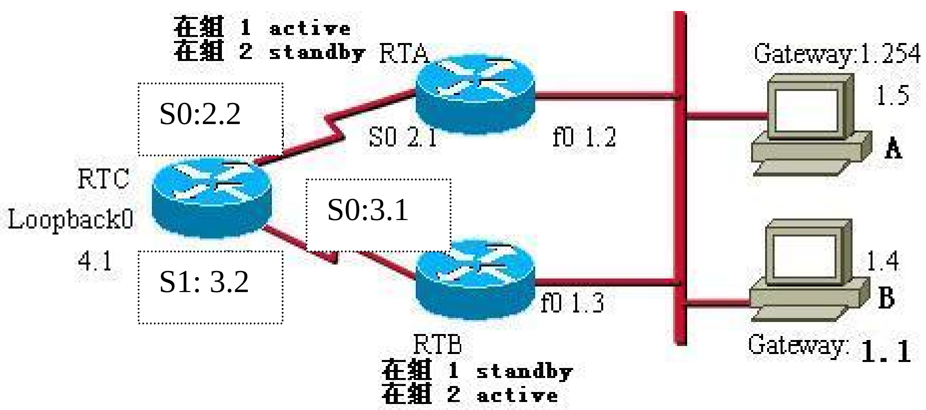
1）60 的作用是使得其优先级降低的值。重新执行上面的操作，观察有什么不同，说明该命令有什么作用。

2）可以试着将 60 变为小于 50 的值，然后重新执行上面的操作，观察数据包的走向。

14. HSRP 负载均衡

在实现 HSRP 时，最少需要两台路由器，一个作为 active 的，至少一个作为 standby 的。显然，当 active 的路由器起作用时，就热备份这个角度来说，standby 路由器相当于闲置了。因一台路由器可以属于多个 HSRP 组，故为了充分发挥各台路由器的作用，可以让某一组的 active 路由器是另一个组的 standby 路由器，同理让某一组的 standby 路由器同时又是另一个组的 active 路由器，这样就既可以充分地利用路由器又可以达到热待机的目的，在一定程度上可以实现均衡负载。

就某个子网而言，可以让某些主机配置某个组的虚拟网关地址（虚拟路由器的 IP 地址），而同时让另一部分的主机配置另外一个组的虚拟网关地址。这样，在两个虚拟网关地址分别用两台不同的路由器充当 active 角色，从而可以达到负载均衡的目的。如下图所示：



两台 PC 使用不同的缺省网关，主机 A 以 HSRP 组 1 的虚拟 IP 地址 192.1.1.1 为缺省网

关，而主机 B 以组 2 的虚拟 IP 地址 192.1.1.11 为缺省网关。在正常工作状态下，局域网的数据流量在两台路由器之间均分；一旦发生故障，备份路由器被激活，所有流量被路由至该路由器的端口。上图中的两台路由器均同时属于两个 HSRP 组，路由器 A 是组 1 的 active 路由器及组 2 的 standby 路由器，路由器 B 是组 2 的 active 路由器及组 1 的 standby 路由器。相应的配置命令如下：

1） 路由器 A

RTA(Config-if)#standby preempt　！全局可抢占模式

RTA (Config-if)#standby 1 ip 192.1.1.1

RTA (Config-if)#standby 1 priority 150

RTA (Config-if)#standby 2 ip 192.1.1.254

2）路由器 B

RTB(Config-if)#standby preempt

RTB (Config-if)#standby 1 ip 192.1.1.1

RTB (Config-if)#standby 2 ip 192.1.1.254

RTB (Config-if)#standby 2 priority 200

通过控制路由器的 priority，可以有效地控制哪一台路由器成为 active 路由器。

上述做法在 VLAN 环境中同样适用。对于某些 VLAN，选取其中的一台作为 active；另外的 VLAN，则用另外一台作为 active。

【实验思考】

1) 与设置多个网关相比，HSRP 有什么优点?
2) 能否让一个路由器同时属于多个 HSRP 组? 假如可以的话，一个路由器能否同时在多个组里都处于 Active 状态?
3) 在第 13 步配置中，没启动 interface tracking 之前，我们将 s0 shutdown 后，ping 信息出现短暂的目标不可达信息，然后又重新能 ping 通 RTC 的 loopback0 口，为什么?

网络安全实验

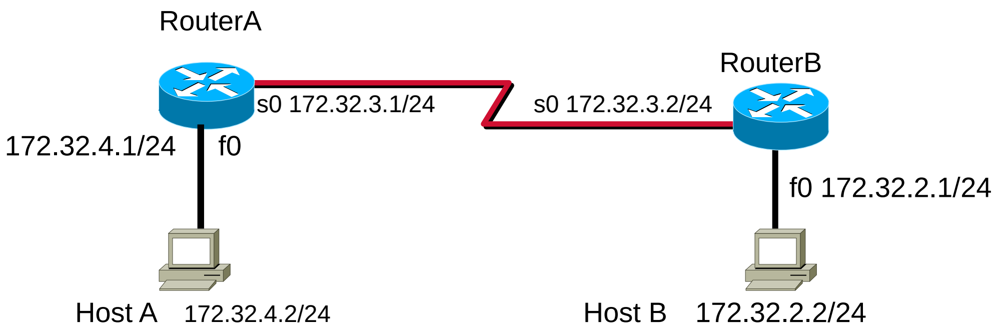
一．实验目的：

1．理解 Lock-and-Key 的主要用途及配置方法；
2．理解 Reflexive access list 的主要用途；Reflexive access list 的配置步骤；
3．掌握 CBAC 的主要用途和配置方法；
4．比较三种访问控制的优缺点，所用场合的差异，以便根据不同的环境灵活选择不同的配置策略；

二．实验设备：

1700 系列路由器两台，装有超级终端的计算机三台，集线器两个,网线等。

三．实验拓扑：



四．实验内容：

（一）. **Lock-and-Key 配置实验**

1．配置 Lock-and-Key 的常用命令：

Lock-and-Key 常用的命令有以下几个：access-list，ip access-group, login tacacs , username，password&login local ,show ip interface, show access-lists。我们简单介绍一下：

access-list *access-list-number* **dynamic** *dynamic-name* [**timeout** *minutes*] {**deny**|**permit**} *protocol source-address source-wildcard destination-address destination-wildcard* ：该命令使用关键字"**dynamic**"，它创建一个动态访问控制列表。"**timeout** *minutes*"参数指定了动态访问控制列表的绝对超时值，它代表该动态访问控制列表中每个条目的最大时间限制（以分为单位），时间到后，就算连接仍在传输数据，我们也需要重新认证。

ip access-group *access-list-number* {**in**|**out**}：把一个 ACL 表应用于路由器的具体的端口。"**in**"是入方向，"**out**"是出方向。

username username **password** password："**username**"参数配置一个用户名，以标识用户的身份，它可以保证对用户的验证更为有效。"**password**"参数配置一个认证密码。"**login local**"一个注册命令，它将所有线路配置为根据本地用户名/口令数据库对用户进行认证。

autocommand access-enable [**host**] [**timeout** *minutes*]：该命令用于自动创建一个临时性访问控制列表条目，关键字"**host**"使该临时性条目不包括我们所在子网的其他地址，"**timeout** *minutes*"参数指定连接的闲置时间，如果连接闲置超过该时间，我们不得不重新进行认证。

show ip interface：这个命令不是 ACL 的特有命令，但是它可以看到一个端口上的 ACL 的配置信息。

show access-lists：这个命令用于查看某个 ACL 表里的访问控制规则。

2 注意事项：

A．ACL 规则

路由器是根据 ACL 里面的规则对数据包进行检验的，如果发现一个数据包不符合表里定义的所有规则，路由器就会把数据包丢弃。所以在写 ACL 规则时，如果前面几条规则是 deny 某种类型的数据包通过的话，那么一定要在最后加上一条 perimt any，让其它不满足条件的数据包通过。

B．Lock-and-Key 使用的是 IP 的扩展 ACL，所以你在配置 Lock-and-Key 之前必须对 ACL 访问控制的原理有一个深入的理解。

C．在开始这个实验之前，建议删除各路由器的初始配置后再重新启动路由器，这样可以防止由残留配置所造成的问题。

D．在配置中带关键字“dynamic”的语句是同一个扩展 ACL100 的一部分。记住，对于一种协议，一个接口和一个方向只能有一个访问控制列表。

3.实验步骤

1．按上面实验拓扑图连接好设备，并配置好各设备的 ip 地址；

2．使用 RIP 协议作为该网络的路由协议，实现网络的动态路由配置。完成配置后使用 show ip route,show interface,show running-configuration 查看路由配置的正确性或者使用 ping 命令验证网络之间是否完全互连。

3． Router-A 上配置动态访问控制列表：

(1)建立一个访问控制列表号为 100 的访问控制列表：

Router-A#config t

Router-A(config)#access-list 100 permit tcp any host 172.32.3.1 eq telnet

Router-A(config)#access-list 100 dynamic CISCO timeout 5 permit ip any any

（2）将建立的访问控制列表 100 应用在 Router-A 的 f0 端口上，一切从该端口进入的数据流都需要通过 ACL 的验证：

Router-A(config)#int f0

Router-A(config-if)# ip access-group 100 in

Router-A(config-if)#exit

（3）定义将使用 Lock-and-Key 的虚拟终端：

单台主机：

Router-A(config)#line vty 0 4

Router-A(config-line)#login local

Router-A(config-line)# autocommand access-enable host timeout 2

Router-A(config-line)#exit

整个子网：

Router-A(config)#line vty 0 4

Router-A(config-line)#login local

Router-A(config-line)# autocommand access-enable timeout 2

Router-A(config-line)#exit

（4）为所有需要通过 Router-A 而访问外部网络的用户配置用户的验证

证明（包括用户名和密码）：

Router-A(config)#username CISCO password CISCO

Router-A(config)#^z

4．验证 Lock-and-Key 配置是否成功：

1）使用了 host 命令，仅允许单台主机通过：

(1) 试着从 HostB 去 ping HostA，到主机的 ping 应该失败。

(2) 在确认了防火墙阻止我们到达 172.32.4.0 网段之后，我们可以从 HostB telnet 到 Router-A，我们会被提示输入用户名和密码以进行认证，输入正确的登陆信息后，telnet 会话立刻被切断。这时 RouterA 已经在防火墙上打开了一个通道，让数据报通过。

(3) 再试着从 HostB ping 一下 172.32.4.0 网段主机，该 ping 是成功的。从 RouterB 上 ping 172.32.4.0 网段主机，ping 不成功，因为我们用 host 参数规定了只有单台主机能够使用这个通道传输数据

(4) 此时可以使用 show ip access lists 来查看 lock and key 的配置：

Router-A#show ip access_lists

Extended IP access list 100

permit tcp any host 172.32.3.1 eq telnet (94 matches)

Dynamic cisco permit ip any any

permit ip host 172.32.4.2 any (19 matches) (time left 52)

可见其数据包头源地址被动态的替换为了 172.32.4.2，这就是参数 host 的作用

2）不使用 host 命令，允许整个子网的所有主机通过：

（1）试着从 Host_2 去 ping Host_1，到主机的 ping 应该失败。

（2）在确认了防火墙阻止我们到达 172.32.4.0 网段之后，我们可以从 HostB telnet 到 Router-A，我们会被提示输入用户名和密码以进行认证，输入正确的登陆信息后，telnet 会话立刻被切断。这时 RouterA 已经在防火墙上打开了一个通道，让数据报通过。

（3）再试着从 HostB ping 一下 172.32.4.0 网段主机，该 ping 是成功的，从 RouterB 上 ping 172.32.4.0 网段主机，ping 也是成功的，因为我们没有使用 host 参数，这使得该网段内的所有主机都能够使用这个通道传输数据

（4）此时可以使用 show ip access lists 来查看 lock and key 的配置：

Router-A#show ip access_lists

Extended IP access list 100

permit tcp any host 172.32.3.1 eq telnet (94 matches)

Dynamic cisco permit ip any any

permit ip any any (20 matches) (time left 45)

可见路由器还是让任何 ip 包通过。

（二）. Reflexive Access List 配置实验

1 概述：

按上图拓扑，在该实验中，我们在两个路由器之间启动 rip 路由协议。其中 RouterA 担当防火墙的角色，即将 Reflexive access list 放在 RouterA 的 f0 口处，在 RouterB 的 f0 口处连接的是 172.32.2.0 网段。HostB 上安装 FTP 服务器软件，作为外部网络的一台 FTP 服务器.

Reflexive access list 的放置有两种方法：放在 internal 接口处或者放在 external 接口处，要弄清出两种放置方法有什么不同之处，他们分别用于什么场合上。

该实验可分别以 ping 命令，telnet，ftp 请求三种方式来验证配置的可行性：

A: 以 ping 命令来证明配置是否可行：当配置完成后，在 HostA 上 ping RouterB 的 f0 网段内的主机 ip 地址，都可以有 icmp 包返回；但在防火墙外 ping RouterA 内部的网络设备时，则不能 ping 通。

B：以 FTP 方式来验证：注意，由于 FTP 的控制端口为 21，而传输数据的端口为 20，因此，当 FTP client 以普通方式尝试与 FTP server 建立会话时，会发现虽然双方已经在控制与同步方面都磋商完毕，但当 FTP server 开始发送第一个数据包过来时，由于它是以端口 20 传输的，而基于这个端口的会话的发起方属于防火墙外部，因此 reflexive access list 会认为该会话非法，从而不允许通过. 因此在 FTP client 方看来，尽管已经连上了 FTP server，但却看不到任何服务器的 FTP 目录上的内容；要想得到 FTP 服务，必须将 client 的 FTP 工作方式设为 passive 模式(这是 FTP 的两种工作方式之一，详细内容可参考 RFC1635，RFC1579).

2. 实验步骤：

1. 按拓扑图连接好设备并打开电源；
2. 按图配置好各设备地址，并在两个路由器之间启动默认路由；
3. 验证路由配置的正确性：以 ping 命令分别在各设备上 ping 其他网段的设备，应保证整个网络都能互通；
4. 在 RouterA 上配置 Reflexive access list:

(1) 首先，定义一个名为 FILTER-IN 的 inbound access list，该 ACL 将运行在 RouterA 的 f0 口处检查所有进入的数据包，并在其上定义了一条 entry，该 entry 允许所有 ip 包通过，并且创建了一个名为 IPTraffic 的 reflexive access list，当一个 inbound packet 第一次通过该接口和外面建立起会话的时候，路由器就会相应的在 IPTraffic 中加入一条 entry，以便双方能通过该路由器对话。

```
RouterA(config)#ip access-list extended FILTER-IN
RouterA(config-ext-nacl)#permit ip any any reflect IPTraffic
RouterA(config-ext-nacl)#exit
```

(2)然后，定义一个名为FILTER-OUT的outbound access list，并将IPTraffic嵌套在该ACL中；

```
RouterA(config)#ip access-list extended FILTER-OUT
RouterA(config-ext-nacl)#evaluate IPTraffic
RouterA(config-ext-nacl)#exit
```

(3)将两个ACL应用在f0口上；

```
RouterA(config)#int f0
```

RouterA(config-if)#**ip access-group FILTER-IN in**

RouterA(config-if)#**ip access-group FILTER-OUT out**

5． 用show命令确认配置正确后，在在防火墙外部ping防火墙内部的设备时，这时是不能ping通的；而在防火墙内部设备上(如 Host A)ping外部的设备,这时icmp包则可返回，想想原因。同样,telnet方式的结果也一样.

需要注意的就是FTP访问时的问题.如果想防火墙内部的client能访问外部的FTP server,可以有两种方案选择:第一,将client的FTP访问方式设为passive模式,如果用ftp软件的话(如leapftp)一般可以设置,或者在比较高版本的ie下,在internet选项下的高级子菜单,选中"enable folder view for FTP sites",则可以正确访问.但这需要client方懂得设置的方法;另外一种方案就是在作为防火墙的路由器端口上加上一条entry,让所有原端口为20而目的端口大于1024的包通过,比如在上面的实验中,我们可以在控制表FILTER-OUT中加入这样一条:

permit tcp any eq 20 any gt 1024 , 则可以让所有从原端口为20且目标端口大于1024的数据包通过,相当于开了一道后门,当然,这也会存在着安全隐患.

3．注意事项：

1．Reflexive access list只能定义成扩展的命名ACL,不能定义成数字的或者是标准的命名ACL;

2．由于Reflexive access list的内容是动态生成的，所以开始的时候它是一个空表，而cisco路由器对于空的ACL它是不显示出来的，因此当没有会话建立起来时，用show命令是看不到你所定义的reflexive access list的；但当实验过程中内部与外部之间建立起对话后，再用show命令查看的时候，你就会发现存在该表了；

3．必须注意，reflexive access list并不直接应用到端口上，而是嵌套在应用于该端口的另一个扩展的命名ACL上，因此它并不象其他的ACL那样，在最后用缺省的deny any any的条项;

4．弄清楚一般的ACL中关键词established与reflexive access list的区别：虽然他们表面上都似乎完成相同的功能，但事实上他们的实现原理和安全程度都不同: established是通过检查数据包中的ACK和RST位来决定该数据包是否合法；而reflexive access list不仅仅检查这个，而且检查数据包的源地址，目标地址，端口号等，并且它有可调节的timeout，因此它比established更安全。

5．由于自反访问控制表的作用是为防火墙内部的设备提供安全保护并能正确访问外部网络，因此它必须保持内外路由信息的正确交换，换句话说，就是reflexive access list既要有效阻止外部网络设备的非法访问，也应保证路由包能在正常通过该路由器，而不被访问表所拦截. 由于rip协议包是有路由器内部发出传到相邻路由器的，因此reflexive access list 不能将它所在的路由器上所发出的rip包过滤掉.因此,对于运行rip协议的网络中,reflexive access list不须做额外的配置; 而对于igrp,eigrp,ospf等路由协议来说,由于他们是可以跨路由器转发的,因此,当在防火墙外部的路由器想将其路由信息跨过运行reflexive access list的路由器送给防火墙内部的路由器时,reflexive access list将把该路由包视为由外面初始的数据包,因此会被过滤掉,从而造成路由信息交换失败.因此,要避免这种情况的出现,我们必须在用于控制进入防火墙内部的扩展访问控制表中(该实验中为FILTER-OUT)加入相应的条目,如permit eigrp any any , permit ospf any any 等.

（三）．CBAC（Context-Based Access Control）配置实验（选做）

注意：由于当前所用的 2600 系列路由器的 IOS 仍未升级，因此不支持 CBAC，所以以 1720 路由器作为 CBAC 的配置平台。

配置步骤：

1. 主要的配置命令：
   应用层协议审查配置：
   Router(config-if)# **ip inspect name** inspection-name protocol [**timeout** seconds]
   在接口上应有检查规则命令：
   Router(config)#**int e0**
   Router(config-if)#**ip inspect FIREWALL out**

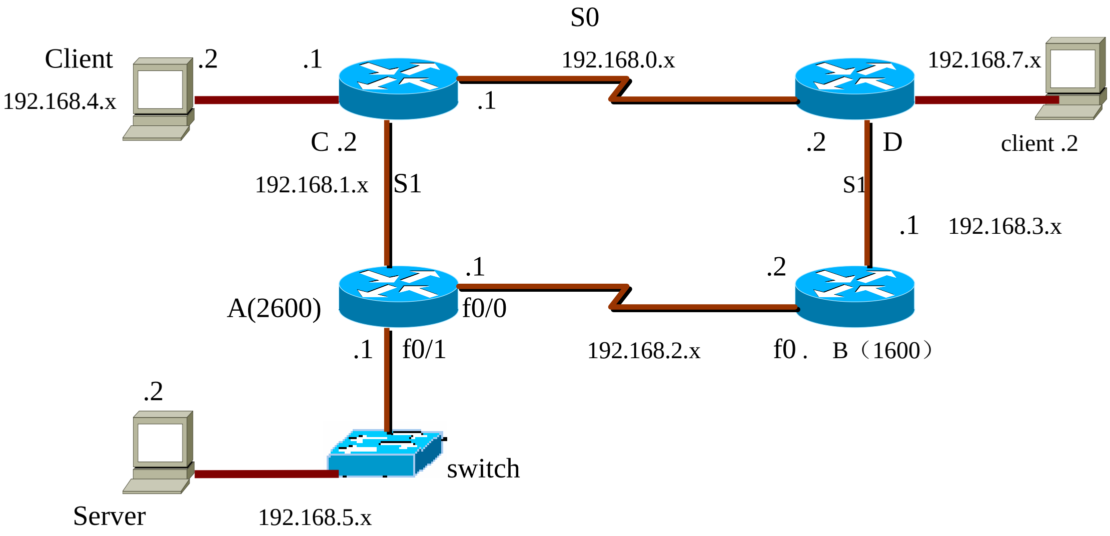
2. 一个简单例子：一个审查 HTTP 协议的 CBAC 配置：
   审查 HTTP 协议
   Router(config-if)# **ip inspect name** checkhttp **http**
   在接口上应用检查规则命令：
   Router(config)#**int e0**
   Router(config-if)#**ip inspect** checkhttp **out**

组播实验

一　实验目的

1) 理解 Multicast 的一些基本概念。
2) 掌握 pim dense-mode 的基本配置。
3) 理解 pim dense-mode 的 flood 和 prune 过程。
4) 理解 pim dense-mode 的 assert 机制
5) 掌握 cgmp 的配置，及其优点。
6) 掌握 pim sparse-mode 的基本配置。

二、实验拓扑和器材



拓扑如上所示，需要路由器四台、交换机一台，主机三台（一台能作组播的服务器，需要 Server 级的 windows 操作系统）。

三、实验原理

1．组播基本原理

Multicast 应用在一点对多点、多点对多点的网络传输中，可以大大的减少网络的负载。因此，Multicast 广泛地应用在流媒体的传输、远程教学、视频/音频会议等网络应用方面。

Multicast 采用 D 类 IP 地址，即 224.0.0.0~239.255.255.255。其中 224.0.0.0~224.0.0.255 是保留地址，239.0.0.0~239.255.255.255 是私有地址，类似于 unicast 的私有地址。

Multicast 的 IP 地址与 MAC 地址的映射：MAC 地址有 48 位，前面 24 位规定为 01-00-5E，接着一位为 0，后面 23 位是 IP 地址的后 23 位。

路由器间要通过组播协议（如 DVMRP、MOSPF、PIM）来建立组播树和转发组播数据包。组播树有两类：源树和共享树。

多播时，路由器采用组管理协议 IGMP 来管理和维护主机参与组播。IGMP 协议 v1 中，主机发送 report 包来加入组；路由器发送 query 包来查询主机（地址是 224.0.0.1），同一个组的同一个子网的主机只有一台主机成员响应，其它主机成员抑制响应。一般路由器要发送 3 次 query 包，如果 3 次都没响应，才认为组超时（约 3 分钟）。IGMPv2 中，主机可以发送

leave 信息给路由器（地址 224.0.0.2）；路由器收到信息后，发送一个特别的 query 包，在 3 秒内没收到组成员响应，就认为组超时。

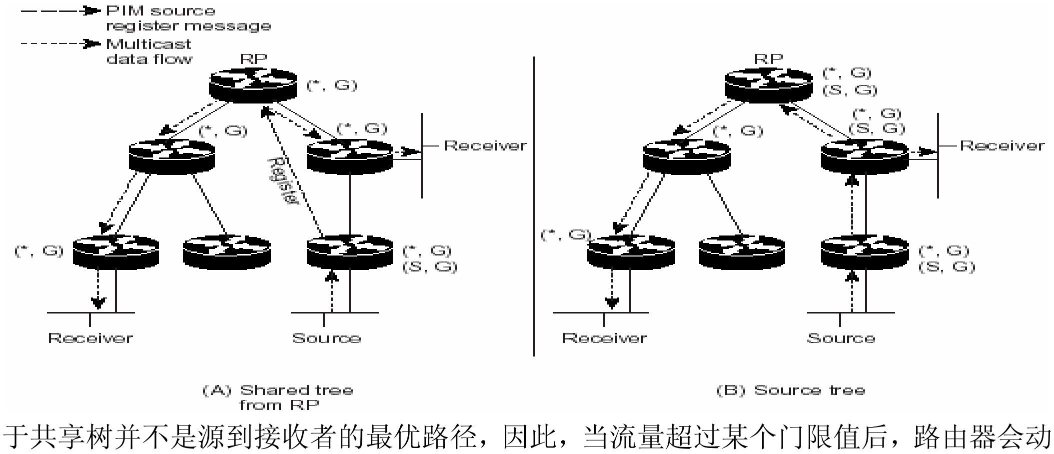
由于组播的 MAC 不是具体某台主机的 MAC，根据交换机的工作原理，交换机会对组播数据包进行广播。因此，对某些不参加组播的主机而言，这些都是不必要的流。为了解决这个问题，cisco 公司开发了 CGMP 协议。该协议用于管理参与组播的主机。每当有主机加入或离开某个组时，路由器就会把该主机的多播 IP 地址（转换成组播 MAC 地址）、主机的 MAC 地址以及消息类型（加入或离开）以 CGMP 消息告知交换机。交换机根据这些信息就可以建立起组播转发表。

2．PIM 协议

Cisco 的路由器只支持 PIM 组播协议。PIM 是一种可利用多种单播路由表（如 EIGRP、OSPF、BGP 和静态路由等）的组播路由协议，它根据这些路由表实现组播数据的转发。尽管它是组播路由协议，然而它实际上只是使用单播路由表来完成 RPF 检验功能，并没有重新建立组播路由表。不像其他的路由协议，PIM 并不会在路由之间收发路由更新信息。

PIM分为Dense-mode与Sparse-mode两种。密集模式的PIM（PIM-DM）使用“推”的方式，把组播流向网络的各个地方转发，从而把流“推”给不同接收者。这种方式适用于网络中的各个子网都有接收者（即接收者密集）的情况。PIM-DM一开始向网络中的各处发组播流，路由器每隔3分钟检查一次自己是否还存在“下游”的邻居，如果没有（即它无需转发组播流），就把这个流“剪”掉（即不再转发）。路由器会积累数据流所带有的源和组的信息，使得“下游”的路由器可以建立它们的组播转发表。PIM-DM只支持源树，而无法使用共享树。

松散模式的PIM（PIM-SM）使用“拉”的方式，只有存在接收者的网段才会接收到数据流（即接收者把流“拉”出来）。PIM-SM通过在共享树中转发数据包来散布组播源的信息。PIM-SM使用共享树（至少在组播开始的时候需要使用），因此，它需要指定一个汇聚点（RP）。源在RP中“注册”后，数据就通过共享树转发到接收者。一旦其它路由器收到从共享树来的数据后，就知道了数据的源在哪里。于是，路由器就会向源发送PIM（S，G）加入信息。在反向路径上的每个路由器比较自己的单播路由表中它到RP的度量和它到源的度量，如果到源的度量更优，它就会继续发送PIM（S，G）加入信息。否则（包括度量相等的情况），PIM（S，G）信息就会沿着RP的方向来发送。这样，就生成了共享树和源树。如下图所示的单向共享树，靠近源的路由器先向RP注册，然后在源和RP之间生成源树，数据通过共享树（*，G）到达接收者。



由于共享树并不是源到接收者的最优路径，因此，当流量超过某个门限值后，路由器会动态地生成源树。该门限值默认的情况为0（例如，在Cisco的路由器中，可通过ip pim spt-threshold infinity命令来修改该门限值）。同时，为了减轻RP的负担，在PIM-SM的第二个版本中，规

定源要周期性的向RP注册，使得RP不必要维护大量的源的信息。

五、实验步骤：

1. 路由器基本配置

1） 按上面的拓扑配置好各台路由器及主机的 IP 地址；

2） 启用 eigrp 协议，AS 号为 100，配置 no auto-summary。

2. 每台路由器上启动 multicast-routing。

在全局配置模式下键入：(config)#ip multicast-routing

3. 路由器的每一个端口上配置 pim dense-mode

命令如下：

(config-if)#ip pim dense-mode

4. 验证 multicast 的相关命令

show ip pim neighbor ： 观察 pim 邻居；

show ip pim interface ： 观察端口上的 pim 信息；

show ip mroute ： 观察 multicast 路由表；

debug ip pim ： 显示 pim 的 debug 信息；

debug ip igmp ： 显示 igmp 信息。

5. Multicast 验证

验证分为四个阶段进行验证，都采用第 4 点所列出的命令

1) 在服务器未连接时（拔掉与 server 连接的线）

只看到关于 224.0.1.40 的多播组的信息，看不到其它多播组的信息。

2) 接上与服务器连接的网线，但 client 还未连接

可以看到服务器上启动的节目组的多播组信息。但由于没有 client，稳定状况下所有端口都是 prune 状态的。

3) 在 client 端打开 media player，连接上服务器

访问组播用以下命令：http://192.168.5.2/station1.nsc。打开服务器上的*.nsc文件,等读取了*.nsc文件信息后，就自动开始播放节目，因.nsc文件中已经包含访问组播服务器所需要的组播IP地址、端口号、流媒体文件等信息。

这时就可以看到一些端口的状态由 prune 变成 forward，打开 debug ip igmp 就可以看到主机加入某个组的信息。

4) 断开 client 与服务器的连接，即关闭 media player 的播放

可以看到主机离开某个组的信息，并且在 show ip mroute 后发现某些端口已经有 forward 变为 prune。

6. 配置 cgmp

1) 配置前，在 switch 上用 show mac-address-table 以及 show cgmp 查看一下相关信息，以同配置后的信息进行对比。

2) 在 A 及 Switch 上配置 cgmp。

对于路由器 A，配置命令是在端口（连接主机的以太网口）模式下，键入：

(config-if)#ip cgmp

对于 Switch，配置命令是：

（config）＃cgmp leave-processing

3) 验证

在 A 上，用 debug ip cgmp 查看 debug 信息；在 Switch 上用命令 debug cgmp 查看

debug 信息。但要注意 1900 没有 debug 命令。

在Switch上再用命令show mac-address-table以及show cgmp看看前后有什么不同。

7. 配置 pim sparse-mode(配置之前要把 PIM Dense-mode 的设置去掉)

1） 基本配置

每台路由器上启动 multicast-routing。

在全局配置模式下键入：(config)#ip multicast-routing

路由器的每一个端口上配置 pim dense-mode

命令如下：(config-if)#ip pim sparse-dense-mode //配置了 RP 后自动为 sparse-mode 式，否则为 dense-mode。

2） static-RP 的 PIM-SM

静态 RP 的配置时，只需要在连接有 client 的路由器上配置，用于指定需要去注册的 RP 的 IP 地址。还可以通过相应的 ACL 来控制哪些组的 RP 是谁。一台路由上可以指定多个 RP。

静态指定 RP 时，RP 那台路由器并不需要知道它自己就是 RP。这就是说 RP 无需本身无需配置。

A、C 和 D 的配置一样：

Router (config)#access-list 20 deny 224.0.1.39

Router (config)#access-list 20 deny 224.0.1.40

Router (config)#access-list 20 permit 224.0.0.0 15.255.255.255

Router(config)#ip pim rp-address 10.10.10.10 20 //10.10.10.10 为 RouterB 的回环接口地址

B 的配置：

Router (config)#int loopback 0

Router (config-if)#ip address 10.10.10.10 255.255.255.0

Router (config-if)#no shut

Router (config)#router eigrp 100

Router (config-router)#network 10.10.10.0 0.0.0.255

验证：1) show ip pim rp 或 show ip pim rp mappings

2) 与密集模式的相同。

3) auto-RP 的 PIM-SM

由于静态指定 RP 必须为每一台末端（连接有 client）的路由器手工配置 RP，且当 RP 改变时还要手动进行更改，带来很大的管理工作量。而自动 RP 则可以解决这个问题。自动 RP 模型中，分为候选 RP 和 RP 映射代理。前者可以配置作为某些组的候选 RP 而以 224.0.1.39 多播组地址向后者通告；后者接收这些信息后再以 224.0.1.40 得多播组地址通告候选 RP 的信息。末端路由器接收到这个 224.0.1.40 多播组的信息后就可以知道有哪些 RP，并且这些 RP 对应哪些多播组，从而可以自动发现 RP。

候选 RP 和 RP 映射代理可以相互独立，不一定属于同一台路由器。但为了可靠起见，而通常将它们合为一体。本实验中 B 是两者合为一体的，但 C 则只是候选 RP 通告而不做 RP 映射代理。

A 和 D 的配置一样：

Router(config)#access-list 20 deny 224.0.1.39
Router(config)#access-list 20 deny 224.0.1.40
Router(config)#access-list 20 permit 224.0.0.0 15.255.255.255

Router(config)#ip pim rp-address 1.1.1.1 20
// 1.1.1.1 为不存在的地址，目的是让些非自动 RP 通告的多播组找不到 RP。在协议中这称为 sink RP。

B 的配置：

Router (config)#access-list 20 deny 224.0.1.39
Router (config)#access-list 20 deny 224.0.1.40
Router (config)#access-list 20 permit 224.0.0.0 15.255.255.255
Router (config)#ip pim rp-address 1.1.1.1 20 //注释同上

Router (config)#access-list **30** permit 224.2.80.80 //作为 224.2.80.80 组的候选 RP
Router(config)#ip pim send-rp-announce loopback 0 scope 32 group-list **30**
//作为符合 ACL30 条件的多播组的候选 RP 而向 RP mapping Agent 通告
Router(config)#ip pim send-rp-discovery loopback 0 scope 32
//作为 RP 的 mapping Agent 而向 224.0.1.40 组通告 RP 的信息

C 的配置：

Router (config)#int loopback 0
Router (config-if)#ip address 10.10.20.1 255.255.255.0
Router (config-if)#no shut

Router (config)#router eigrp 100
Router (config-router)#network 10.10.20.0 0.0.0.255

Router (config)#access-list 20 deny 224.0.1.39
Router (config)#access-list 20 deny 224.0.1.40
Router (config)#access-list 20 permit 224.0.0.0 15.255.255.255
Router (config)#ip pim rp-address 1.1.1.1 20 //注释同上

Router (config)#access-list 30 permit 224.2.169.22
Router(config)#ip pim send-rp-announce loopback 0 scope 32 group-list 30

验证：同静态 RP。

七、实验结果

//
/////////**no server**
///

（1） Router_C

debug ip igmp/pim:

00:30:03: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
00:30:03: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
00:30:03: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
00:30:03: IGMP: Updating EXCLUDE group timer for 224.0.1.40
00:30:16: PIM: Send v2 Hello on FastEthernet0
00:30:21: PIM: Send v2 Hello on Serial0
00:30:21: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:30:21: PIM: Hello packet has unknown option 20, ignored
00:30:23: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:30:24: PIM: Send v2 Hello on Serial1
00:30:46: PIM: Send v2 Hello on FastEthernet0
00:30:51: PIM: Send v2 Hello on Serial0
00:30:51: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:30:51: PIM: Hello packet has unknown option 20, ignored
00:30:53: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:30:54: PIM: Send v2 Hello on Serial1
00:31:00: IGMP: Send v2 general Query on FastEthernet0
00:31:00: IGMP: Set report delay time to 2.2 seconds for 224.0.1.40 on FastEthernet0
00:31:03: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
00:31:03: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
00:31:03: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
00:31:03: IGMP: Updating EXCLUDE group timer for 224.0.1.40
00:31:16: PIM: Send v2 Hello on FastEthernet0
00:31:21: PIM: Send v2 Hello on Serial0
00:31:21: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:31:21: PIM: Hello packet has unknown option 20, ignored
00:31:23: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:31:24: PIM: Send v2 Hello on Serial1
00:31:46: PIM: Send v2 Hello on FastEthernet0
00:31:51: PIM: Send v2 Hello on Serial0
00:31:51: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:31:51: PIM: Hello packet has unknown option 20, ignored
00:31:53: PIM: Received v2 Hello on Serial1 from 192.168.1.2

00:31:54: PIM: Send v2 Hello on Serial1
00:32:00: IGMP: Send v2 general Query on FastEthernet0
00:32:00: IGMP: Set report delay time to 3.8 seconds for 224.0.1.40 on FastEthernet0
00:32:04: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
00:32:04: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
00:32:04: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
00:32:04: IGMP: Updating EXCLUDE group timer for 224.0.1.40

Router_C#sh ip mrou
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.1.40), 00:26:52/00:00:00, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial1, Forward/Dense, 00:26:43/00:00:00
Serial0, Forward/Dense, 00:26:47/00:00:00
FastEthernet0, Forward/Dense, 00:26:52/00:00:00

Router_C#sh ip pim neighbor
PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
192.168.0.2	Serial0	00:28:48/00:01:29	v2	1 / S
192.168.1.2	Serial1	00:28:44/00:01:30	v2	1 / B S

Router_C#sh ip pim interface

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
192.168.4.1	FastEthernet0	v2/D	0	30	1	192.168.4.1
192.168.0.1	Serial0	v2/D	1	30	1	0.0.0.0
192.168.1.1	Serial1	v2/D	1	30	1	0.0.0.0

（2） Router_A
show ip mroute

```
01:12:33: PIM: Send v2 Hello on Serial0/1
01:12:33: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1route
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, s - SSM
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.1.40), 00:11:33/00:00:00, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0/1, Forward/Dense, 00:11:33/00:00:00
    FastEthernet0/0, Forward/Dense, 00:11:33/00:00:00
```

（3） Router_B

```
RouterB#show ip pim neighbor
PIM Neighbor Table
Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                                            Prio/Mode
192.168.2.1       Ethernet0                01:08:38/00:01:39 v2    1 / S
192.168.3.1       Serial0                  00:45:55/00:01:15 v2    1 / S
```

```
RouterB# show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, Z - Multicast Tunnel
       Y - Joined MDT-data group, y - Sending to MDT-data group
Outgoing interface flags: H - Hardware switched
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.1.40), 01:09:10/00:02:53, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Dense, 00:46:25/00:00:00
```

Ethernet0, Forward/Dense, 01:09:10/00:00:00

RouterB#debug ip pim
PIM debugging is on
RouterB#debug ip igmp

IGMP debugging is on
RouterB#
*Mar 1 01:10:15.123: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:10:19.039: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:10:20.694: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:10:28.959: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:10:41.125: IGMP(0): Received v2 Query on Ethernet0 from 192.168.2.1
*Mar 1 01:10:41.129: IGMP(0): Set report delay time to 3.6 seconds for 224.0.1.40 on Ethernet0
*Mar 1 01:10:44.780: IGMP(0): Send v2 Report for 224.0.1.40 on Ethernet0
*Mar 1 01:10:44.784: IGMP(0): Received v2 Report on Ethernet0 from 192.168.2.2 for 224.0.1.40
*Mar 1 01:10:44.787: IGMP(0): Received Group record for group 224.0.1.40, mode 2 from 192.168.2.2 for 0 sources
Mar 1 01:10:44.791: IGMP(0): MRT Add/Update Ethernet0 for (,224.0.1.40) by 0
*Mar 1 01:10:44.795: IGMP(0): Updating EXCLUDE group timer for 224.0.1.40
*Mar 1 01:10:45.141: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:10:48.799: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:10:50.724: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:10:58.719: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:11:15.166: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:11:18.670: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:11:20.777: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:11:28.662: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:11:41.149: IGMP(0): Received v2 Query on Ethernet0 from 192.168.2.1
*Mar 1 01:11:41.153: IGMP(0): Set report delay time to 6.6 seconds for 224.0.1.40 on Ethernet0
*Mar 1 01:11:45.165: IGMP(0): Received v2 Report on Ethernet0 from 192.168.2.1 for 224.0.1.40
*Mar 1 01:11:45.169: IGMP(0): Received Group record for group 224.0.1.40, mode 2 from 192.168.2.1 for 0 sources
*Mar 1 01:11:45.172: IGMP(0): Cancel report for 224.0.1.40 on Ethernet0
Mar 1 01:11:45.176: IGMP(0): MRT Add/Update Ethernet0 for (,224.0.1.40) by 0
*Mar 1 01:11:45.180: IGMP(0): Updating EXCLUDE group timer for 224.0.1.40
*Mar 1 01:11:45.184: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:11:48.573: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:11:50.795: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:11:58.505: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:12:15.171: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:12:18.353: PIM(0): Send periodic v2 Hello on Ethernet0

*Mar 1 01:12:20.865: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1

//
/////////**server on , no multicast stream**
//

(1)Router_C

debug ip igmp/pim

00:58:00: IGMP: Send v2 general Query on FastEthernet0
00:58:00: IGMP: Set report delay time to 9.2 seconds for 224.0.1.40 on FastEthersh ip mroute
Router_C#clear ip mrou *
Router_C#
00:58:10: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
00:58:10: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
00:58:10: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
00:58:10: IGMP: Updating EXCLUDE group timer for 224.0.1.40
00:58:11: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
00:58:11: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
00:58:11: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
00:58:11: IGMP: Updating EXCLUDE group timer for 224.0.1.40
00:58:12: PIM: Building Graft message for 224.0.1.40, Serial1: no entries
00:58:12: PIM: Building Graft message for 224.0.1.40, Serial0: no entries
00:58:12: PIM: Building Graft message for 224.0.1.40, FastEthernet0: no entries
00:58:16: PIM: Send v2 Hello on FastEthernet0
00:58:21: PIM: Send v2 Hello on Serial0
00:58:24: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:58:24: PIM: Hello packet has unknown option 20, ignored
00:58:24: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:58:24: PIM: Send v2 Hello on Serial1
00:58:46: PIM: Send v2 Hello on FastEthernet0
00:58:48: PIM: Send v2 Prune on Serial0 to 192.168.0.2 for (192.168.5.2/32, 224.2.184.234)—没有 CILENT
00:58:48: PIM: Send v2 Prune on Serial0 to 192.168.0.2 for (192.168.5.2/32, 224.2.231.192)
00:58:51: PIM: Send v2 Hello on Serial0
00:58:54: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:58:54: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:58:54: PIM: Hello packet has unknown option 20, ignored
00:58:54: PIM: Send v2 Hello on Serial1
00:59:00: IGMP: Send v2 general Query on FastEthernet0
00:59:00: IGMP: Set report delay time to 7.0 seconds for 224.0.1.40 on FastEthernet0
00:59:07: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0

00:59:07: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
00:59:07: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
00:59:07: IGMP: Updating EXCLUDE group timer for 224.0.1.40
00:59:16: PIM: Send v2 Hello on FastEthernet0
00:59:21: PIM: Send v2 Hello on Serial0
00:59:24: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:59:24: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:59:24: PIM: Hello packet has unknown option 20, ignored
00:59:24: PIM: Send v2 Hello on Serial1
00:59:46: PIM: Send v2 Hello on FastEthernet0
00:59:51: PIM: Send v2 Hello on Serial0
00:59:54: PIM: Received v2 Hello on Serial1 from 192.168.1.2
00:59:54: PIM: Received v2 Hello on Serial0 from 192.168.0.2
00:59:54: PIM: Hello packet has unknown option 20, ignored
00:59:54: PIM: Send v2 Hello on Serial1
01:00:00: IGMP: Send v2 general Query on FastEthernet0
01:00:00: IGMP: Set report delay time to 8.4 seconds for 224.0.1.40 on FastEthernet0
01:00:09: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
01:00:09: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
01:00:09: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
01:00:09: IGMP: Updating EXCLUDE group timer for 224.0.1.40
01:00:16: PIM: Send v2 Hello on FastEthernet0
01:00:21: PIM: Send v2 Hello on Serial0
01:00:24: PIM: Received v2 Hello on Serial1 from 192.168.1.2
01:00:24: PIM: Received v2 Hello on Serial0 from 192.168.0.2
01:00:24: PIM: Hello packet has unknown option 20, ignored
01:00:24: PIM: Send v2 Hello on Serial1
01:00:24: PIM: Received v2 Assert on Serial0 from 192.168.0.2
01:00:24: PIM: Assert metric to source 192.168.5.2 is [90/2198016]
01:00:24: PIM: We lose, our metric [90/20514560]
01:00:24: PIM: Prune Serial0/224.2.184.234 from (192.168.5.2/32, 224.2.184.234)
01:00:24: PIM: (192.168.5.2/32, 224.2.184.234) oif Serial0 in Prune state
01:00:24: PIM: Received v2 Assert on Serial0 from 192.168.0.2
01:00:24: PIM: Assert metric to source 192.168.5.2 is [90/2198016]
01:00:24: PIM: We lose, our metric [90/20514560]
01:00:24: PIM: Prune Serial0/224.2.231.192 from (192.168.5.2/32, 224.2.231.192)
01:00:24: PIM: (192.168.5.2/32, 224.2.231.192) oif Serial0 in Prune state
01:00:25: PIM: Send v2 Prune on Serial1 to 192.168.1.2 for (192.168.5.2/32, 224.2.184.234)
01:00:25: PIM: Send v2 Prune on Serial1 to 192.168.1.2 for (192.168.5.2/32, 224.2.231.192)
01:00:46: PIM: Send v2 Hello on FastEthernet0
01:00:51: PIM: Send v2 Hello on Serial0
01:00:54: PIM: Received v2 Hello on Serial1 from 192.168.1.2

```
01:00:54: PIM: Received v2 Hello on Serial0 from 192.168.0.2
01:00:54: PIM: Hello packet has unknown option 20, ignored
01:00:54: PIM: Send v2 Hello on Serial1
01:01:00: IGMP: Send v2 general Query on FastEthernet0
01:01:00: IGMP: Set report delay time to 9.2 seconds for 224.0.1.40 on FastEthernet0
01:01:10: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
01:01:10: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
01:01:10: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
01:01:10: IGMP: Updating EXCLUDE group timer for 224.0.1.40
01:01:16: PIM: Send v2 Hello on FastEthernet0
01:01:21: PIM: Send v2 Hello on Serial0
01:01:24: PIM: Received v2 Hello on Serial1 from 192.168.1.2
01:01:24: PIM: Received v2 Hello on Serial0 from 192.168.0.2
01:01:24: PIM: Hello packet has unknown option 20, ignored
01:01:24: PIM: Send v2 Hello on Serial1
```

```
Router_C#sh ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.184.234), 00:14:56/00:02:59, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:14:56/00:00:00
    Serial0, Forward/Dense, 00:14:56/00:00:00


(192.168.5.2, 224.2.184.234), 00:01:12/00:01:47, flags: PT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    Serial0, Prune/Dense, 00:01:12/00:01:47

(*, 224.2.231.192), 00:14:56/00:02:59, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
```

```
  Outgoing interface list:
    Serial1, Forward/Dense, 00:15:02/00:00:00
    Serial0, Forward/Dense, 00:15:02/00:00:00

(192.168.5.2, 224.2.231.192), 00:01:18/00:01:41, flags: PT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    Serial0, Prune/Dense, 00:01:18/00:01:41

(*, 224.0.1.40), 00:15:36/00:00:00, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:15:36/00:00:00
    Serial0, Forward/Dense, 00:15:36/00:00:00
    FastEthernet0, Forward/Dense, 00:15:36/00:00:00
```

Router_C#sh ip pim neighbor

```
PIM Neighbor Table
Neighbor          Interface              Uptime/Expires     Ver    DR
Address                                                             Prio/Mode
192.168.0.2       Serial0                01:03:12/00:01:38 v2     1 / S
192.168.1.2       Serial1                01:03:08/00:01:37 v2     1 / B S
```

Router_C#sh ip pim int

```
Address           Interface              Ver/    Nbr     Query   DR      DR
                                           Mode   Count   Intvl   Prior
192.168.4.1       FastEthernet0          v2/D    0       30      1       192.168.4.1
192.168.0.1       Serial0                v2/D    1       30      1       0.0.0.0
192.168.1.1       Serial1                v2/D    1       30      1       0.0.0.0
```

(2)**Router_B**

debug ip pim/igmp

```
*Mar  1 01:26:44.345: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar  1 01:26:44.520: IGMP(0): Received v2 Report on Ethernet0 from 192.168.2.1 for 224.0.1.40
*Mar  1 01:26:44.524: IGMP(0): Received Group record for group 224.0.1.40, mode 2 from 192.168.2.1 for 0 sources
*Mar  1 01:26:44.528: IGMP(0): Cancel report for 224.0.1.40 on Ethernet0
*Mar  1 01:26:44.532: IGMP(0): MRT Add/Update Ethernet0 for (*,224.0.1.40) by 0
*Mar  1 01:26:44.536: IGMP(0): Updating EXCLUDE group timer for 224.0.1.40
*Mar  1 01:26:45.524: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar  1 01:26:52.087: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
```

*Mar 1 01:26:53.321: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:27:14.157: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:27:15.530: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:27:22.180: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:27:23.093: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:27:41.528: IGMP(0): Received v2 Query on Ethernet0 from 192.168.2.1
*Mar 1 01:27:41.532: IGMP(0): Set report delay time to 4.4 seconds for 224.0.1.40 on Ethernet0
*Mar 1 01:27:43.528: IGMP(0): Received v2 Report on Ethernet0 from 192.168.2.1 for 224.0.1.40
*Mar 1 01:27:43.532: IGMP(0): Received Group record for group 224.0.1.40, mode 2 from 192.168.2.1 for 0 sources
*Mar 1 01:27:43.536: IGMP(0): Cancel report for 224.0.1.40 on Ethernet0
Mar 1 01:27:43.540: IGMP(0): MRT Add/Update Ethernet0 for (,224.0.1.40) by 0
*Mar 1 01:27:43.544: IGMP(0): Updating EXCLUDE group timer for 224.0.1.40
*Mar 1 01:27:43.940: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:27:45.544: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:27:52.178: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:27:52.932: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:28:13.907: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:28:15.546: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:28:22.263: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:28:22.847: PIM(0): Send periodic v2 Hello on Serial0
*Mar 1 01:28:41.548: IGMP(0): Received v2 Query on Ethernet0 from 192.168.2.1
*Mar 1 01:28:41.548: IGMP(0): Set report delay time to 3.2 seconds for 224.0.1.40 on Ethernet0
*Mar 1 01:28:43.699: PIM(0): Send periodic v2 Hello on Ethernet0
*Mar 1 01:28:45.571: PIM(0): Received v2 Hello on Ethernet0 from 192.168.2.1
*Mar 1 01:28:45.683: IGMP(0): Send v2 Report for 224.0.1.40 on Ethernet0
*Mar 1 01:28:45.687: IGMP(0): Received v2 Report on Ethernet0 from 192.168.2.2 for 224.0.1.40
*Mar 1 01:28:45.690: IGMP(0): Received Group record for group 224.0.1.40, mode 2 from 192.168.2.2 for 0 sources
Mar 1 01:28:45.694: IGMP(0): MRT Add/Update Ethernet0 for (,224.0.1.40) by 0
*Mar 1 01:28:45.698: IGMP(0): Updating EXCLUDE group timer for 224.0.1.40
*Mar 1 01:28:52.269: PIM(0): Received v2 Hello on Serial0 from 192.168.3.1
*Mar 1 01:28:52.666: PIM(0): Send periodic v2 Hello on Serial0

RouterB#show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
    L - Local, P - Pruned, R - RP-bit set, F - Register flag,
    T - SPT-bit set, J - Join SPT, M - MSDP created entry,
    X - Proxy Join Timer Running, A - Candidate MSDP Advertisement,

U - URD, I - Received Source Specific Host Report, Z - Multicast Tunnel
Y - Joined MDT-data group, y - Sending to MDT-data group
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.1.40), 01:29:23/00:02:50, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0, Forward/Dense, 01:06:39/00:00:00
Ethernet0, Forward/Dense, 01:29:23/00:00:00

(*, 224.2.231.192), 00:07:16/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0, Forward/Dense, 00:07:16/00:00:00
Ethernet0, Forward/Dense, 00:07:16/00:00:00

(192.168.5.2, 224.2.231.192), 00:04:11/00:02:53, flags: T
Incoming interface: Ethernet0, RPF nbr 192.168.2.1
Outgoing interface list:
Serial0, Forward/Dense, 00:04:11/00:00:00

(*, 224.2.184.234), 00:07:17/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0, Forward/Dense, 00:07:18/00:00:00
Ethernet0, Forward/Dense, 00:07:18/00:00:00

(192.168.5.2, 224.2.184.234), 00:04:12/00:02:54, flags: T
Incoming interface: Ethernet0, RPF nbr 192.168.2.1
Outgoing interface list:
Serial0, Forward/Dense, 00:04:12/00:00:00

(3) **Router_A**

RouterA#u all
All possible debugging has been turned off
RouterA#show ip m
01:27:41: PIM: Send v2 Hello on FastEthernet0/1route
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry,

```
        X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
        U - URD, I - Received Source Specific Host Report, s - SSM
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.184.234), 00:04:43/00:02:59, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0/1, Forward/Dense, 00:04:43/00:00:00
    FastEthernet0/0, Forward/Dense, 00:04:43/00:00:00

(192.168.5.2, 224.2.184.234), 00:04:43/00:02:59, flags: T
  Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
  Outgoing interface list:
    FastEthernet0/0, Forward/Dense, 00:01:38/00:00:00
    Serial0/1, Prune/Dense, 00:01:41/00:01:18

(*, 224.2.231.192), 00:04:44/00:02:59, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0/1, Forward/Dense, 00:04:45/00:00:00
    FastEthernet0/0, Forward/Dense, 00:04:45/00:00:00

(192.168.5.2, 224.2.231.192), 00:04:45/00:02:59, flags: T
  Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
  Outgoing interface list:
    FastEthernet0/0, Forward/Dense, 00:01:40/00:00:00
    Serial0/1, Prune/Dense, 00:01:43/00:01:16

(*, 224.0.1.40), 00:26:42/00:00:00, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0/1, Forward/Dense, 00:26:42/00:00:00
    FastEthernet0/0, Forward/Dense, 00:26:42/00:00:00

RouterA#

1:36:10: IGMP: MRT Add/Update FastEthernet0/0 for (*,224.0.1.40) by 0
01:36:10: IGMP: Updating EXCLUDE group timer for 224.0.1.40
01:36:11: PIM: Send v2 Hello on FastEthernet0/1
01:36:30: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
01:36:30: PIM: Hello packet has unknown option 20, ignored
01:36:33: PIM: Send v2 Hello on Serial0/1
```

01:36:33: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
01:36:35: PIM: Send v2 Hello on FastEthernet0/0
01:36:41: PIM: Send v2 Hello on FastEthernet0/1
01:37:00: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
01:37:00: PIM: Hello packet has unknown option 20, ignored
01:37:01: IGMP: Send v2 general Query on FastEthernet0/0
01:37:01: IGMP: Set report delay time to 4.0 seconds for 224.0.1.40 on FastEthernet0/0
01:37:02: IGMP: Send v2 general Query on FastEthernet0/1
01:37:03: PIM: Send v2 Hello on Serial0/1
01:37:03: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
01:37:04: IGMP: Received v2 Report on FastEthernet0/0 from 192.168.2.2 for 224.0.1.40
01:37:04: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.2.2 for 0 sources
01:37:04: IGMP: Cancel report for 224.0.1.40 on FastEthernet0/0
01:37:04: IGMP: MRT Add/Update FastEthernet0/0 for (*,224.0.1.40) by 0
01:37:04: IGMP: Updating EXCLUDE group timer for 224.0.1.40
01:37:05: PIM: Send v2 Hello on FastEthernet0/0
01:37:11: PIM: Send v2 Hello on FastEthernet0/1
01:37:29: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
01:37:29: PIM: Hello packet has unknown option 20, ignored
01:37:33: PIM: Send v2 Hello on Serial0/1
01:37:33: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
01:37:35: PIM: Send v2 Hello on FastEthernet0/0
01:37:41: PIM: Send v2 Hello on FastEthernet0/1
01:37:59: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
01:37:59: PIM: Hello packet has unknown option 20, ignored
01:38:01: IGMP: Send v2 general Query on FastEthernet0/0
01:38:01: IGMP: Set report delay time to 5.2 seconds for 224.0.1.40 on FastEthernet0/0
01:38:02: IGMP: Send v2 general Query on FastEthernet0/1
01:38:03: PIM: Send v2 Hello on Serial0/1
01:38:03: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
01:38:05: PIM: Send v2 Hello on FastEthernet0/0
01:38:05: IGMP: Received v2 Report on FastEthernet0/0 from 192.168.2.2 for 224.0.1.40
01:38:05: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.2.2 for 0 sources
01:38:05: IGMP: Cancel report for 224.0.1.40 on FastEthernet0/0
01:38:05: IGMP: MRT Add/Update FastEthernet0/0 for (*,224.0.1.40) by 0
01:38:05: IGMP: Updating EXCLUDE group timer for 224.0.1.40
01:38:06: PIM: Received v2 Join/Prune on Serial0/1 from 192.168.1.1, to us
01:38:06: PIM: Prune-list: (192.168.5.2/32, 224.2.184.234)
01:38:06: PIM: Prune Serial0/1/224.2.184.234 from (192.168.5.2/32, 224.2.184.234)
01:38:06: PIM: Received v2 Join/Prune on Serial0/1 from 192.168.1.1, to us
01:38:06: PIM: Prune-list: (192.168.5.2/32, 224.2.231.192)
01:38:06: PIM: Prune Serial0/1/224.2.231.192 from (192.168.5.2/32, 224.2.231.192)

01:38:11: PIM: Send v2 Hello on FastEthernet0/1
01:38:29: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
01:38:29: PIM: Hello packet has unknown option 20, ignored
01:38:33: PIM: Send v2 Hello on Serial0/1
01:38:33: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
01:38:35: PIM: Send v2 Hello on FastEthernet0/0

///server on , client on
//

(1) Router_C

Debug ip igmp

03:51:58: IGMP: Received Leave from 192.168.4.2 (FastEthernet0) for 224.2.169.22
03:51:58: IGMP: Received Group record for group 224.2.169.22, mode 3 from 192.168.4.2 for 0 sources
03:51:58: IGMP: Lower expiration timer to 1 seconds for 224.2.169.22 on FastEthernet0
03:51:58: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
03:51:59: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
03:52:00: IGMP: Switching to INCLUDE mode for 224.2.169.22 on FastEthernet0
03:52:00: IGMP: Deleting FastEthernet0 from (192.168.5.2,224.2.169.22) olist (no PIM joins active)
03:52:03: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.2 for 224.2.169.22
03:52:03: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.4.2 for 0 sources
03:52:03: IGMP: Switching to EXCLUDE mode for 224.2.169.22 on FastEthernet0
03:52:03: IGMP: Updating EXCLUDE group timer for 224.2.169.22
03:52:05: IGMP: Send v2 general Query on FastEthernet0
03:52:05: IGMP: Set report delay time to 5.8 seconds for 224.0.1.40 on FastEthernet0
03:52:08: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.2 for 224.2.169.22
03:52:08: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.4.2 for 0 sources
03:52:08: IGMP: Updating EXCLUDE group timer for 224.2.169.22
03:52:11: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
03:52:11: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
03:52:11: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0 sources
03:52:11: IGMP: Updating EXCLUDE group timer for 224.0.1.40

Router_C#sh ip mrou
IP Multicast Routing Table

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.169.22), 00:00:42/00:02:59, RP 0.0.0.0, flags: DC
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:00:42/00:00:00
    Serial0, Forward/Dense, 00:00:42/00:00:00
    FastEthernet0, Forward/Dense, 00:00:42/00:00:00

(192.168.5.2, 224.2.169.22), 00:00:29/00:02:59, flags: CT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    FastEthernet0, Forward/Dense, 00:00:29/00:00:00
    Serial0, Prune/Dense, 00:00:29/00:02:30

(*, 224.0.1.40), 00:00:59/00:00:00, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:00:59/00:00:00
    Serial0, Forward/Dense, 00:00:59/00:00:00
    FastEthernet0, Forward/Dense, 00:00:59/00:00:00

(*, 224.2.80.80), 00:00:31/00:02:59, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:00:31/00:00:00
    Serial0, Forward/Dense, 00:00:31/00:00:00

(192.168.5.2, 224.2.80.80), 00:00:31/00:02:28, flags: PT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
Serial0, Prune/Dense, 00:00:31/00:02:22
```

Debug ip pim

```
04:08:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
04:08:40: PIM: Hello packet has unknown option 20, ignored
```

04:08:41: PIM: Building Graft message for 224.0.1.40, Serial1: no entries
04:08:41: PIM: Building Graft message for 224.0.1.40, Serial0: no entries
04:08:41: PIM: Building Graft message for 224.0.1.40, FastEthernet0: no entries
04:08:42: PIM: Received v2 Assert on Serial0 from 192.168.0.2
04:08:42: PIM: Assert metric to source 192.168.5.2 is [90/2198016]
04:08:42: PIM: We lose, our metric [90/20514560]
04:08:42: PIM: Prune Serial0/224.2.169.22 from (192.168.5.2/32, 224.2.169.22)
04:08:42: PIM: (192.168.5.2/32, 224.2.169.22) oif Serial0 in Prune state
04:08:51: PIM: Send v2 Hello on FastEthernet0
04:08:56: PIM: Send v2 Hello on Serial0
04:08:58: PIM: Received v2 Hello on Serial1 from 192.168.1.2
04:08:59: PIM: Send v2 Hello on Serial1
04:09:10: PIM: Received v2 Hello on Serial0 from 192.168.0.2
04:09:10: PIM: Hello packet has unknown option 20, ignored
04:09:21: PIM: Send v2 Hello on FastEthernet0
04:09:26: PIM: Send v2 Hello on Serial0
04:09:28: PIM: Received v2 Hello on Serial1 from 192.168.1.2
04:09:29: PIM: Send v2 Hello on Serial1
04:09:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
04:09:40: PIM: Hello packet has unknown option 20, ignored
04:09:51: PIM: Send v2 Hello on FastEthernet0
04:09:56: PIM: Send v2 Hello on Serial0
04:09:58: PIM: Received v2 Hello on Serial1 from 192.168.1.2
04:09:59: PIM: Send v2 Hello on Serial1
04:10:09: PIM: Send v2 Prune on Serial1 to 192.168.1.2 for (192.168.5.2/32, 224.2.169.22)
04:10:11: PIM: Received v2 Hello on Serial0 from 192.168.0.2
04:10:11: PIM: Hello packet has unknown option 20, ignored
//
client 停止时候的信息

04:00:01: IGMP: Received Leave from 192.168.4.2 (FastEthernet0) for 224.2.169.22
04:00:01: IGMP: Received Group record for group 224.2.169.22, mode 3 from 192.168.4.2 for 0 sources
04:00:01: IGMP: Lower expiration timer to 1 seconds for 224.2.169.22 on FastEthernet0
04:00:01: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
04:00:03: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
04:00:03: IGMP: Switching to INCLUDE mode for 224.2.169.22 on FastEthernet0
04:00:03: IGMP: Deleting FastEthernet0 from (192.168.5.2,224.2.169.22) olist (no PIM joins active)
04:00:05: IGMP: Send v2 general Query on FastEthernet0
04:00:05: IGMP: Set report delay time to 1.8 seconds for 224.0.1.40 on FastEthernet0
04:00:07: IGMP: Send v2 Report for 224.0.1.40 on FastEthernet0
04:00:07: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.1 for 224.0.1.40
04:00:07: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.4.1 for 0

sources
04:00:07: IGMP: Updating EXCLUDE group timer for 224.0.1.40

```
Router_C#sh ip mrou
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.169.22), 00:02:25/00:02:59, RP 0.0.0.0, flags: DC
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:02:25/00:00:00
    Serial0, Forward/Dense, 00:02:25/00:00:00
    FastEthernet0, Forward/Dense, 00:02:25/00:00:00

(192.168.5.2, 224.2.169.22), 00:02:12/00:02:59, flags: CT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    FastEthernet0, Forward/Dense, 00:02:12/00:00:00
    Serial0, Prune/Dense, 00:02:12/00:00:47

(*, 224.0.1.40), 00:02:42/00:00:00, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:02:42/00:00:00
    Serial0, Forward/Dense, 00:02:42/00:00:00
    FastEthernet0, Forward/Dense, 00:02:42/00:00:00

(*, 224.2.80.80), 00:02:14/00:02:59, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1, Forward/Dense, 00:02:14/00:00:00
    Serial0, Forward/Dense, 00:02:14/00:00:00
```

```
(192.168.5.2, 224.2.80.80), 00:02:14/00:00:45, flags: PT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    Serial0, Prune/Dense, 00:02:14/00:00:45
```

(2) **Router_A**

```
04:20:04: IGMP: Send v2 general Query on FastEthernet0/0
04:20:04: IGMP: Set report delay time to 3.6 seconds for 224.0.1.40 on FastEthernet0/0
04:20:05: IGMP: Send v2 general Query on FastEthernet0/1
04:20:07: IGMP: Received v2 Report on FastEthernet0/0 from 192.168.2.2 for 224.0.1.40
04:20:07: IGMP: Received Group record for group 224.0.1.40, mode 2 from 192.168.2.2 for 0 sources
04:20:07: IGMP: Cancel report for 224.0.1.40 on FastEthernet0/0
04:20:07: IGMP: MRT Add/Update FastEthernet0/0 for (*,224.0.1.40) by 0
04:20:07: IGMP: Updating EXCLUDE group timer for 224.0.1.40
04:20:14: IGMP: Received v2 Report on FastEthernet0/1 from 192.168.5.2 for 224.2.169.22
04:20:14: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.5.2 for 0 sources
04:20:14: IGMP: MRT Add/Update FastEthernet0/1 for (*,224.2.169.22) by 0
04:20:14: IGMP: Updating EXCLUDE group timer for 224.2.169.22

RouterA#show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, s - SSM
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.169.22), 00:12:52/00:02:59, RP 0.0.0.0, flags: DC
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    FastEthernet0/1, Forward/Dense, 00:11:05/00:00:00
    Serial0/1, Forward/Dense, 00:12:52/00:00:00
    FastEthernet0/0, Forward/Dense, 00:12:52/00:00:00

(192.168.5.2, 224.2.169.22), 00:12:52/00:02:59, flags: CT
  Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
```

```
    Outgoing interface list:
      FastEthernet0/0, Forward/Dense, 00:00:30/00:00:00
      Serial0/1, Prune/Dense, 00:01:46/00:01:14

(*, 224.0.1.40), 02:04:54/00:00:00, RP 0.0.0.0, flags: DCL
    Incoming interface: Null, RPF nbr 0.0.0.0
    Outgoing interface list:
      Serial0/1, Forward/Dense, 02:04:54/00:00:00
      FastEthernet0/0, Forward/Dense, 02:04:54/00:00:00

(*, 224.2.141.141), 00:50:17/00:02:59, RP 0.0.0.0, flags: D
    Incoming interface: Null, RPF nbr 0.0.0.0
    Outgoing interface list:
      Serial0/1, Forward/Dense, 00:50:17/00:00:00
      FastEthernet0/0, Forward/Dense, 00:50:17/00:00:00

(192.168.5.2, 224.2.141.141), 00:50:17/00:02:59, flags: T
    Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
    Outgoing interface list:
      FastEthernet0/0, Forward/Dense, 00:47:12/00:00:00
      Serial0/1, Prune/Dense, 00:01:57/00:01:02
```

//
/////////enable cgmp (for Router_A &Switch)
//

```
Switch#show mac
Dynamic Address Count:                      2
Secure Address Count:                       0
Static Address (User-defined) Count:        0
System Self Address Count:                  49
Total MAC addresses:                        51
Maximum MAC addresses:                      2048
Non-static Address Table:
Destination Address    Address Type    VLAN    Destination Port
-------------------    ------------    ----    --------------------
0007.5081.a001         Dynamic            1    FastEthernet0/16
00e0.4c43.7b20         Dynamic            1    FastEthernet0/15


Switch#show mac-address-table
Dynamic Address Count:                      2
Secure Address Count:                       0
Static Address (User-defined) Count:        1
```

```
System Self Address Count:                    49
Total MAC addresses:                          52
Maximum MAC addresses:                        2048
Non-static Address Table:
Destination Address    Address Type    VLAN    Destination Port
-------------------    ------------    ----    --------------------
0007.5081.a001         Dynamic            1    FastEthernet0/16
00e0.4c43.7b20         Dynamic            1    FastEthernet0/15

Static Address Table:
Destination Address     VLAN    Input Port    Output Ports
-------------------     ----    ----------    -----------------------
0100.5e02.5050             1    Fa0/1         Fa0/15 Fa0/16
                           1    Fa0/2         Fa0/15 Fa0/16
                           1    Fa0/3         Fa0/15 Fa0/16
                           1    Fa0/4         Fa0/15 Fa0/16
                           1    Fa0/5         Fa0/15 Fa0/16
                           1    Fa0/6         Fa0/15 Fa0/16
                           1    Fa0/7         Fa0/15 Fa0/16
                           1    Fa0/8         Fa0/15 Fa0/16
                           1    Fa0/9         Fa0/15 Fa0/16
                           1    Fa0/10        Fa0/15 Fa0/16
                           1    Fa0/11        Fa0/15 Fa0/16
                           1    Fa0/12        Fa0/15 Fa0/16
                           1    Fa0/13        Fa0/15 Fa0/16
                           1    Fa0/14        Fa0/15 Fa0/16
                           1    Fa0/15        Fa0/16
                           1    Fa0/16        Fa0/15
                           1    Fa0/17        Fa0/15 Fa0/16
                           1    Fa0/18        Fa0/15 Fa0/16
                           1    Fa0/19        Fa0/15 Fa0/16
                           1    Fa0/20        Fa0/15 Fa0/16
                           1    Fa0/21        Fa0/15 Fa0/16
                           1    Fa0/22        Fa0/15 Fa0/16
                           1    Fa0/23        Fa0/15 Fa0/16
                           1    Fa0/24        Fa0/15 Fa0/16
Switch#

Switch#show mac-address-table
Dynamic Address Count:                        3
Secure Address Count:                         0
Static Address (User-defined) Count:     2
System Self Address Count:                    49
Total MAC addresses:                          54
```

Maximum MAC addresses: 2048

Non-static Address Table:

Destination Address	Address Type	VLAN	Destination Port
-------------------	------------	----	--------------------
0007.5081.a001	Dynamic	1	FastEthernet0/16
00e0.4c43.5a00	Dynamic	1	FastEthernet0/13
00e0.4c43.7b20	Dynamic	1	FastEthernet0/15

Static Address Table:

Destination Address	VLAN	Input Port	Output Ports
-------------------	----	----------	-----------------------
0100.5e02.5050	1	Fa0/1	Fa0/15 Fa0/16
	1	Fa0/2	Fa0/15 Fa0/16
	1	Fa0/3	Fa0/15 Fa0/16
	1	Fa0/4	Fa0/15 Fa0/16
	1	Fa0/5	Fa0/15 Fa0/16
	1	Fa0/6	Fa0/15 Fa0/16
	1	Fa0/7	Fa0/15 Fa0/16
	1	Fa0/8	Fa0/15 Fa0/16
	1	Fa0/9	Fa0/15 Fa0/16
	1	Fa0/10	Fa0/15 Fa0/16
	1	Fa0/11	Fa0/15 Fa0/16
	1	Fa0/12	Fa0/15 Fa0/16
	1	Fa0/13	Fa0/15 Fa0/16
	1	Fa0/14	Fa0/15 Fa0/16
	1	Fa0/15	Fa0/16
	1	Fa0/16	Fa0/15
	1	Fa0/17	Fa0/15 Fa0/16
	1	Fa0/18	Fa0/15 Fa0/16
	1	Fa0/19	Fa0/15 Fa0/16
	1	Fa0/20	Fa0/15 Fa0/16
	1	Fa0/21	Fa0/15 Fa0/16
	1	Fa0/22	Fa0/15 Fa0/16
	1	Fa0/23	Fa0/15 Fa0/16
	1	Fa0/24	Fa0/15 Fa0/16
0100.5e02.a916	1	Fa0/1	Fa0/13 Fa0/16
	1	Fa0/2	Fa0/13 Fa0/16
	1	Fa0/3	Fa0/13 Fa0/16
	1	Fa0/4	Fa0/13 Fa0/16
	1	Fa0/5	Fa0/13 Fa0/16
	1	Fa0/6	Fa0/13 Fa0/16
	1	Fa0/7	Fa0/13 Fa0/16
	1	Fa0/8	Fa0/13 Fa0/16
	1	Fa0/9	Fa0/13 Fa0/16

```
                              1    Fa0/10          Fa0/13 Fa0/16
                              1    Fa0/11          Fa0/13 Fa0/16
                              1    Fa0/12          Fa0/13 Fa0/16
                              1    Fa0/13          Fa0/16
                              1    Fa0/14          Fa0/13 Fa0/16
                              1    Fa0/15          Fa0/13 Fa0/16
                              1    Fa0/16          Fa0/13
                              1    Fa0/17          Fa0/13 Fa0/16
                              1    Fa0/18          Fa0/13 Fa0/16
                              1    Fa0/19          Fa0/13 Fa0/16
                              1    Fa0/20          Fa0/13 Fa0/16
                              1    Fa0/21          Fa0/13 Fa0/16
                              1    Fa0/22          Fa0/13 Fa0/16
                              1    Fa0/23          Fa0/13 Fa0/16
                              1    Fa0/24          Fa0/13 Fa0/16
Switch#show mac-address-table
Dynamic Address Count:                        3
Secure Address Count:                         0
Static Address (User-defined) Count:     2
System Self Address Count:                   49
Total MAC addresses:                          54
Maximum MAC addresses:                        2048
Non-static Address Table:
Destination Address    Address Type    VLAN    Destination Port
-------------------    ------------    ----    --------------------
0007.5081.a001           Dynamic              1    FastEthernet0/16
00e0.4c43.5a00           Dynamic              1    FastEthernet0/13
00e0.4c43.7b20           Dynamic              1    FastEthernet0/15

Static Address Table:
Destination Address     VLAN    Input Port    Output Ports
-------------------     ----    ----------    ----------------------
0100.5e02.5050                1    Fa0/1           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/2           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/3           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/4           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/5           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/6           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/7           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/8           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/9           Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/10          Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/11          Fa0/13 Fa0/15 Fa0/16
                              1    Fa0/12          Fa0/13 Fa0/15 Fa0/16
```

```
                        1    Fa0/13          Fa0/15 Fa0/16
                        1    Fa0/14          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/15          Fa0/13 Fa0/16
                        1    Fa0/16          Fa0/13 Fa0/15
                        1    Fa0/17          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/18          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/19          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/20          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/21          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/22          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/23          Fa0/13 Fa0/15 Fa0/16
                        1    Fa0/24          Fa0/13 Fa0/15 Fa0/16
0100.5e02.a916          1    Fa0/1           Fa0/16
                        1    Fa0/2           Fa0/16
                        1    Fa0/3           Fa0/16
                        1    Fa0/4           Fa0/16
                        1    Fa0/5           Fa0/16
                        1    Fa0/6           Fa0/16
                        1    Fa0/7           Fa0/16
                        1    Fa0/8           Fa0/16
                        1    Fa0/9           Fa0/16
                        1    Fa0/10          Fa0/16
                        1    Fa0/11          Fa0/16
                        1    Fa0/12          Fa0/16
                        1    Fa0/13          Fa0/16
                        1    Fa0/14          Fa0/16
                        1    Fa0/15          Fa0/16
                        1    Fa0/16
                        1    Fa0/17          Fa0/16
                        1    Fa0/18          Fa0/16
                        1    Fa0/19          Fa0/16
                        1    Fa0/20          Fa0/16
                        1    Fa0/21          Fa0/16
                        1    Fa0/22          Fa0/16
                        1    Fa0/23          Fa0/16
                        1    Fa0/24          Fa0/16
Switch#


Switch# debug cgmp
CGMP debugging is on
Switch#
05:08:31: CGMP: Rx Host (00e0.4c43.7b20) Join for group 0100.5e02.5050 on Fa0/16, vlan 1
05:08:31: CGMP: Host 00e0.4c43.7b20 on Fa0/15, vlan 1 Joined group 0100.5e02.5050
```

05:08:38: CGMP: Rx Router (0007.5081.a001) Join on Fa0/16, vlan 1

RouterA#debug ip cgmp
CGMP debugging is on
RouterA#
05:11:40: CGMP: Received IGMP Report on FastEthernet0/1
05:11:40: from 192.168.5.2 for 224.2.80.80
05:11:40: CGMP: Sending Join on FastEthernet0/1
05:11:40: GDA 0100.5e02.5050, USA 00e0.4c43.7b20
05:11:45: CGMP: Sending self Join on FastEthernet0/1
05:11:45: GDA 0000.0000.0000, USA 0007.5081.a001
05:12:08: CGMP: Received IGMP Report on FastEthernet0/1
05:12:08: from 192.168.5.28 for 224.2.80.80
05:12:08: CGMP: Sending Join on FastEthernet0/1
05:12:08: GDA 0100.5e02.5050, USA 00e0.4c43.5a00
//
/////////pim sparse mode
//

(1) Router_C

```
Router_C#sh ip mrou
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.169.22), 00:00:31/00:02:59, RP 10.10.10.10, flags: SJC
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    FastEthernet0, Forward/Sparse-Dense, 00:00:31/00:02:30

(192.168.5.2, 224.2.169.22), 00:00:30/00:02:59, flags: CJT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    FastEthernet0, Forward/Sparse-Dense, 00:00:30/00:02:30

(*, 224.0.1.39), 00:02:04/00:02:59, RP 0.0.0.0, flags: D
```

```
    Incoming interface: Null, RPF nbr 0.0.0.0
    Outgoing interface list:
        Serial1, Forward/Sparse-Dense, 00:02:04/00:00:00
        Serial0, Forward/Sparse-Dense, 00:02:05/00:00:00

(10.10.10.10, 224.0.1.39), 00:02:05/00:01:54, flags: PT
    Incoming interface: Serial1, RPF nbr 192.168.1.2
    Outgoing interface list:
        Serial0, Prune/Sparse-Dense, 00:01:05/00:01:54

(*, 224.0.1.40), 00:02:36/00:00:00, RP 0.0.0.0, flags: DCL
    Incoming interface: Null, RPF nbr 0.0.0.0
    Outgoing interface list:
        Serial1, Forward/Sparse-Dense, 00:02:36/00:00:00
        Serial0, Forward/Sparse-Dense, 00:02:37/00:00:00

(192.168.2.2, 224.0.1.40), 00:02:08/00:02:50, flags: PCLT
    Incoming interface: Serial1, RPF nbr 192.168.1.2
    Outgoing interface list:
        Serial0, Prune/Sparse-Dense, 00:02:08/00:00:51

(192.168.3.2, 224.0.1.40), 00:02:08/00:02:50, flags: CLT
    Incoming interface: Serial0, RPF nbr 192.168.0.2
    Outgoing interface list:
        Serial1, Forward/Sparse-Dense, 00:02:08/00:00:00

(*, 224.2.80.80), 00:01:24/00:02:44, RP 10.10.10.10, flags: SJP
    Incoming interface: Serial1, RPF nbr 192.168.1.2
    Outgoing interface list: Null

(192.168.5.2, 224.2.80.80), 00:01:24/00:02:25, flags: PJT
    Incoming interface: Serial1, RPF nbr 192.168.1.2
    Outgoing interface list: Null

Router_C#
06:41:18: PIM: Building Graft message for 224.0.1.40, Serial1: no entries
06:41:18: PIM: Building Graft message for 224.0.1.40, Serial0: no entries
06:41:18: PIM: Check RP 10.10.10.10 into the (*, 224.2.169.22) entry
06:41:19: PIM: Send v2 Join on Serial1 to 192.168.1.2 for (192.168.5.2/32, 224.2.169.22), S-bit
06:41:24: PIM: Send v2 Hello on FastEthernet0
06:41:36: PIM: Send v2 Hello on Serial0
06:41:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:41:40: PIM: Hello packet has unknown option 20, ignored
06:41:40: PIM: Send v2 Hello on Serial1
```

06:41:40: PIM: Received v2 Assert on Serial0 from 192.168.0.2
06:41:40: PIM: Assert metric to source 192.168.2.2 is [90/2195456]
06:41:40: PIM: We lose, our metric [90/20537600]
06:41:40: PIM: Prune Serial0/224.0.1.40 from (192.168.2.2/32, 224.0.1.40)
06:41:40: PIM: (192.168.2.2/32, 224.0.1.40) oif Serial0 in Prune state
06:41:40: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:41:54: PIM: Send v2 Hello on FastEthernet0
06:42:06: PIM: Send v2 Hello on Serial0
06:42:10: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:42:10: PIM: Hello packet has unknown option 20, ignored
06:42:10: PIM: Send v2 Hello on Serial1
06:42:10: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:42:18: PIM: Building Join/Prune message for 224.2.169.22
06:42:18: PIM: v2, for RP, Join-list: 10.10.10.10/32, RP-bit, WC-bit, S-bit
06:42:18: PIM: v2, for RP, Join-list 192.168.5.2/32
06:42:18: PIM: Send v2 periodic Join/Prune to RP via 192.168.1.2 (Serial1)
06:42:21: PIM: Received RP-Reachable on Serial1 from 10.10.10.10
06:42:21: for group 224.2.169.22
06:42:21: PIM: Update RP expiration timer (270 sec) for 224.2.169.22
06:42:24: PIM: Send v2 Hello on FastEthernet0
06:42:36: PIM: Send v2 Hello on Serial0
06:42:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:42:40: PIM: Hello packet has unknown option 20, ignored
06:42:40: PIM: Send v2 Hello on Serial1
06:42:40: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:42:54: PIM: Send v2 Hello on FastEthernet0
06:43:06: PIM: Send v2 Hello on Serial0
06:43:10: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:43:10: PIM: Hello packet has unknown option 20, ignored
06:43:10: PIM: Send v2 Hello on Serial1
06:43:10: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:43:17: PIM: Building Join/Prune message for 224.2.169.22
06:43:17: PIM: v2, for RP, Join-list: 10.10.10.10/32, RP-bit, WC-bit, S-bit
06:43:17: PIM: v2, for RP, Join-list 192.168.5.2/32
06:43:17: PIM: Send v2 periodic Join/Prune to RP via 192.168.1.2 (Serial1)
06:43:24: PIM: Send v2 Hello on FastEthernet0
06:43:36: PIM: Send v2 Hello on Serial0
06:43:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:43:40: PIM: Hello packet has unknown option 20, ignored
06:43:40: PIM: Send v2 Hello on Serial1
06:43:40: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:43:52: PIM: Received RP-Reachable on Serial1 from 10.10.10.10
06:43:52: for group 224.2.169.22
06:43:52: PIM: Update RP expiration timer (270 sec) for 224.2.169.22

06:43:54: PIM: Send v2 Hello on FastEthernet0Router_C#
06:41:18: PIM: Building Graft message for 224.0.1.40, Serial1: no entries
06:41:18: PIM: Building Graft message for 224.0.1.40, Serial0: no entries
06:41:18: PIM: Check RP 10.10.10.10 into the (*, 224.2.169.22) entry
06:41:19: PIM: Send v2 Join on Serial1 to 192.168.1.2 for (192.168.5.2/32, 224.2.169.22), S-bit
06:41:24: PIM: Send v2 Hello on FastEthernet0
06:41:36: PIM: Send v2 Hello on Serial0
06:41:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:41:40: PIM: Hello packet has unknown option 20, ignored
06:41:40: PIM: Send v2 Hello on Serial1
06:41:40: PIM: Received v2 Assert on Serial0 from 192.168.0.2
06:41:40: PIM: Assert metric to source 192.168.2.2 is [90/2195456]
06:41:40: PIM: We lose, our metric [90/20537600]
06:41:40: PIM: Prune Serial0/224.0.1.40 from (192.168.2.2/32, 224.0.1.40)
06:41:40: PIM: (192.168.2.2/32, 224.0.1.40) oif Serial0 in Prune state
06:41:40: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:41:54: PIM: Send v2 Hello on FastEthernet0
06:42:06: PIM: Send v2 Hello on Serial0
06:42:10: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:42:10: PIM: Hello packet has unknown option 20, ignored
06:42:10: PIM: Send v2 Hello on Serial1
06:42:10: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:42:18: PIM: Building Join/Prune message for 224.2.169.22
06:42:18: PIM: v2, for RP, Join-list: 10.10.10.10/32, RP-bit, WC-bit, S-bit
06:42:18: PIM: v2, for RP, Join-list 192.168.5.2/32
06:42:18: PIM: Send v2 periodic Join/Prune to RP via 192.168.1.2 (Serial1)
06:42:21: PIM: Received RP-Reachable on Serial1 from 10.10.10.10
06:42:21: for group 224.2.169.22
06:42:21: PIM: Update RP expiration timer (270 sec) for 224.2.169.22
06:42:24: PIM: Send v2 Hello on FastEthernet0
06:42:36: PIM: Send v2 Hello on Serial0
06:42:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:42:40: PIM: Hello packet has unknown option 20, ignored
06:42:40: PIM: Send v2 Hello on Serial1
06:42:40: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:42:54: PIM: Send v2 Hello on FastEthernet0
06:43:06: PIM: Send v2 Hello on Serial0
06:43:10: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:43:10: PIM: Hello packet has unknown option 20, ignored
06:43:10: PIM: Send v2 Hello on Serial1
06:43:10: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:43:17: PIM: Building Join/Prune message for 224.2.169.22
06:43:17: PIM: v2, for RP, Join-list: 10.10.10.10/32, RP-bit, WC-bit, S-bit
06:43:17: PIM: v2, for RP, Join-list 192.168.5.2/32

06:43:17: PIM: Send v2 periodic Join/Prune to RP via 192.168.1.2 (Serial1)
06:43:24: PIM: Send v2 Hello on FastEthernet0
06:43:36: PIM: Send v2 Hello on Serial0
06:43:40: PIM: Received v2 Hello on Serial0 from 192.168.0.2
06:43:40: PIM: Hello packet has unknown option 20, ignored
06:43:40: PIM: Send v2 Hello on Serial1
06:43:40: PIM: Received v2 Hello on Serial1 from 192.168.1.2
06:43:52: PIM: Received RP-Reachable on Serial1 from 10.10.10.10
06:43:52: for group 224.2.169.22
06:43:52: PIM: Update RP expiration timer (270 sec) for 224.2.169.22
06:43:54: PIM: Send v2 Hello on FastEthernet0

IGMP debugging is on
Router_C#
06:46:06: IGMP: Received Leave from 192.168.4.2 (FastEthernet0) for 224.2.169.22
06:46:06: IGMP: Received Group record for group 224.2.169.22, mode 3 from 192.168.4.2 for 0 sources
06:46:06: IGMP: Lower expiration timer to 1 seconds for 224.2.169.22 on FastEthernet0
06:46:06: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
06:46:06: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
06:46:07: IGMP: Switching to INCLUDE mode for 224.2.169.22 on FastEthernet0
06:46:07: IGMP: Deleting FastEthernet0 from (192.168.5.2,224.2.169.22) olist (no PIM joins active)
06:46:09: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.2 for 224.2.169.22
06:46:09: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.4.2 for 0 sources
06:46:09: IGMP: Switching to EXCLUDE mode for 224.2.169.22 on FastEthernet0
06:46:09: IGMP: Updating EXCLUDE group timer for 224.2.169.22
06:46:09: IGMP: Received Leave from 192.168.4.2 (FastEthernet0) for 224.2.169.22
06:46:09: IGMP: Received Group record for group 224.2.169.22, mode 3 from 192.168.4.2 for 0 sources
06:46:09: IGMP: Lower expiration timer to 1 seconds for 224.2.169.22 on FastEthernet0
06:46:09: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
06:46:09: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.2 for 224.2.169.22
06:46:09: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.4.2 for 0 sources
06:46:09: IGMP: Updating EXCLUDE group timer for 224.2.169.22
06:46:10: IGMP: Send v2 Query on FastEthernet0 for group 224.2.169.22
06:46:10: IGMP: Lower expiration timer to 1 seconds for 224.2.169.22 on FastEthernet0
06:46:11: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.2 for 224.2.169.22
06:46:11: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.4.2 for 0

sources
06:46:11: IGMP: Updating EXCLUDE group timer for 224.2.169.22
06:46:11: IGMP: Send v2 general Query on FastEthernet0
06:46:21: IGMP: Received v2 Report on FastEthernet0 from 192.168.4.2 for 224.2.169.22
06:46:21: IGMP: Received Group record for group 224.2.169.22, mode 2 from 192.168.4.2 for 0 sources
06:46:21: IGMP: Updating EXCLUDE group timer for 224.2.169.22

//

配了 RP

(*, 224.2.169.22), 00:00:30/00:02:59, RP 10.10.10.10, flags: SJC
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    FastEthernet0, Forward/Sparse-Dense, 00:00:30/00:02:38

(192.168.5.2, 224.2.169.22), 00:00:29/00:02:59, flags: CJT
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    FastEthernet0, Forward/Sparse-Dense, 00:00:29/00:02:38

(*, 224.0.1.40), 00:00:42/00:00:00, RP 10.10.10.10, flags: SJCL
  Incoming interface: Serial1, RPF nbr 192.168.1.2
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:00:43/00:02:16

(2) Router_A

RouterA#debug ip pim
PIM debugging is on
RouterA#
05:45:33: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
05:45:33: PIM: Hello packet has unknown option 20, ignored
05:45:37: PIM: Building Join/Prune message for 224.2.169.22
05:45:37: PIM: No sources in join or prune list
05:45:38: PIM: Send v2 Data-header Register to 192.168.2.2 for 192.168.5.2, group

224.2.169.22
05:45:38: PIM: Building Join/Prune message for 224.0.1.40
05:45:38: PIM: No sources in join or prune list
05:45:38: PIM: Received v2 Register-Stop on FastEthernet0/0 from 192.168.2.2

05:45:38: PIM: for source 192.168.5.2, group 224.2.169.22
05:45:38: PIM: Clear register flag to 192.168.2.2 for (192.168.5.2/32, 224.2.169.22)
05:45:39: PIM: Send v2 Data-header Register to 192.168.2.2 for 192.168.5.2, group

224.2.80.80
05:45:39: PIM: Building Join/Prune message for 224.2.80.80
05:45:39: PIM: No sources in join or prune list
05:45:39: PIM: Received v2 Register-Stop on FastEthernet0/0 from 192.168.2.2
05:45:39: PIM: for source 192.168.5.2, group 224.2.80.80
05:45:39: PIM: Clear register flag to 192.168.2.2 for (192.168.5.2/32, 224.2.80.80)
05:45:40: PIM: Send v2 Hello on FastEthernet0/0
05:45:46: PIM: Send v2 Hello on FastEthernet0/1
05:45:46: PIM: Send v2 Hello on Serial0/1
05:45:46: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
05:46:03: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
05:46:03: PIM: Hello packet has unknown option 20, ignored
05:46:10: PIM: Send v2 Hello on FastEthernet0/0
05:46:16: PIM: Send v2 Hello on FastEthernet0/1
05:46:16: PIM: Send v2 Hello on Serial0/1
05:46:16: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
05:46:32: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
05:46:32: PIM: Hello packet has unknown option 20, ignored
05:46:36: PIM: Building Join/Prune message for 224.2.169.22
05:46:36: PIM: No sources in join or prune list
05:46:37: PIM: Building Join/Prune message for 224.0.1.40
05:46:37: PIM: No sources in join or prune list
05:46:39: PIM: Send v2 Null Register to 192.168.2.2
05:46:39: PIM: Building Join/Prune message for 224.2.80.80
05:46:39: PIM: No sources in join or prune list
05:46:39: PIM: Received v2 Register-Stop on FastEthernet0/0 from 192.168.2.2
05:46:39: PIM: for source 0.0.0.0, group 0.0.0.0
05:46:40: PIM: Send v2 Hello on FastEthernet0/0
05:46:46: PIM: Send v2 Hello on FastEthernet0/1
05:46:46: PIM: Send v2 Hello on Serial0/1
05:46:47: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
05:47:02: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
05:47:02: PIM: Hello packet has unknown option 20, ignored
05:47:10: PIM: Send v2 Hello on FastEthernet0/0
05:47:16: PIM: Send v2 Hello on FastEthernet0/1
05:47:16: PIM: Send v2 Hello on Serial0/1
05:47:17: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1
05:47:32: PIM: Received v2 Hello on FastEthernet0/0 from 192.168.2.2
05:47:32: PIM: Hello packet has unknown option 20, ignored
05:47:36: PIM: Building Join/Prune message for 224.2.169.22

```
05:47:36: PIM: No sources in join or prune list
05:47:36: PIM: Building Join/Prune message for 224.0.1.40
05:47:36: PIM: No sources in join or prune list
05:47:38: PIM: Send v2 Data-header Register to 192.168.2.2 for 192.168.5.2, group

224.2.169.22
05:47:38: PIM: Building Join/Prune message for 224.2.80.80
05:47:38: PIM: No sources in join or prune list
05:47:38: PIM: Received v2 Register-Stop on FastEthernet0/0 from 192.168.2.2
05:47:38: PIM:      for source 192.168.5.2, group 224.2.169.22
05:47:38: PIM: Clear register flag to 192.168.2.2 for (192.168.5.2/32, 224.2.169.22)
05:47:39: PIM: Send v2 Data-header Register to 192.168.2.2 for 192.168.5.2, group

224.2.80.80
05:47:39: PIM: Received v2 Register-Stop on FastEthernet0/0 from 192.168.2.2
05:47:39: PIM:      for source 192.168.5.2, group 224.2.80.80
05:47:39: PIM: Clear register flag to 192.168.2.2 for (192.168.5.2/32, 224.2.80.80)
05:47:40: PIM: Send v2 Hello on FastEthernet0/0
05:47:46: PIM: Send v2 Hello on FastEthernet0/1
05:47:46: PIM: Send v2 Hello on Serial0/1
05:47:47: PIM: Received v2 Hello on Serial0/1 from 192.168.1.1

RouterA#show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, s - SSM
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.169.22), 00:07:29/00:03:16, RP 10.10.10.10, flags: SF
  Incoming interface: FastEthernet0/0, RPF nbr 192.168.2.2
  Outgoing interface list:
    Serial0/1, Forward/Sparse-Dense, 00:07:26/00:03:16

(192.168.5.2, 224.2.169.22), 00:07:29/00:03:29, flags: FT
  Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0/1, Forward/Sparse-Dense, 00:07:26/00:03:16

(*, 224.0.1.39), 00:24:35/00:02:30, RP 0.0.0.0, flags: DC
```

```
    Incoming interface: Null, RPF nbr 0.0.0.0
    Outgoing interface list:
        Serial0/1, Forward/Sparse-Dense, 00:24:36/00:00:00
        FastEthernet0/0, Forward/Sparse-Dense, 00:24:36/00:00:00

(*, 224.0.1.40), 01:19:10/00:00:00, RP 0.0.0.0, flags: DCL
    Incoming interface: Null, RPF nbr 0.0.0.0
    Outgoing interface list:
        Serial0/1, Forward/Sparse-Dense, 01:19:10/00:00:00
        FastEthernet0/0, Forward/Sparse-Dense, 01:19:10/00:00:00

(192.168.2.2, 224.0.1.40), 00:23:38/00:02:06, flags: CLT
    Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0
    Outgoing interface list:
        Serial0/1, Forward/Sparse-Dense, 00:23:38/00:00:00

(192.168.3.2, 224.0.1.40), 00:00:53/00:02:06, flags: CL
    Incoming interface: FastEthernet0/0, RPF nbr 192.168.2.2
    Outgoing interface list:
        Serial0/1, Forward/Sparse-Dense, 00:00:53/00:00:00

(*, 224.2.80.80), 00:07:30/00:02:59, RP 10.10.10.10, flags: SJCF
    Incoming interface: FastEthernet0/0, RPF nbr 192.168.2.2
    Outgoing interface list:
        FastEthernet0/1, Forward/Sparse-Dense, 00:07:30/00:02:08

(192.168.5.2, 224.2.80.80), 00:07:32/00:03:29, flags: CFT
    Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
    Outgoing interface list:
        FastEthernet0/0, Forward/Sparse-Dense, 00:06:46/00:02:
```

(3) Router_B

```
RouterB#show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, Z - Multicast Tunnel
       Y - Joined MDT-data group, y - Sending to MDT-data group
Outgoing interface flags: H - Hardware switched
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode
```

```
(*, 224.2.169.22), 00:10:37/stopped, RP 10.10.10.10, flags: S
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Ethernet0, Forward/Sparse-Dense, 00:10:04/00:03:27

(192.168.5.2, 224.2.169.22), 00:10:37/00:02:43, flags: PT
  Incoming interface: Ethernet0, RPF nbr 192.168.2.1
  Outgoing interface list: Null

(*, 224.0.1.39), 00:12:09/00:02:14, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:12:10/00:00:00
    Ethernet0, Forward/Sparse-Dense, 00:12:10/00:00:00

(*, 224.0.1.40), 00:12:10/stopped, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:12:10/00:00:00
    Ethernet0, Forward/Sparse-Dense, 00:12:11/00:00:00

(192.168.3.2, 224.0.1.40), 00:00:46/00:02:44, flags: LT
  Incoming interface: Serial0, RPF nbr 0.0.0.0
  Outgoing interface list:
    Ethernet0, Forward/Sparse-Dense, 00:00:46/00:00:00

(*, 224.2.80.80), 00:10:38/stopped, RP 10.10.10.10, flags: S
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:07:37/00:02:51
    Ethernet0, Forward/Sparse-Dense, 00:09:51/00:03:08

(192.168.5.2, 224.2.80.80), 00:10:38/00:03:24, flags: T
  Incoming interface: Ethernet0, RPF nbr 192.168.2.1
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:07:37/00:02:51

RouterB#
```

///statically configured rp address

```
RouterB#show ip mro
IP Multicast Routing Table
```

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, Z - Multicast Tunnel
       Y - Joined MDT-data group, y - Sending to MDT-data group
Outgoing interface flags: H - Hardware switched
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.169.22), 00:00:10/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:00:10/00:00:00
    Ethernet0, Forward/Sparse-Dense, 00:00:10/00:00:00

(192.168.5.2, 224.2.169.22), 00:00:10/00:02:56, flags: T
  Incoming interface: Ethernet0, RPF nbr 192.168.2.1
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:00:10/00:00:00

(*, 224.0.1.40), 00:00:11/00:02:48, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:00:11/00:00:00
    Ethernet0, Forward/Sparse-Dense, 00:00:11/00:00:00

(*, 224.2.80.80), 00:00:11/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:00:13/00:00:00
    Ethernet0, Forward/Sparse-Dense, 00:00:13/00:00:00

(192.168.5.2, 224.2.80.80), 00:00:13/00:02:56, flags: T
  Incoming interface: Ethernet0, RPF nbr 192.168.2.1
  Outgoing interface list:
    Serial0, Forward/Sparse-Dense, 00:00:13/00:00:00
```