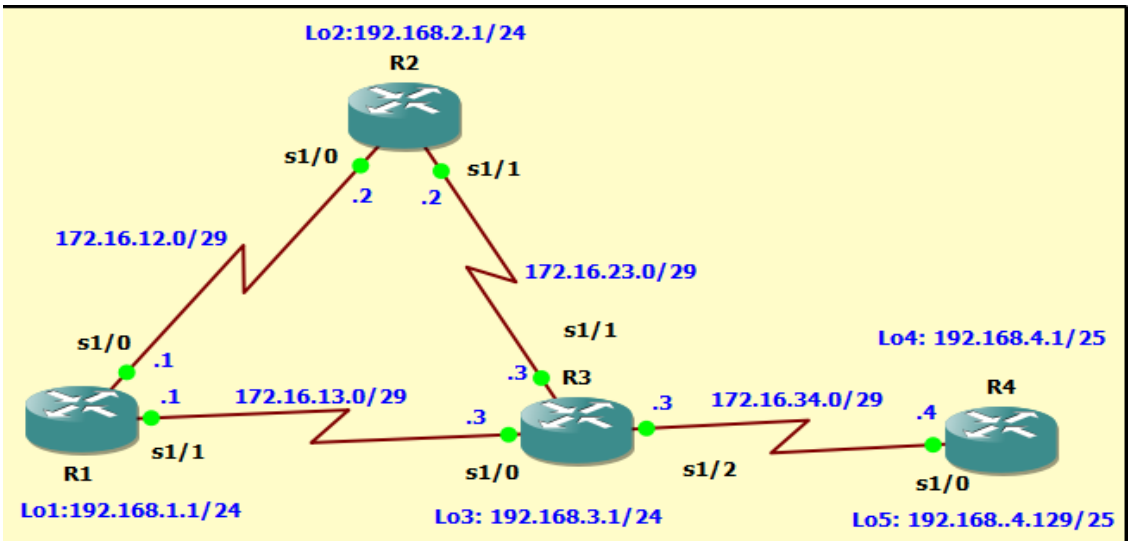
Practical No - 5

Aim: Configure and Verify Path Control Using PBR

Topology:



Objectives

- Configure and verify policy-based routing.
- Select the required tools and commands to configure policy-based routing operations.
- Verify the configuration and operation by using the proper show and debug commands.

Step 1: Configure loopbacks and assign addresses.

1. Cable the network as shown in the topology diagram. Erase the startup configuration and reload each router to clear previous configurations.
2. Using the addressing scheme in the diagram, create the loopback interfaces and apply IP addresses to these and the serial interfaces on R1, R2, R3, and R4. On the serial interfaces connecting R1 to R3 and R3 to R4, specify the bandwidth as 64 Kb/s and set a clock rate on the DCE using the **clock rate 64000** command. On the serial interfaces connecting R1 to R2 and R2 to R3, specify the bandwidth as 128 Kb/s and set a clock rate on the DCE using the **clock rate 128000** command.

You can copy and paste the following configurations into your routers to begin.

Note: Depending on the router model, interfaces might be numbered differently than those listed. You might need to alter them accordingly.

Router R1

interface Lo1

ip address 192.168.1.1 255.255.255.0

interface Serial 0/0/0

ip address 172.16.12.1 255.255.255.248

no shutdown interface

Serial0/0/1

ip address 172.16.13.1 255.255.255.248

no shutdown End.

```
R1(config)#int Lo1
```

```
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#int s1/0
R1(config-if)#ip address 172.16.12.1 255.255.255.248
R1(config-if)#no shutdown
```

```
R1(config-if)#int s1/1
R1(config-if)#ip address 172.16.13.1 255.255.255.248
R1(config-if)#no shutdow
*May 19 23:06:21.987: %LINEPROTO-5-UPDOWN: Line proto
R1(config-if)#no shutdown
```

Router R2

interface Lo2

ip address 192.168.2.1 255.255.255.0

interface Serial0/0/0

ip address 172.16.12.2 255.255.255.248

no shutdown

interface Serial 0/0/1

ip address 172.16.23.2 255.255.255.248

no shutdown End.

```
R2(config)#int Lo2
R2(config-if)#
*May 19 23:06:13.083: %LINEPROTO-5-UPDOWN: Line proto
R2(config-if)#ip address 192.168.2.1 255.255.255.0
R2(config-if)#int s1/0
R2(config-if)#ip address 172.16.12.2 255.255.255.248
R2(config-if)#no shutdown
```

```
R2(config)#int s1/1
R2(config-if)#ip address 172.16.23.2 255.255.255.248
R2(config-if)#no shutdown
```

Router R3

interface Lo3

ip address 192.168.3.1 255.255.255.0

interface Serial 0/0/0

ip address 172.16.13.3 255.255.255.248

no shutdown interface

Serial0/0/1

ip address 172.16.23.3 255.255.255.248

no shutdown interface

Serial0/1/0

ip address 172.16.34.3 255.255.255.248

no shutdown End

```
R3(config)#int Lo3
R3(config-if)#
*May 19 23:07:08.351: %LINEPROTO-5-UPDOWN: Line proto
R3(config-if)#ip address 192.168.3.1 255.255.255.0
R3(config-if)#int s1/0
R3(config-if)#ip address 172.16.13.3 255.255.255.248
R3(config-if)#no shutdown
```

```
R3(config-if)#int s1/1
R3(config-if)#ip address 172.16.23.3 255.255.255.248
R3(config-if)#no shutdown
```

```
R3(config-if)#int s1/2
R3(config-if)#ip address 172.16.34.3 255.255.255.248
R3(config-if)#no shutdown
R3(config-if)#exit
```

Router R4

interface Lo4

ip address 192.168.4.1 255.255.255.128

interface Lo5

ip address 192.168.4.129 255.255.255.128

interface Serial0/0/0

ip address 172.16.34.4 255.255.255.248

no shutdown End

```
R4(config)#int lo4
R4(config-if)#
*May 19 23:08:16.239: %LINEPROTO-5-UPDOWN: Line protoc
R4(config-if)#ip address 192.168.4.1 255.255.255.128
R4(config-if)#interface Lo5
R4(config-if)#
*May 19 23:08:32.527: %LINEPROTO-5-UPDOWN: Line protoc
R4(config-if)#ip address 192.168.4.129 255.255.255.128
R4(config-if)#int s1/0
R4(config-if)#ip address 172.16.34.4 255.255.255.248
R4(config-if)#no shutdown
```

3. Verify the configuration with the **show ip interface brief**, **show protocols, and show interfaces description** commands. The output from router R3 is shown here as an example.

R3# show ip interface brief

```
R3#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            unassigned      YES unset  administratively down down
Serial1/0                  172.16.13.3     YES manual up                    up
Serial1/1                  172.16.23.3     YES manual up                    up
Serial1/2                  172.16.34.3     YES manual up                    up
Serial1/3                  unassigned      YES unset  administratively down down
Loopback3                  192.168.3.1     YES manual up                    up
```

R3# **show protocols**

```
R3#show protocols
Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is administratively down, line protocol i
Serial1/0 is up, line protocol is up
  Internet address is 172.16.13.3/29
Serial1/1 is up, line protocol is up
  Internet address is 172.16.23.3/29
Serial1/2 is up, line protocol is up
  Internet address is 172.16.34.3/29
Serial1/3 is administratively down, line protocol is down
Loopback3 is up, line protocol is up
  Internet address is 192.168.3.1/24
```

R3# **show interfaces description**

```
R3#show interfaces description
Interface                      Status         Protocol Description
Fa0/0                          admin down     down
Se1/0                          up             up
Se1/1                          up             up
Se1/2                          up             up
Se1/3                          admin down     down
```

Step 3: Configure basic EIGRP.

aa. Implement EIGRP AS 1 over the serial and loopback interfaces as you have configured it for the other EIGRP labs.

bb. Advertise networks 172.16.12.0/29, 172.16.13.0/29, 172.16.23.0/29, 172.16.34.0/29, 192.168.1.0/24,

192.168.2.0/24, 192.168.3.0/24, and 192.168.4.0/24 from their respective routers.

You can copy and paste the following configurations into your routers.

Router R1

router eigrp 1

network 192.168.1.0

network 172.16.12.00.0.0.7

network 172.16.13.00.0.0.7

no auto-summary

```
R1(config)#router eigrp 1
R1(config-router)#network 192.168.1.0
R1(config-router)#network 172.16.12.0 0.0.0.7
R1(config-router)#network 172.16.13.0 0.0.0.7
R1(config-router)#no auto-summary
```

Router R2

router eigrp 1

network 192.168.2.0

network 172.16.12.00.0.0.7

network 172.16.23.00.0.0.7

no auto-summary

```
R2(config)#router eigrp 1
R2(config-router)#network 192.168.2.0
R2(config-router)#network 172.16.12.0 0.0.0.7
R2(config-router)#network 172.16.23.0 0.0.0.7
R2(config-router)#no auto-summary
```

Router R3

router eigrp 1

network 192.168.3.0

network 172.16.13.00.0.0.7

network 172.16.23.00.0.0.7

network 172.16.34.00.0.0.7

no auto-summary

```
R3(config)#router eigrp 1
R3(config-router)#network 192.168.3.0
R3(config-router)#network 172.16.13.0 0.0.0.7
R3(config-router)#network 172.16.23.0 0.0.0.7
R3(config-router)#network 172.16.34.0 0.0.0.7
R3(config-router)#no auto-summary
```

Router R4 router eigrp

1

network 192.168.4.0

network 172.16.34.0 0.0.0.7

no auto-summary

```
R4(config)#router eigrp 1
R4(config-router)#network 192.168.4.0
R4(config-router)#network 172.16.34.0 0.0.0.7
R4(config-router)#no auto-summary
```

You should see EIGRP neighbor relationship messages being generated.

Step 4: Verify EIGRP connectivity.

cc. Verify the configuration by using the **show ip eigrp neighbors** command to check which routers have EIGRP adjacencies.

R1# show ip eigrp neighbors

```
R1#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   172.16.13.3             Se1/1             11 00:00:31   26   200  0  18
0   172.16.12.2             Se1/0             12 00:00:44   37   222  0  13
```

R2# **show ip eigrp neighbors**

```
R2#show ip eigrp neighbors
*May 19 23:13:42.783: %SYS-5-CONFIG_I: Configured from console by console
R2#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   172.16.23.3             Se1/1             11 00:00:50   41   246  0  20
0   172.16.12.1             Se1/0             11 00:01:04   30   200  0  18
```

R3# show ip eigrp neighbors

```
R3#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
2   172.16.34.4             Se1/2             12 00:00:44   48   288  0  6
1   172.16.23.2             Se1/1             11 00:00:58   26   200  0  19
0   172.16.13.1             Se1/0             12 00:00:58  281  1686  0  20
```

R4# **show ip eigrp neighbors**

```
R4#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
0   172.16.34.3             Se1/0             10 00:00:55   23   200  0  26
```

Run the following Tcl script on all routers to verify full connectivity.

R1# **tclsh**

```
R1#tclsh
R1(tcl)#foreach address {
+>(tcl)#172.16.12.1
+>(tcl)#172.16.12.2
+>(tcl)#172.16.13.1
+>(tcl)#172.16.13.3
+>(tcl)#172.16.23.2
+>(tcl)#172.16.23.3
+>(tcl)#172.16.34.3
+>(tcl)#172.16.34.4
+>(tcl)#192.168.1.1
+>(tcl)#192.168.2.1
+>(tcl)#192.168.3.1
+>(tcl)#192.168.4.1
+>(tcl)#192.168.4.129
+>(tcl)#} { ping $address }
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.12.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 44/61/76 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/27/40 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.13.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/58/80 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.13.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/31/44 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.23.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/28/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.23.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 24/40/48 ms
Type escape sequence to abort.
```

Step 5: Verify the current path.

Before you configure PBR, verify the routing table on R1.

On R1, use the **show ip route** command. Notice the next-hop IP address for all networks discovered by EIGRP.

R1# **show ip route**

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

Gateway of last resort is not set

     172.16.0.0/29 is subnetted, 4 subnets
D       172.16.34.0 [90/2681856] via 172.16.13.3, 00:01:50, Serial1/1
D       172.16.23.0 [90/2681856] via 172.16.13.3, 00:01:50, Serial1/1
                    [90/2681856] via 172.16.12.2, 00:01:50, Serial1/0
C       172.16.12.0 is directly connected, Serial1/0
C       172.16.13.0 is directly connected, Serial1/1
D    192.168.4.0/24 [90/2809856] via 172.16.13.3, 00:01:38, Serial1/1
C    192.168.1.0/24 is directly connected, Loopback1
D    192.168.2.0/24 [90/2297856] via 172.16.12.2, 00:01:50, Serial1/0
D    192.168.3.0/24 [90/2297856] via 172.16.13.3, 00:01:50, Serial1/1
```

R4# traceroute 192.168.1.1 source 192.168.4.1

```
R4#traceroute 192.168.1.1 source 192.168.4.1

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 36 msec 32 msec 32 msec
  2 172.16.13.1 28 msec 56 msec 84 msec
```

R4# **traceroute 192.168.1.1 source 192.168.4.129**

```
R4#traceroute 192.168.1.1 source 192.168.4.129

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 44 msec 28 msec 28 msec
  2 172.16.13.1 64 msec 28 msec 64 msec
```

On R3, use the **show ip route** command and note that the preferred route from R3 to R1 LAN 192.168.1.0/24 is via R2 using the R3 exit interface S0/0/1.

R3# **show ip route**

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

Gateway of last resort is not set
```

```
     172.16.0.0/29 is subnetted, 4 subnets
C       172.16.34.0 is directly connected, Serial1/2
C       172.16.23.0 is directly connected, Serial1/1
D       172.16.12.0 [90/2681856] via 172.16.23.2, 00:02:29, Serial1/1
                    [90/2681856] via 172.16.13.1, 00:02:29, Serial1/0
C       172.16.13.0 is directly connected, Serial1/0
D    192.168.4.0/24 [90/2297856] via 172.16.34.4, 00:02:17, Serial1/2
D    192.168.1.0/24 [90/2297856] via 172.16.13.1, 00:02:29, Serial1/0
D    192.168.2.0/24 [90/2297856] via 172.16.23.2, 00:02:29, Serial1/1
C    192.168.3.0/24 is directly connected, Loopback3
```

R3#

On R3, use the **show interfaces serial 0/0/0** and **show interfaces s0/0/1** commands.

R3# show interfaces serial0/0/0

```
R3#show int s1/0
Serial1/0 is up, line protocol is up
  Hardware is M4T
  Internet address is 172.16.13.3/29
  MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
```

```
  Routing Descriptor Blocks:
  172.16.13.1 (Serial1/0), from 172.16.13.1, Send flag is 0x0
      Composite metric is (2297856/128256), Route is Internal
      Vector metric:
        Minimum bandwidth is 1544 Kbit
        Total delay is 25000 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 1
  172.16.23.2 (Serial1/1), from 172.16.23.2, Send flag is 0x0
```

Confirm that R3 has a valid route to reach R1 from its serial 0/0/0 interface using the **show ip eigrp topology 192.168.1.0** command.

R3# **show ip eigrp topology 192.168.1.0**

```
R3#show ip eigrp topology 192.168.1.0
IP-EIGRP (AS 1): Topology entry for 192.168.1.0/24
  State is Passive, Query origin flag is 1, 1 Successor(s), FD is
  Routing Descriptor Blocks:
  172.16.13.1 (Serial1/0), from 172.16.13.1, Send flag is 0x0
      Composite metric is (2297856/128256), Route is Internal
      Vector metric:
        Minimum bandwidth is 1544 Kbit
        Total delay is 25000 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 1
  172.16.23.2 (Serial1/1), from 172.16.23.2, Send flag is 0x0
```

Step 6: Configure PBR to provide path control.

The steps required to implement path control include the following:

- Choose the path control tool to use. Path control tools manipulate or bypass the IP routing table. For PBR, **route-map** commands are used.
- Implement the traffic-matching configuration, specifying which traffic will be manipulated. The **match** commands are used within route maps.
- Define the action for the matched traffic using **set** commands within route maps.
- Apply the route map to incoming traffic.

As a test, you will configure the following policy on router R3:

- All traffic sourced from R4 LAN A must take the R3 --> R2 --> R1 path.
- All traffic sourced from R4 LAN B must take the R3 --> R1 path.

hh. On router R3, create a standard access list called **PBR-ACL** to identify the R4 LAN B network.

R3(config)# **ip access-list standard PBR-ACL**

R3(config-std-nacl)# **remark ACL matches R4 LAN B**

traffic R3(config-std-nacl)# **permit 192.168.4.128 0.0.0.127**

R3(config- std-nacl)# **exit**

```
R3(config)#ip access-list standard PBR-ACL
R3(config-std-nacl)#remark ACL matches R4 LAN B traffic
R3(config-std-nacl)#permit 192.168.4.128 0.0.0.127
R3(config-std-nacl)#exit
```

R3(config)#

i. Create a route map called **R3-to-R1** that matches PBR-ACL and sets the next-hop
ii. interface to the R1serial 0/0/1 interface.

R3(config)# **route-map R3-to-R1 permit**

R3(config-route-map)# **description RM to forward LAN B traffic to R1**

R3(config-route-map)# **match ip address PBR-ACL**

R3(config-route-map)# **set ip next-hop 172.16.13.1**

R3(config-route-map)# **exit**

```
R3(config)#route-map R3-to-R1 permit
R3(config-route-map)#match ip address PBR-ACL
R3(config-route-map)#set ip next-hop 172.16.13.1
R3(config-route-map)#exit
```

jj. Apply the R3-to-R1 route map to the serial interface on R3 that receives the traffic from R4. Use the **ip policy route-map** command on interface S0/1/0.

R3(config)# **interface s0/1/0**

R3(config-if)# **ip policy route-map R3-to-R1**

R3(config-if)# **end**

```
R3(config)#int s1/2
R3(config-if)#ip policy route-map R3-to-R1
R3(config-if)#end
```

kk. On R3, display the policy and matches using the **show route-map** command.

R3# **show route-map**

```
R3#show route-map
route-map R3-to-R1, permit, sequence 10
  Match clauses:
    ip address (access-lists): PBR-ACL
  Set clauses:
    ip next-hop 172.16.13.1
  Policy routing matches: 0 packets, 0 bytes
```

Step 7: Test the policy.

ll. On R3, create a standard ACL which identifies all of the R4 LANs.

R3# **conf t**

Enter configuration commands, one per line. End with CNTL/Z.

R3(config)# **access-list 1 permit 192.168.4.0 0.0.0.255** R3(config)#

exit

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#access-list 1 permit 192.168.4.0 0.0.0.255
R3(config)#exit
```

mm. Enable PBR debugging only for traffic that matches the R4 LANs.

R3# debug ip policy ?

```
R3#debug ip policy ?
  <1-199>  Access list
  dynamic  dynamic PBR
  <cr>
```

R3# **debug ip policy 1**

```
R3#debug ip policy 1
Policy routing debugging is on for access list 1
```

nn. Test the policy from R4 with the **trace route** command, using R4 LAN A as the source network.

R4# trace route 192.168.1.1 source 192.168.4.1

```
R4#traceroute 192.168.1.1 source 192.168.4.1

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 40 msec 12 msec 32 msec
  2 172.16.13.1 60 msec 48 msec 88 msec
```

```
R3#
*May 19 23:17:36.819: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1,
*May 19 23:17:36.851: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1,
*May 19 23:17:36.879: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1,
*May 19 23:17:36.915: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1,
g
*May 19 23:17:36.971: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1,
g
*May 19 23:17:37.031: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1
R3#, len 28, FIB policy rejected(no match) - normal forwarding
R3#
```

oo. Test the policy from R4 with the **traceroute** command, using R4 LAN B as the source network.

R4# traceroute 192.168.1.1 source 192.168.4.129

```
R4#traceroute 192.168.1.1 source 192.168.4.129

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 40 msec 28 msec 32 msec
  2 172.16.13.1 60 msec 64 msec 32 msec
```

```
R3#.168.4.129 (Serial1/2), d=192.168.1.1, len 28, FIB policy match
*May 19 23:17:55.763: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.763: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.823: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.823: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.827: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.883: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.883: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
*May 19 23:17:55.887: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1,
```

pp. On R3, display the policy and matches using the **show route-map** command.

```
R3#show route-map
route-map R3-to-R1, permit, sequence 10
  Match clauses:
    ip address (access-lists): PBR-ACL
  Set clauses:
    ip next-hop 172.16.13.1
  Policy routing matches: 6 packets, 192 bytes
```

R3# **show route-map**