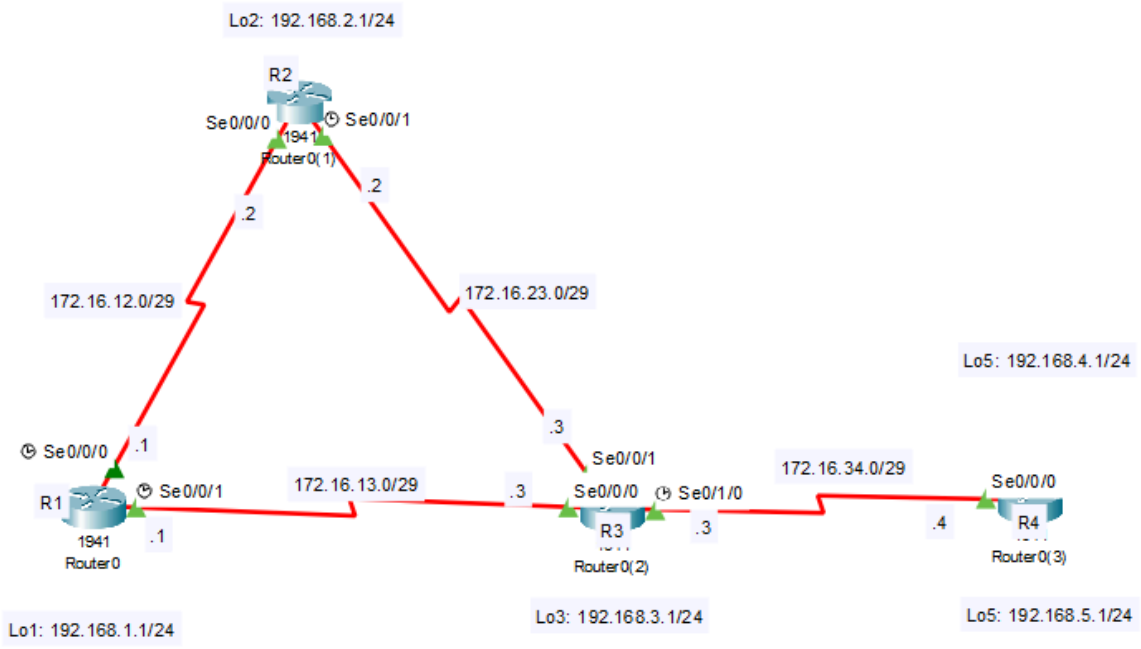
Path Control Using Policy-Based Routing

Objectives

- Configure and verify Policy-Based Routing (PBR).
- Understand how to manipulate packet forwarding based on criteria other than the destination IP address.

Topology



IP Addressing

Interface	Router	IP Address	Subnet Mask	Bandwidth
S0/0/0	R1	172.16.12.1	255.255.255.248	128 Kbps
S0/0/1	R1	172.16.13.1	255.255.255.248	64 Kbps
S0/0/0	R2	172.16.12.2	255.255.255.248	128 Kbps
S0/0/1	R2	172.16.23.2	255.255.255.248	128 Kbps
S0/0/0	R3	172.16.13.3	255.255.255.248	64 Kbps
S0/0/1	R3	172.16.23.3	255.255.255.248	128 Kbps

S0/1/0	R3	172.16.34.3	255.255.255.248	64 Kbps
S0/0/0	R4	172.16.34.4	255.255.255.248	64 Kbps
Loopback 1	R1	192.168.1.1	255.255.255.0	-
Loopback 2	R2	192.168.2.1	255.255.255.0	-
Loopback 3	R3	192.168.3.1	255.255.255.0	-
Loopback 4	R4	192.168.4.1	255.255.255.128	-
Loopback 5	R4	192.168.4.129	255.255.255.128	-

Step 1: Initial Router Configuration

Apply the following configurations to each router.

Router R1

```
hostname R1
!
interface Lo1
 description R1 LAN
 ip address 192.168.1.1 255.255.255.0
!
interface Serial0/0/0
 description R1 --> R2
 ip address 172.16.12.1 255.255.255.248
 clock rate 128000
 bandwidth 128
 no shutdown
!
interface Serial0/0/1
 description R1 --> R3
 ip address 172.16.13.1 255.255.255.248
 bandwidth 64
 no shutdown
!
end
```

Router R2

```
hostname R2
!
interface Lo2
 description R2 LAN
 ip address 192.168.2.1 255.255.255.0
!
interface Serial0/0/0
 description R2 –> R1
 ip address 172.16.12.2 255.255.255.248
 bandwidth 128
 no shutdown
!
interface Serial0/0/1
 description R2 --> R3
 ip address 172.16.23.2 255.255.255.248
 clock rate 128000
 bandwidth 128
 no shutdown
!
end
```

Router R3

```
hostname R3
!
interface Lo3
 description R3 LAN
 ip address 192.168.3.1 255.255.255.0
!
interface Serial0/0/0
 description R3 --> R1
 ip address 172.16.13.3 255.255.255.248
 clock rate 64000
 bandwidth 64
 no shutdown
!
interface Serial0/0/1
 description R3 --> R2
 ip address 172.16.23.3 255.255.255.248
 bandwidth 128
```

```
 no shutdown
!
interface Serial0/1/0
 description R3 --> R4
 ip address 172.16.34.3 255.255.255.248
 clock rate 64000
 bandwidth 64
 no shutdown
!
end
```

Router R4

```
hostname R4
!
interface Lo4
 description R4 LAN A
 ip address 192.168.4.1 255.255.255.128
!
interface Lo5
 description R4 LAN B
 ip address 192.168.4.129 255.255.255.128
!
interface Serial0/0/0
 description R4 --> R3
 ip address 172.16.34.4 255.255.255.248
 bandwidth 64
 no shutdown
!
end
```

Step 2: Configure EIGRP

Configure EIGRP AS 1 on all routers to establish full connectivity.

Router R1

```
router eigrp 1
 network 192.168.1.0 0.0.0.255
 network 172.16.12.0 0.0.0.7
 network 172.16.13.0 0.0.0.7
 no auto-summary
```

Router R2

```
router eigrp 1
 network 192.168.2.0 0.0.0.255
 network 172.16.12.0 0.0.0.7
 network 172.16.23.0 0.0.0.7
 no auto-summary
```

Router R3

```
router eigrp 1
 network 192.168.3.0 0.0.0.255
 network 172.16.13.0 0.0.0.7
 network 172.16.23.0 0.0.0.7
 network 172.16.34.0 0.0.0.7
 no auto-summary
```

Router R4

```
router eigrp 1
 network 192.168.4.0 0.0.0.255
 network 172.16.34.0 0.0.0.7
 no auto-summary
```

Step 3: Verify Current Routing Path

Before configuring PBR, let's observe the default routing behavior.

On R4, trace the route to R1's LAN (192.168.1.1) from both of R4's LANs.

```
R4# traceroute 192.168.1.1 source 192.168.4.1
Tracing the route to 192.168.1.1
1 172.16.34.3 12 msec 12 msec 16 msec
2 172.16.23.2 20 msec 20 msec 20 msec
3 172.16.12.1 24 msec * 24 msec

R4# traceroute 192.168.1.1 source 192.168.4.129
Tracing the route to 192.168.1.1
1 172.16.34.3 12 msec 16 msec 12 msec
```

```
2 172.16.23.2 28 msec 20 msec 16 msec
3 172.16.12.1 24 msec * 24 msec
```

Notice that both traceroutes follow the same path: **R4 -> R3 -> R2 -> R1**.

Why do both paths go through R2?

Check the EIGRP topology table on R3 for the route to 192.168.1.0/24.

```
R3# show ip eigrp topology 192.168.1.0
EIGRP-IPv4 Topology Entry for AS(1)/ID(192.168.3.1) for 192.168.1.0/24
  State is Passive, Query origin flag is 1, 1 Successor(s), FD is 21152000
  Descriptor Blocks:
  172.16.23.2 (Serial0/0/1), from 172.16.23.2, Send flag is 0x0
      Composite metric is (21152000/20640000), route is Internal
      Vector metric:
      Minimum bandwidth is 128 Kbit
      Total delay is 45000 microseconds
      Hop count is 2
  172.16.13.1 (Serial0/0/0), from 172.16.13.1, Send flag is 0x0
    Composite metric is (40640000/128256), route is Internal
    Vector metric:
      Minimum bandwidth is 64 Kbit
      Total delay is 25000 microseconds
      Hop count is 1
```

EIGRP's metric calculation favors the path with the higher bandwidth (128 Kbps to R2) over the path with the lower bandwidth (64 Kbps to R1), even though the latter is a more direct hop count. This is why the default path is R3 -> R2 -> R1.

Step 4: Configure PBR on R3

Now, let's implement PBR to override the default routing behavior. We'll create a policy that forces traffic from R4's LAN B to take the R3 -> R1 path.

1. **Create a standard access list** to match traffic sourced from R4's LAN B.

```
R3(config)# ip access-list standard PBR-ACL
R3(config-std-nacl)# permit 192.168.4.128 0.0.0.127
R3(config-std-nacl)# exit
```

2. **Create a route-map** that sets the next-hop for the matched traffic.

```
R3(config)# route-map R3-to-R1 permit 10
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
```

3. **Apply the route-map** to the interface that receives the traffic from R4 (S0/1/0).

```
R3(config)# interface s0/1/0
R3(config-if)# ip policy route-map R3-to-R1
R3(config-if)# end
```

Step 5: Test the PBR Policy

Enable debugging on R3 to watch the policy in action.

1. **Create a temporary ACL for debugging** all traffic from R4's 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
```

2. **Enable policy routing debugging** for the ACL you just created.

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

3. **From R4, run a traceroute using R4 LAN A as the source.** This traffic should *not* match the PBR policy.

```
R4# traceroute 192.168.1.1 source 192.168.4.1
```

The debug output on R3 will show the traffic being **policy rejected -- normal forwarding**. This confirms that the PBR is not applied, and the traffic follows the default EIGRP path (via R2).

4. **From R4, run a traceroute using R4 LAN B as the source.** This traffic *should* match the PBR policy.

```
R4# traceroute 192.168.1.1 source 192.168.4.129
```

The traceroute output should now show the path: **R4 -> R3 -> R1**.

The debug output on R3 will show **policy match** and **policy routed**, confirming that PBR is successfully overriding the normal routing table decision.

Final Verification:
Use the show route-map command on R3 to see the policy matches and byte count.

```
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: <number of packets> packets, <number of bytes> bytes
```