Bialystok University of Technology
Faculty of Electrical Engineering

LABORATORY REPORT

Computer Networks
IS-FEE-10082S

Subject:
Configuring and testing dynamic routing protocols

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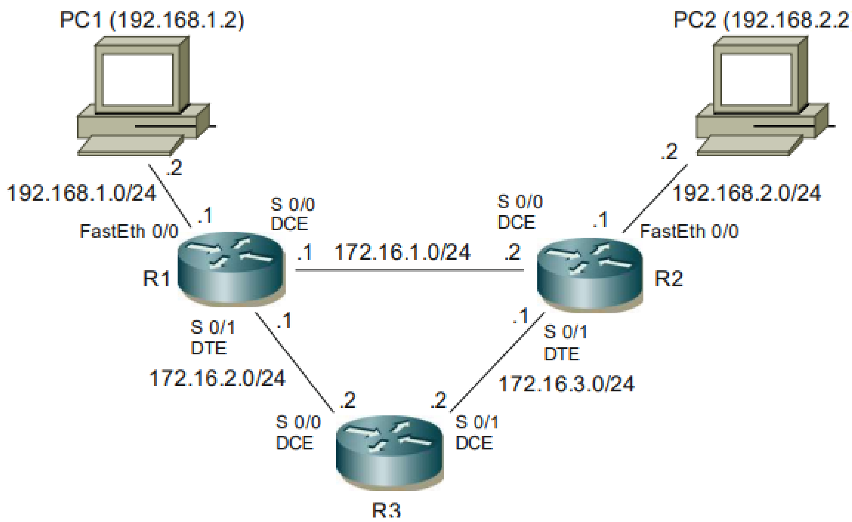
Contents

1 Objective

The objective of this report is to document the configuration, operation, and behavior of RIP version 2 (Routing Information Protocol) in a real router-based network. The report covers the step-by-step setup of RIP on Cisco routers, verification of routing functionality through routing tables and connectivity tests, analysis of RIP message exchanges, and evaluation of the protocol's response to interface shutdowns and passive interface settings. The goal is to demonstrate the practical capabilities of RIP v2 as a classless, distance-vector routing protocol in a physical networking environment.

2 Initial Configuration of the Network System

Since we already showed this part on the last laboratory report, we will skip this part. Here is the diagram of our configured network system.



3 RIP Protocol Configuration

In this part of the setup, we configured the RIP (Routing Information Protocol) version 2 on the routers in our network. RIP is a dynamic routing protocol that helps routers share information about reachable networks. We used version 2 because it supports subnetting and is better suited for modern networks.

We also disabled automatic summarization using the `no auto-summary` command. This is important because auto-summary can cause issues when we're working with subnets from different major networks — it would otherwise try to summarize them, which we don't want.

3.1 Configuration on Router R1

Here's what we entered on Router R1:

```
R1(config)# router rip
R1(config-router)# version 2
R1(config-router)# no auto-summary
```

On R1, we enabled RIP and set it to use version 2. We also turned off auto-summary. However, we didn't add any `network` statements yet, so RIP isn't actually active on any interfaces. To make it fully functional, we still need to add the specific networks connected to R1.

3.2 Configuration on Router R3

Here's what we entered on Router R3:

```
R3(config)# router rip
R3(config-router)# version 2
R3(config-router)# no auto-summary
R3(config-router)# network 172.16.2.0
R3(config-router)# network 172.16.3.0
R3(config-router)# end
```

On R3, we completed the RIP setup. After enabling version 2 and turning off auto-summary, we used the `network` commands to tell RIP which interfaces to use. In this case, interfaces connected to the 172.16.2.0 and 172.16.3.0 networks are now running RIP and can exchange routing information.

3.3 Conclusion

To sum up, RIP version 2 was set up on both R1 and R3. R3 is fully configured and participating in RIP, while R1 still needs its networks added. Disabling auto-summary helps avoid routing issues by making sure subnets are advertised accurately without being grouped into major network blocks.

4 Network Operation Verification

In this step, we verified that the RIP routing configuration works correctly by checking the routing table and using the `ping` and `traceroute` commands. These tools help us confirm that all routers and hosts can communicate with each other across the network.

Routing Table on R1

To check the routes known by Router R1, we used the `show ip route` command:

```
R1# show ip route
```

```
Codes: C - connected, R - RIP, S - static, etc.

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
C       172.16.1.0 is directly connected, Serial0/0
C       172.16.2.0 is directly connected, Serial0/1
R       172.16.3.0 [120/1] via 172.16.2.2, Serial0/1
                   [120/1] via 172.16.1.2, Serial0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

This output shows that R1 has learned about the `172.16.3.0/24` network via RIP from both neighboring routers. The `C` entries indicate directly connected networks, while the `R` entry confirms that RIP is working as expected and R1 can reach the remote network.

4.1 Connectivity Testing

To further confirm network connectivity, we used the `ping` and `traceroute` commands from R1 and other devices. For example, from R1:

```
R1# ping 172.16.3.1
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/5/9 ms

R1# traceroute 172.16.3.1
Tracing the route to 172.16.3.1
  1  172.16.2.2  8 msec  8 msec  8 msec
  2  172.16.3.1  12 msec  11 msec  12 msec
```

The `ping` was successful, showing that the destination is reachable. The `traceroute` output confirms the path taken to reach the 172.16.3.0 network, showing that packets are being routed correctly through the network.

4.2 Conclusion

The routing table on R1 and the successful results from `ping` and `traceroute` commands confirm that RIP is functioning properly and that all configured networks are reachable. This demonstrates that our network is fully connected and operating as intended.

8. Analysis of RIP Message Exchanges

To observe how RIP version 2 exchanges routing information between routers, we used the `debug ip rip` command on Router R1. This command allows us to monitor both sent and received RIP messages in real-time.

4.3 Received RIP Updates

The debug output shows that R1 received RIP version 2 updates from its neighbors (e.g., `172.16.2.2` and `172.16.1.2`) on interfaces `Serial0/1` and `Serial0/0`. For example:

```
*Dec 22 15:09:30.962: RIP: received v2 update from 172.16.2.2 on Serial0/1
*Dec 22 15:09:30.962:      172.16.3.0/24 via 0.0.0.0 in 1 hops
*Dec 22 15:09:30.966:      192.168.2.0/24 via 0.0.0.0 in 2 hops
```

This confirms that R1 is learning routes from its neighboring routers. The route to `192.168.2.0/24` is learned with a metric of 2, meaning it's two hops away, and therefore R1 does not consider this the best path if a shorter path exists (e.g., metric of 1). RIP uses the lowest hop count to determine the best route, so higher-metric routes are only stored if no better option is available.

4.4 Sent RIP Updates

R1 also periodically sends out RIP updates to its neighbors using multicast address `224.0.0.9`, as shown below:

```
*Dec 22 15:09:38.106: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (172.16.1.1
*Dec 22 15:09:38.106: RIP: build update entries
*Dec 22 15:09:38.106:   172.16.2.0/24 via 0.0.0.0, metric 1, tag 0
*Dec 22 15:09:38.106:   192.168.1.0/24 via 0.0.0.0, metric 1, tag 0
```

These entries show that R1 is correctly advertising its directly connected networks with a metric of 1, as expected.

4.5 Classless Routing with RIP v2

One important feature of RIP version 2 is its support for classless routing, meaning that subnet masks are included with each route entry. This allows for more flexible and efficient IP address management compared to RIP version 1, which does not support subnet information and assumes classful boundaries.

For example, in the update messages we observed:

```
*Dec 22 15:10:18.392:   172.16.3.0/24 via 0.0.0.0, metric 2, tag 0
*Dec 22 15:10:18.392:   192.168.2.0/24 via 0.0.0.0, metric 2, tag 0
```

These entries explicitly specify the subnet mask (`/24`), which confirms the classless nature of RIP v2. This makes RIP v2 more compatible with modern subnetted networks.

4.6 Conclusion

The debug output confirms that RIP version 2 is functioning correctly on R1. It is both receiving and sending route updates, and correctly advertising all connected and learned networks with appropriate metrics. The inclusion of subnet information in all updates confirms that the protocol is operating in classless mode, as expected for RIP version 2.

5 Behavior of RIP Protocol After Interface Disconnection

To observe the behavior of RIP version 2 under failure conditions, we disconnected one of the Ethernet networks from Router R1. This was done in two scenarios: a complete shutdown of the interface and enabling passive mode for the given interface in the RIP configuration.

5.1 Effect of Interface Shutdown

In the first scenario, the Ethernet interface `FastEthernet0/0` was disabled using the `shutdown` command. As a result, R1 marked the directly connected network `192.168.1.0/24` as unreachable and began advertising it with a metric of 16, indicating an infinite distance:

```
*Dec 22 15:15:17.474:   192.168.1.0/24 via 0.0.0.0, metric 16, tag 0
```

Neighboring routers also started to receive this updated unreachable route:

```
*Dec 22 15:15:23.620: RIP: received v2 update from 172.16.1.2 on Serial0/0
*Dec 22 15:15:23.620:      192.168.1.0/24 via 0.0.0.0 in 16 hops  (inaccessible)
```

This behavior aligns with RIP's standard mechanism of route invalidation: when a network becomes unavailable, it is advertised with a metric of 16, effectively removing it from the routing tables of RIP-speaking routers after the timeout period.

5.2 Routing Table Verification

The `show ip route` command confirmed that the route to `192.168.1.0/24` was no longer present in R1's routing table. However, all other networks remained reachable:

```
R    192.168.2.0/24 [120/1] via 172.16.1.2, 00:00:10, Serial0/0
R    172.16.3.0/24 [120/1] via 172.16.2.2, 00:00:17, Serial0/1
```

5.3 Passive Interface Behavior

In the second scenario, instead of shutting down the interface, we set it to passive mode in RIP using the command `passive-interface fastethernet0/0`. This prevented RIP updates from being sent out that interface while still allowing the router to learn and advertise networks through other active interfaces.

After configuring passive mode, RIP continued to send updates about other networks, excluding the passive interface:

```
*Dec 22 15:19:46.075: RIP: build update entries
*Dec 22 15:19:46.075:   172.16.1.0/24 via 0.0.0.0, metric 1, tag 0
*Dec 22 15:19:46.075:   192.168.2.0/24 via 0.0.0.0, metric 2, tag 0
```

Notably, the previously invalidated network `192.168.1.0/24` was no longer included in updates, confirming that RIP recognizes the interface's passive status and refrains from advertising disconnected networks.

5.4 Conclusion

These observations demonstrate RIP version 2's dynamic route management capabilities. Upon complete interface shutdown, RIP marks the affected network with a metric of 16 and informs neighboring routers, effectively withdrawing the route. In contrast, passive mode disables RIP advertisements without affecting the interface's operational state, allowing continued participation in RIP routing for other active links. This supports stable and adaptable network routing behavior as expected from a classless distance-vector protocol.

6 Behavior of RIP Protocol After Network Reconnection

Following the earlier disconnection, the interface `FastEthernet0/0` on R1 was reactivated using the `no shutdown` command to analyze how RIP handles network reconnection.

6.1 RIP Update and Flash Behavior

Upon interface reactivation, R1 began to immediately send RIP version 2 updates, including flash updates, to inform neighboring routers of the restored network:

```
*Dec 22 15:21:43.944: RIP: sending v2 update to 224.0.0.9
via Serial0/0 (172.16.1.1)
*Dec 22 15:21:49.685: RIP: sending v2 flash update to 224.0.0.9
via Serial0/1 (172.16.2.1)
*Dec 22 15:21:49.685:   192.168.1.0/24 via 0.0.0.0, metric 1, tag 0
```

These updates indicated that the network `192.168.1.0/24` was now reachable with a metric of 1. R1 also resumed receiving valid RIP updates from neighbors, restoring dynamic routes to other networks.

6.2 Routing Table Convergence

After the reconnection, the routing table on R1 reflected complete and accurate information about all networks:

```
R     192.168.2.0/24 [120/1] via 172.16.1.2, 00:00:18, Serial0/0
R     172.16.3.0/24 [120/1] via 172.16.2.2, 00:00:04, Serial0/1
                           [120/1] via 172.16.1.2, 00:00:18, Serial0/0
```

This confirms that RIP quickly responded to the reconnected interface and advertised the restored route to neighbors, allowing the routing topology to stabilize dynamically.

6.3 Conclusion

RIP v2 demonstrates immediate responsiveness to physical interface changes. The use of flash updates ensures rapid propagation of routing information, minimizing convergence time and maintaining network reachability.

7 Behavior of RIP Protocol After Shutting Down R2's S0/0 Interface

To assess RIP's reaction to partial route failure, the `Serial0/0` interface on Router R2 was administratively shut down.

7.1 Detection and RIP Reaction

After the shutdown, RIP on R1 began marking routes through the now-inaccessible interface as unreachable by increasing their metric to 16:

```
*Dec 22 15:23:56.297:   172.16.1.0/24 via 0.0.0.0, metric 16, tag 0
*Dec 22 15:24:01.321:      172.16.1.0/24 via 0.0.0.0 in 16 hops  (inaccessible)
```

RIP behaved as expected, invalidating the affected route and continuing to exchange updated routing information via still-active interfaces.

Routing Table Recalculation

The routing table on R1 adapted to the new topology, removing the route via the disconnected interface and recalculating best available paths:

```
R    172.16.3.0/24 [120/1] via 172.16.2.2, 00:00:14, Serial0/1
R    192.168.2.0/24 [120/2] via 172.16.2.2, 00:00:14, Serial0/1
```

Although the metric to reach `192.168.2.0/24` increased to 2, the network remained reachable, showcasing RIP's capability to maintain redundancy.

7.2 Conclusion

RIP's metric-based path selection ensures continued network operation even in the presence of failures. The shutdown of a single interface triggers automatic path invalidation and rerouting, preserving network reachability with minimal disruption.

7.3 RIP Message Analysis via Wireshark

In this part of the experiment, RIP version 2 messages were captured on Router R1 using the Wireshark protocol analyzer. The analysis was focused on verifying the destination MAC and IP addresses used for RIP message dissemination and understanding the structure of the messages.

7.3.1 Capture Details

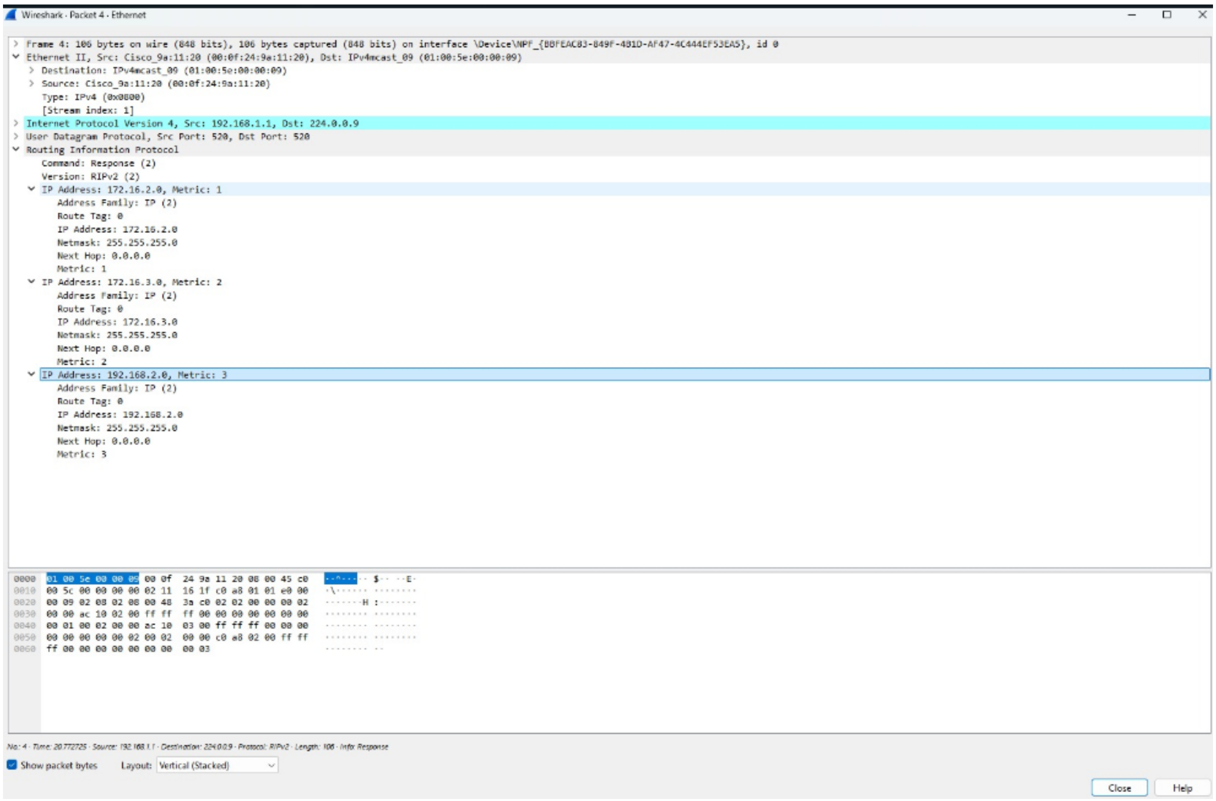


Figure 1: Screenshot from Capture

The following observations were made from the captured RIP message:

- **Source IP Address:** `192.168.1.1`
- **Destination IP Address:** `224.0.0.9`
- **Source MAC Address:** `Cisco_9a:11:a0`
- **Destination MAC Address:** `01:00:5e:00:00:09`
- **Protocol:** UDP, Port 520 (RIP)

7.3.2 Interpretation

RIP version 2 uses multicast IP address `224.0.0.9` to distribute routing updates. The corresponding multicast MAC address is derived from the lower 23 bits of the IP address, resulting in `01:00:5e:00:00:09`, as observed in the capture. This ensures that only RIP-enabled devices receive these updates, reducing unnecessary load on other network devices.

7.3.3 Routing Entries in Message

The captured RIP packet included multiple routing entries:

- `172.16.2.0/24`, Metric: 1
- `172.16.3.0/24`, Metric: 2
- `192.168.2.0/24`, Metric: 3

Each entry contains the network address, subnet mask, and hop count (metric). As the metric increases, the distance to the network increase

8 EIGRP Protocol Configuration and Testing

8.1 Network Topology

The network topology used for EIGRP testing consists of three routers (R1, R2, R3) and two PCs (PC1 and PC2), interconnected via Ethernet and serial interfaces, each router was configured with IP addresses according to the laboratory guide. Connectivity was verified using the `ping` command.

8.2 Router Configuration

Enhanced Interior Gateway Routing Protocol (EIGRP) was configured on all three routers using the following general procedure:

- Enable EIGRP routing with a unique AS (Autonomous System) number.
- Specify the directly connected networks using the `network` command.
- Disable automatic summarization using the `no auto-summary` command.

8.2.1 Sample Configuration (Router R1)

```
R1(config)#router eigrp 100
R1(config-router)#no auto-summary
R1(config-router)#network 192.168.1.0 0.0.0.255
R1(config-router)#network 172.16.1.0 0.0.0.255
R1(config-router)#network 172.16.2.0 0.0.0.255
```

Similar configurations were applied on R2 and R3, with appropriate network addresses.

8.3 Verification and Testing

The operation of EIGRP was verified using the following methods:

- **Routing Table Check**: Confirmed presence of dynamically learned routes using `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 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, 2 subnets
C       172.16.2.0 is directly connected, Serial0/1
D       172.16.3.0 [90/2681856] via 172.16.2.2, 00:00:12, Serial0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
D    192.168.2.0/24 [90/2684416] via 172.16.2.2, 00:00:12, Serial0/1
```

- **Ping and Traceroute**: Verified end-to-end connectivity between hosts and routers.

```
R1#ping 192.168.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/9/12 ms
----------------------------------------------------------------------
C:\Users\Student>tracert -d 192.168.2.2

Tracing route to 192.168.2.2 over a maximum of 30 hops

  1     1 ms     1 ms     1 ms  192.168.1.1
  2     4 ms     4 ms     4 ms  172.16.2.2
  3     7 ms     6 ms     6 ms  172.16.3.1
  4     8 ms     7 ms     7 ms  192.168.2.2

Trace complete.
```

- **Neighbor Relationships**: Verified with `show ip eigrp neighbors`.

```
R2#show ip eigrp nei
IP-EIGRP neighbors for process 100
```

8.4 EIGRP Metric Calculation

The EIGRP metric for the network `192.168.2.0/24` was manually calculated on Router R1 using the EIGRP formula:

$$\text{Metric} = \left[\left(10^7/\text{min BW}\right) + \text{Sum of Delays}\right] \times 256$$

Bandwidth and delay were obtained using the `show interfaces` command. The manually computed metric was compared with the value shown in the routing table and matched closely, confirming correct operation of the EIGRP algorithm.

```
R1#show interfaces
FastEthernet0/0 is up, line protocol is up
Hardware is AmdFE, address is 000f.249a.1120 (bia 000f.249a.1120)
Internet address is 192.168.1.1/24
MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
```

R1 Serial0/1 to R3:

BW = 1544 kbps delay = 20000 usec

R2 Serial0/1 to R3:

BW = 1544 kbps delay = 20000 usec

R3 Serial0/0 to R2: BW = 1544 kbps delay = 20000 usec

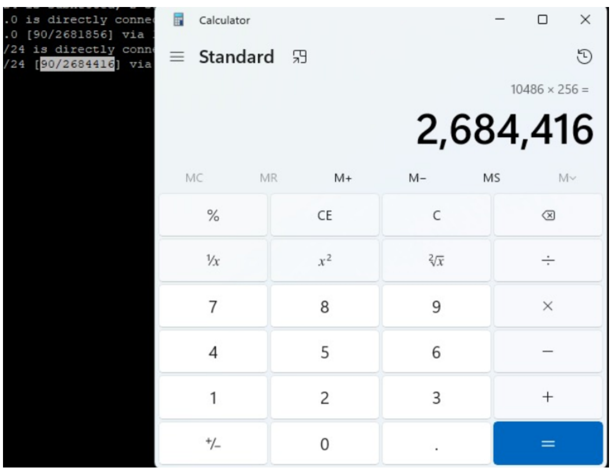


Figure 2: Calculation of Metric

8.5 Observations and Conclusions

The calculated EIGRP metric closely matched the values observed in the routing tables, confirming proper interface configuration and metric interpretation. Compared to RIP, EIGRP demonstrated faster convergence and greater scalability due to its use of the DUAL algorithm and composite metric.

- EIGRP quickly adapted to topology changes and provided loop-free routing.
- Unlike RIP, EIGRP uses DUAL (Diffusing Update Algorithm) to ensure more efficient and faster convergence.
- Manual metric calculation aligned with router-generated values, confirming correct configuration and metric interpretation.

The experiment demonstrated the benefits of dynamic routing protocols like EIGRP in larger and more complex networks.

9 References

1. Sloan, J.D. (2001). Network Troubleshooting Tools. O'Reilly Media, Inc.
2. Wireshark Documentation: `https://www.wireshark.org/docs/`
3. Lab Manual by Andrzej Zankiewicz, PhD