IR.1101 - Réseaux/Networks
Final Project

Comparative Analysis of

Distance-Vector & Link-State Routing Protocols

Based on RIP and OSPF

PRESENTATION

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1.Introduction

Dynamic routing protocols are essential in modern networking, allowing routers to exchange information dynamically, enabling networks to adapt seamlessly to changes.

- **Protocol Categories**
  Distance-Vector and Link-State protocols are distinguished by their wide adoption and unique operational mechanisms.

- **Focus on RIP and OSPF**
  This presentation will concentrate on two protocols: the Routing Information Protocol (RIP) and Open Shortest Path First (OSPF).

- **Monitoring and Distribution**
  Monitoring network changes and distributing this information across routers, making the choice of a suitable routing protocol a key decision in network design and management.

2.Routing Protocol

- Operate at **3rd** of OSI model(Network Layer)
- Purpose: **sorting** & **distribution** of IP packets
- Attribute and Characteristics:
  - Best Possible Routers
  - Faster Convergence
  - Security Options
  - Avoiding Loops

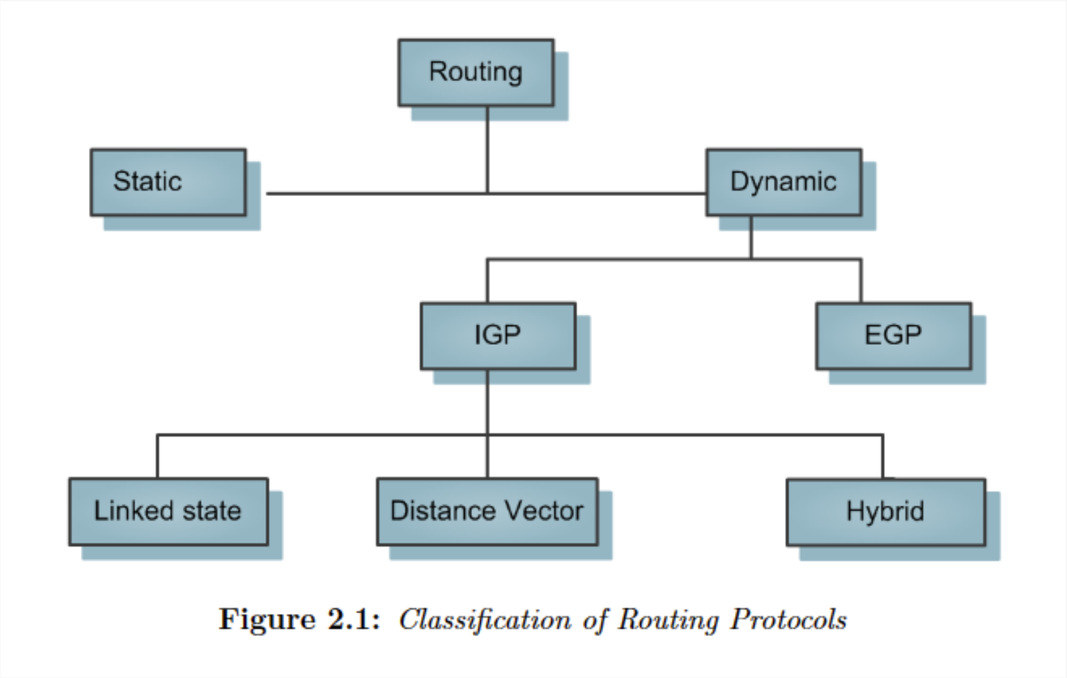


Figure 2.1: *Classification of Routing Protocols*

Figure Source: Khan, Murad; Javaid, Nadeem. (2019, February). "Routing in IP-based Networks." Thesis. pp.10.[51].

- **Dynamic Route**: selected using routing protocol
- **IGP(Interior Gateway Routing Protocols)**
  - Use for route selection within the autonomous system
  - Each of routing protocol has their own metric & administrative distances

2.1 Distance-Vector Routing

- **The DV Routers**
  - Not know about the complete network topology
  - Only have info passed by the neighbour devices

- **The characteristics of DVR protocol**
  - Bellman-Ford Algorithm
  - Metrics: Distance and Vector (mainly based on Hop-Counts vector)
  - Defines Routing Table (neighbor routers direct connection)
  - Periodic Updates
  - Simple and Efficient

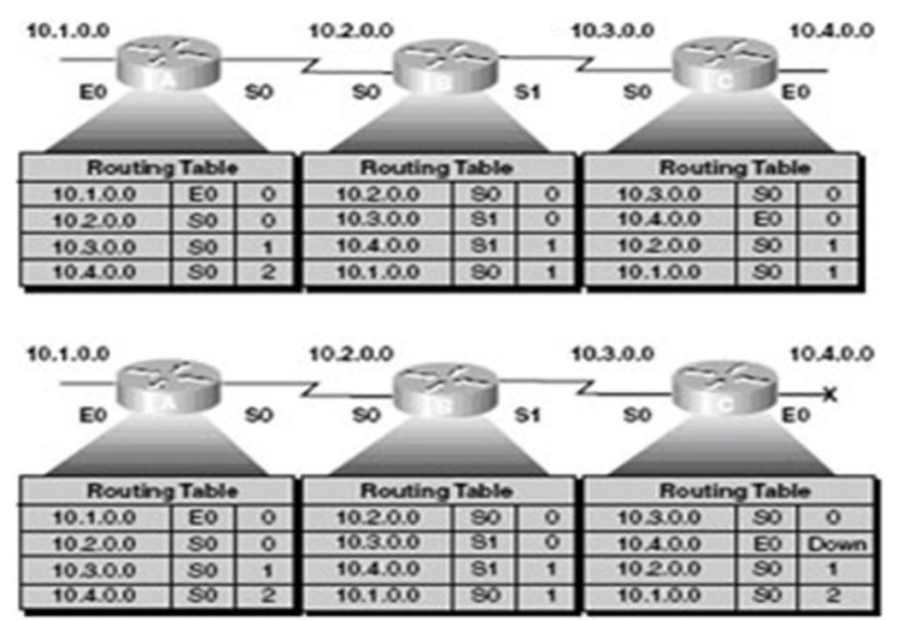


Figure 2.6: *Distance Vector Routing [5]*

Figure Source: Khan, Murad; Javaid, Nadeem. (2019, February). "Routing in IP-based Networks." Thesis. pp.16.[51].

- **Pros and Cons of DVR**
  - ✓ Simple Algorithm
  - ✓ Easy To Implement
  - ✓ Occupies Less Memory & Processor
  - x Loops May Occur
  - x Regularly Updated
  - x Single Parameter

2.1.1Routing Information Protocol

RIP:

- Suitable for small IP networks.
- Use **hop-count** as metric (up to 15 hops)
- Convergence time required
- Low memory and processor requirements
- Routing loops may occur during network failures

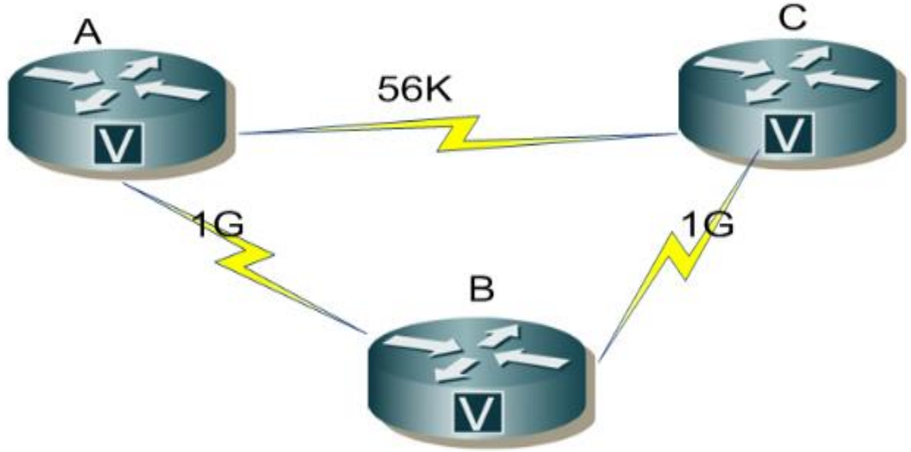


Figure 1.1: *Distance vector protocol*

Figure Source: Khan, Murad; Javaid, Nadeem. (2019, February). “Routing in IP-based Networks.” Thesis. pp.3.[51].

2.2Link-State Routing

- **The characteristics of LSR protocol**
  - SPF (Shortest Path First Algorithm) [Dijkstra's Algorithm]
  - Precise Metrics(Bandwidth, Delay and other QoS parameter)
  - Identical Database
  - Provides Hierarchical Structure
  - Triggered Update
  - Efficient and Fast Convergence Without Any Loop

- **Pros and Cons of LSR**
  - ✓ Respond Quickly
  - ✓ Small Packet Size
  - x Complex Algorithm
  - x High Memory Consumption & Processor Requirements
  - x Difficult to Configure
  - x Poor Performance on Constantly Changing Links

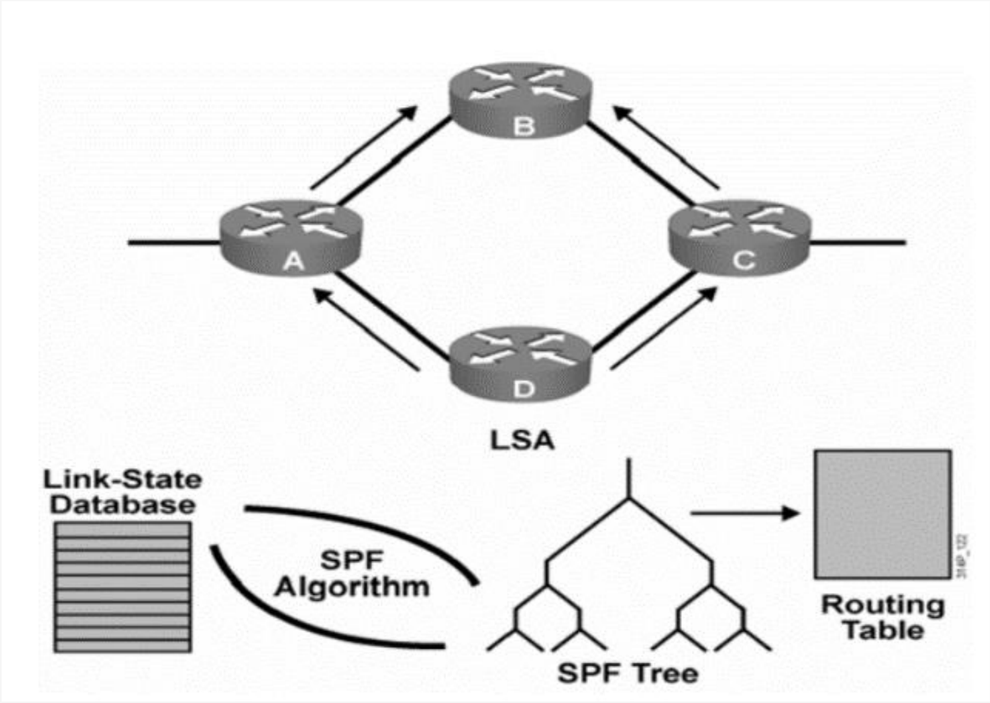


Figure Source: Khan, Murad; Javaid, Nadeem. (2019, February). "Routing in IP-based Networks." Thesis. pp.14.[51].

2.2.1Open Shortest Path First

OSPF:

- Suitable for large networks or environments that require rapid convergence
- Specifically designed for IP networks, so IP routing is calculated directly
- Calculating costs mainly relies on **bandwidth**

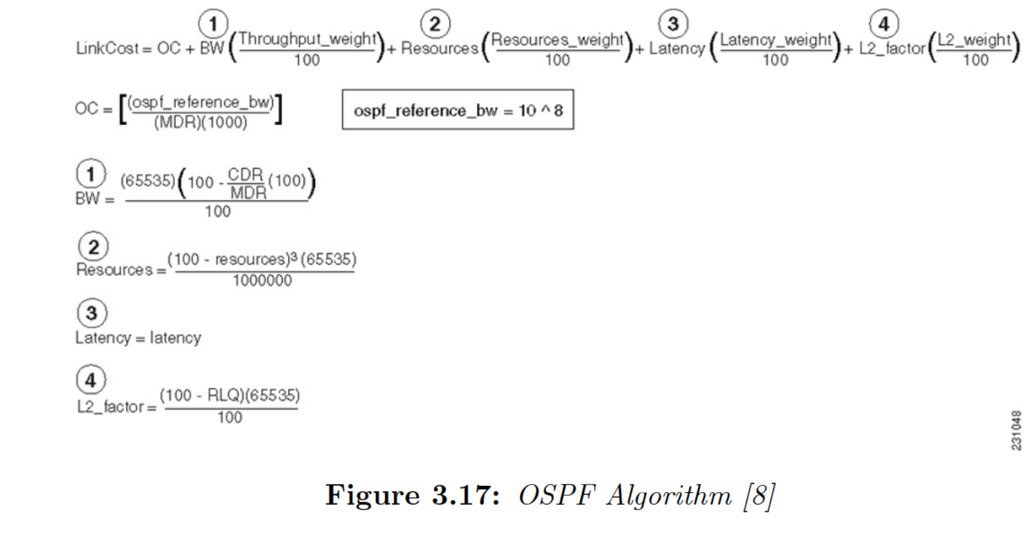
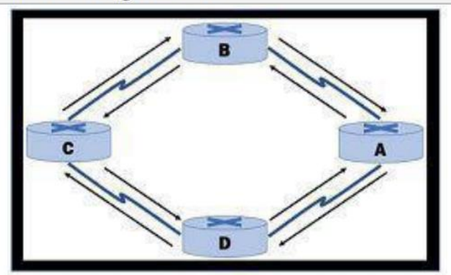
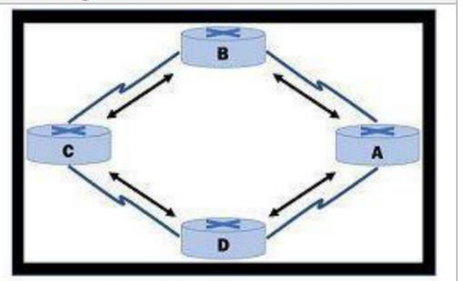
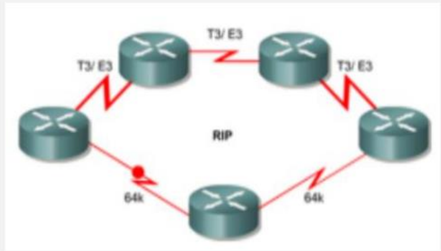
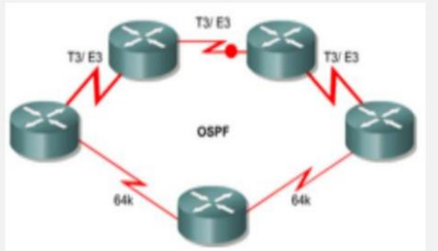


Figure 3.17: *OSPF Algorithm [8]*

Figure Source: Khan, Murad; Javaid, Nadeem. (2019, February). "Routing in IP-based Networks." Thesis. pp.33.[51].

2.3Comparative Analysis

	Distance-Vector	Link-State
Metric	Utilizes hop count	Uses the shortest path algorithm
Perspective	View the network from neighbour's view	Maintains a comprehensive network view
Updates	Sends updates periodically	Has event triggered updates.
Convergence	Slow convergence	Faster convergence
Loops	Susceptible to routing loops	Better at preventing routing loops
Configuration	Easier to configure and manage	More complex in configuration
Resources	Requires less memory and CPU	Needs more memory and CPU
Bandwidth	Consumes a lot of Bandwidth	More efficient in bandwidth usage
Sharing	Exchanges full routing tables with neighbours	Exchanges link-state updates among routers
Distance vector vs. Link state	 Distance Vector Routing	 Link State Routing
RIP vs. OSPF		

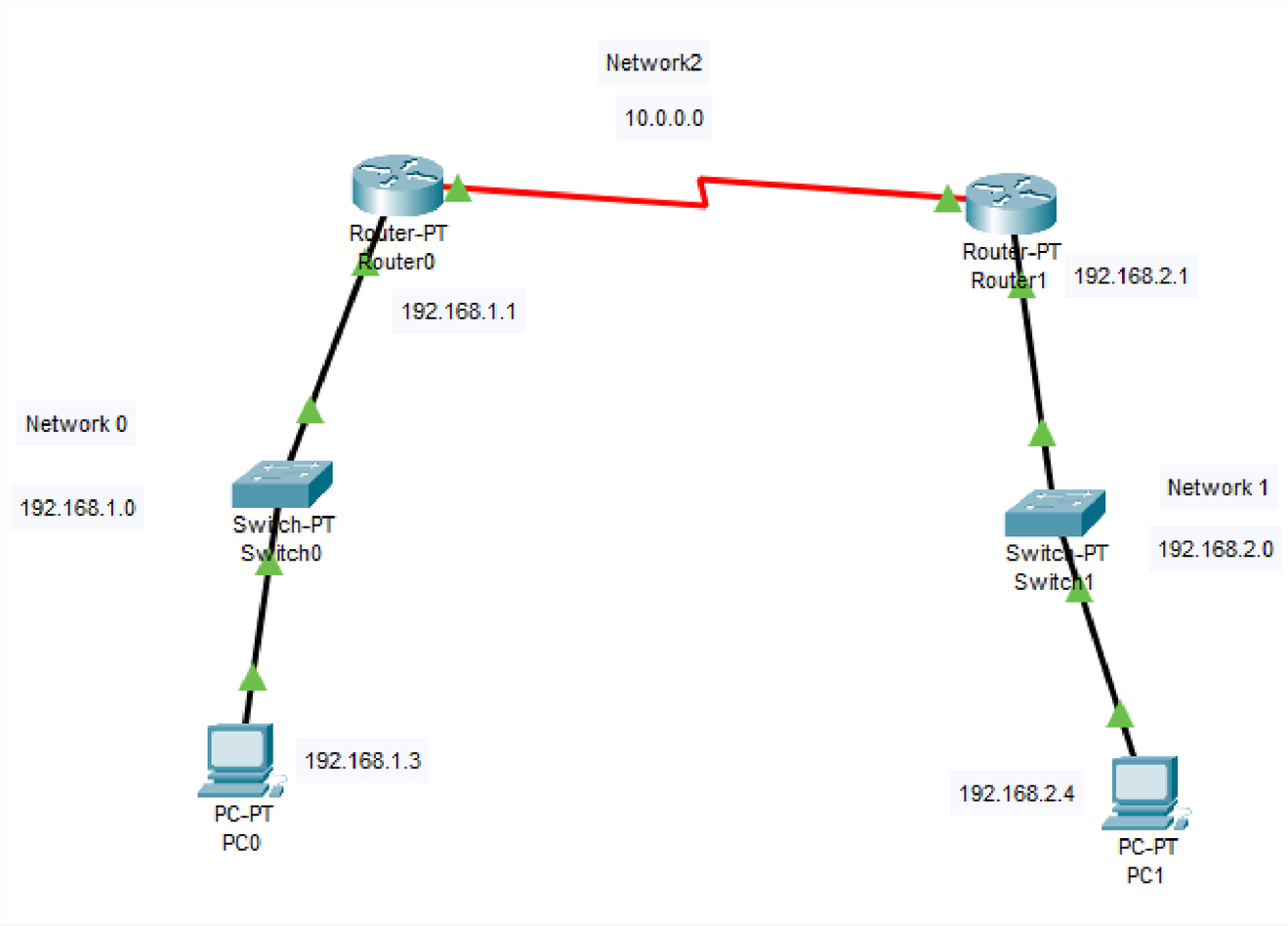
3.Implementation

Use Cisco to build the following simulation scenario:

3.1 Small-Scale Network (Suitable for RIP)
3.2 Large Enterprise Network (Suitable for OSPF)
3.3 Hybrid Network (Coexistence of RIP and OSPF)

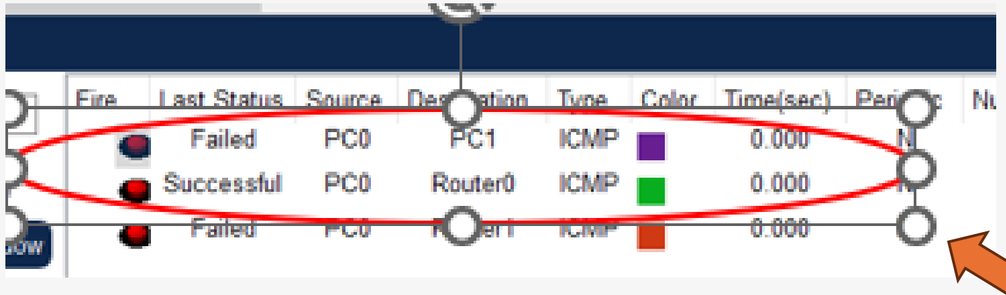
3.1Small-Scale Network (RIP)

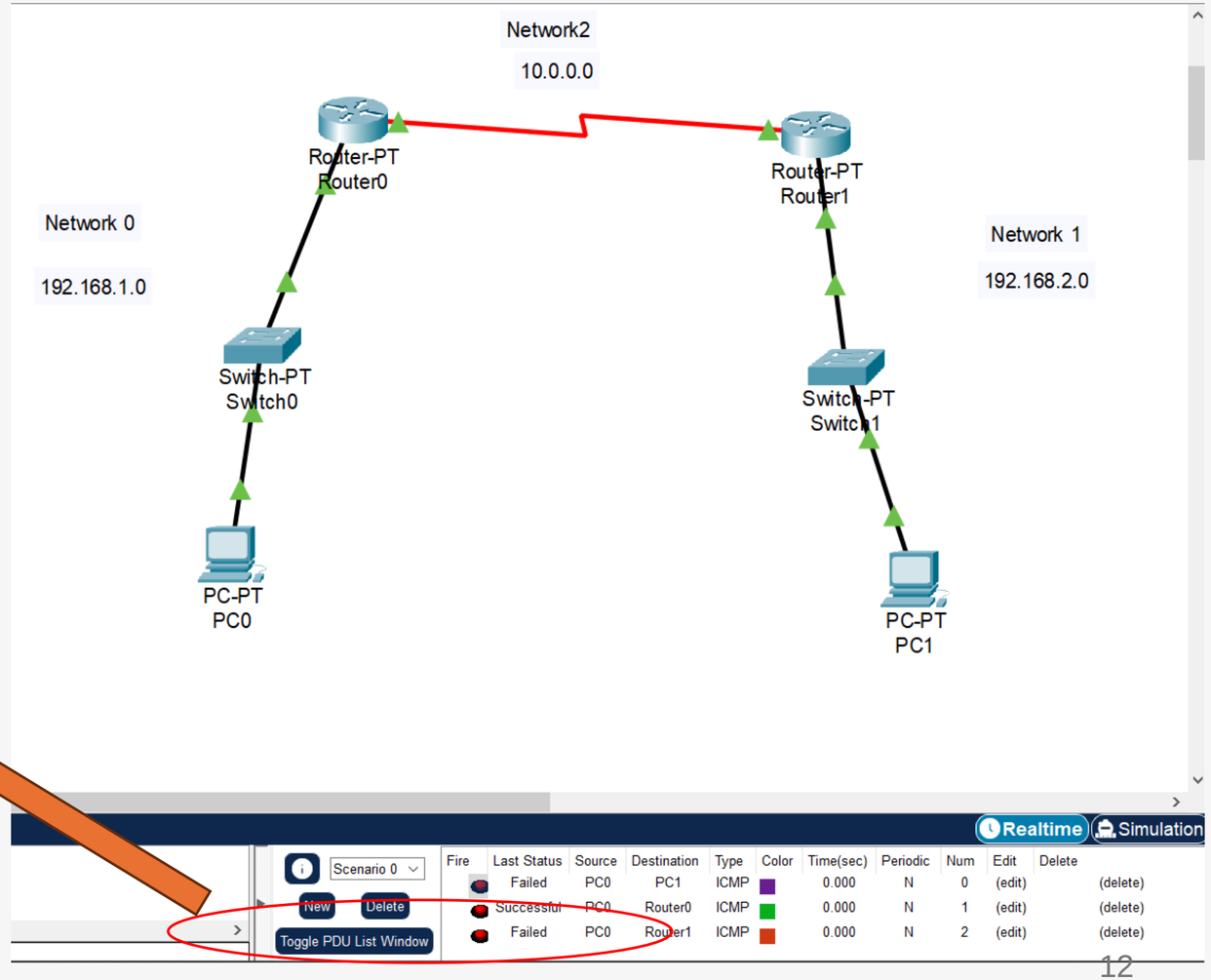
- **Build a Small-Scale Network**



3.1Small-Scale Network (RIP)

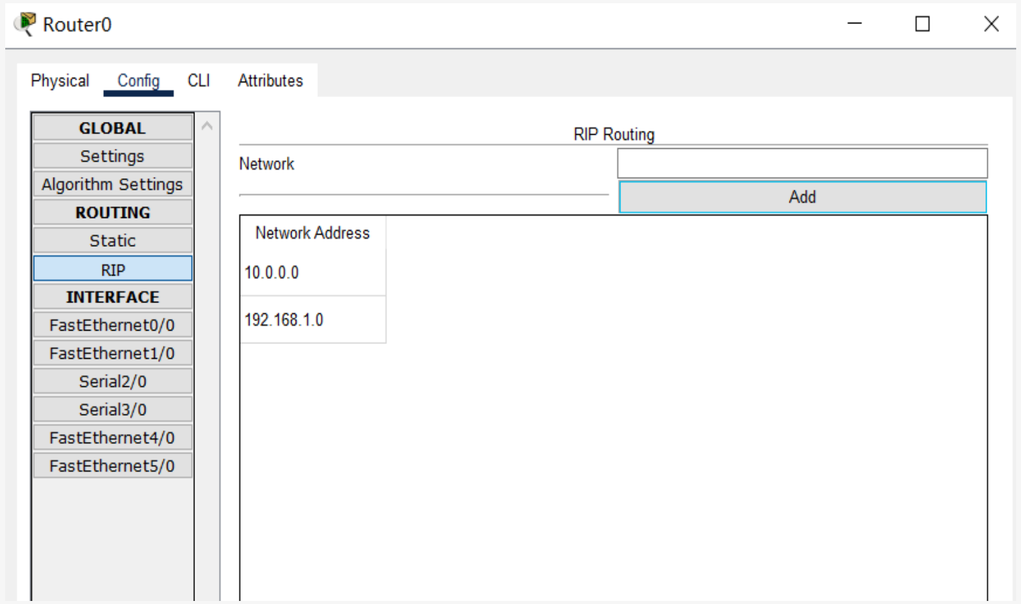
- Ping PC1 from PC0 failed,
- Ping Router0 from PC0 succeeded.
- Because RIP is not configured yet
  → nework0 and network1 cannot communicate.

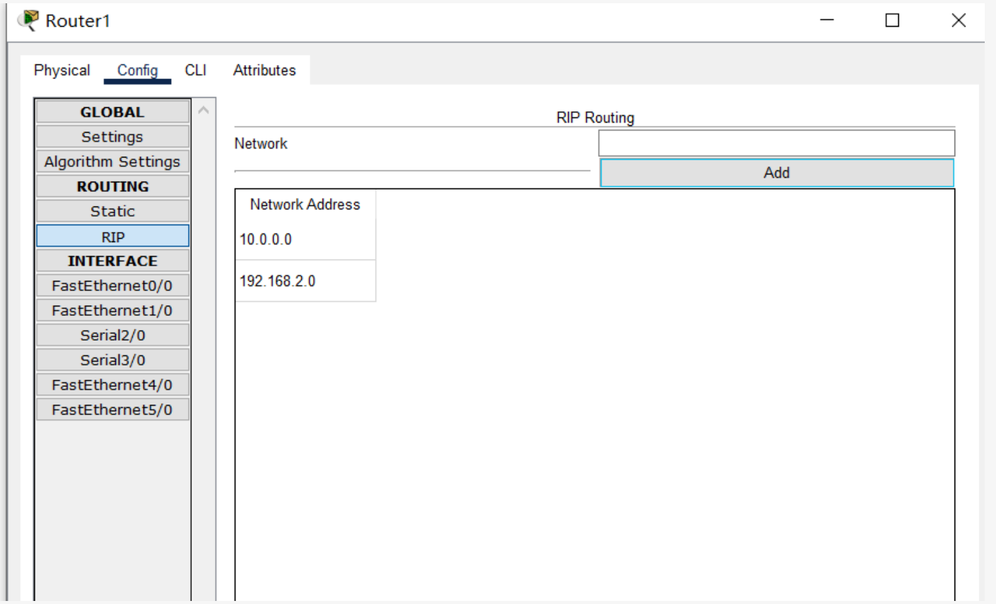




3.1Small-Scale Network (RIP)

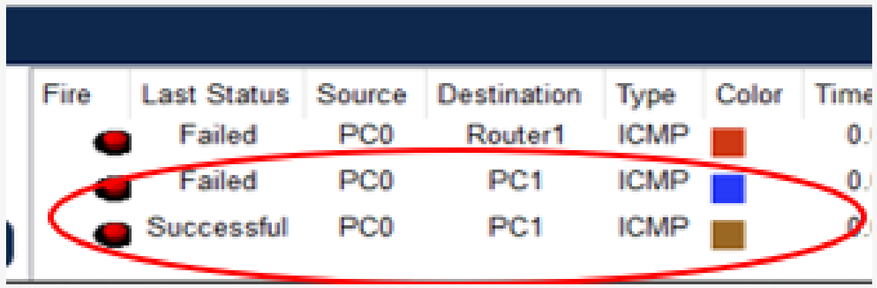
- **Configure RIP on Router1 and Route0 save it.**

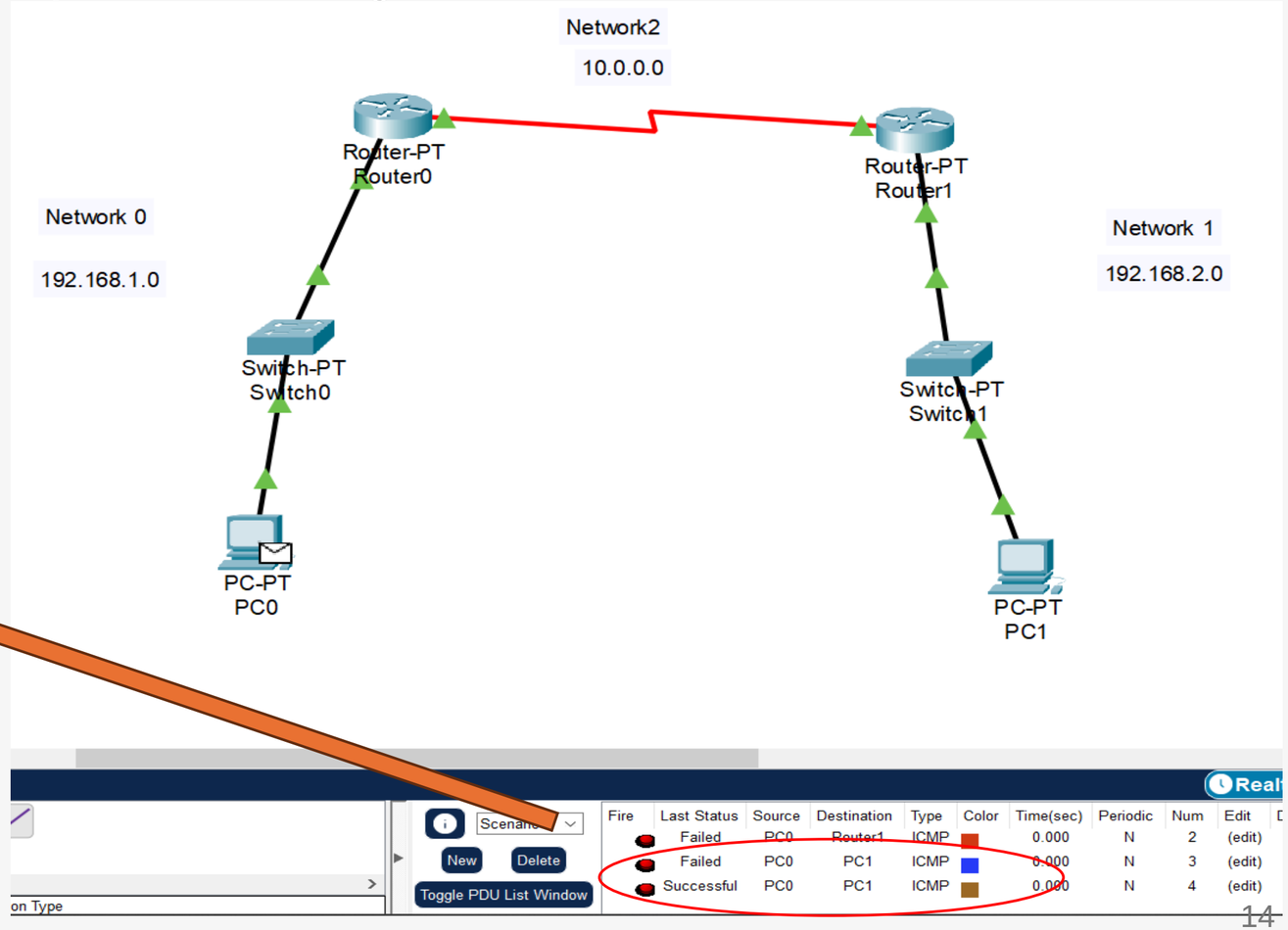




3.1Small-Scale Network (RIP)

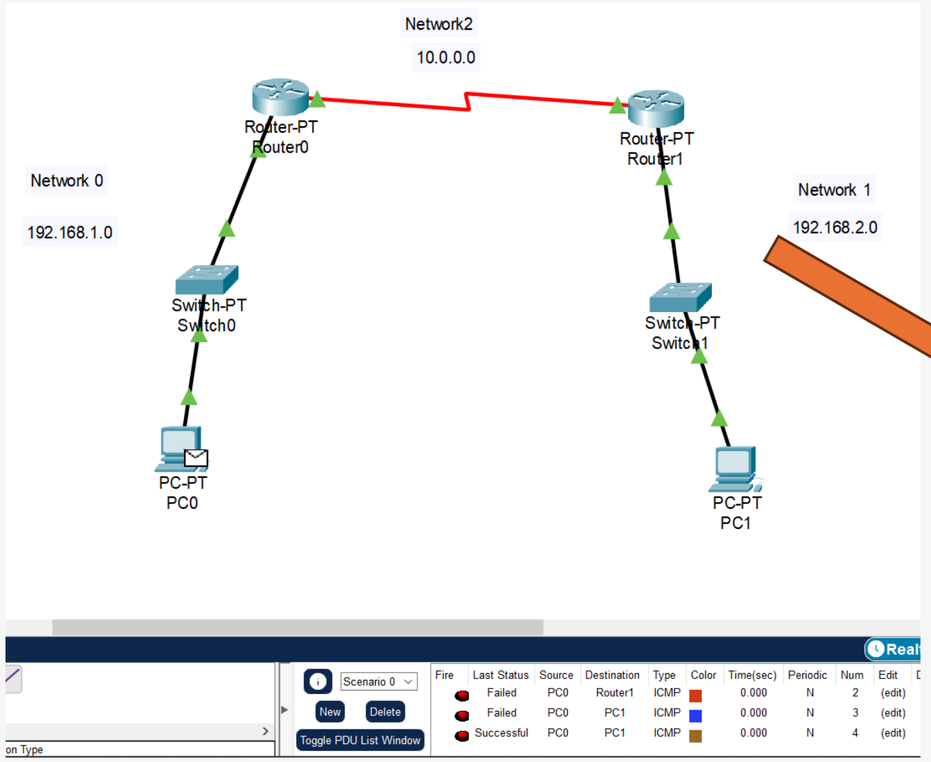
- Ping PC1 from PC0 failed the first time
- Ping succeeded the second time.
- Because it takes time for the RIP protocol to update the routing table.





3.1Small-Scale Network (RIP)

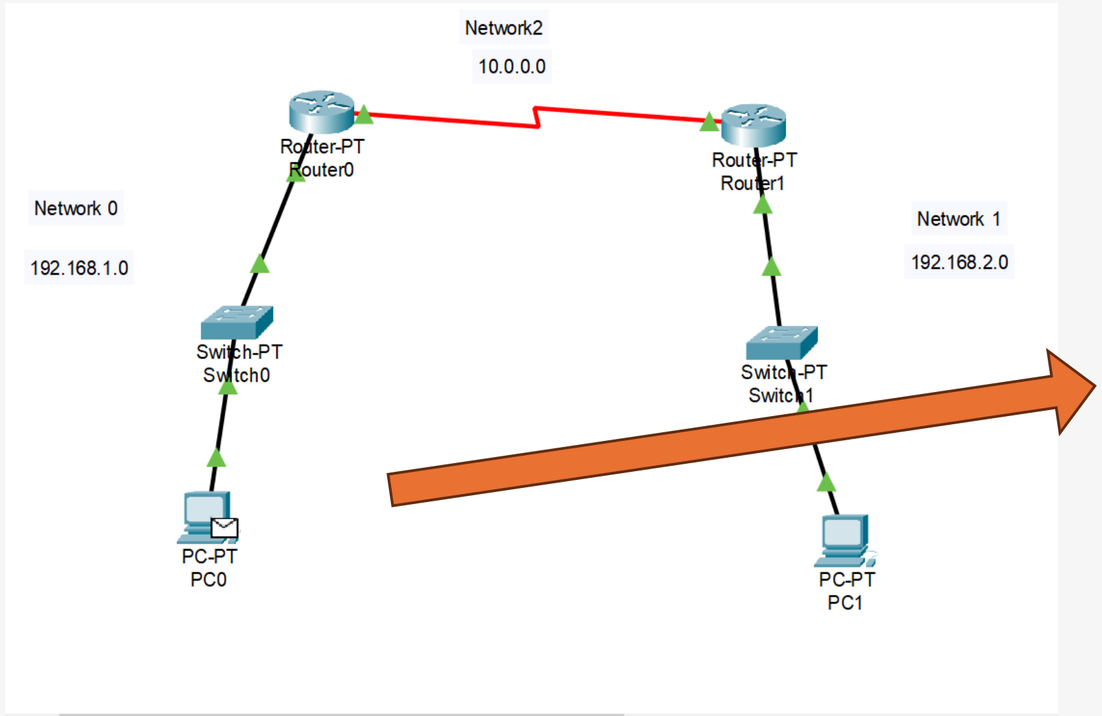
- **Check Routing Table of R1**

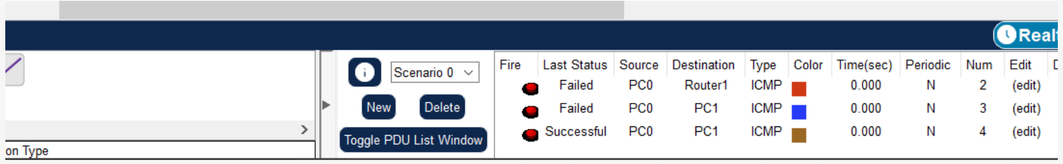



```
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E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

C    10.0.0.0/8 is directly connected, Serial2/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
R    192.168.2.0/24 [120/1] via 10.10.0.3, 00:00:19, Serial2/0

Router#show ip rip database
10.0.0.0/8    auto-summary
10.0.0.0/8    directly connected, Serial2/0
192.168.1.0/24    auto-summary
192.168.1.0/24    directly connected, FastEthernet0/0
192.168.2.0/24    auto-summary
192.168.2.0/24
    [1] via 10.10.0.3, 00:00:26, Serial2/0
Router#  tractraceroute 192.168.1.1
```

3.1Small-Scale Network (RIP)

- **Check HOP form PC0 to PC1**






```
Tracing the route to 192.168.2.4

  1    10.10.0.3       14 msec    1 msec     3 msec
  2    *       3 msec     3 msec
Router#
```

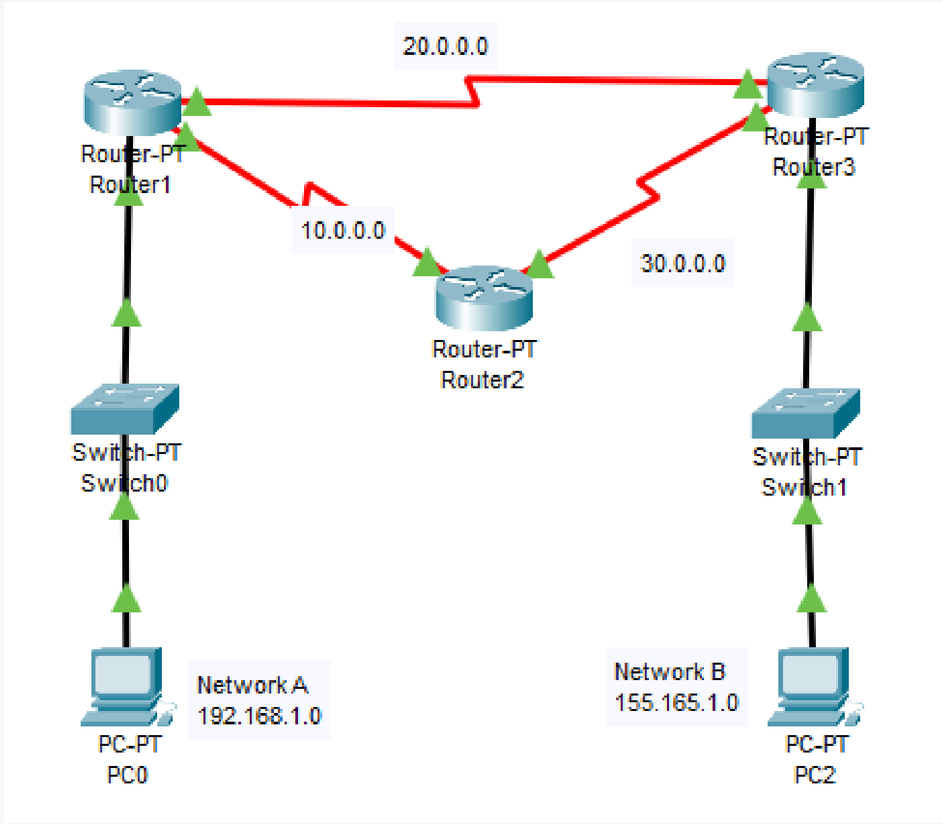
3.2Large Enterprise Network (OSPF)

- **Build a simplified single-area OSPF network**

```
Enter configuration commands, one per line.
Router(config)#interface se3/0
Router(config-if)#bandwidth 50
```

```
Router(config)#interface se2/0
Router(config-if)#bandwidth 1000
Router(config-if)#exit
```

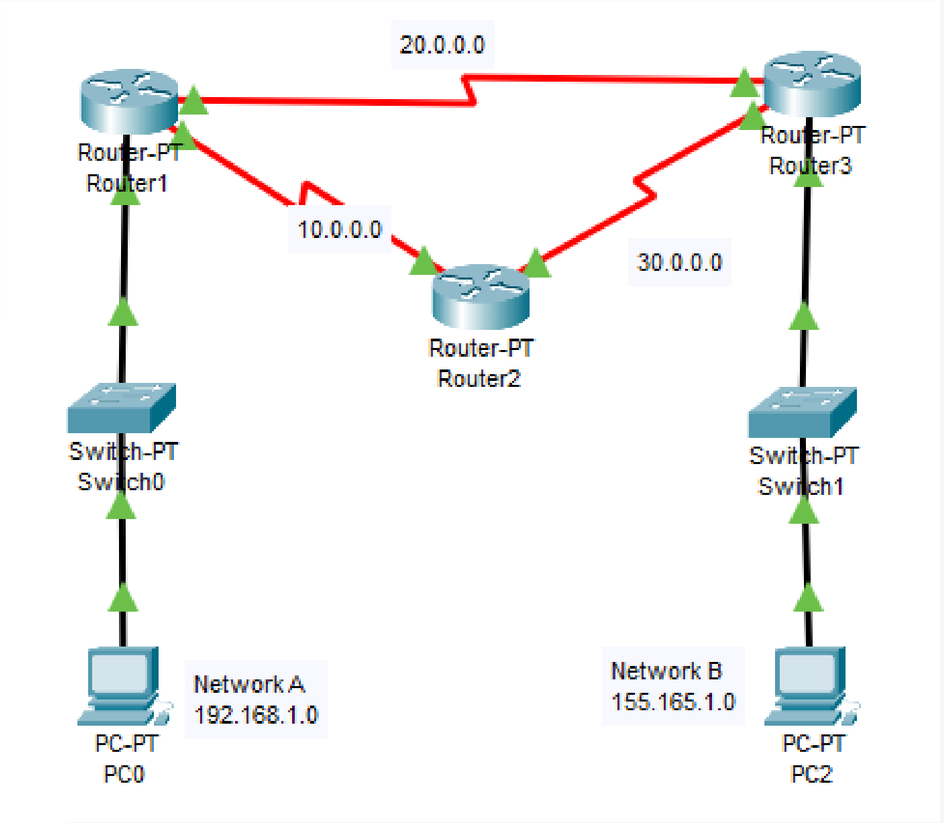
$$Cost = \frac{Reference\ Bandwidth}{Interface\ Bandwidth}$$



3.2Large Enterprise Network (OSPF)

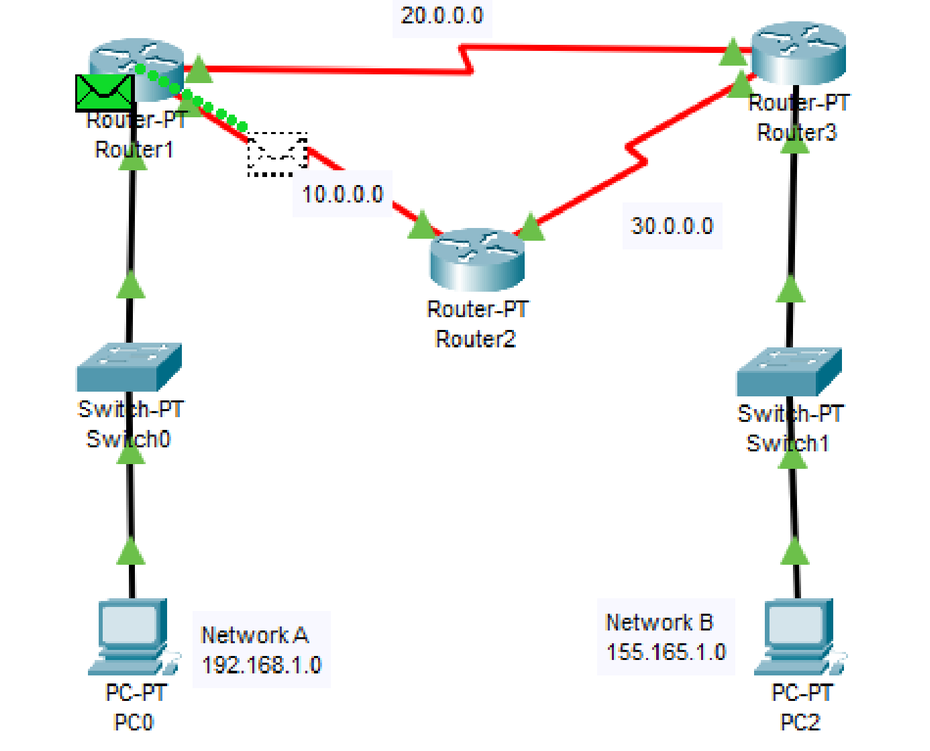
- **Configure OSPF protocol on routers**

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#router ospf 1
Router(config-router)#network
% Incomplete command.
Router(config-router)#network 192.168.1.0 0.0.0.225 area 0
OSPF: Invalid address/mask combination (discontiguous mask)
Router(config-router)#network 192.168.1.0 0.0.0.255 area 0
Router(config-router)#network 10.0.0.0 0.255.255.255 area 0
Router(config-router)#network 20.0.0.0 0.255.255.255 area 0
Router(config-router)#exit
```



3.2Large Enterprise Network (OSPF)

- **Stimulate the OSPF network**

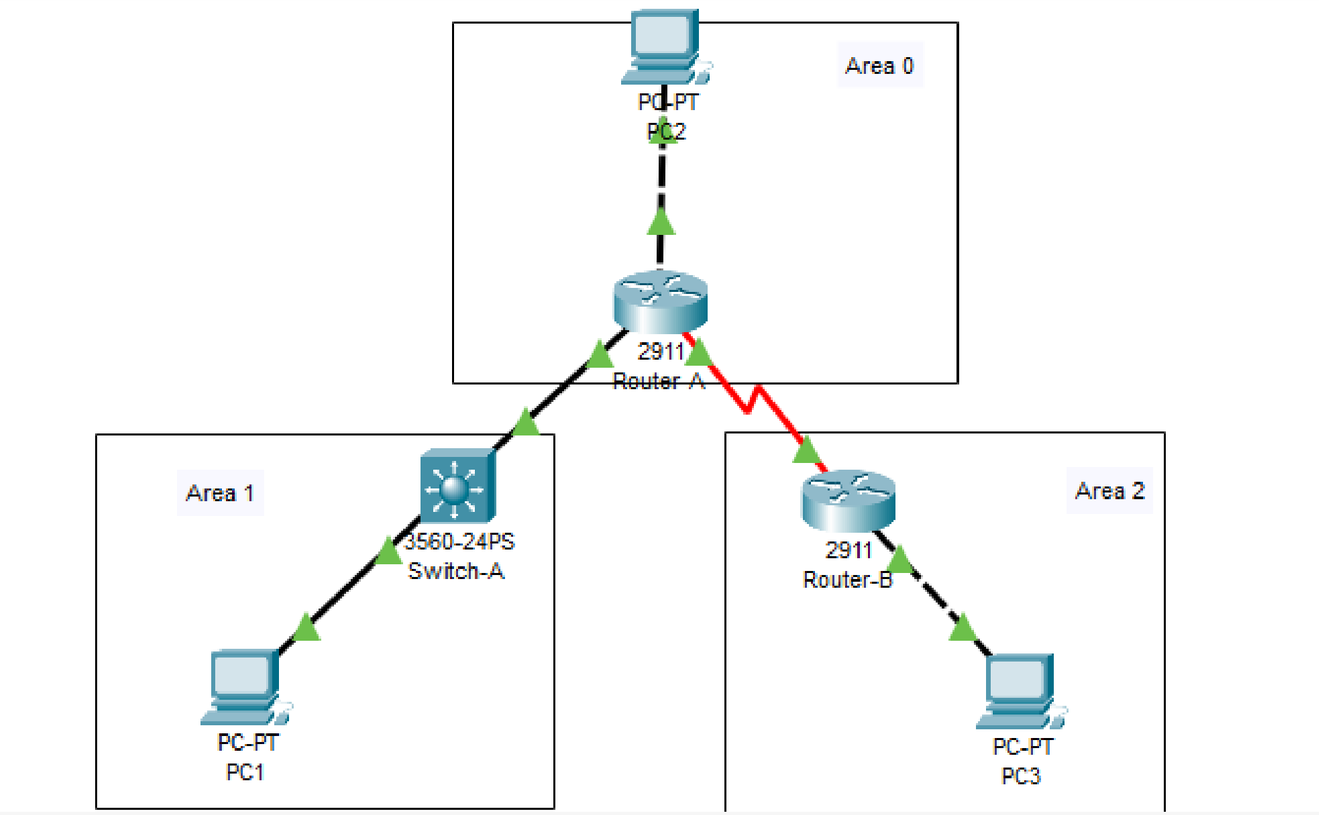


Event List

Vis.	Time(sec)	Last Device	At Device
	0.000	--	PC0
	0.001	PC0	Switch0
	0.003	Switch0	Router1
	0.006	Router1	Router2
	0.009	Router2	Router3
	0.010	Router3	Switch1
	0.012	Switch1	PC2
	0.013	PC2	Switch1

3.2Large Enterprise Network (OSPF)

- **Build the multi-area OSPF network**



3.2Large Enterprise Network (OSPF)

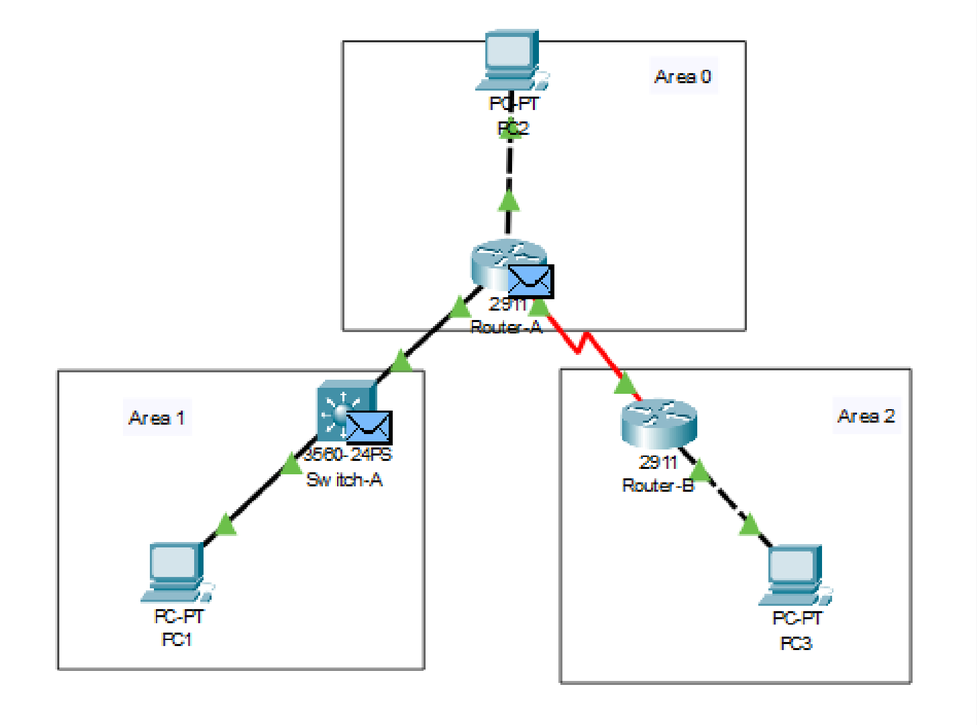
- **Configure OSPF protocol on routers**

```
Router-A(config-if)#exit
Router-A(config)#router ospf 1
Router-A(config-router)#network 192.168.1.0 0.0.0.255 area 0
Router-A(config-router)#network 192.168.2.0 0.0.0.255 area 0
00:18:49: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.1 on GigabitEthernet0/1
Router-A(config-router)#network 192.168.1.0 0.0.0.255 area 0
Router-A(config-router)#network 192.168.2.0 0.0.0.255 area 2
Router-A(config-router)#network 192.168.20.0 0.0.0.255 area 1
```

```
Router-B(config-if)#exit
Router-B(config)#router ospf 1
Router-B(config-router)#network 192.168.2.0 0.0.0.255 area 2
Router-B(config-router)#network 192.168.30.0 0.0.0.255 area 2
00:20:43: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.20.1 on Serial0/3/0 from LOADING to
FULL, Loading Done

Router-B(config-router)#network 192.168.2.0 0.0.0.255 area 2
Router-B(config-router)#network 192.168.30.0 0.0.0.255 area 2
```

3.2Large Enterprise Network (OSPF)

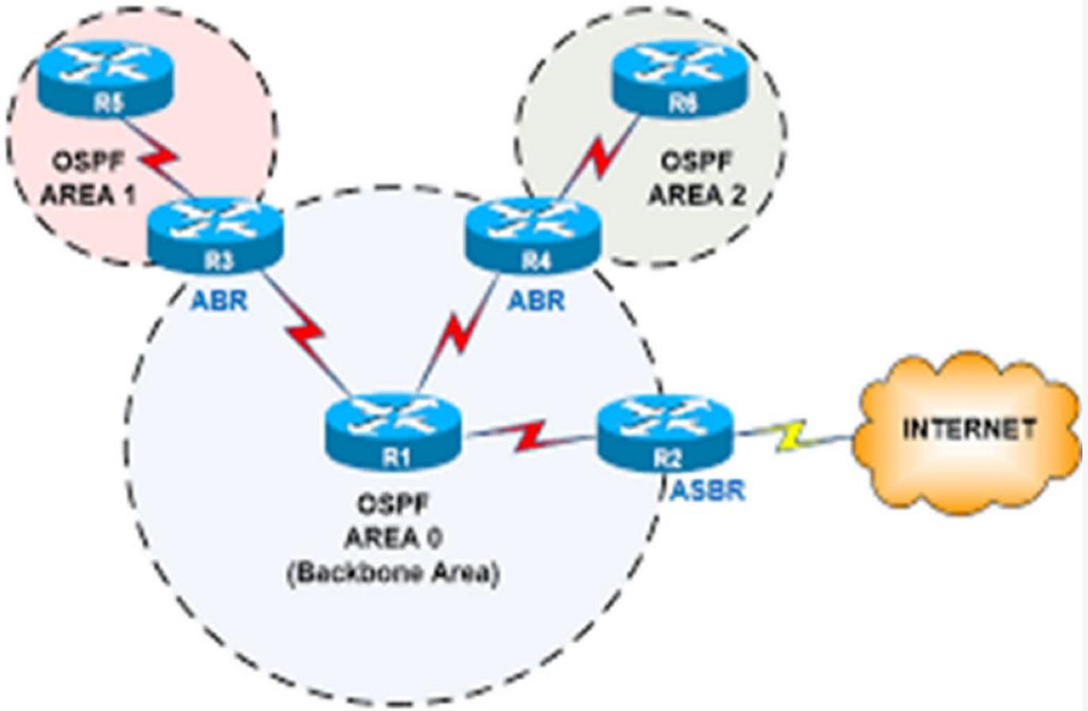
- **Stimulate the netork**



Event List

Vis.	Time(sec)	Last Device	At Device
	0.000	--	PC1
	0.001	PC1	Switch-A
	0.002	Switch-A	Router-A
	0.003	Router-A	Router-B
	0.004	Router-B	PC3
	0.005	PC3	Router-B

3.2Large Enterprise Network (OSPF)

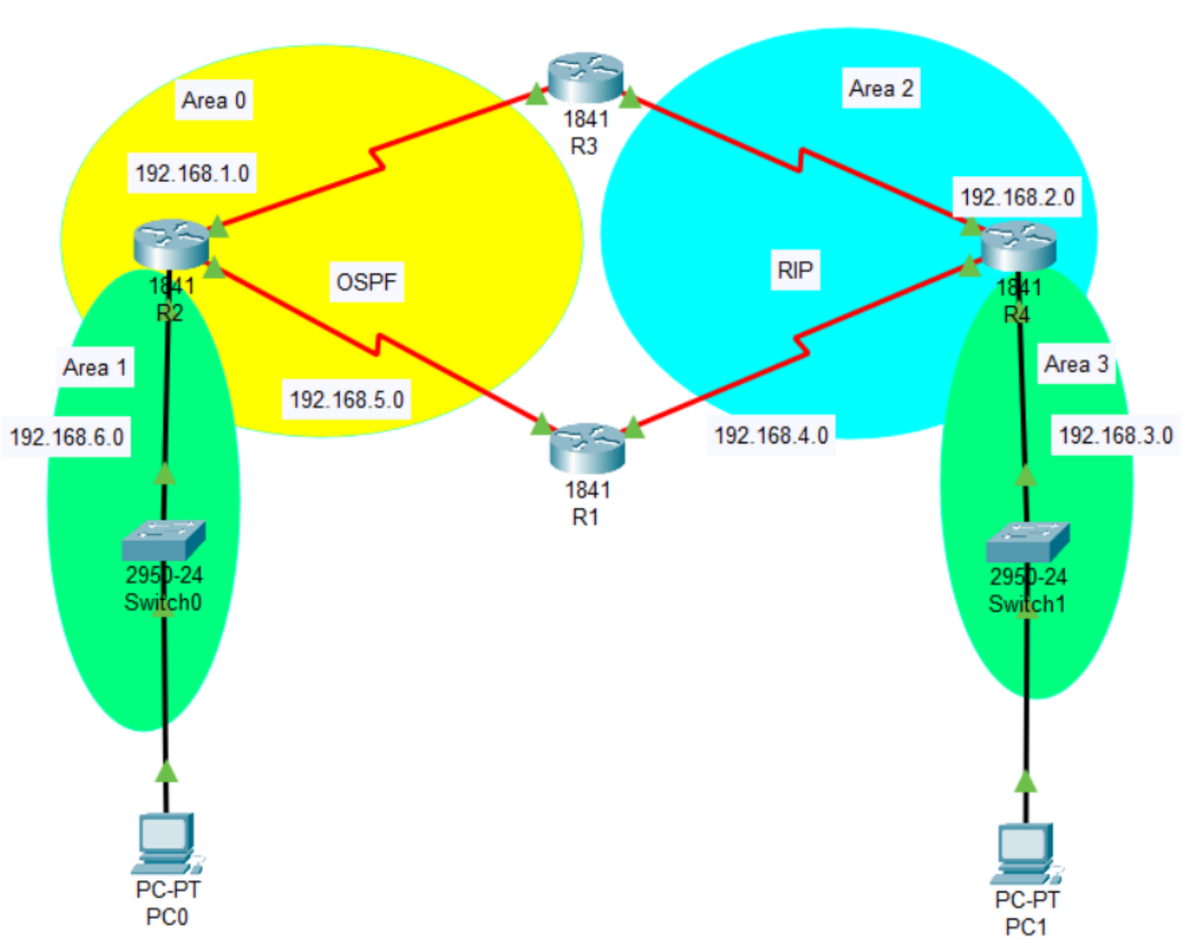


- **Advantage**
  - Scalability
  - Efficient Routing
- **Disadvantages**
  - Complexity
  - Resource Intensive

3.3Hybrid Network (RIP and OSPF)

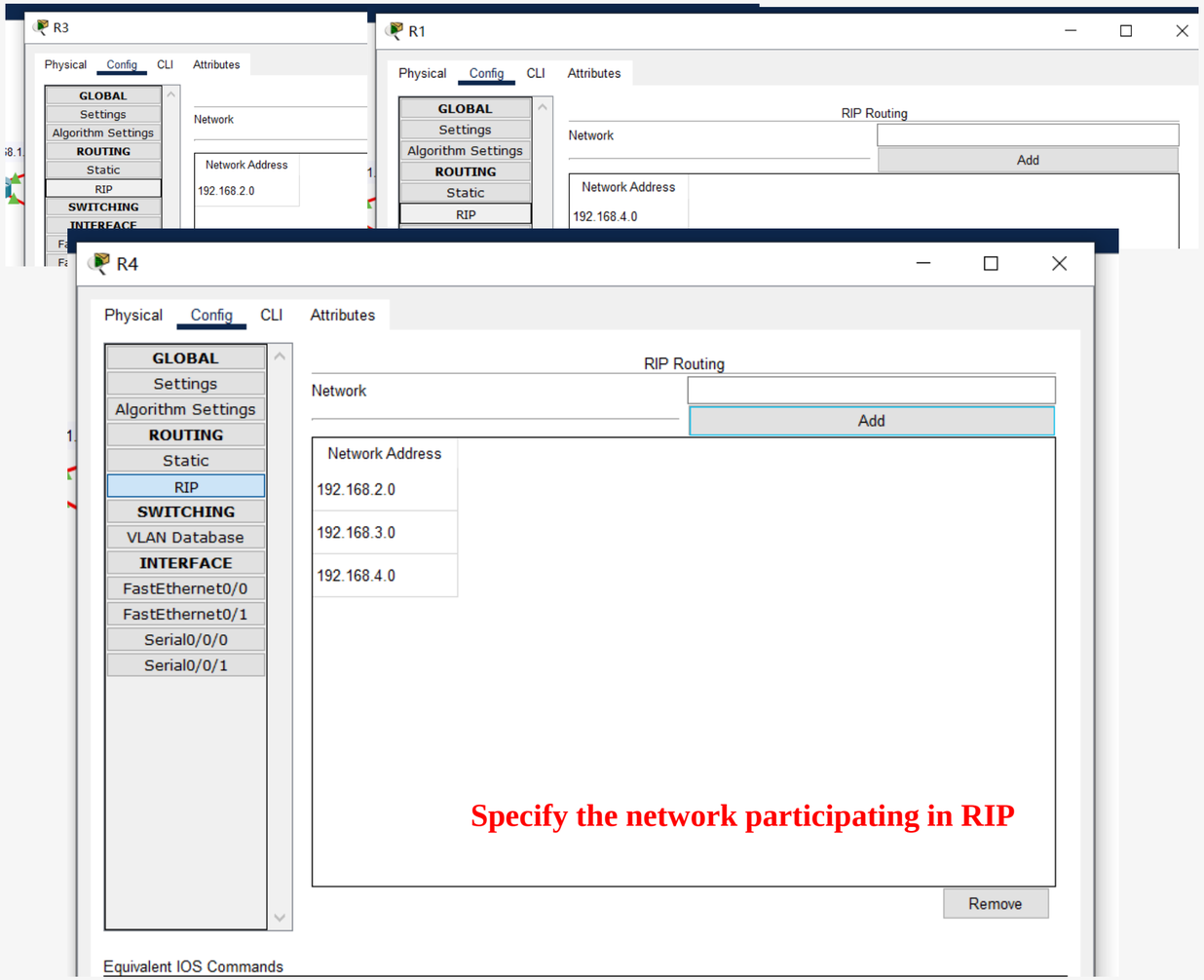
Redistribution

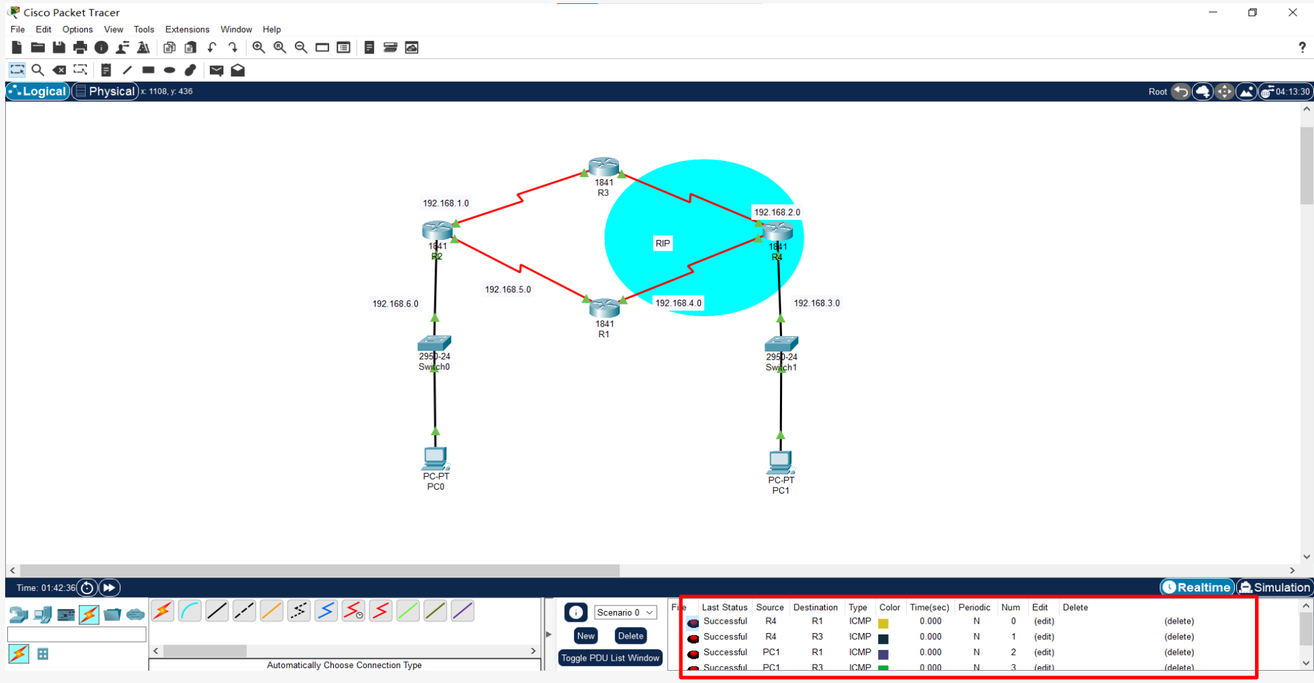
Convert RIP and OSPF metrics to make them compatible



3.3Hybrid Network (RIP and OSPF)

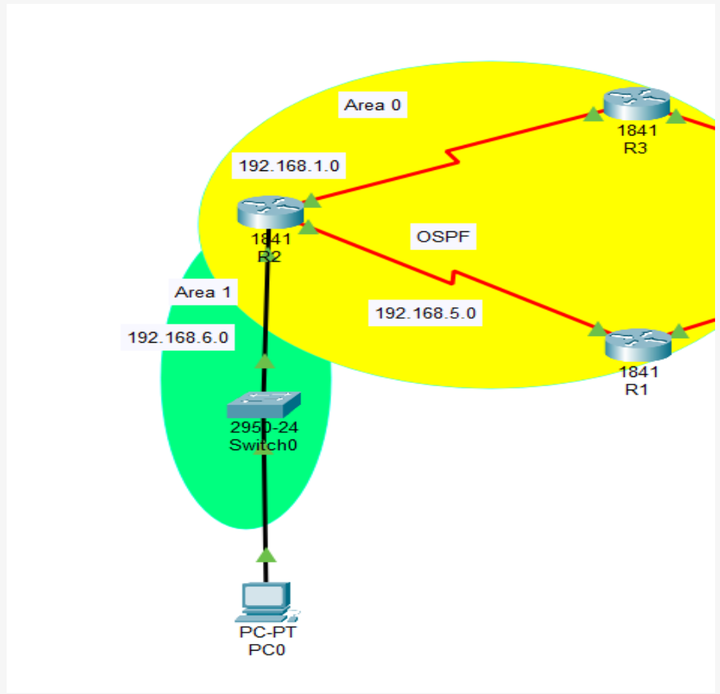
Configure RIP for the router in Area2





3.3Hybrid Network (RIP and OSPF)

Configure OSPF for the router in Area 0 and Area 1



OSPF area division

```
Router(config-router)#exit
Router(config)#router ospf 1
Router(config-router)#network 192.168.1.0 0.0.0.255
0
Router(config-router)#exit
Router(config)#
```

R3

```
Router(config)#router ospf 1
Router(config-router)#network 192.168.5.0 0.0.0.255 area
0
Router(config-router)#exit
```

R1

R2

Physical Config CLI Attributes

IOS Command Line Interface

```
Press RETURN to get started!



Router>
Router>
Router>enable
Router#
Router#configure terminal
Enter configuration commands, one per line.  End with
CNTL/Z.
Router(config)#router rip
Router(config-router)#eixt
                     ^
% Invalid input detected at '^' marker.

Router(config-router)#router ospf 1
Router(config-router)#network 192.168.1.0 0.0.0.255 area
0
Router(config-router)#network 192.168.5.0 0.0.0.255 area
0
Router(config-router)#network 192.168.6.0 0.0.0.255 area
1
Router(config-router)#exit
Router(config)#
```

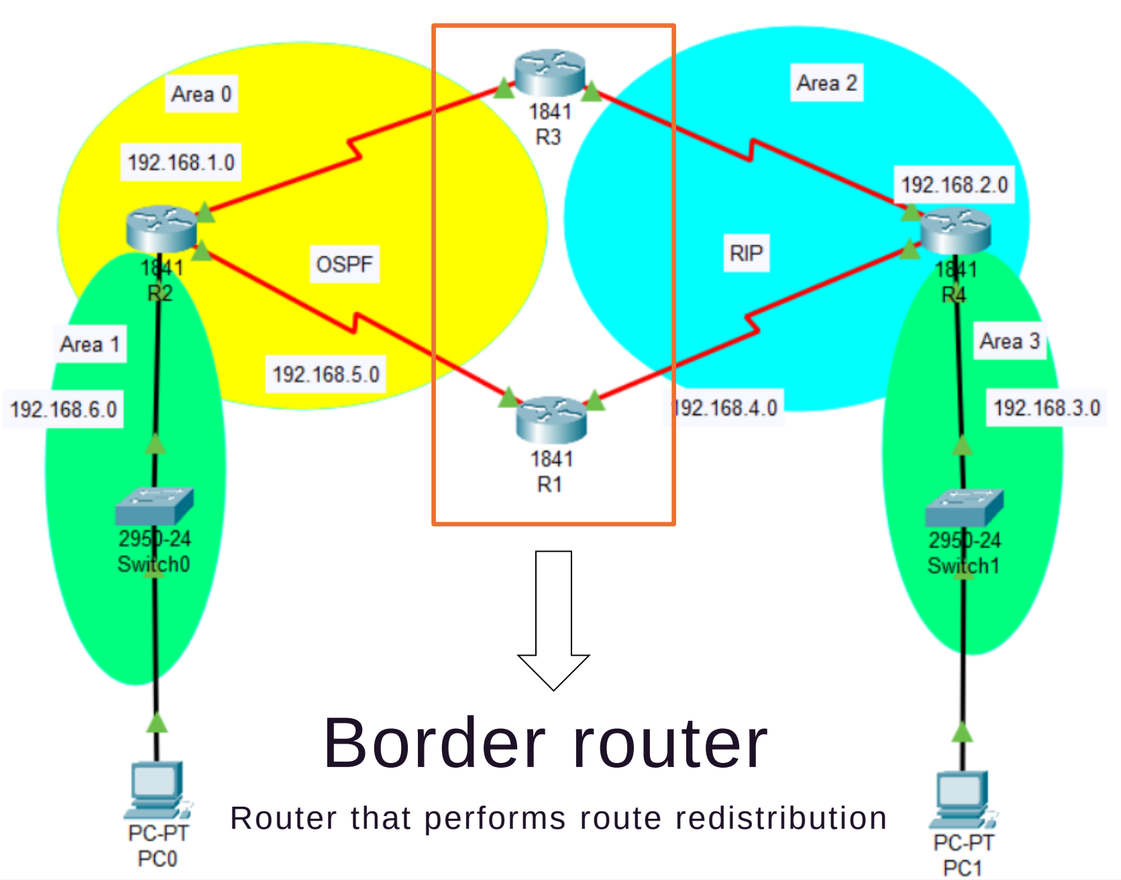
Copy Paste

Top

The OSPF process numbers of adjacent routers must be the same.

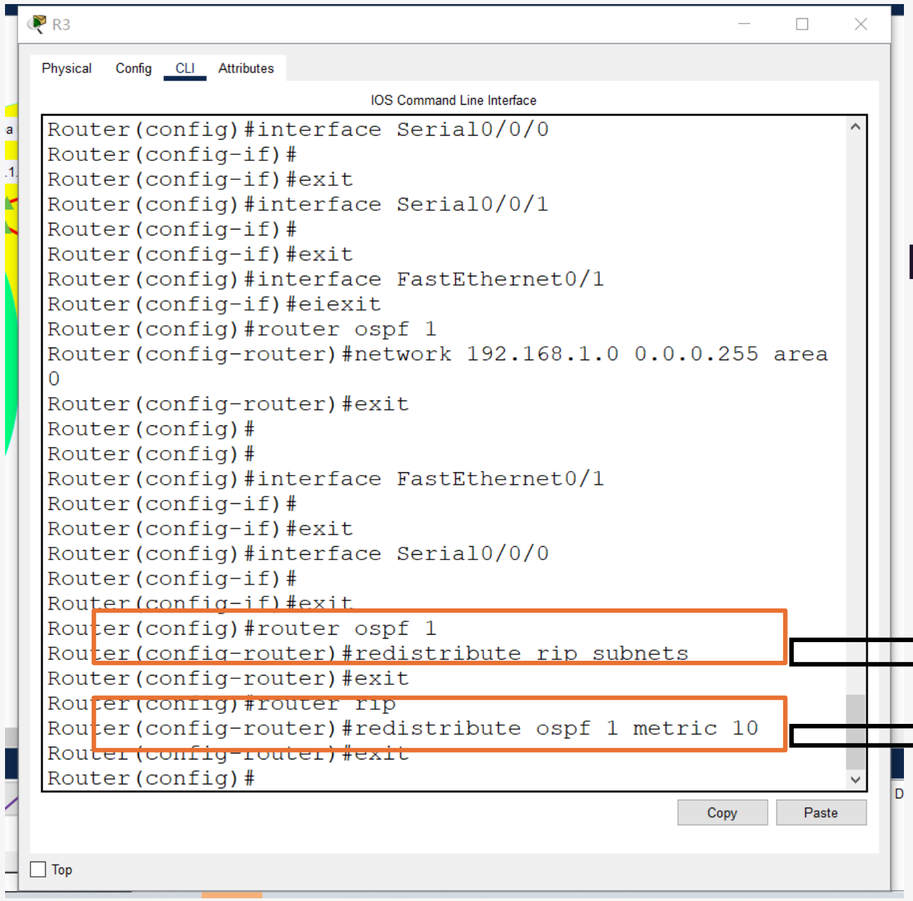
3.3Hybrid Network (RIP and OSPF)

Configure OSPF redistribution into RIP



3.3Hybrid Network (RIP and OSPF)

Configure OSPF redistribution into RIP



Redistribute RIP routing information in the OSPF process

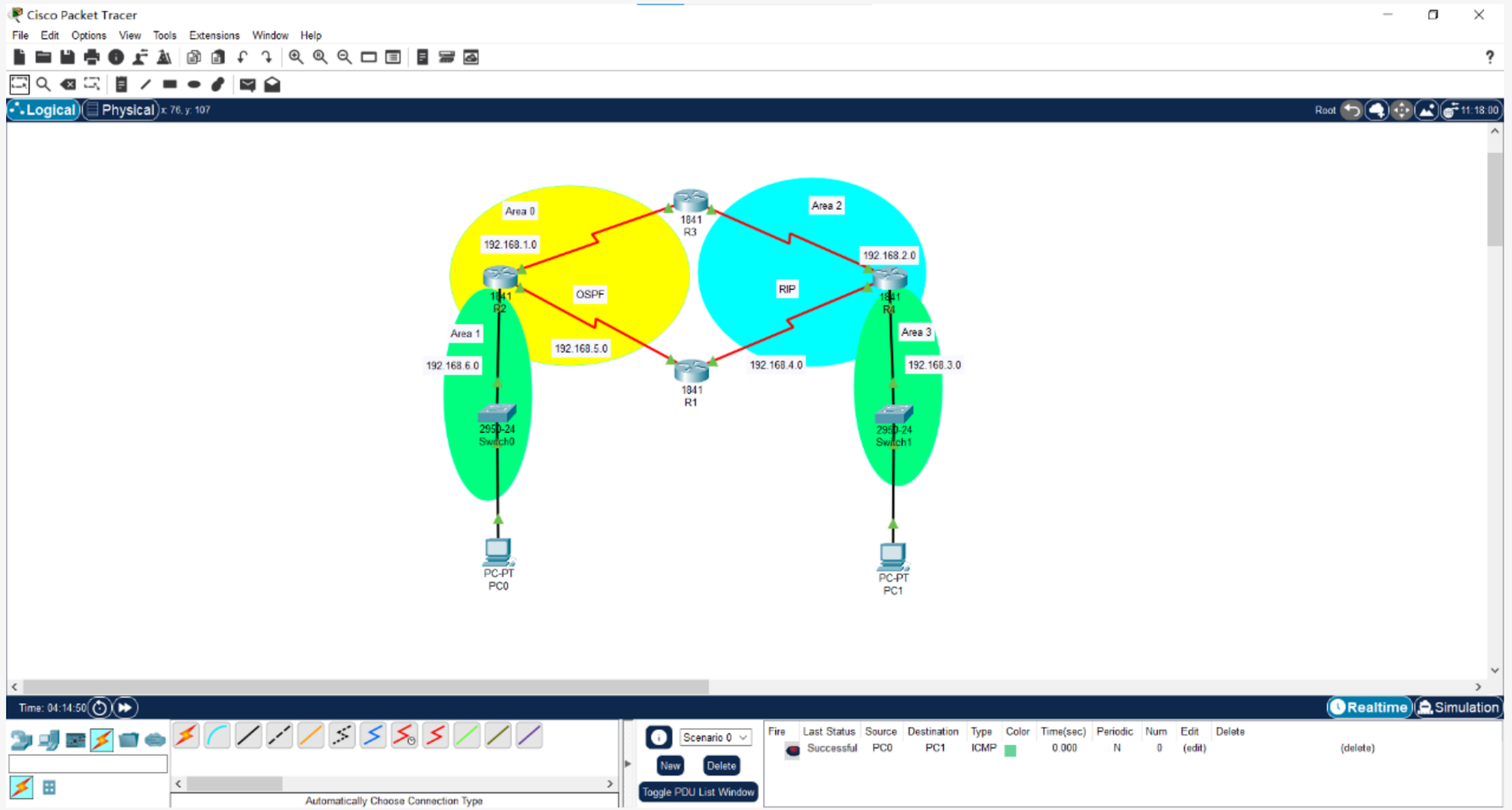
OSPF incorporates the subnet information learned by RIP into the OSPF routing table

Redistribute OSPF routing information in the RIP process

The imported OSPF route will be set with a metric value of 10 instead of using the default RIP hop count.

3.3Hybrid Network (RIP and OSPF)

Verify network connectivity



3.3Hybrid Network (RIP and OSPF)

Advantages

- **Interoperability:** Supports legacy systems where RIP is already in place, allowing for a smoother transition to more advanced OSPF without immediate full-scale upgrades.
- **Flexibility:** Enables phased network upgrades, transitioning individual segments to OSPF while maintaining overall network service.
- **Cost-Effectiveness:** May defer costs associated with upgrading hardware that does not support OSPF.

Disadvantages

- **Complexity:** Managing two protocols increases the complexity of the network, necessitating advanced knowledge and careful configuration to prevent issues like routing loops and asynchronous routing tables.
- **Inconsistency in Metrics:** OSPF and RIP use different metrics for determining the best path, which can lead to suboptimal routing decisions when the protocols interact.
- **Administrative Overhead:** Requires careful tuning of redistribution between the protocols to maintain a consistent and loop-free environment.

4.Conclusion

How Choosing Between RIP and OSPF:

Depends on network size, complexity, and requirements for efficiency and scalability.

Each protocol has its specific use case and operational objectives.

	RIP	OSPF
Scale	Small	Large
Complexity	Low	High
Overhead	High in bandwidth Low in computation	Low in bandwidth High in computation
User friendly	High	Low