Lab 8: Dynamic Routing Using Cisco Packet Tracer: RIP, OSPF, and BGP

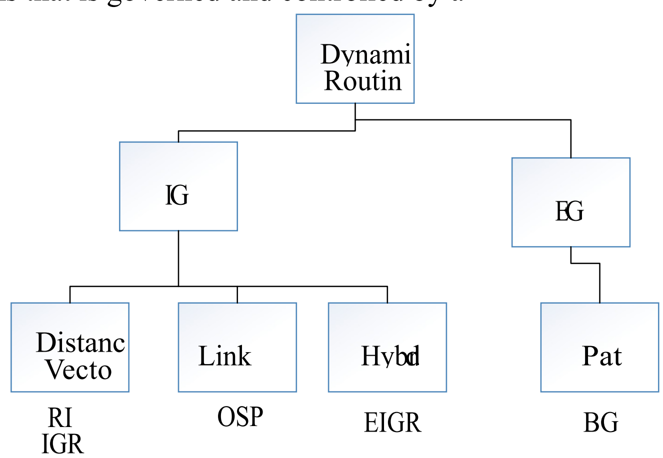
Dynamic routing is a networking technique that provides optimal data routing. Unlike static routing, dynamic routing enables routers to select paths according to real-time logical network layout changes.

Advantages of Dynamic Routing -

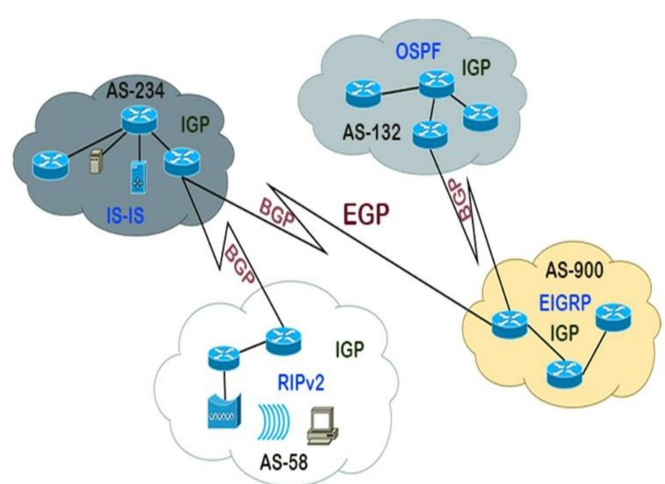
- Allows the exchange of routing information whenever the network experiences a change in topology.
- Since the routes do not have to be configured manually, there is less administrative overhead.
- Less error-prone than static routing.
- Allows scalability since there is less administrative overhead involved.

Classification of Dynamic routing

- An Autonomous System is a group of networks that is governed and controlled by a single administrative entity. For example, a network created by a single company, organization, corporation, or ISP is a single AS.



- An AS number is a unique identity of the AS on the Internet. If you want to connect your AS to the Internet, you must obtain an AS number. Internet Assigned Numbers Authority (IANA) has the worldwide right to assign AS numbers. It delegates that right to the organizations that assign public IP addresses. For example, in Asia, the Asia Pacific Network Information Centre (APNIC) assigns both IP addresses and AS numbers.
- An AS can contain multiple networks. To connect these networks, the administrator can use a routing protocol. The routing protocol the administrator uses to connect the networks within the autonomous system is known as an interior gateway routing protocol. Since all networks in an autonomous system belong to the same administrative entity, the administrator can configure any IGP protocol to connect them.
- RIPv1, IGRP, OSPF, EIGRP, RIPv2, and IS-IS are some examples of interior gateway routing protocols.



- An EGP protocol provides connectivity between different autonomous systems. Since different autonomous systems belong to different administrative entities, administrators cannot use routing protocols of their choices to connect them. They have to use a uniform routing protocol. A uniform routing protocol that connects different autonomous systems is known as an exterior gateway routing protocol.

- Nowadays, BGP is the only used exterior routing protocol. BGP connects all public autonomous systems on the Internet.

Distance Vector Routing

As the name implies, distance vector routing uses the parameters: distance and direction to calculate the best possible path to forward the packet from source to destination. Distance is calculated by counting the numbers of routers in between the source and destination. Every router counts its adjacent router as a next-hop. The minimum number of hop count between the source router and the destination router makes the best possible path for routing.

Distance vector routing uses the Bellman-Ford Algorithm or Ford-Fulkerson algorithms to choose the best path. In distance vector routing, routing advertisements are received from the directly connected or the neighbour router and update its routing information periodically. The update process continues router to router till the destination is reached. It shares entire routing table information to its immediate neighbour router.

Examples of distance vector routing protocols are RIP v1, RIPv2, and IGRP.

Link State Routing

Unlike distance-vector, link-state routing does not rely on the neighbour router for routing information. Instead, it maps the overall state of the entire network that includes the topology, bandwidth, traffic congestion in a particular link, etc.

In link-state routing, each router retrieves information about itself, its directly connected link, and the state of that link. This information is passed from router to router, without changing the entire routing information of the adjacent router. Each router makes only a copy of the information received from its neighbour. Thus, every router has identical information and can independently calculate its best path for forwarding packets from source to destination.

Link State routing uses Dijkstra's Algorithm. It is also referred to as the Shortest Path First (SPF) Algorithm.

Although link-state is more complex than distance-vector, however, it is more reliable and minimizes the shortcomings of distance vector routing. The basic functionality of link-state routing are:

- Every router establishes an adjacency relationship with its neighbours.
- Link state advertisements (LSAs) are sent by each router to its neighbour
- Each router stores a copy of all the LSAs as a database. These databases in all routers are identical.
- Each router maintains a complete topological database, also called the link-state database.
- Each router calculates the shortest path to each network using Dijkstra's Algorithm and enters this information into the route table.

Examples of link-state routing are OSPF, IS-IS, etc.

Hybrid Routing

It is a combination of both distance vector and link-state routing. Basically, hybrid routing is considered to be the advanced distance-vector, however, it also contains some of the features of the link-state routing protocol.

An example of a hybrid routing protocol is EIGRP. Enhanced Interior Gateway Routing Protocol has the features of both the distance vector and the link-state routing. It does not send Link state advertisement, but it sends traditional distance vector routing information to the neighbour router. It synchronizes with the routing updates of the neighbour router. After that, it sends a specific link-state update to its neighbour.

8.a To understand the concept and operation of Routing Information Protocol (RIP)

Requirements -

- Windows pc – 2 Nos
- CISCO Packet Tracer Software (Student Version)
- 8 port switch – 2 No
- Router – 2 Nos
- Cat-5 LAN cable

Procedure

- Open the CISCO Packet tracer software
- Drag and drop 5 pcs using End Device Icons on the left corner
- Select 8 port switch from switch icon list in the left bottom corner
- Select Routers and Give the IP address for serial ports of router and apply clock rate as per the table.
- Make the connections using Straight through Ethernet cables
- Ping between PCs and observe the transfer of data packets in real and simulation mode.

Theory

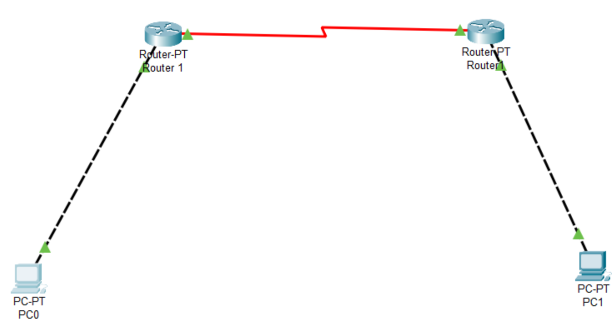
RIP (Routing Information Protocol) is one of the oldest distance vector routing protocols. It is usually used on small networks because it is very simple to configure and maintain, but lacks some advanced features of routing protocols like OSPF or EIGRP. Two versions of the protocol exist - version 1 and version 2. Both versions use hop count as a metric and have the administrative distance of 120. RIP version 2 is capable of advertising subnet masks and uses multicast to send routing updates, while version 1 doesn't advertise subnet masks and uses broadcast for updates. Version 2 is backwards compatible with version 1. RIPv2 sends the entire routing table every 30 seconds, which can consume a lot of bandwidth. RIPv2 uses multicast address of 224.0.0.9 to send routing updates, supports authentication and triggered updates (updates that are sent when a change in the network occurs).

Downsides of RIP:

- RIP sends the entire routing table every 30 seconds, which can consume a lot of network bandwidth.
- It lacks some more advanced of features of the newer routing protocols like OSPF or EIGRP and is not widely used in modern networks. For example, RIP doesn't support route summarization.

Network Topology Diagram for RIP

1. Build the network topology.



2. Configure IP addresses on the PCs and the routers.

Router 1

```
R1(config)#
R1(config)#int fa0/0
R1(config-if)#ip address 10.0.0.1 255.0.0.0
R1(config-if)#no shut

R1(config-if)#
R1(config-if)#int serial 0/0/0
R1(config-if)#ip add 20.0.0.1 255.0.0.0
R1(config-if)#no shut
```

Router 2

```
R2(config)#
R2(config)#int fa0/0
R2(config-if)#ip add 30.0.0.1 255.0.0.0
R2(config-if)#no shut

R2(config-if)#
R2(config-if)#int serial 0/0/0
R2(config-if)#ip add 20.0.0.2 255.0.0.0
R2(config-if)#no shut
```

IP configuration on PCs
Click PC->Desktop->IP Configuration.
On each PC assign these addresses:
PC1: IP address: 10.0.0.2 Subnet mask 255.0.0.0 Default Gateway 10.0.0.1
PC2: IP address: 30.0.0.2 Subnet mask 255.0.0.0 Default Gateway 30.0.0.1

2. Configure RIPv2 on the routers
Router 1

```
R1(config)#

R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#network 10.0.0.0
R1(config-router)#network 20.0.0.0
```

Router 2

```
R2(config)#

R2(config)#router rip
R2(config-router)#version 2
R2(config-router)#network 20.0.0.0
R2(config-router)#network 30.0.0.0
```

As you can see,to configure rip on each router,we enable enable RIP using router rip command then advertise the networks directly connected to the router interfaces using network command.
That's all for RIP configuration.

3. We'll now verify RIP configuration.

To verify that RIP is indeed advertising routes, we can use the show ip route command on R1.

```
R1#
R1#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, FastEthernet0/0
C    20.0.0.0/8 is directly connected, Serial0/0/0
R    30.0.0.0/8 [120/1] via 20.0.0.2, 00:00:17, Serial0/0/0
```

You can see that R1 has learned about the 30.0.0/8 network. The letter R indicates that the route was learned using RIP.Note the administrative distance of 120 and the metric of 1 in the [120/1] part.
To specifically display routes learnt through RIP use show ip route rip command on the router.
Now lets Ping PC2 from PC1 to further confirm that connectivity is really established between the two subnets.

```
Pinging 30.0.0.2 with 32 bytes of data:

Reply from 30.0.0.2: bytes=32 time=18ms TTL=126
Reply from 30.0.0.2: bytes=32 time=19ms TTL=126
Reply from 30.0.0.2: bytes=32 time=11ms TTL=126
Reply from 30.0.0.2: bytes=32 time=11ms TTL=126

Ping statistics for 30.0.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 11ms, Maximum = 19ms, Average = 14ms
```

How do we configure rip? Specify the commands.
#Router rip
#network 10.0.0.0

Which command is used to check RIP routing?
#show ip route
#show ip protocols

8.b Configuration of Open shortest Path First (OSPF) Algorithm - To construct multiple router networks and understand the operation of OSPF Protocol.

Requirements

- Windows pc – 3 Nos
- CISCO Packet Tracer Software (Student Version)
- 8 port switch – 3 No
- Router – 3 Nos
- Cat-5 LAN cable

Procedure

- Open the CISCO Packet tracer software.
- Drag and drop 5 pcs using End Device Icons on the left corner.
- Select 8 port switch from switch icon list in the left bottom corner.
- Select Routers and Give the IP address for serial ports of router and apply clock rate.
- Add HWIC -2T Peripheral to all routers, type CLI's for all routers.
- Make the connections using Straight through Ethernet cables.
- Ping between PCs and observe the transfer of data packets in real and simulation mode.

Theory

The OSPF routing protocol has largely replaced the older Routing Information Protocol (RIP) in corporate networks. Using OSPF, a router that learns of a change to a routing table (when it is reconfigured by network staff, for example) or detects a change in the network immediately multicasts the information to all other OSPF hosts in the network so they will all have the same routing table information. Unlike RIP, which requires routers to send the entire routing table to neighbours every 30 seconds, OSPF sends only the part that has changed and only when a
change has taken place. When routes change -- sometimes due to equipment failure -- the time it takes OSPF routers to find a new path between endpoints with no loops (which is called "open") and that minimizes the length of the path is called the convergence time.

Input Details for OSPF

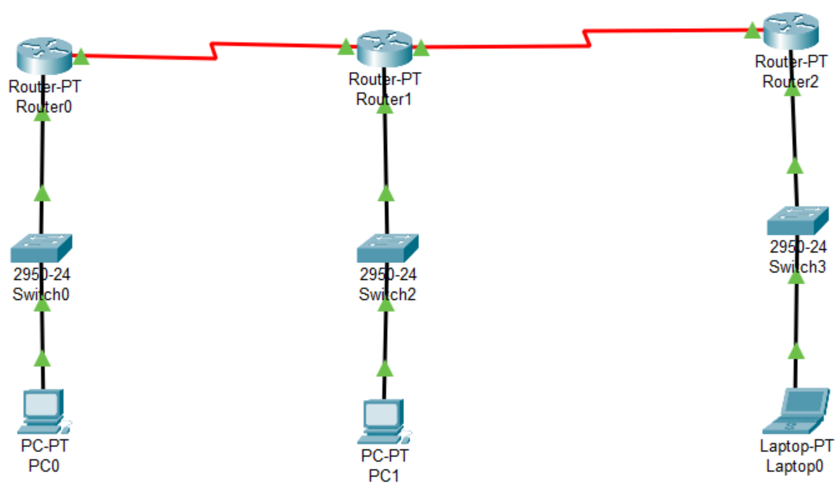
PC0	PC1	PC2
IP Address : 192.168.1.2 Gate way : 192.168.1.1	IP Address: 192.168.2.2 Gate way : 192.168.2.1	IP Address: 192.168.3.2 Gate way : 192.168.3.1

Router 0	Router 1	Router 2
fa 0/0 IP Address: 192.168.1.1 Serial 0/0/0 : 10.0.0.1 @ 2000000 clock rate Serial 0/0/1 : -	fa 0/0 IP Address : 192.168.2.1 Serial 0/0/0 : 10.0.0.2 Serial 0/0/1 : - @ 2000000 clock rate	Fa 0/0 IP Address : 192.168.3.1 Serial 0/0/0 : 10.0.0.2 @ no clock rate Se 0/0/1 : 11.0.0.1

Commands to Configuring OSPF:
(config)# router ospf<process ID>
(config-router)# network<network ID><wildcard mask>area<area ID>

Implement the OSPF Single Area Network:
Step 1: Initialize the interface and host with IP addresses and default gateway respectively:

- Network topology consists of 3 Host, 3 Interfaces, and 3 switches
- HOST1: IP 192.168.1.2, Default gateway: 192.168.1.1
- HOST2: IP 192.168.2.2, Default gateway: 192.168.2.1
- HOST3: IP 192.168.3.2, Default gateway: 192.168.3.1



As we can see we have configured interface 1 (Router0) with Host 1 which is PC0 and the Serial port.

IOS Command Line Interface

```
Press RETURN to get started!


Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#int fa0/0
Router(config-if)#ip add 192.168.1.1 255.255.255.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
up

%LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/0, changed state to up

Router(config-if)#exit
Router(config)#int se2/0
Router(config-if)#ip add 10.0.0.1 255.0.0.0
Router(config-if)#no shut

%LINK-5-CHANGED: Interface Serial2/0, changed state to down
Router(config-if)#
```

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Step 2: Configuring the Interface 2 which is router1.

IOS Command Line Interface

```
Router(config)#int fa0/0
Router(config-if)#ip add 192.168.2.1 255.255.255.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
up

%LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/0, changed state to up

Router(config-if)#exit
Router(config)#int se2/0
Router(config-if)#ip add 10.0.0.2 255.0.0.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface Serial2/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/0,
changed state to up

Router(config-if)#exit
Router(config)#int se3/0
Router(config-if)#ip add 20.0.0.2 255.0.0.0
Router(config-if)#no shut
```

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Step 3: Configuring the Interface 3 which is router2.

IOS Command Line Interface

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#int fa0/0
Router(config-if)#ip add 192.168.3.1 255.255.255.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
up

%LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/0, changed state to up

Router(config-if)#exit
Router(config)#int se2/0
Router(config-if)#ip add 20.0.0.1 255.0.0.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface Serial2/0, changed state to up

Router(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/0,
changed state to up
```

Ctrl+F6 to exit CLI focus | Copy | Paste

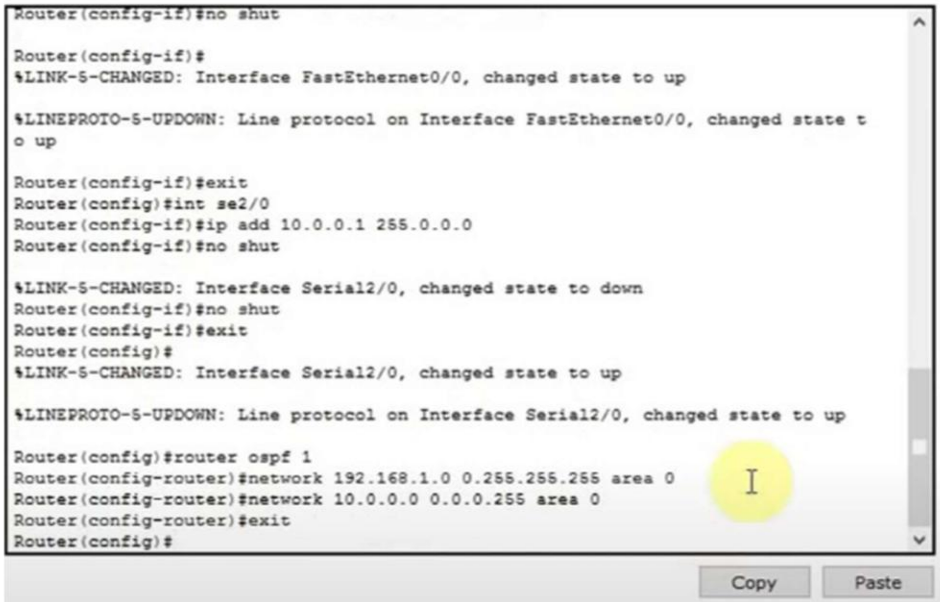
Now comes the main part now we have to configure the OSPF implementation:

Step 1: Configure the Router0 and create router OSPF1 and then add network id with wildcard mask.

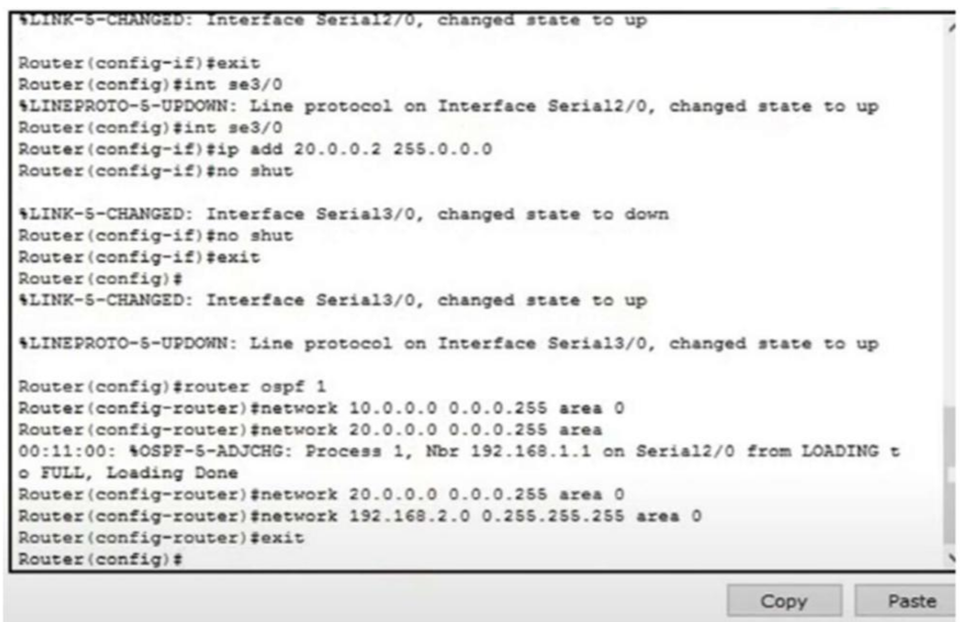
Router(config)#router ospf 1

Router(config-router)#network 192.168.1.0 0.255.255.255 area 0

Router(config-router)#network 10.0.0.0 0.0.0.255 area 0



Step2: Configure the Router1 and create router OSPF 1 and then add network id with wildcard mask.
Router(config)#router ospf 1
Router(config-router)#network 10.0.0.0 0.0.0.255 area 0
Router(config-router)#network 20.0.0.0 0.0.0.255 area 0
Router(config-router)#network 192.168.2.0 0.255.255.255 area 0



Step 3: Configure the Router2 and create router OSPF 1 and then add network id with wildcard mask.
Router(config)#router ospf 1
Router(config-router)#network 192.168.3.0 0.255.255.255 area 0
Router(config-router)#network 255.0.0.0 0.0.0.255 area 0

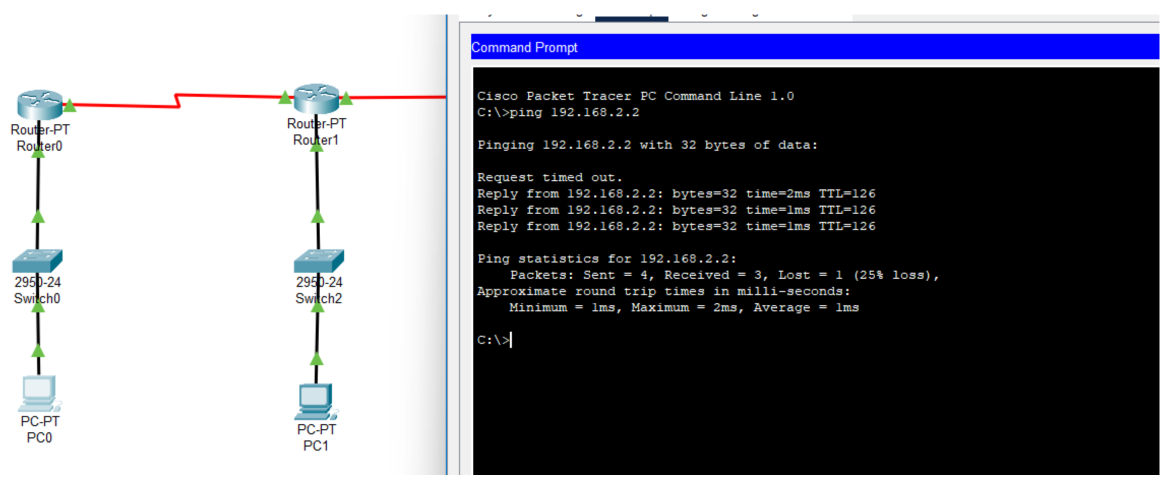
- Verifying the OSPF routing

OSPF shares routing information only with neighbours. We use the show ip ospf neighbour command to verify OSPF neighbours. The following image shows the output of this command on R1.

The output includes the following fields.

Neighbour ID - This field displays the RID of the neighbour.
State - This field displays the convergency state. An OSPF router goes through seven states to reach convergency. The Full state in this field verifies the router has reached convergency with the router listed in the neighbour ID field.
Interface - This field displays the local interface connected to the neighbour.
Address - This field displays the IP address of the neighbour.
Dead time - This field displays the dead interval. Viewing OSPF routes
The show ip route ospf command displays a list of all OSPF routes in the routing table. Testing connectivity between end devices

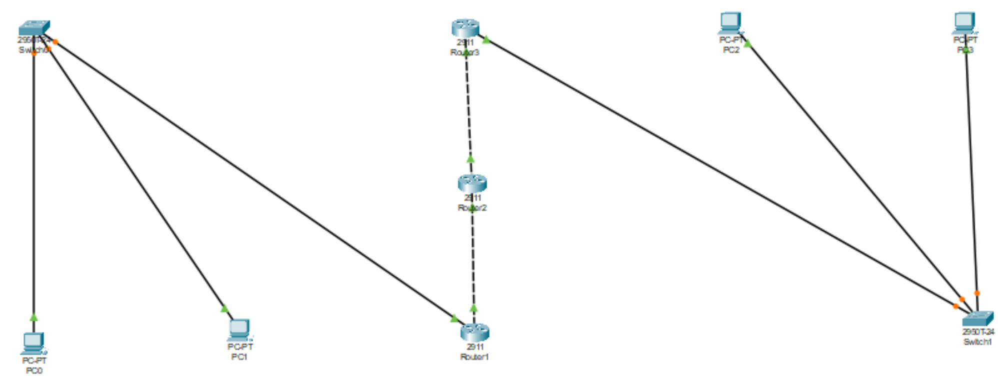
We can test connectivity between end devices to verify the OSPF configuration on all routers. Send ping requests from PC to Server. If it gets replies, it verifies the OSPF configuration. We can also use the tracert command to print the path the data packets take to reach the destination.



8.c Configure BGP using packet tracer

BGP (Border Gateway Protocol) is the core routing protocol of the Internet. It is described as a path vector protocol as BGP does not use traditional IGP (OSPF, EIGRP, RIP) metrics, but makes routing decisions based on path, network policies and/or rulesets. It maintains a table of IP networks or 'prefixes' which designate network reachability among autonomous systems (AS). Here three AS are there 1, 71 and 79 respectively. Configure accordingly using three routers.

Step 1:Draw BGP Topology Diagram.



Step 2: Assign ip address on each device as mentioned in Diagram.

Step 3: bgp configuration on Router R1:

```
R1(config)#router bgp 1
R1(config-router)#neighbor 172.16.0.2 remote-as 71
R1(config-router)#network 10.0.0.0 mask 255.0.0.0
R1(config-router)#exit
R1(config)#do write
Building configuration...[OK]
R1(config)#
```

Step 4: bgp configuration on Router R2:

```
R2(config)#router bgp 71
R2(config-router)#neighbour 172.16.0.1 remote-as 1
R2(config-router)#neighbour 172.14.0.2 remote-as 79
R2(config-router)#network 40.0.0.0 mask 255.0.0.0
R2(config-router)#exit
R2(config)#do write
Building configuration...[OK]
R2(config)#
```

Step 5: bgp configuration on Router R3:

```
R3(config)#router bgp 79
R3(config-router)#neighbour 172.14.0.1 remote-as 71
R3(config-router)#network 40.0.0.0 mask 255.0.0.0
R3(config-router)#exit
R3(config)#do write
Building configuration...[OK
R3(config)#
```

Step 6: bgp configuration Testing and troubleshooting.

PC>ipconfig
PC>ping 192.168.10.10

```
Pinging 192.168.10.10 with 32 bytes of data:

Reply from 192.168.10.10: bytes=32 time<1ms TTL=128
Reply from 192.168.10.10: bytes=32 time<1ms TTL=128
Reply from 192.168.10.10: bytes=32 time<1ms TTL=128
Reply from 192.168.10.10: bytes=32 time=2ms TTL=128

Ping statistics for 192.168.10.10:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 2ms, Average = 0ms

C:\>
```

Step 7: check bgp route on router R1:

R1#show ip route

Step 8: Check whether bgp protocols configure or not on Routre R1:

R1#show ip protocols

Step 9: Show BGP Status

R1#show ip bgp summary

Show bgp neighbours status:

R1#show ip bgp neighbours

Similarly we check bgp route on Router R2:

R2#show ip route
R2#show ip protocols

Similarly check bgp route on Router R3:

R3#show ip route
R3#show ip protocols