CSCI 5010 – Fundamentals of Data Communications

Lab
Static and Dynamic Routing

University of Colorado Boulder
Department of Computer Science
Network Engineering

Professor Levi Perigo, Ph.D.

Summary

This lab is intended to be an overview of Cisco IOS configuration, and routing technologies, such as static routes, default routes, link failover, and dynamic routing protocols.

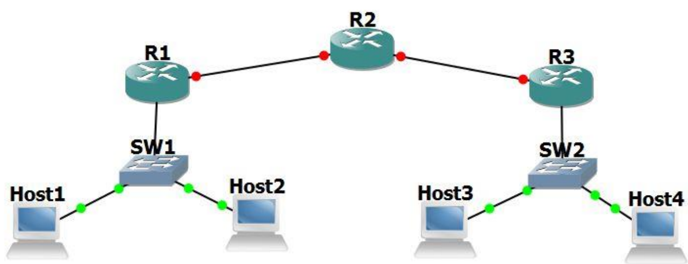
The questions in the lab are intentionally vague. The purpose of this is for you not only to research, investigate, and learn the technologies, but also become proficient at interpreting both non-technical and technical questions. Being able to research and discover answers on your own will be critical as you progress in your career.

- Learn how to perform basic router configuration & troubleshooting including:
  - Configure static routes and populate the routing tables
  - Apply administrative distance for automatic route failover
  - Designing and configuring a routing protocol to create dynamically learned routes
  - Routing protocol convergence and failover

Part 1

Objective 1: Network Design and Setup [16 points]

Create the following network topology, enable all the appropriate ports, and configure the basic setup for the devices in the topology.



1. Use /24 subnets for all LANs (Each host is in a different subnet) (private IPv4 addresses). Other than IP and subnet, nothing else is configured on the hosts.
2. Use /30 subnets for network connecting routers (private IPv4 addresses)
3. Add your addressing scheme to the network diagram (drawing) indicating the subnets for each network, as well as the interface/PC addresses used in your design [**10 points**]

   For PC0 subnet=192.168.1.0/24, IP address =192.168.1.2, Router 1 (subinterface)=192.168.1.1

   For PC1 subnet=192.168.10.0/24, IP address =192.168.10.2, Router 1 (subinterface)=192.168.10.1

   For PC2 subnet=192.168.20.0/24, IP address =192.168.20.2, Router 3 (subinterface)=192.168.20.1

   For PC3 subnet=192.168.30.0/24, IP address =192.168.30.2, Router 3 (subinterface)=192.168.30.1

   Router 1 and Router 2 :10.0.0.0/30 (Router 1=10.0.0.1, Router 2=10.0.0.2)

   Router 2 and Router 3 :10.0.0.4/30 (Router 2=10.0.0.5, Router 2=10.0.0.6)

4. Make sure there is IP connectivity from each PC to the local router (ping the LAN & WAN interfaces).
5. Can PC1 ping the IP address of the R1 interface that connects to R2? Explain why or why not. If it is not reachable, list the steps you took to make it work. **[4 points]**

By default, it won't be able to ping the 10.0.0.0/30 interface without proper routing because PC1 is in different subnet. To make it reachable I enabled routing between subnets on router 1 and added static routes. Inter- VLAN routing should also be enabled, this allows traffic from different VLAN/subnets to be routed.

For router 1

Router(config)#int gi0/1

Router(config-if)#ip add 10.0.0.1 255.255.255.252

Router(config-if)#no shutdown

Router(config-if)#

%LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to up

Router(config-if)#exit

Router(config)#ip route 192.168.20.0 255.255.255.0 10.0.0.2

Router(config)#ip route 192.168.30.0 255.255.255.0 10.0.0.2

Router(config)#exit

6. Can PC1 ping the IP address of the R2 interface that connects to R1? Explain why or why not. **[2 points]**

PC1 can ping Router 2 when proper routing is configured.PC1 is in 192.168.10.0/24 subnet and PC1 knows only about its own subnet and its default gateway, which is router1's subinterface in the same VLAN. Since it is completely in different network the PC1 doesn't know how to route traffic. So to ping to take place routing must be configured. So I had to enable routing. The static routes I mentioned ensures router 1 can forward traffic towards router 2 and router 3 can return traffic to router 1. Once the routing the configured we will have routes of R2 in the R1 routing table. So it will be able to ping.

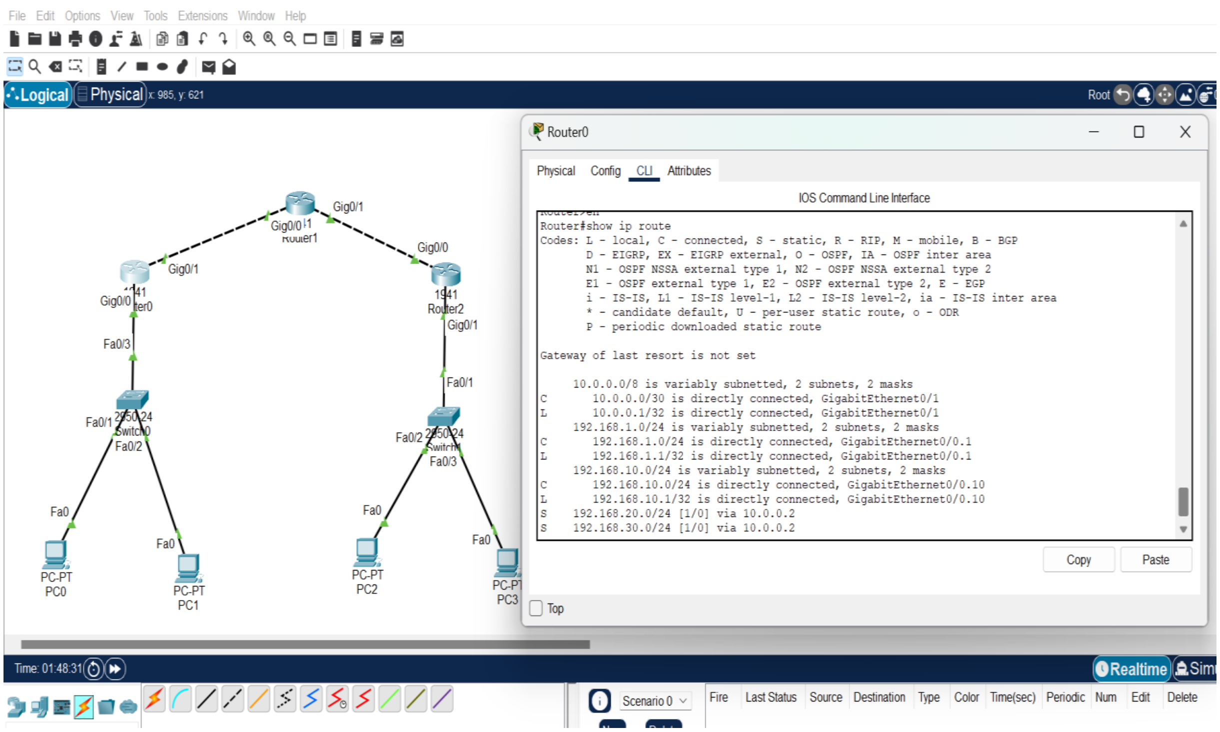
Router(config)#ip route 192.168.20.0 255.255.255.0 10.0.0.2

Router(config)#ip route 192.168.30.0 255.255.255.0 10.0.0.2

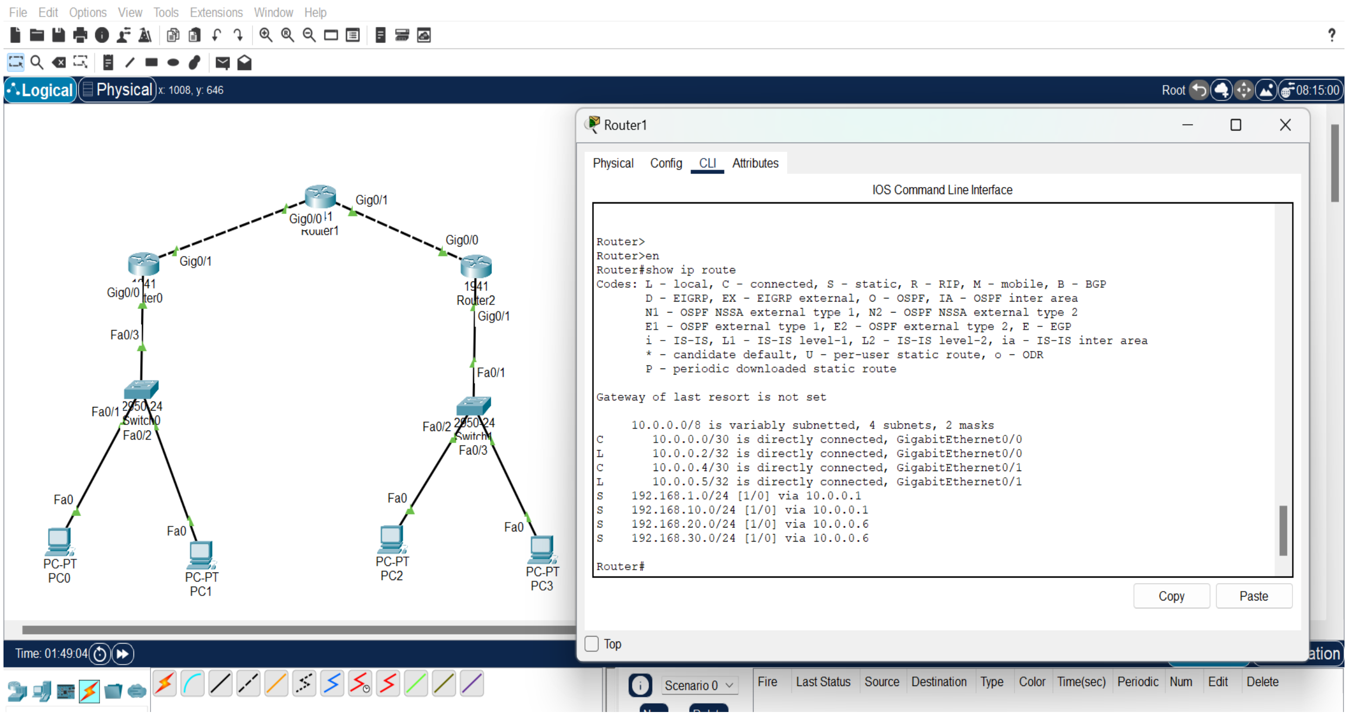
Objective 2: Static Routing [14 points]

1. Configure static routes in each router to ensure connectivity between all routers and PCs in the network.
   a. Show the static routes configured
      i. Show the routes in the route table of R1 and R2 [**2 points**]

Router 0:-

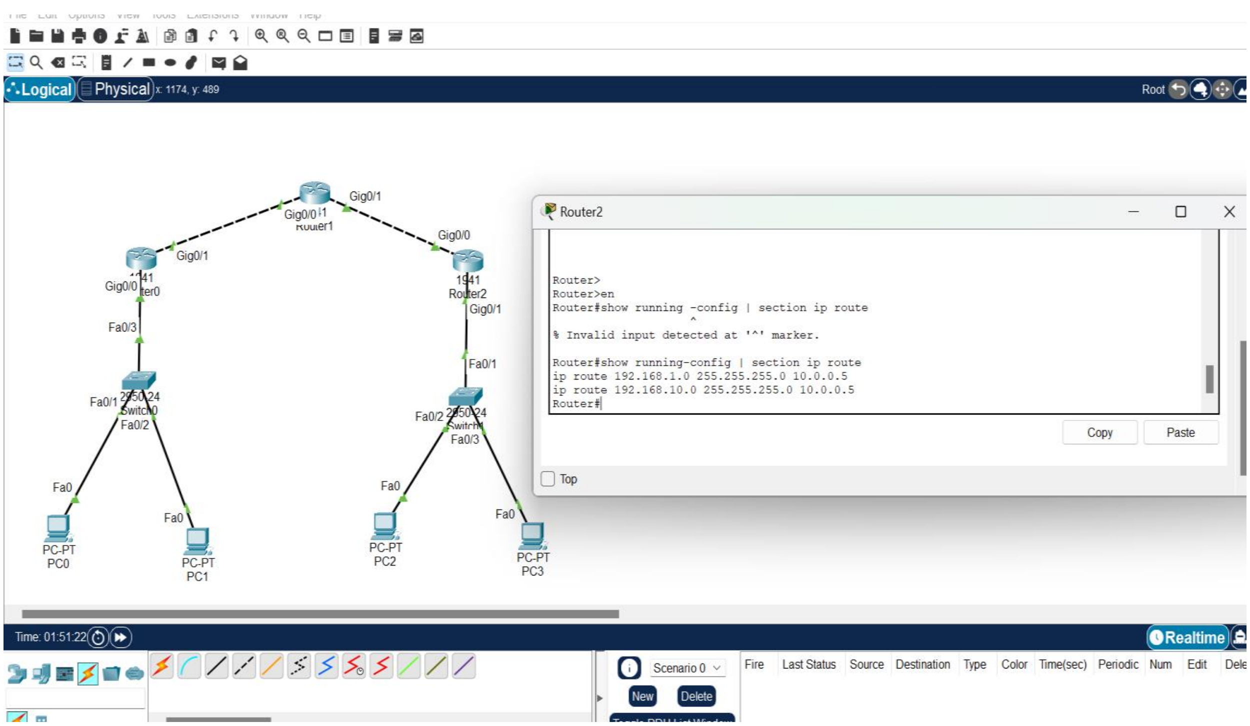


Router1:-

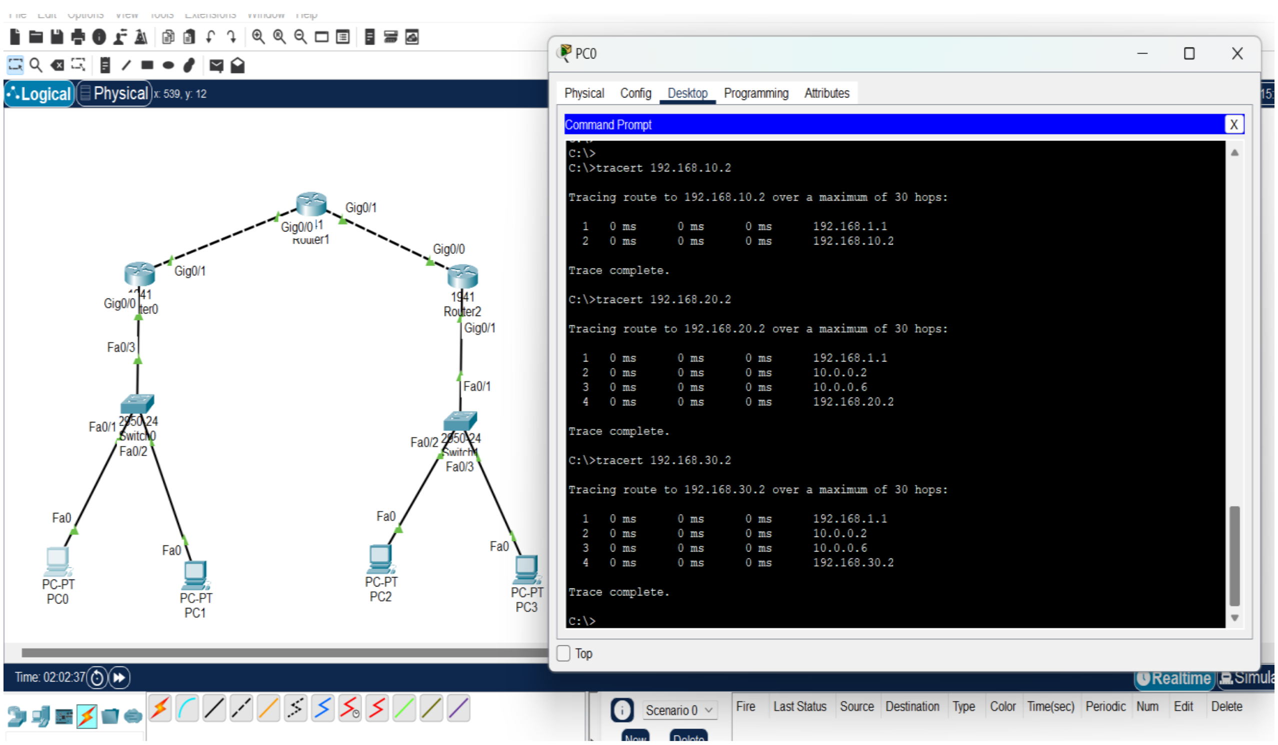


ii. Show the routes in the running configuration of R3 [**2 points**]

Router2:-

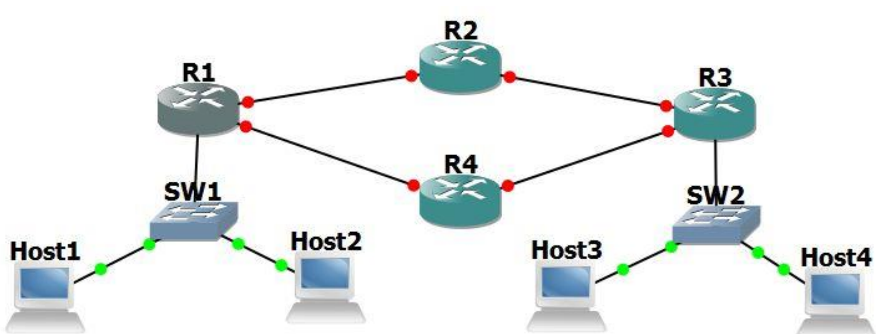


2. Configure Inter-VLAN routing, ensure and maintain 100% connectivity between all devices in the network.
    a. Provide the output from traceroutes from PC1 to PC2, 3, & 4 [**10 points**]



Objective 3: Dynamic Routing (RIP or OSPF) [30 points]

Create the following network topology, enable all the appropriate ports, and configure the basic setup for the devices in the topology.



1. Remove the static routes from all router configurations.
2. Configure RIPv2 or OSPF on all router interfaces and networks.
    a. Provide commands used to implement, screenshot of the route table

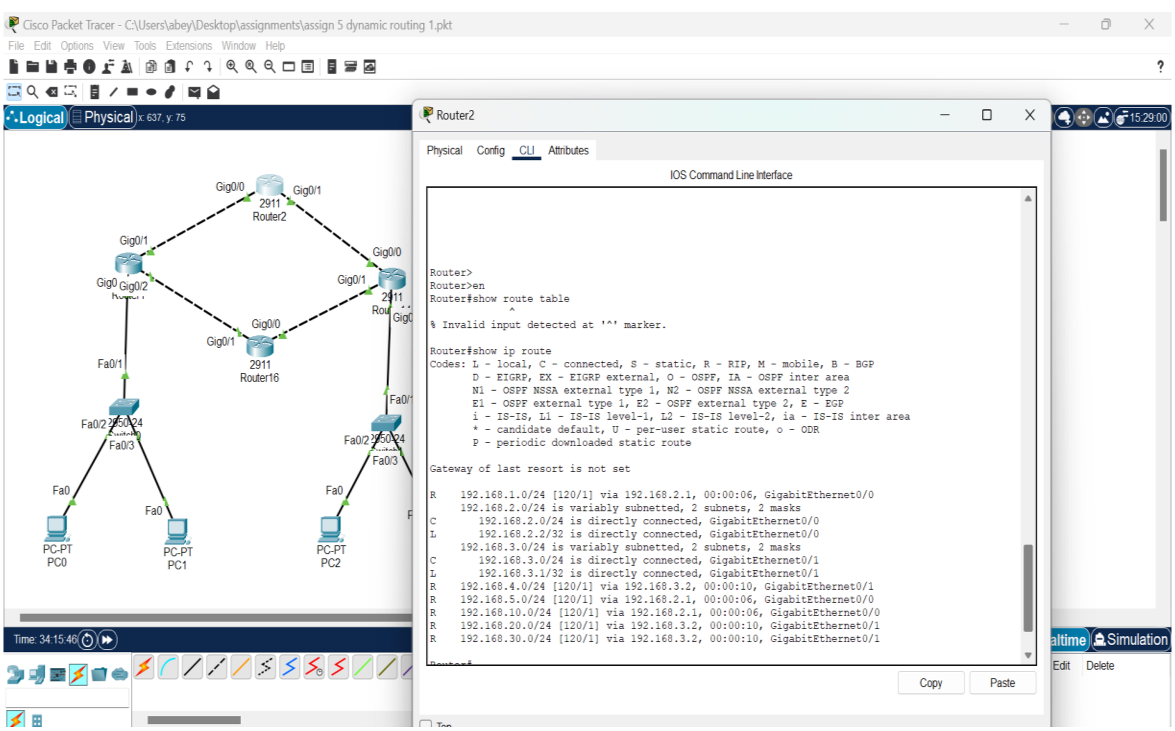
(from R2 & R4) indicating the network has converged [**20 points**]

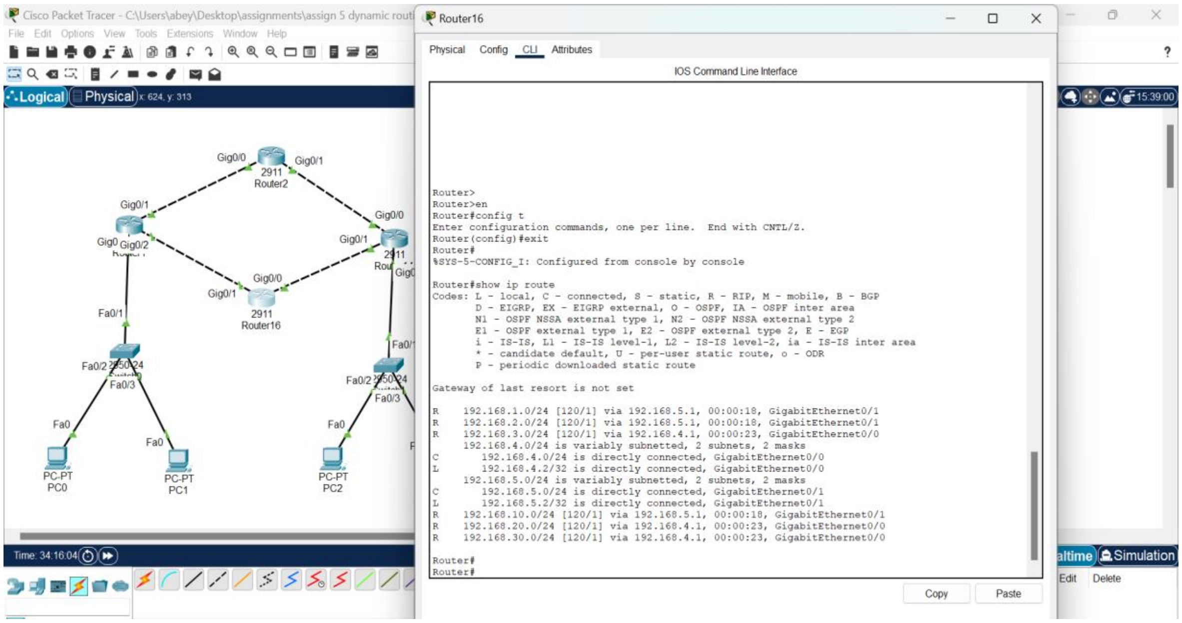
```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#interface gi0/0
Router(config-if)#no shutdown
Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state
to up
Router(config-if)#ip add 192.168.2.2 255.255.255.0
Router(config-if)#exit
Router(config)#interface gi0/1
Router(config-if)#no shutdown
Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to up
Router(config-if)#ip add 192.168.3.1 255.255.255.0
Router(config-if)#exit
Router(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state
to up

Router(config)#
Router(config)#
Router(config)#router rip
Router(config-router)#version 2
Router(config-router)#network 192.168.2.0
Router(config-router)#network 192.168.3.0
Router(config-router)#no auto-summary
Router(config-router)#exit
Router(config)#
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#
Router(config)#int gi0/0
Router(config-if)#ip add 192.168.4.2 255.255.255.0
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to up
```

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up
Router(config-if)#exit
Router(config)#
Router(config)#int gi0/1
Router(config-if)#ip add 192.168.5.2 255.255.255.0
Router(config-if)#no shutdown
Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to up
Router(config-if)#exit
Router(config)#router rip
Router(config-router)#version 2
Router(config-router)#network 192.168.4.0
Router(config-router)#network 192.168.5.0
Router(config-router)#no auto-summary
Router(config-router)#exit
Router(config)#

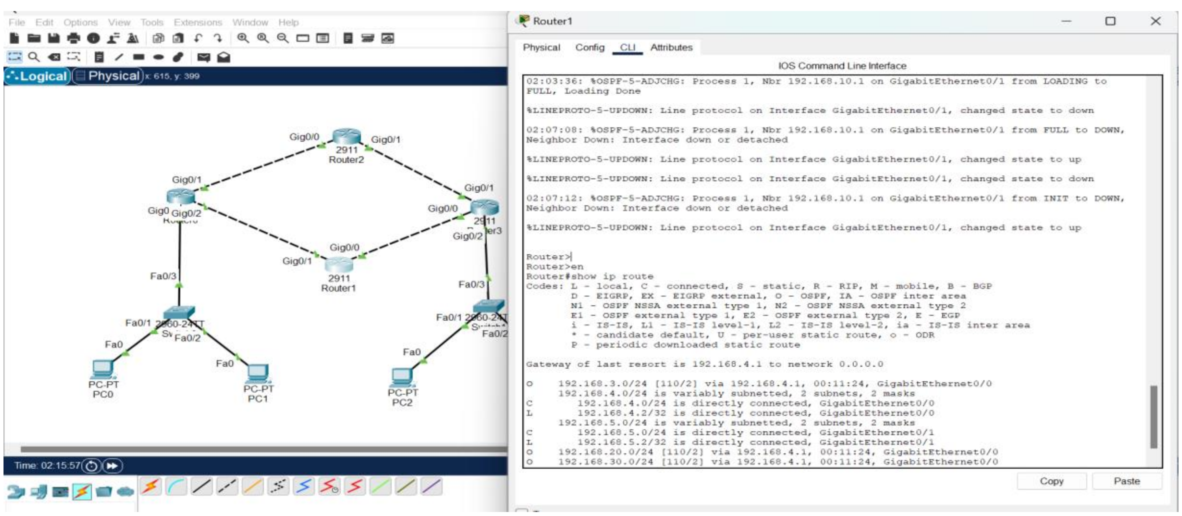




i. What does convergence mean, and why is it important? [**10 points**]

Convergence means that all the routers in the network have the recent routing information. When there is a link failure the network is converged, and the routing table is updated. If the network does not converge, there can be inconsistent routing, resulting in network outages and reduced performance. It ensures that traffic is efficiently routed across the network without any loops or lost packets.

Extra Credit: Implement RIPv2 as well as OSPF separately on the network and answer question for Objective 4. **[+5 points]**

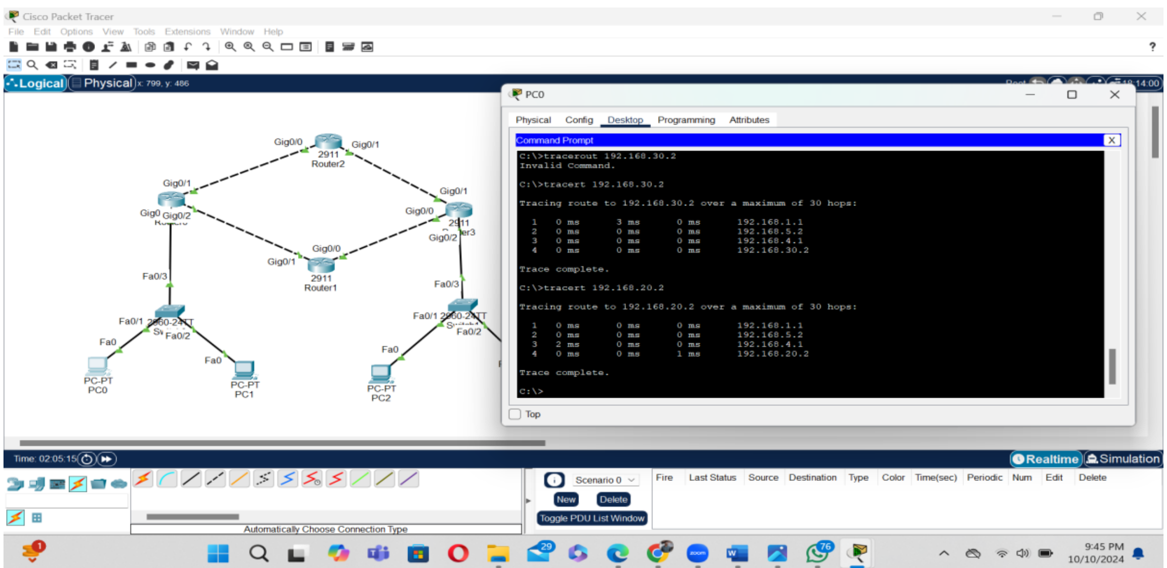


Configured OSPF in the separate network the bottom network is OSPF, and top network is RIP.

Objective 4: Routing Protocol Failover [17 points]

1. Demonstrate Failover
   a. Issue a traceroute from PC1 to PC3. Which path is it taking? [**2 points**]

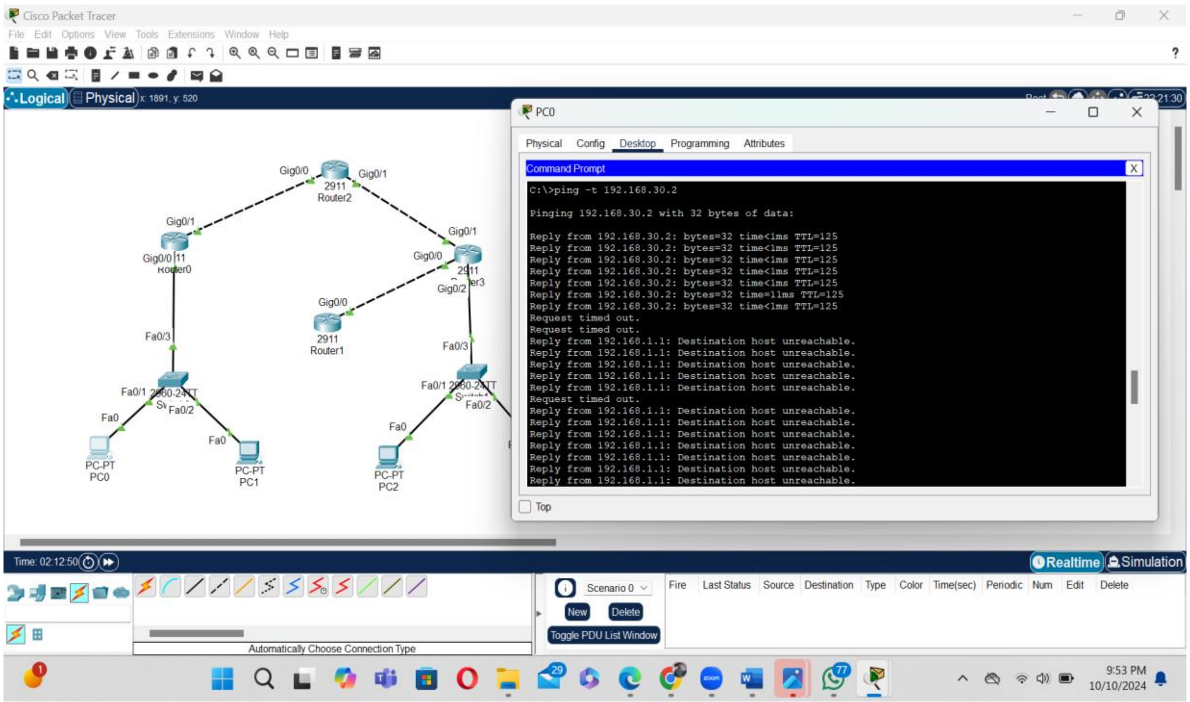
      Issued a traceroute from PC1 to PC3 it was taking the bottom network which 192.168.5.2 and 192.168.4.1. I have configured OSPF in that network.

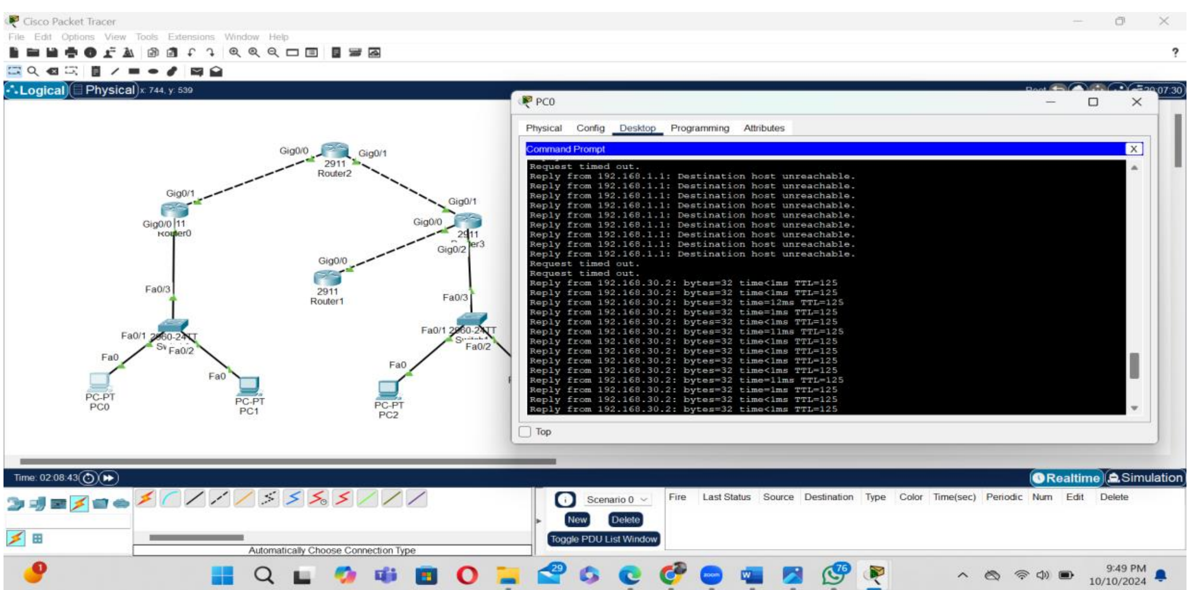


   b. Issue a continuous ping from PC1 to PC3.
   c. Remove the router link/connection between the active path routers (discovered in above [1.a]). *For example, if the path was R1, R2, R3, then remove the connection to R2*.
      i. Were any packets lost? If packets were lost, how long was the network down? Explain this, and indicate how the traffic failed over and the new traffic flow [**5 points**]

         Yes, a few packets were lost, and the network was down for 20-25 seconds. After a link is down it reroutes the traffic over a backup path. It took some time to make changes in the routing table and provide a backup path so that traffic is forwarded. After rerouting the traffic will continue to flow through the new path without any manual configuration. The initial path was R1-R4-

R3 and now the new route is R1-R2-R3. The initial path was configured with OSPF and the path upwards is configured with RIP.





d. Do some critical thinking and research. Could failover be achieved with this network design using only static routes? Explain [**10 points**]

Yes, failover can be achieved using static routes but is less efficient and more complex compared to dynamic routing protocols. Static routing does not have the ability to detect network failures automatically. To detect network failures, floating static routes can be configured. A floating static route is another static route with higher administrative distance. This route will only be used if the primary static route becomes unavailable. So if the primary link is down it is removed from the routing table and the floating static routes is configured. Static routes must be manually configured by the network administrator. For more complex networks static routes do not offer the same level of flexibility or efficiency as dynamic protocols. If any failures the network administrator should manually adjust the route to ensure proper traffic flow which can be slow.

Report Questions: [18 points]

- What are the advantages of using routing protocols?

  Advantages of routing protocols are: -

  Routing protocols can automatically adjust to changes in network such as link failures or new routes becoming available.

  Scalability: - They can manage large and complex networks more efficiently rather than in static we must add routes statically which is not possible in large networks.

  Dynamic Protocols can reroute traffic in case of failures, enhancing overall network reliability.

- What is the difference between Distance Vector and Link State Routing protocols?

  Distance Vector- Each router sends its entire routing table to its immediate intervals. Each router knows only knows the distance to each destination through its neighbors. Share the routing table with direct neighbors. It has slow convergence and works well in small networks.

  Link State- Each router knows the entire network topology. Routers exchange information about the state of their links with all the others in the network, allowing each router to independently compute the shortest path to all destinations. Shares link state information with all routers in the network. It has faster convergence and scales better for larger networks.

- What are the advantages of using static routing or when would static routing be preferred over dynamic routing?

  Static routing is simpler to configure, especially for small networks. Routes are the same unless we make any changes manually and can lead to more predictable performance. No overhead for routing updates or maintenance, which can save bandwidth.
  Static Routing is preferred when the network is a small and simple network where we don't make changes frequently. In network where predictable routes are necessary.
- Classify the below routing protocols as Distance Vector and Link State Routing protocols:
  I. OSPF, BGP, RIP, IS-IS
- Give:
  - ➢ Scenario when distance vector routing protocol would be used in the network.
    Distance vector protocols like RIP are suitable for smaller and simple networks. These protocols are lightweight in terms of memory and CPU usage. BGP is primarily used in scenarios involving the interconnection of different autonomous systems. BGP is used in ISPs to exchange routing information with other ISPs, where policy-based routing is required.
  - ➢ Scenario when link state routing protocol would be used in the network.
    Link state routing protocols like OSPF and IS-IS are ideal for large enterprise networks or ISPs where scalability, fast convergence and detailed control over routing paths.
- What is an Administrative Distance (AD) for a routing protocol? Give AD for OSPF and RIP.
- Administrative Distance is a value that routers use to rate the trustworthiness of the routing information received from a particular routing protocol. The lower the Administrative Distance, the more trustworthy the route. The AD of OSPF =110 and

RIP=120.

- What is a metric in a routing protocol?

  Metric is value used by routing protocols to determine the best path to the destination. It can be accessed based on certain factors such hop count, bandwidth, delay, load , reliability

Extra Credit Q1 - Understanding Routing Protocol [25 points]

E1.1 For the network given below in Figure. 1, give global distance-vector tables **WHEN:**

(a) Each node knows only the distance of its immediate neighbors. **[4pt]**

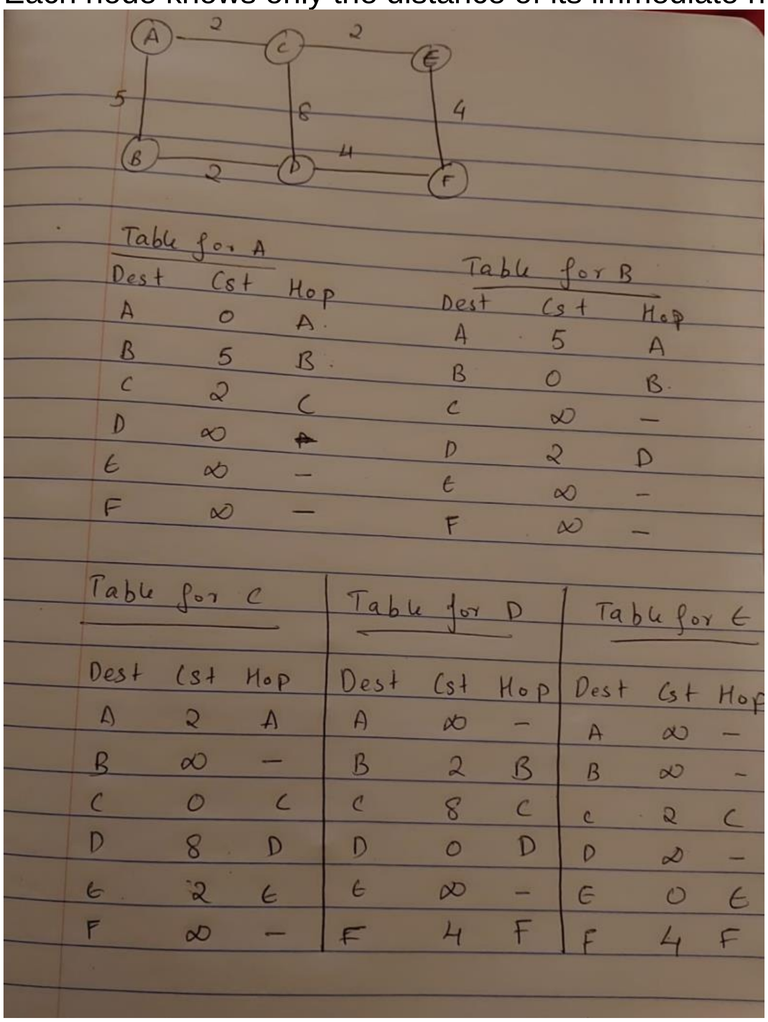


Table for A

Dest	Cst	Hop
A	0	A
B	5	B
C	2	C
D	∞	~~A~~
E	∞	—
F	∞	—

Table for B

Dest	Cst	Hop
A	5	A
B	0	B
C	∞	—
D	2	D
E	∞	—
F	∞	—

Table for C

Dest	Cst	Hop
A	2	A
B	∞	—
C	0	C
D	8	D
E	2	E
F	∞	—

Table for D

Dest	Cst	Hop
A	∞	—
B	2	B
C	8	C
D	0	D
E	∞	—
F	4	F

Table for E

Dest	Cst	Hop
A	∞	—
B	∞	—
C	2	C
D	∞	—
E	0	E
F	4	F

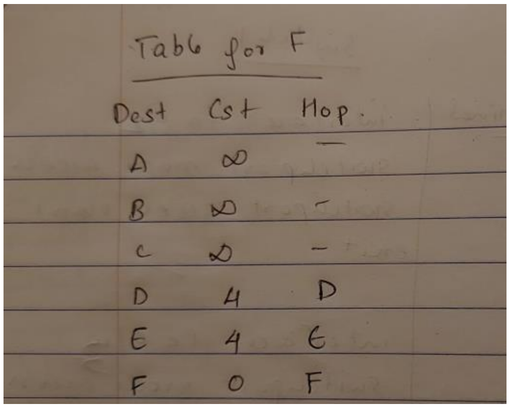
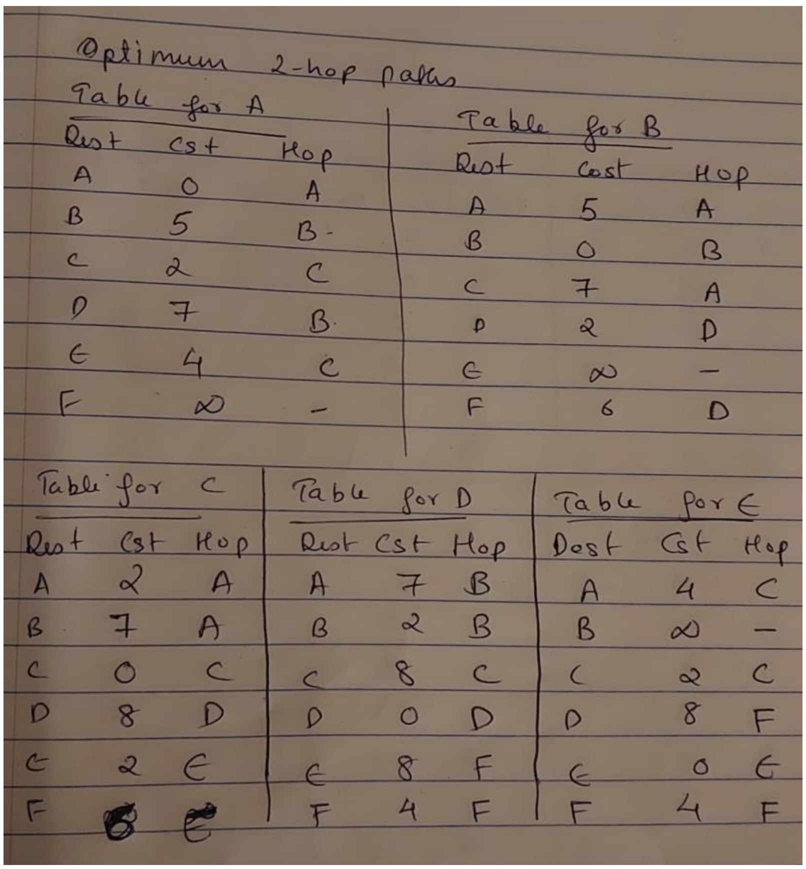


Table for F

Dest	Cst	Hop
A	∞	—
B	∞	—
C	∞	—
D	4	D
E	4	E
F	0	F

(b) Each node has reported the information it had in the preceding step to its immediate neighbors. **[4pt]**



Optimum 2-hop paths

Table for A

Dest	Cst	Hop
A	0	A
B	5	B
C	2	C
D	7	B
E	4	C
F	∞	—

Table for B

Dest	Cost	Hop
A	5	A
B	0	B
C	7	A
D	2	D
E	∞	—
F	6	D

Table for C

Dest	Cst	Hop
A	2	A
B	7	A
C	0	C
D	8	D
E	2	E
F	[illegible]	[illegible]

Table for D

Dest	Cst	Hop
A	7	B
B	2	B
C	8	C
D	0	D
E	8	F
F	4	F

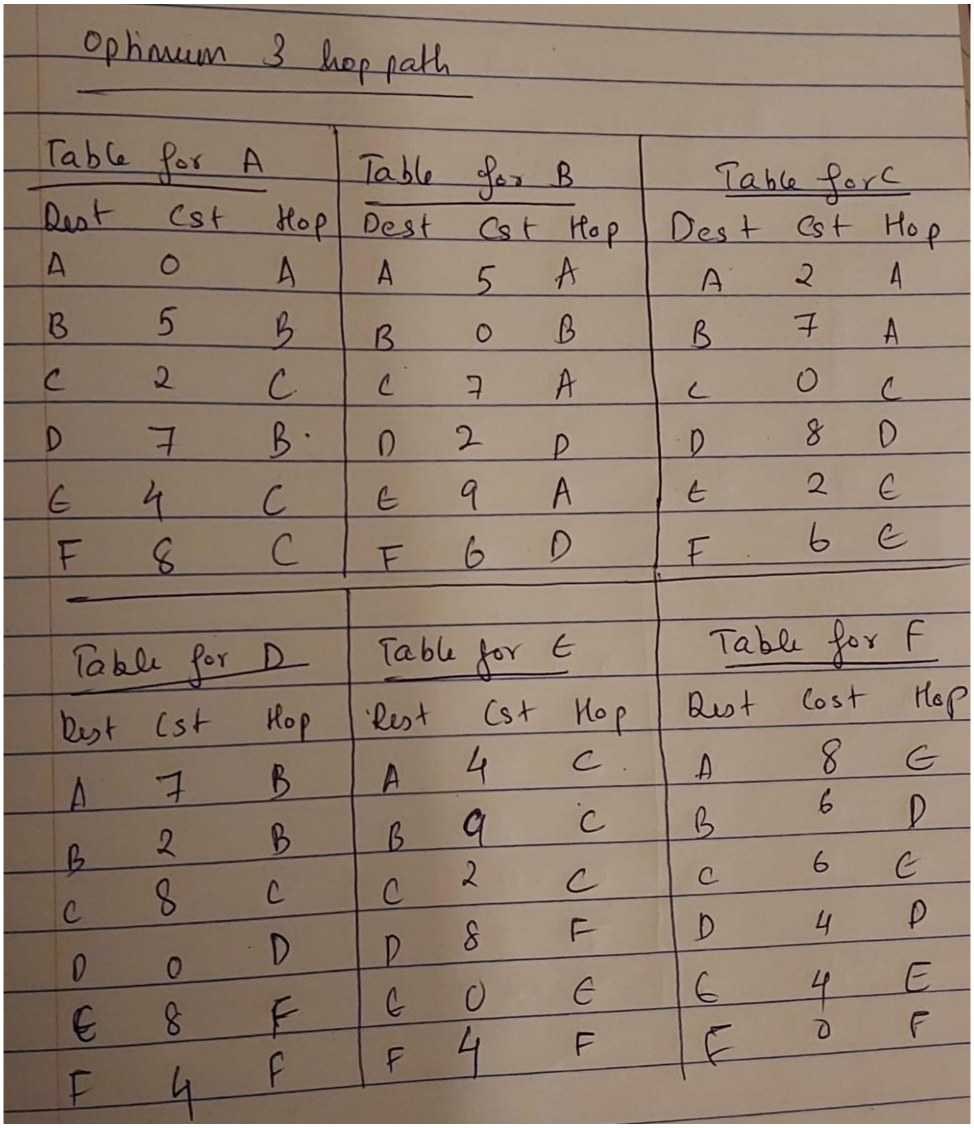
Table for E

Dest	Cst	Hop
A	4	C
B	∞	—
C	2	C
D	8	F
E	0	E
F	4	F

Table for F

Dst	Cst	Hop
A	∞	–
B	6	D
C	6	E
D	4	D
E	4	E
F	0	F

(c) Repeat step (b) one more time. **[4pt]**



Optimum 3 hop path

Table for A

Dest	Cst	Hop
A	0	A
B	5	B
C	2	C
D	7	B
E	4	C
F	8	C

Table for B

Dest	Cst	Hop
A	5	A
B	0	B
C	7	A
D	2	D
E	9	A
F	6	D

Table for C

Dest	Cst	Hop
A	2	A
B	7	A
C	0	C
D	8	D
E	2	E
F	6	E

Table for D

Dest	Cst	Hop
A	7	B
B	2	B
C	8	C
D	0	D
E	8	F
F	4	F

Table for E

Dest	Cst	Hop
A	4	C
B	9	C
C	2	C
D	8	F
E	0	E
F	4	F

Table for F

Dest	Cost	Hop
A	8	E
B	6	D
C	6	E
D	4	D
E	4	E
F	0	F

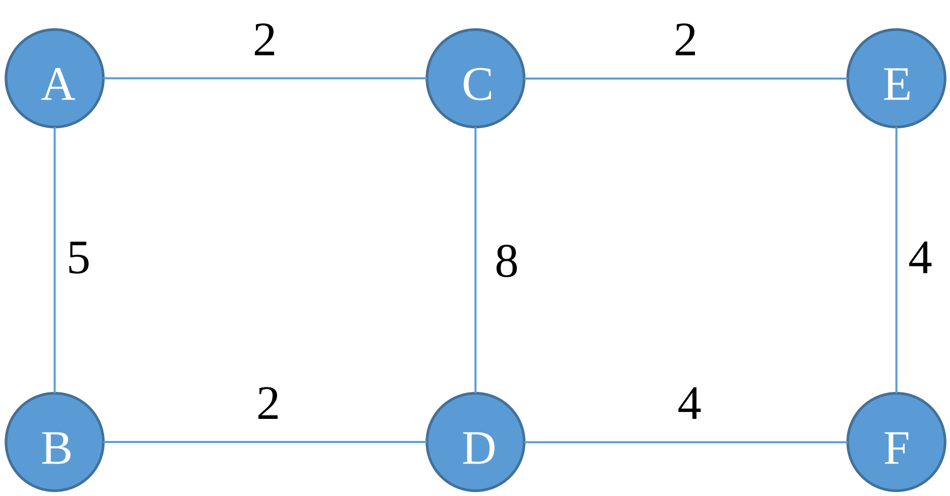


Figure. 1

Refer the slides below for an example of how to do this question:

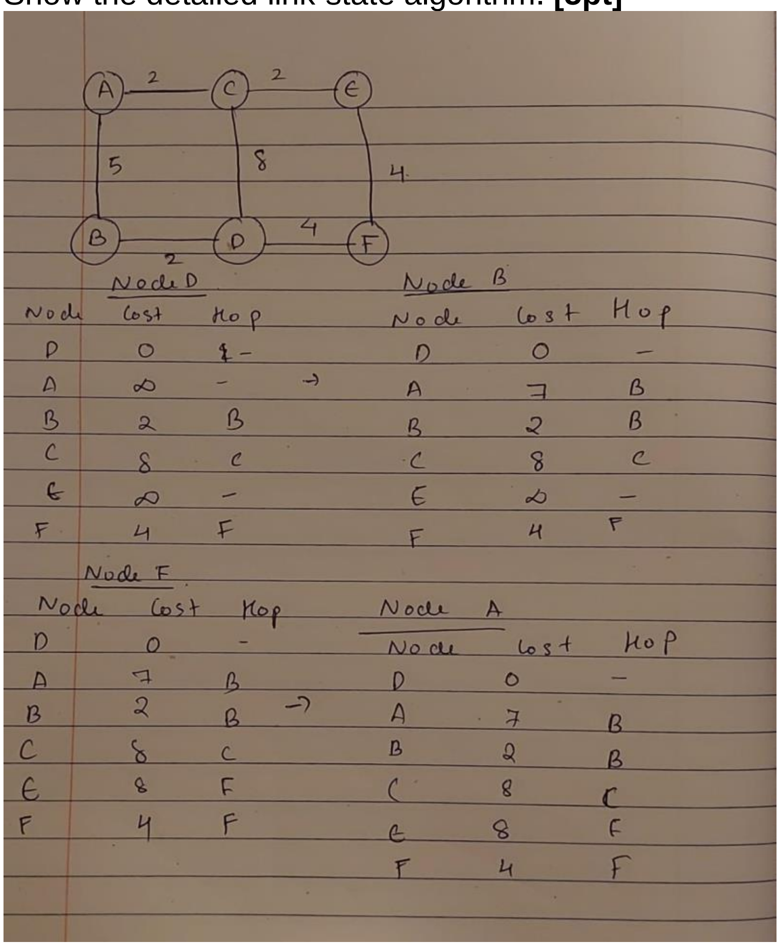
lec10-routing_DV.pdf

https://www.youtube.com/watch?v=dmS1t2twFrI

E1.2 (7 points)

Again for the network graph in Figure. 1. Show how the link-state algorithm builds the routing table for node D.

(a) Show the detailed link-state algorithm. **[5pt]**



Node D

Node	Cost	Hop
D	0	-
A	∞	-
B	2	B
C	8	C
E	∞	-
F	4	F

→

Node B

Node	Cost	Hop
D	0	-
A	7	B
B	2	B
C	8	C
E	∞	-
F	4	F

Node F

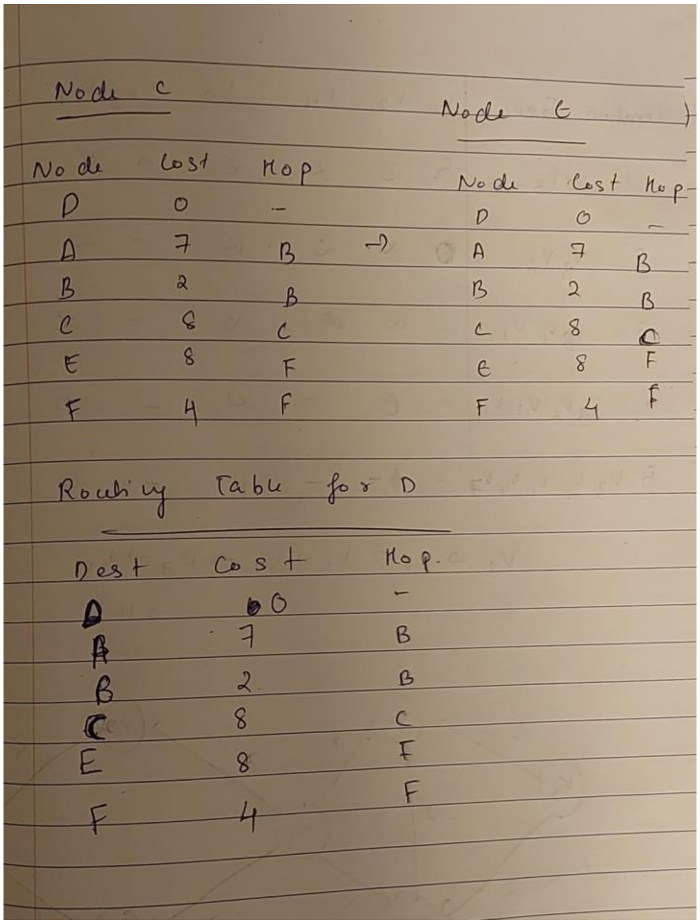
Node	Cost	Hop
D	0	-
A	7	B
B	2	B
C	8	C
E	8	F
F	4	F

→

Node A

Node	Cost	Hop
D	0	-
A	7	B
B	2	B
C	8	C
E	8	F
F	4	F

(b) Show the final routing table of node D. **[2pt]**



Node C

Node	Cost	Hop
D	0	–
A	7	B
B	2	B
C	8	C
E	8	F
F	4	F

Node E

Node	Cost	Hop
D	0	–
A	7	B
B	2	B
C	8	C
E	8	F
F	4	F

Routing Table for D

Dest	Cost	Hop.
D	0	–
A	7	B
B	2	B
C	8	C
E	8	F
F	4	F

Refer the slides below for an example of how to do this question:

lec10-routing_LV.pdf

gb bgp-

E1.3 (6 points)

Consider this directional graph below in Figure 4. Use Dijkstra's algorithm to find the shortest path from node v3 to v5. Write down the **steps**. Do you have any comments on the result (what if the link cost of v3-v1 was 1 instead of 5?)? [**6 pts]**

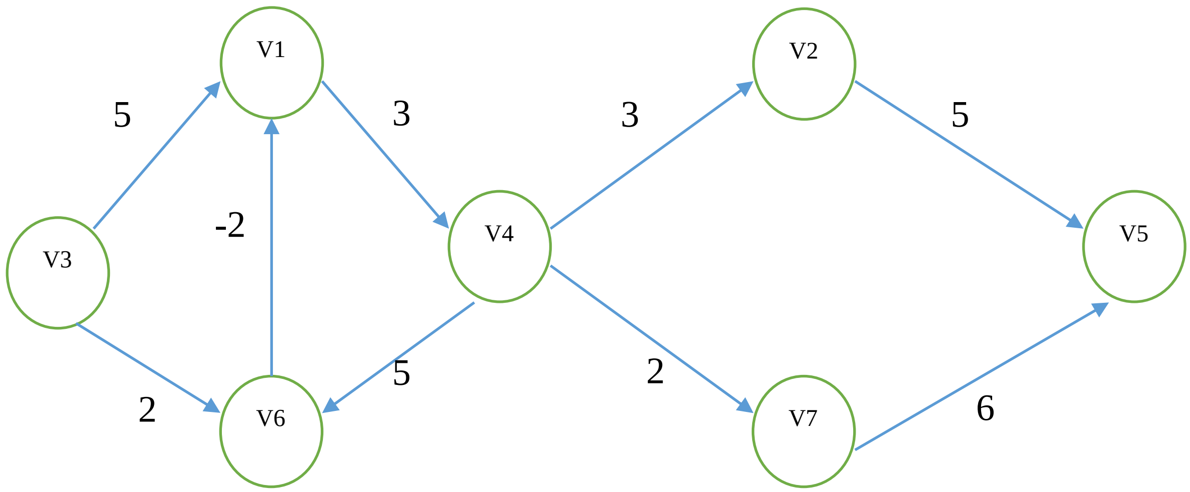
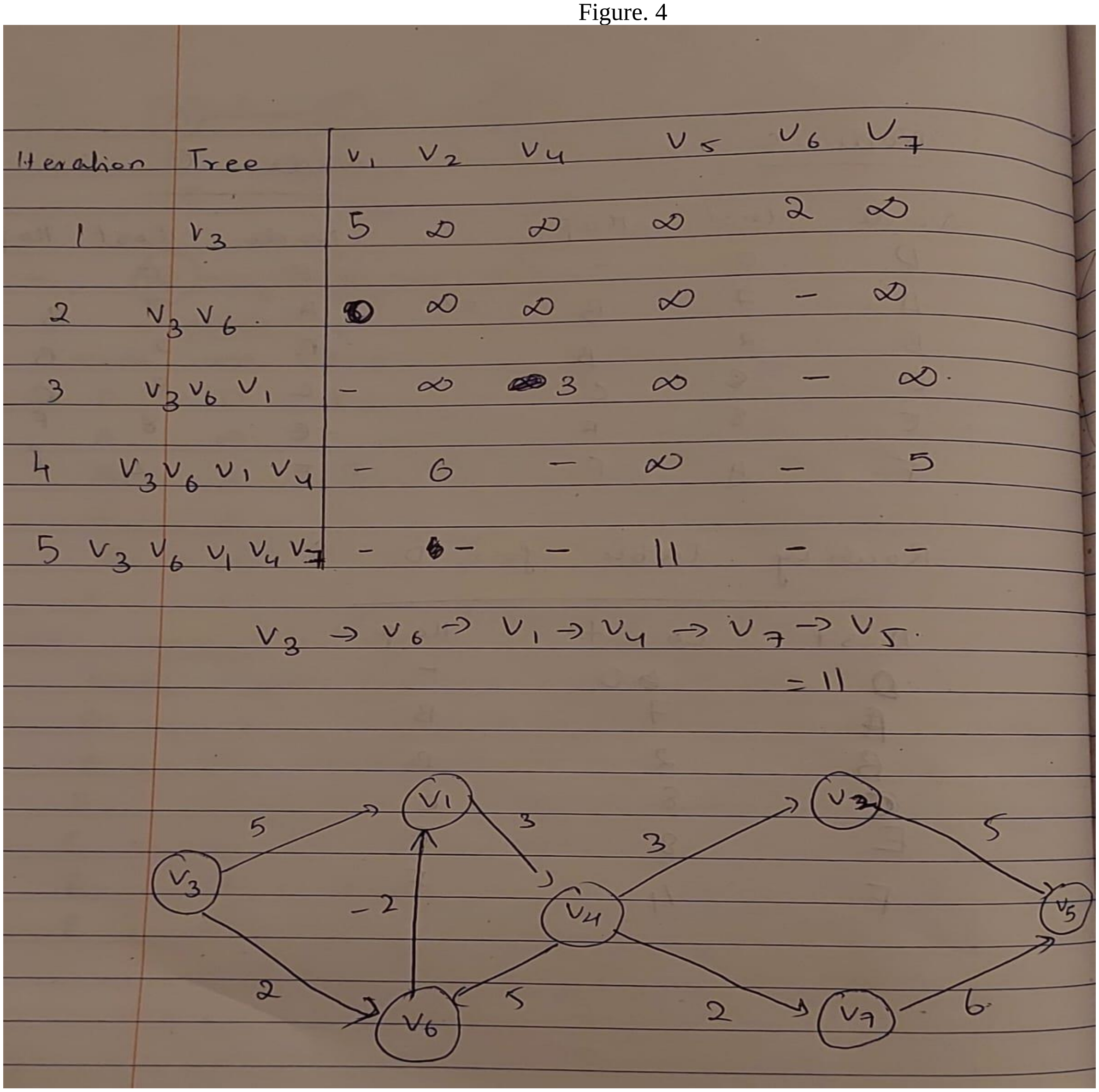


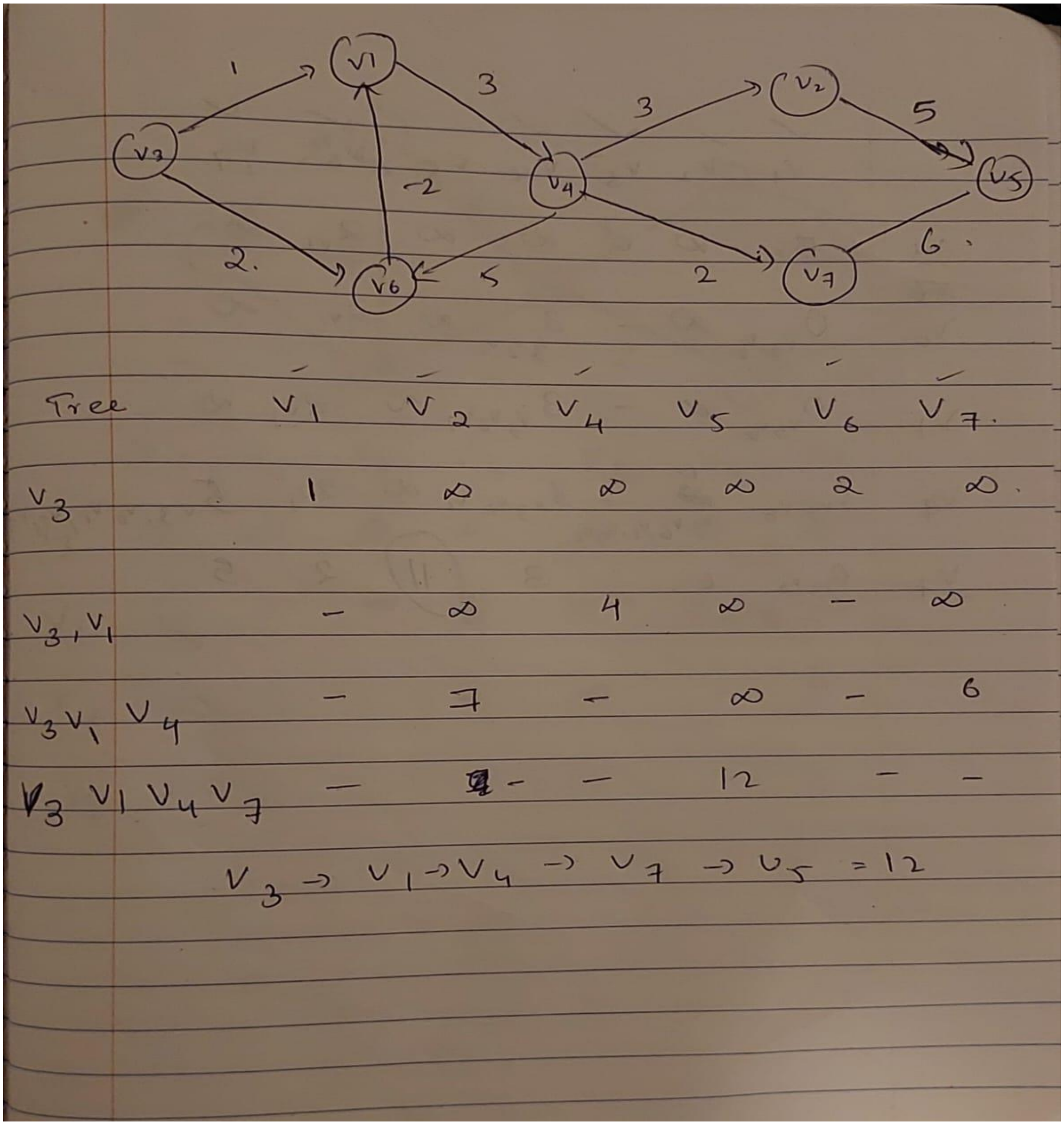
Figure. 4



Iteration	Tree	V_1	V_2	V_4	V_5	V_6	V_7
1	V_3	5	∞	∞	∞	2	∞
2	$V_3 V_6$	[illegible]	∞	∞	∞	–	∞
3	$V_3 V_6 V_1$	–	∞	3	∞	–	∞
4	$V_3 V_6 V_1 V_4$	–	6	–	∞	–	5
5	$V_3 V_6 V_1 V_4 V_7$	–	–	–	11	–	–

$V_3 \rightarrow V_6 \rightarrow V_1 \rightarrow V_4 \rightarrow V_7 \rightarrow V_5$.

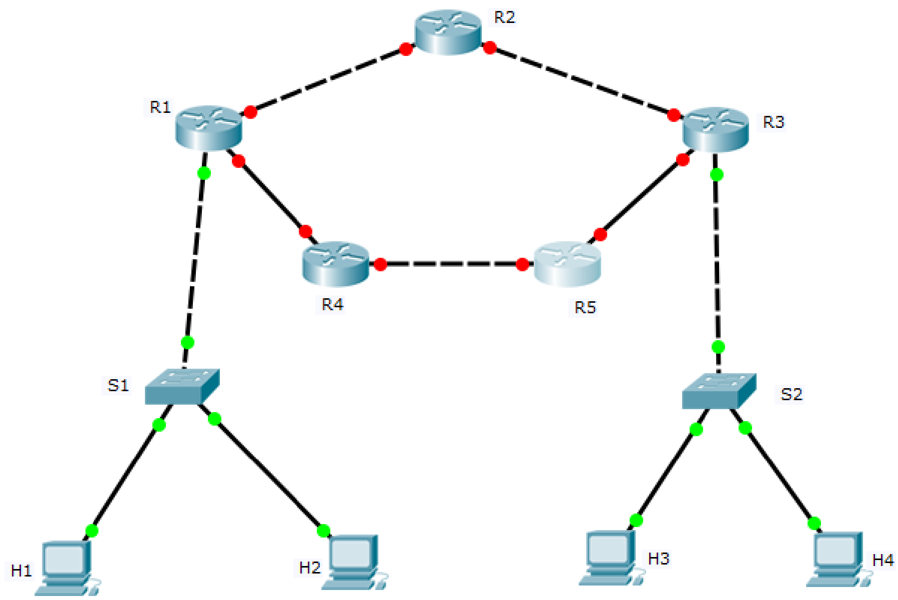
$= 11$



Tree	V_1	V_2	V_4	V_5	V_6	V_7
V_3	1	∞	∞	∞	2	∞
V_3, V_1	–	∞	4	∞	–	∞
$V_3 V_1 V_4$	–	7	–	∞	–	6
$V_3 V_1 V_4 V_7$	–	[illegible] –	–	12	–	–

$V_3 \to V_1 \to V_4 \to V_7 \to V_5 = 12$

Extra Credit Q2 [10 points]:



Consider the above network. RIP and OSPF both are simultaneously working on this network.

For H1 to reach H3, R1 gives a RIP path R1-R2-R3 and OSPF gives R1-R4-R5-R3.

Which path would packets from H1 going to H3 via R1 take?

Explain why you think a particular path would be chosen.

In this scenario where both RIP and OSPF routing protocols are simultaneously running on the network, the path where packets travel depends on the administrative distance of the routing. Administrative distance is a value used by the router to determine the best path, lower the value the better the route. Administrative Distance of RIP is 120 and OSPF is 110. Even though the RIP route exists, the router will choose OSPF route because it trusts OSPF more due to the lower AD. Therefore, Packets from H1 going to H3 take the OSPF route via (R1-R4-R5-R3) because it has lower administrative distance than RIP making it the best route to forward traffic.

Total Score = ___________________/135 (including 40 extra points)