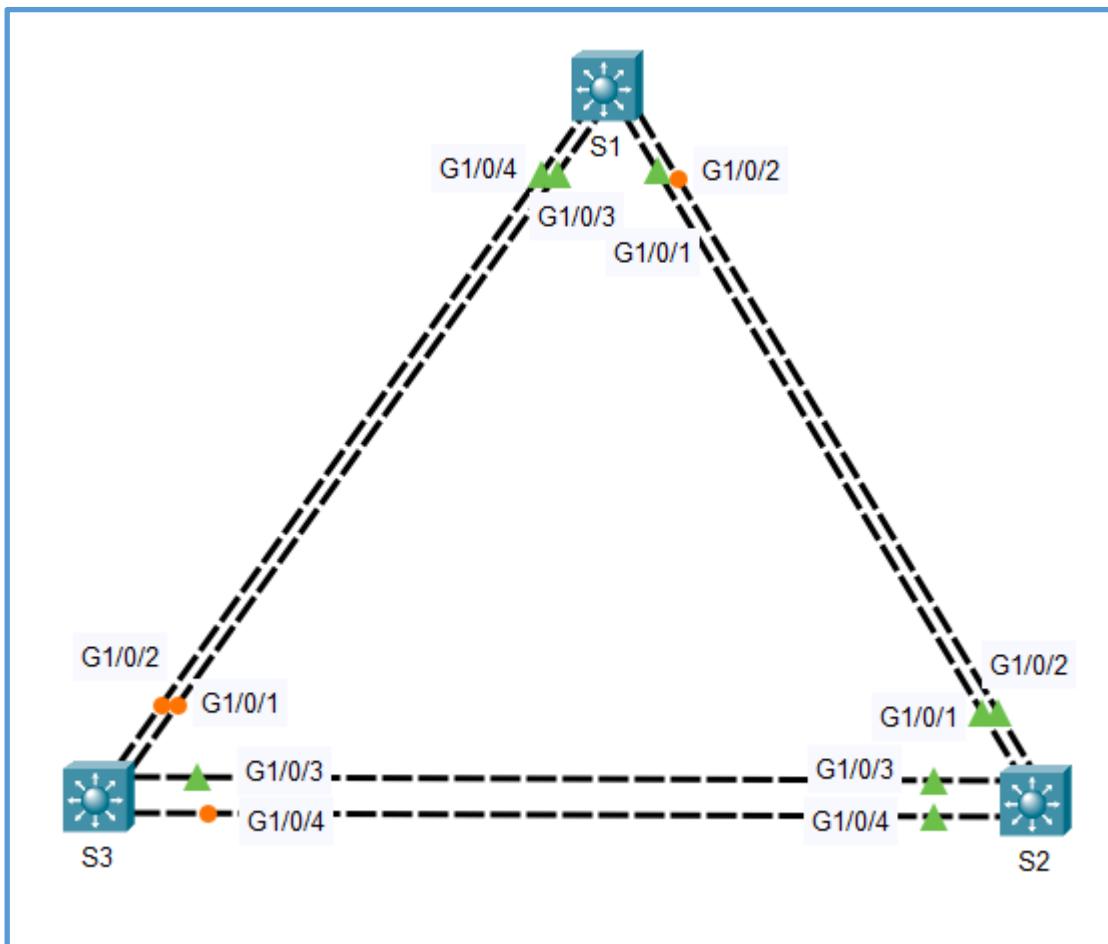


Lab Activity 1 – STP (Spanning Tree Protocol):

There are three switches connected using redundant links in the topology below. Please develop the following topology on the physical pod/rack in the lab room.



Required Resources:

- Three Layer-3/Multilayer Switches (Cisco Catalyst 1000 Series with Cisco IOS Release 15.1+ image).
- Cables:
 - Console cables to configure the Cisco IOS devices through the console port.
 - Ethernet and/or Serial cables as shown in the topology.

Addressing Table:

Device	Interface	IP Address	Default Gateway
S1	VLAN1	172.16.10.10	255.255.255.0
S2	VLAN1	172.16.10.20	255.255.255.0
S3	VLAN1	172.16.10.30	255.255.255.0

Lab Description:

- a. In this lab, please build a LAN based simple switched network with redundant links.
- b. You are also required to do the basic configuration on switches:
 - o Switches: Hostnames, SVI, default gateway, DNS lookup (disable), and so on.

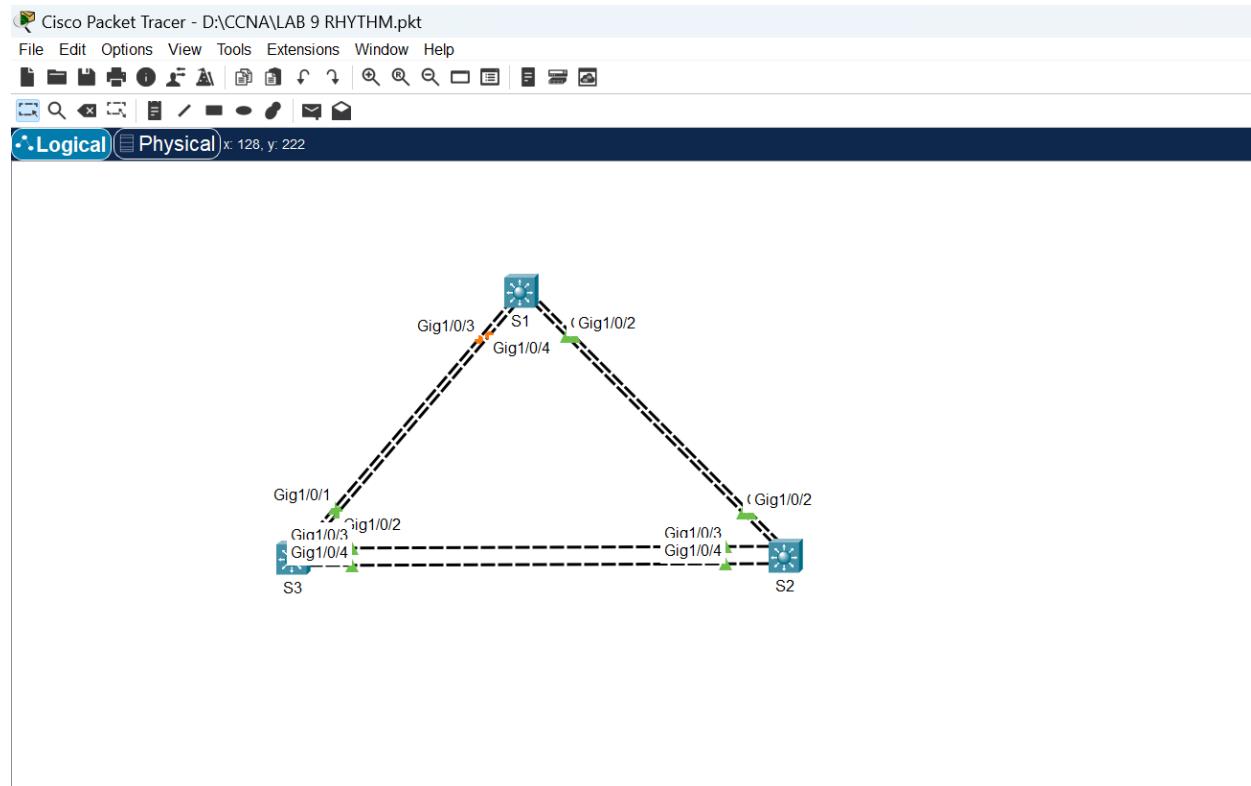
The Spanning Tree Protocol (STP) was developed as a Layer 2 loop-avoidance mechanism for redundant links in a switched network. STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.

In this lab, you will use the show spanning-tree command to observe the STP election process of the root bridge. You will also observe the port selection process based on cost and priority.

Solution:

Step 1: Set up the network topology.

- Develop the topology on a physical rack/pod by using all the devices mentioned above and then cabling them all together:
 - o Turn on the devices.
 - o Connect the switch with the default gateway, if required.
 - o Connect the PCs and server with their respective switch, if required.



Step 2: Configure and verify basic switch settings on all switches.

SW1

Cisco Packet Tracer - D:\CCNA\LAB 9 RHYTHM.pkt

Logical Physical x: 359, y: 40

Physical Config CLI Attributes

IOS Command Line Interface

```

Switch>en
Switch#config t
Enter configuration commands, one per line. End with CNTL/Z.
switch#hostname S1
S1(config)#no ip domain-lookup
S1(config)#banner motd "Authorized User only"
S1(config)#enable secret cisco
S1(config)#line console 0
S1(config-line)#password trios
S1(config-line)#login
S1(config-line)#exit
S1(config)#line vty 0 15
S1(config-line)#password trios
S1(config-line)#login local
S1(config-line)#exit
S1(config)#ip domain-name trios.com
S1(config)#username Admin privilege 15 password cisco123
S1(config)#crypto key generate rsa
The name for the keys will be: S1.trios.com
Choose the size of the key modulus in the range of 360 to 4096 for your
General Purpose Keys. Choosing a key modulus greater than 512 may take
a few minutes.

How many bits in the modulus [512]: 1024
% Generating 1024 bit RSA keys, keys will be non-exportable...[OK]

S1(config)#ip ssh version 2
* Mar 1 0:1:1.908: %SSH-5-ENABLED: SSH 1.99 has been enabled
S1(config)#line vty 0 15
S1(config-line)#transport input ssh
S1(config-line)#exit
S1(config)#service password-encryption
S1(config)#interface vlan 1
S1(config-if)#ip address 172.16.10.10 255.255.255.0
S1(config-if)#no shut

S1(config-if)#exit
S1(config)#ip default-gateway 172.16.10.1
S1(config)#end
S1#copy run st
Destination filename [startup-config]?
Building configuration...
[OK]

```

Time: 00:18:40

Copy Paste

SW2

Cisco Packet Tracer - D:\CCNA\LAB 9 RHYTHM.pkt

Logical Physical x: 405, y: 365

Physical Config CLI Attributes

IOS Command Line Interface

```

Switch#config t
Enter configuration commands, one per line. End with CNTL/Z.
Switch#hostname S2
S2(config)#no ip domain-lookup
S2(config)#banner motd "Authorized User only"
S2(config)#enable secret cisco
S2(config)#line console 0
S2(config-line)#password trios
S2(config-line)#login
S2(config-line)#exit
S2(config)#line vty 0 15
S2(config-line)#password trios
S2(config-line)#login local
S2(config-line)#exit
S2(config)#ip domain-name trios.com
S2(config)#username Admin privilege 15 password cisco123
S2(config)#crypto key generate rsa
The name for the keys will be: S2.trios.com
Choose the size of the key modulus in the range of 360 to 4096 for your
General Purpose Keys. Choosing a key modulus greater than 512 may take
a few minutes.

How many bits in the modulus [512]: 1024
% Generating 1024 bit RSA keys, keys will be non-exportable...[OK]

S2(config)#ip ssh version 2
* Mar 1 0:2:17.645: %SSH-5-ENABLED: SSH 1.99 has been enabled
S2(config)#line vty 0 15
S2(config-line)#transport input ssh
S2(config-line)#exit
S2(config)#service password-encryption
S2(config)#interface vlan 1
S2(config-if)#ip address 172.16.10.20 255.255.255.0
S2(config-if)#no shut

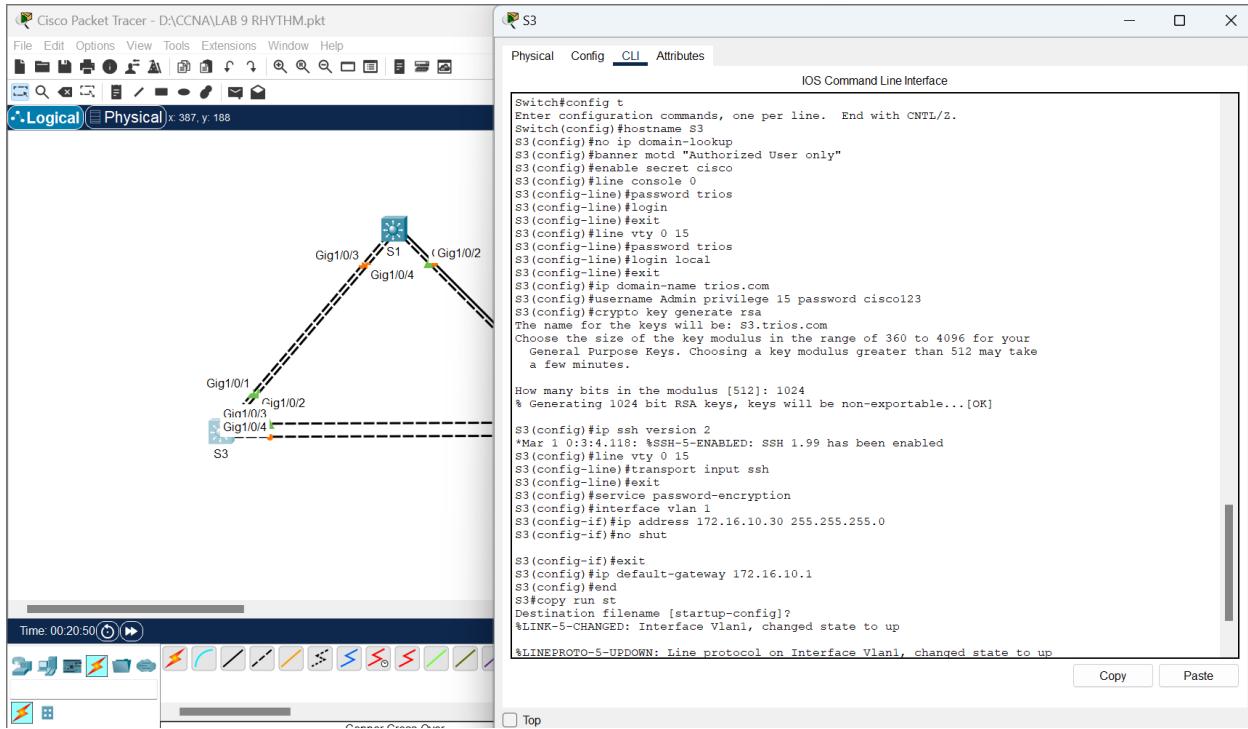
S2(config-if)#exit
S2(config)#ip default-gateway 172.16.10.1
S2(config)#end
S2#copy run st
Destination filename [startup-config]?
Building configuration...
[OK]
S2#

```

Time: 00:19:59

Copy Paste

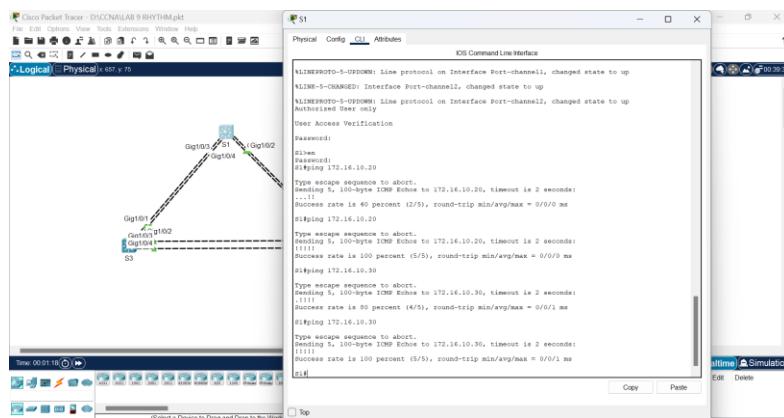
SW3



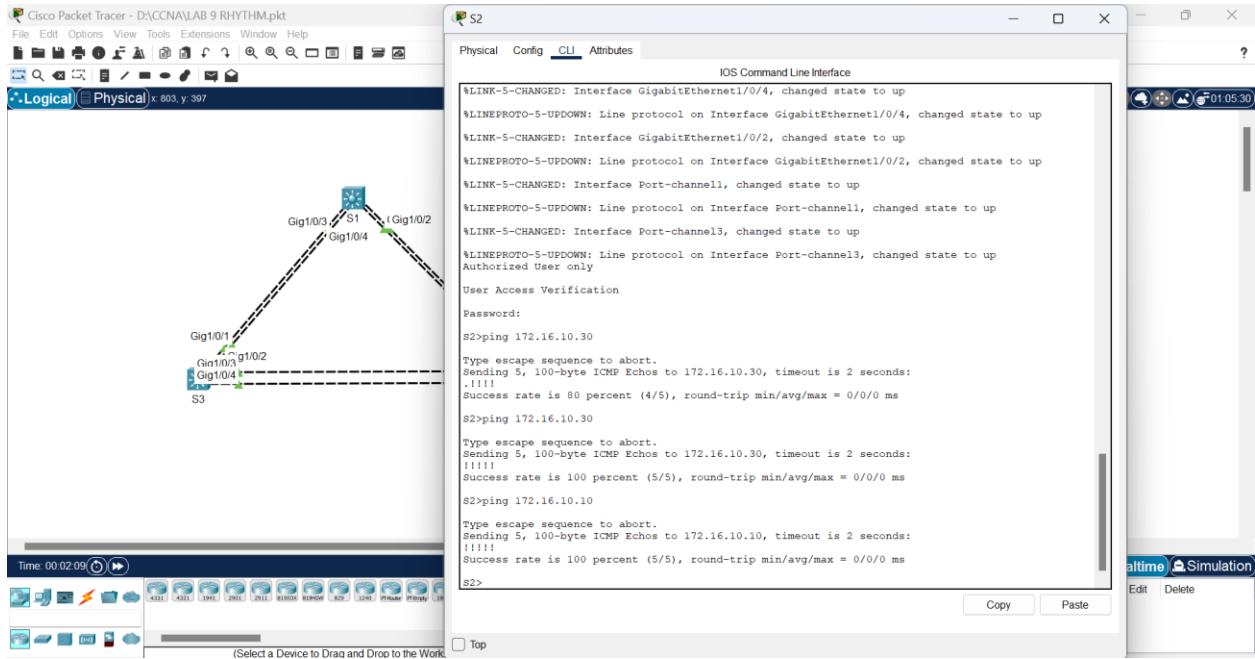
- Console into the switch and enter the global configuration mode:
 - Assign the switch with a host name according to the addressing table.
 - Disable unwanted DNS lookup.
 - Configure a login MOTD banner to warn about illegal access.
 - Assign the encrypted password cisco to privilege exec mode (#).
 - Protect the physical and virtual lines from having console access using the password trios and configure ***logging synchronous*** for the console line.
 - Encrypt all current and future passwords by enabling the required service.
 - Configure and activate SVI according to the addressing table.
 - Configure default gateway according to the addressing table.
 - Save the configuration.

Step 3: Configure and verify connectivity between all the switches.

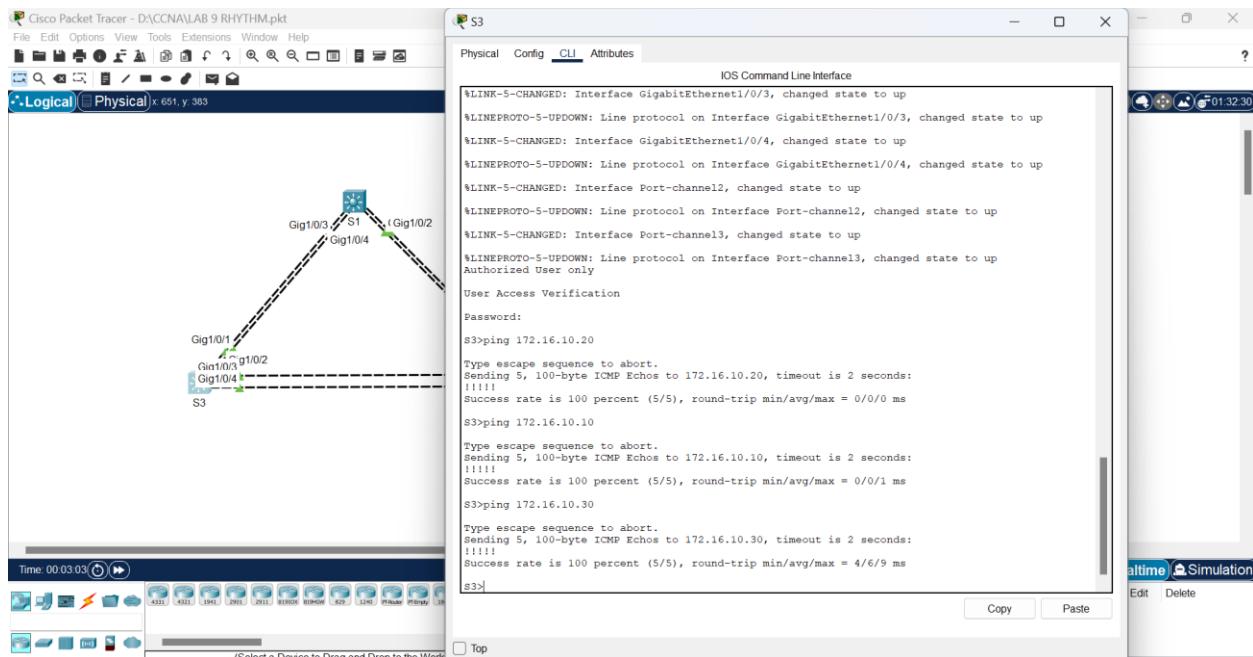
- Troubleshoot any connection issues, if needed.



S2



S3

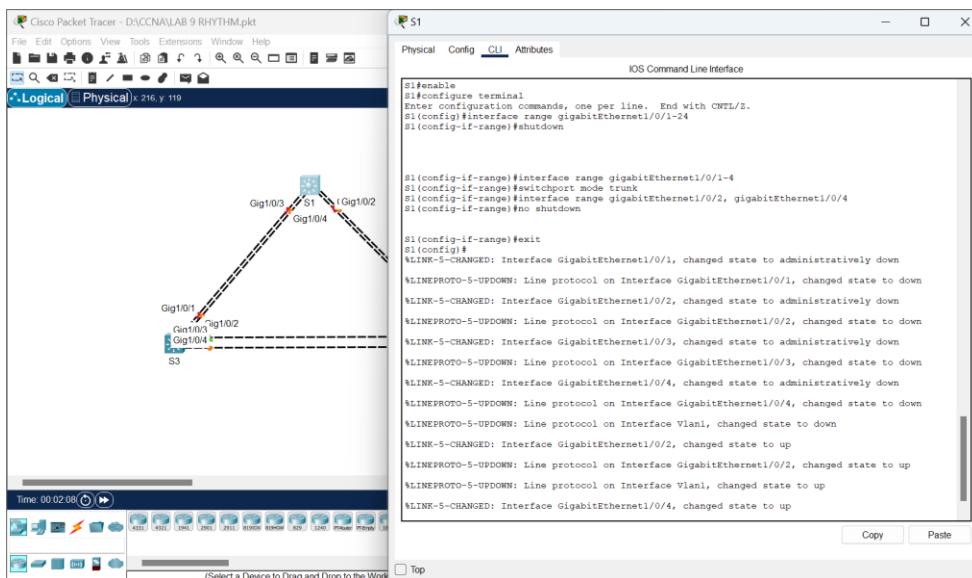


Step 4: Initiate the election process to determine which switch will become the root bridge. The switch with lowest BID (Bridge Priority Value, Extended System ID, and the MAC address of the switch) becomes the Root Bridge. The default value of the bridge priority is 32,768 however the range of priority value is between 0 to 65,535. It can be incremented by 4096.

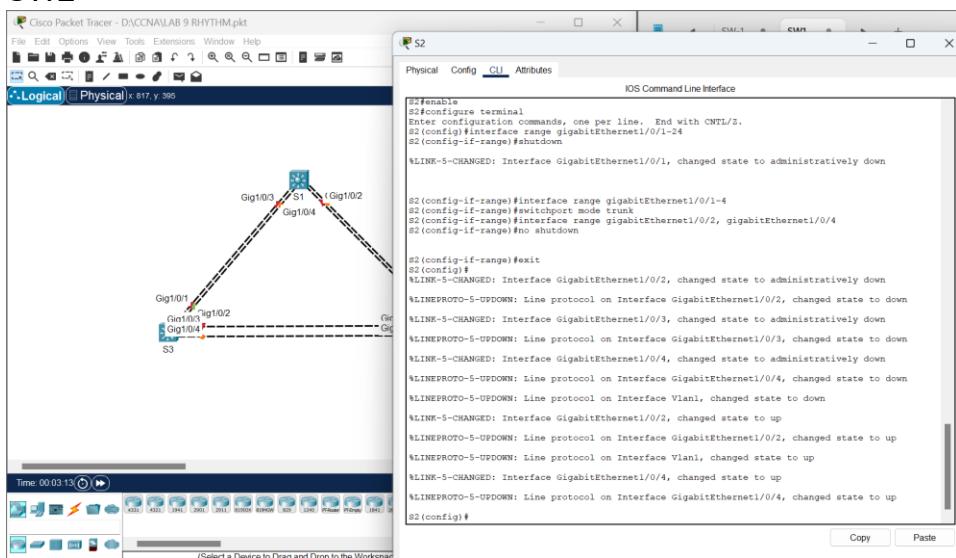
- Shut down all the ports on all the switches using range command, for example:

- interface range g1/0/1-24*
 - shut*
 - exit*
- Configure trunk ports between all the switches using all the active links between switches, for example:
 - interface range g1/0/1-4*
 - switchport mode trunk*
- Activate g1/0/2 and g1/0/4 ports on all the switches, for example:
 - interface range g1/0/2, g1/0/4*
 - no shut*
 - exit*

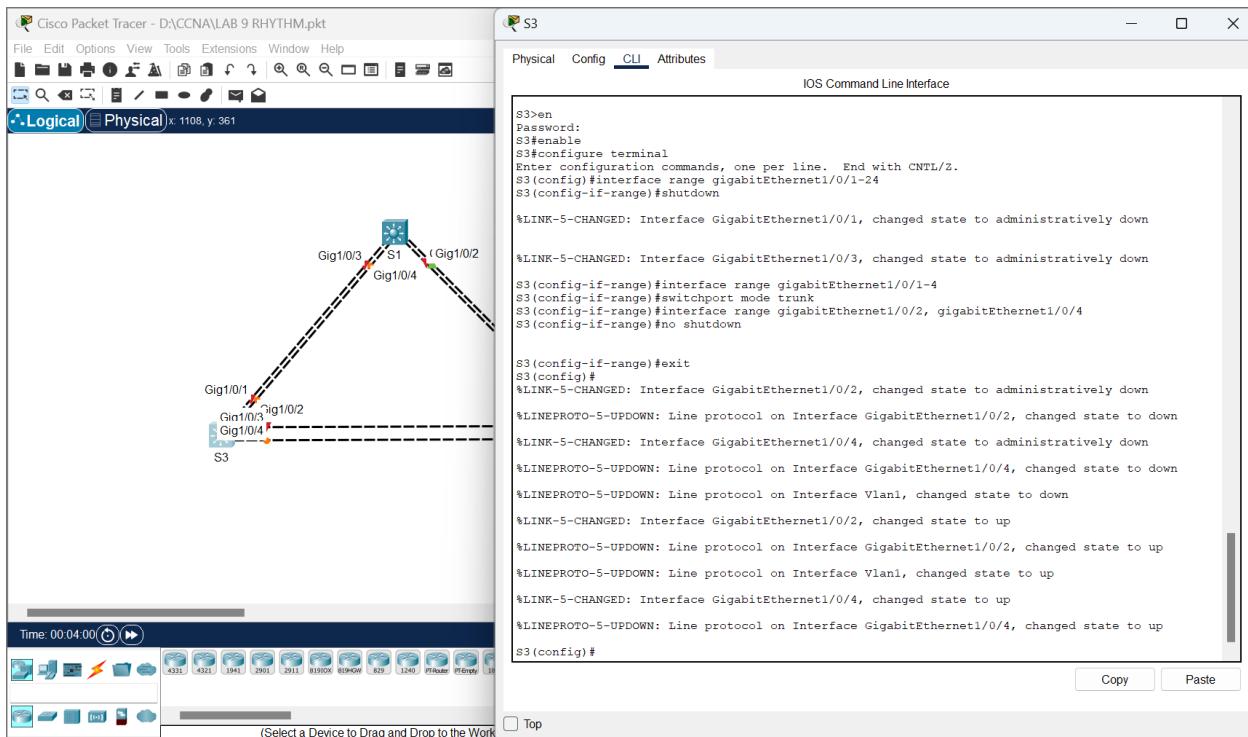
SW1



SW2



SW3



Step 5: Display the Root Bridge information elected by STP.

- Issue the following command on each switch at privilege exec mode#:
 - show spanning-tree*

```
S1#sh spanning-tree
VLAN0001
Spanning tree enabled protocol rstp
Root ID Priority 32769
Address 4464.3c69.7d00
Cost 4
Port 2 (GigabitEthernet1/0/2)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 4464.3c69.7d00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----  

Gi1/0/2 Root FWD 4 128.2 P2p
Gi1/0/4 Altn BLK 4 128.4 P2p

S1#  

S2#sh spanning-tree
VLAN0001
Spanning tree enabled protocol rstp
Root ID Priority 32769
Address 4464.3c69.7d00
Cost 4
Port 2 (GigabitEthernet1/0/2)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 4464.3c69.7d00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----  

Gi1/0/2 Desg FWD 4 128.2 P2p
Gi1/0/4 Desg FWD 4 128.4 P2p

S2#  

S3#sh spanning-tree
VLAN0001
Spanning tree enabled protocol rstp
Root ID Priority 32769
Address 4464.3c69.7d00
Cost 4
Port 4 (GigabitEthernet1/0/4)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

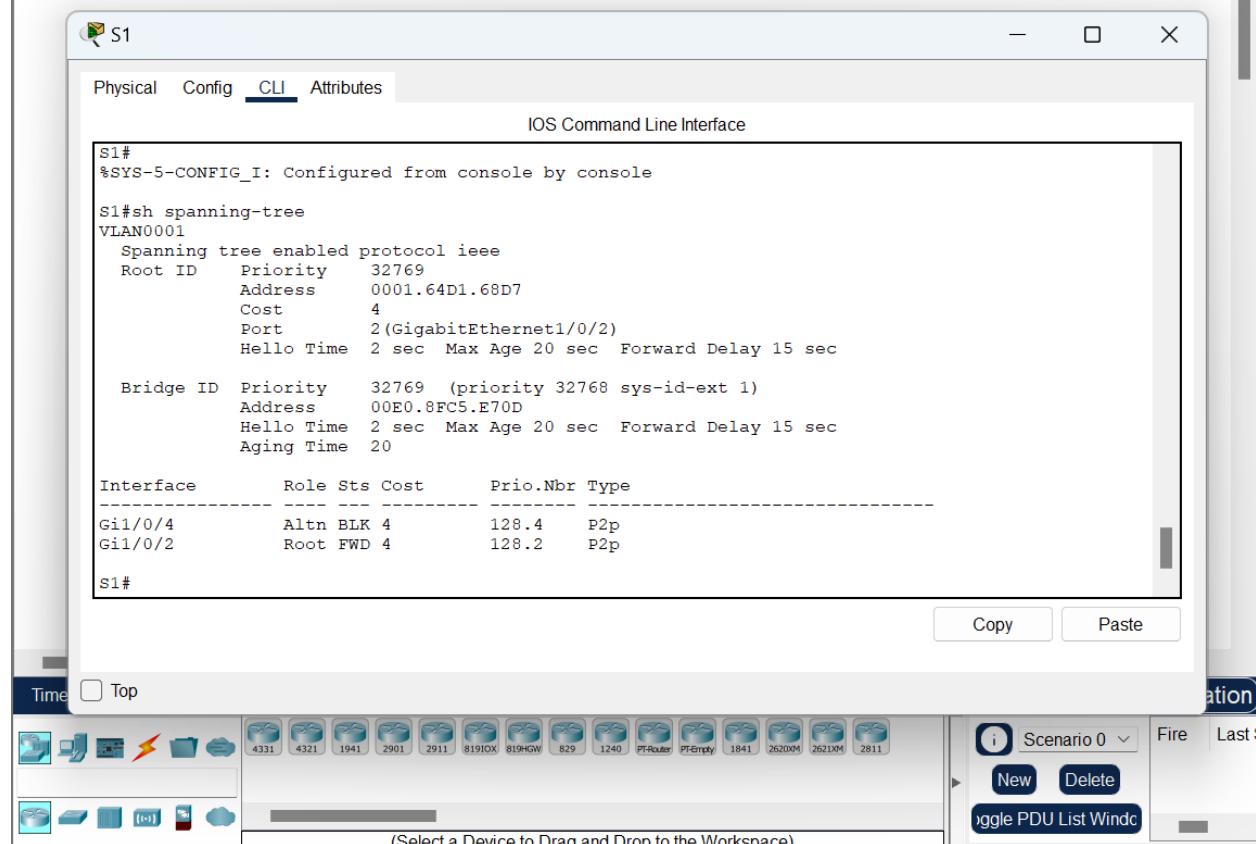
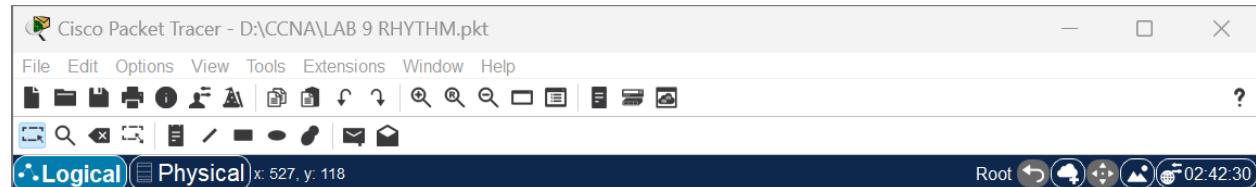
Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 4464.3c69.7d00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----  

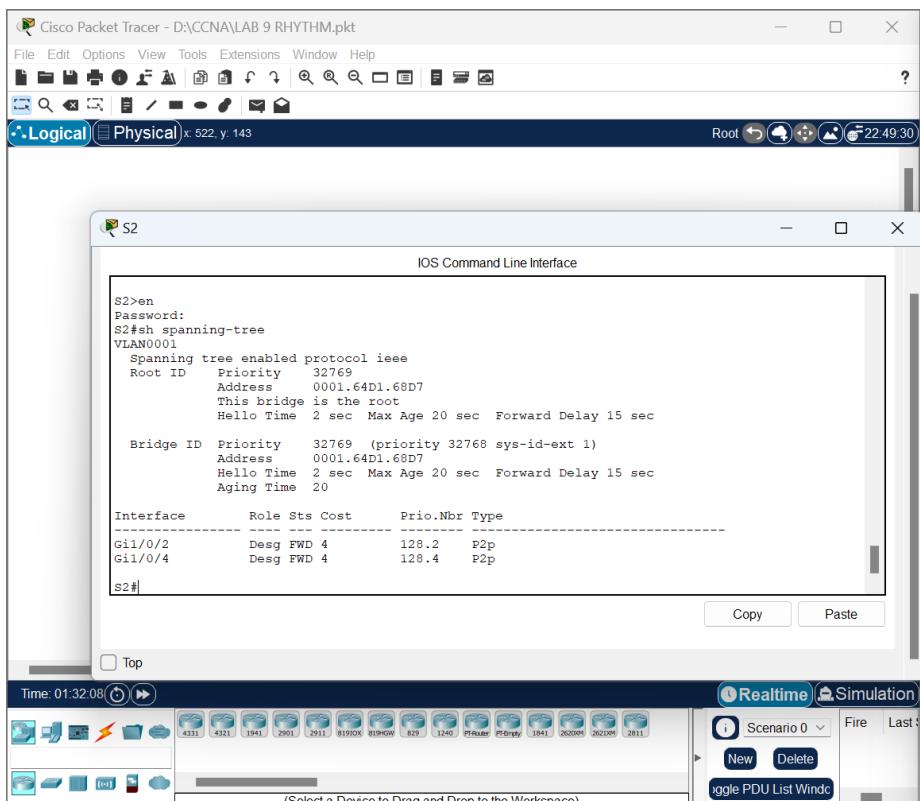
Gi1/0/2 Desg FWD 4 128.2 P2p
Gi1/0/4 Root FWD 4 128.4 P2p

S3#
```

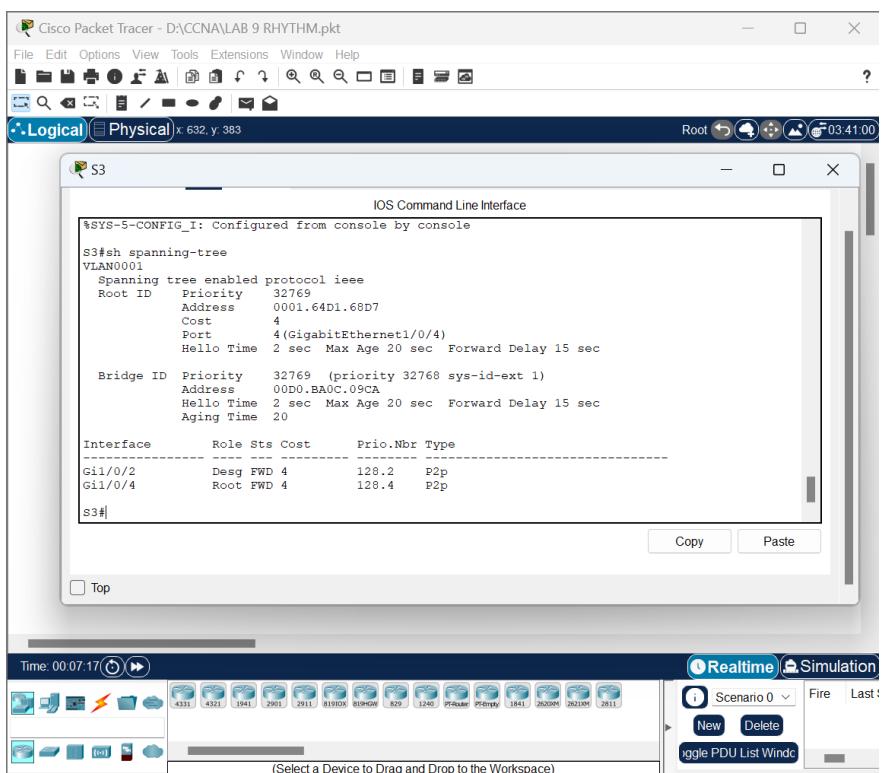
S1



S2



S3



You can see in the above example that the bridge priority is (default) $32768 + (\text{Vlan}) \cdot 1 = 32769$ in all the three switches.

- a) What is the tie breaker?
Answer: to determine the root bridge, you combine the priority of each bridge with its MAC address. If two switches or bridges happen to have the same priority value, the MAC address becomes the tiebreaker for figuring out which one has the lowest.
- b) What is the MAC address of each switch? (Do not write from the above example)
- c) MAC Address of S1: 00E0.8FC5.E70D
- d) MAC Address of S2: 0001.64D1.68D7
- e) MAC Address of S3: 00D0.BA0C.09CA
- f) Which switch has the lowest MAC address?

Answer: S2 is the lowest MAC address.

- g) Which switch has become the Root Bridge? Answer: Switch S2
- h) Why did the spanning tree select this switch to be the Root Bridge?
Answer: The spanning tree protocol selected S2 as the Root Bridge because it has the lowest MAC address among the switches.
- i) Is there any other indication of the Root Bridge from the output of **show spanning-tree** command?
Answer: The line **This bridge is the root** indicate that S2 is the Root bridge.
- j) Which ports are root ports on each switch (if any)?

S1:Gi1/0/2	S2: Root Bridge	S3: Gi1/0/4
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- k) Which ports are designated ports on each switch?

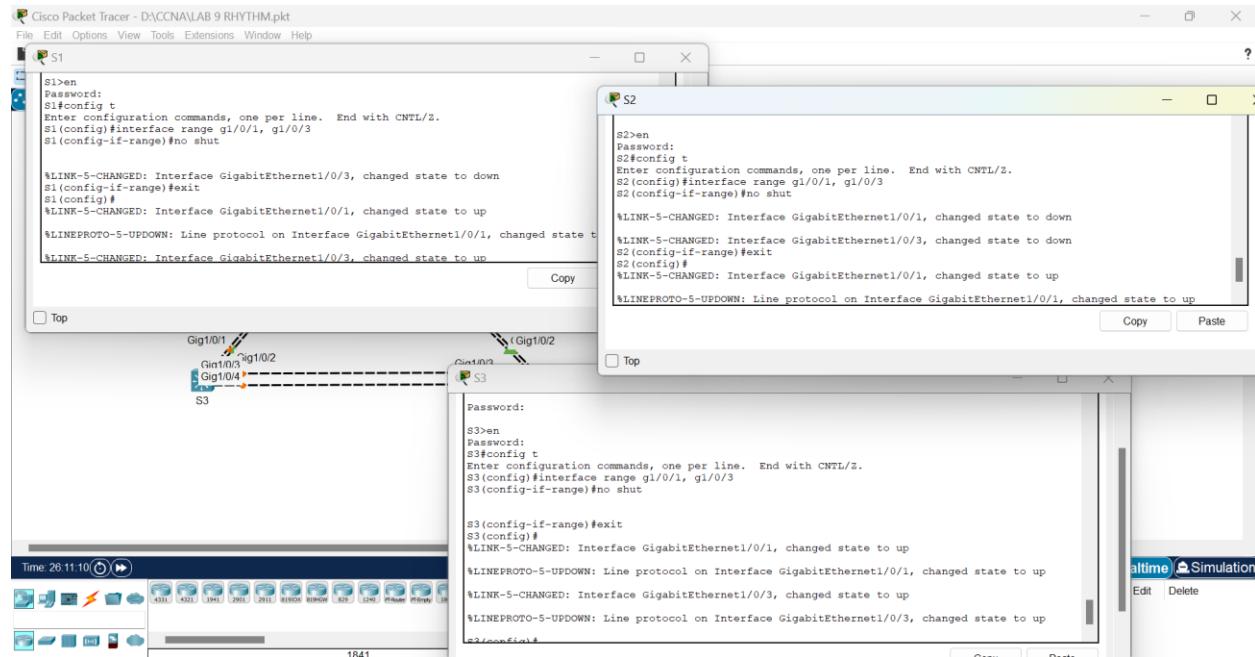
S1: Not applicable	S2: Gi1/0/2, Gi1/0/4	S3: Gi1/0/2
--------------------	----------------------	-------------
- l) Which ports are showing as alternate ports on each switch (if any)?

S1: Gi1/0/4	S2: Not applicable	S3: Not applicable
-------------	--------------------	--------------------
- m) Why was the above-mentioned port selected as a blocked (non-designated) port by spanning tree protocol?

Answer: because it is not part of the shortest path to the Root Bridge, which helps prevent loops in the network topology.

Step 6: Activate ports on all switches to monitor the STP port selection process with regards to port priorities, for example:

- Issue the following command for ports g1/0/1 and g1/0/3 on all switches.
 - interface range g1/0/1, g1/0/3*
 - no shut*
 - exit*



- After some time, issue the following commands on all the switches:
 - show spanning-tree*

S1#show spanning-tree	S2#show spanning-tree	S3#show spanning-tree
VLAN0001 Spanning tree enabled protocol rstp Root ID Priority 32769 Address 4464.3c69.7d00 Cost 4 Port 1 (GigabitEthernet1/0/1) Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec Bridge ID Priority 32769 (priority 32768 sys-id-ext 1) Address 4464.3c69.e300 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec Aging Time 300 sec	VLAN0001 Spanning tree enabled protocol rstp Root ID Priority 32769 Address 4464.3c69.7d00 This bridge is the root Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec Bridge ID Priority 32769 (priority 32768 sys-id-ext 1) Address 4464.3c69.7d00 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec Aging Time 300 sec	VLAN0001 Spanning tree enabled protocol rstp Root ID Priority 32769 Address 4464.3c69.7d00 Cost 4 Port 3 (GigabitEthernet1/0/3) Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec Bridge ID Priority 32769 (priority 32768 sys-id-ext 1) Address 4464.3c69.7d00 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec Aging Time 300 sec
Interface Role Sts Cost Prio.Nbr Type	Interface Role Sts Cost Prio.Nbr Type	Interface Role Sts Cost Prio.Nbr Type
G1/0/1 Root FWD 4 128.1 P2p	G1/0/1 Desg FWD 4 128.1 P2p	G1/0/1 Desg FWD 4 128.1 P2p
G1/0/2 Altn BLK 4 128.2 P2p	G1/0/2 Desg FWD 4 128.2 P2p	G1/0/2 Desg FWD 4 128.2 P2p
G1/0/3 Altn BLK 4 128.3 P2p	G1/0/3 Desg FWD 4 128.3 P2p	G1/0/3 Root FWD 4 128.3 P2p
G1/0/4 Altn BLK 4 128.4 P2p	G1/0/4 Desg FWD 4 128.4 P2p	G1/0/4 Altn BLK 4 128.4 P2p

S1

```

S1#show spanning-tree
VLAN001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 0001.64D1.68D7
Cost 4
Port 1(GigabitEthernet1/0/1)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 00E0.BFC5.E70D
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface Role Sts Cost Prio.Nbr Type
----- -----
Gi1/0/4 Altn BLK 4 128.4 P2p
Gi1/0/3 Altn BLK 4 128.3 P2p
Gi1/0/1 Root FWD 4 128.1 P2p
Gi1/0/2 Altn BLK 4 128.2 P2p

```

S2

```

S2#show spanning-tree
VLAN001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 0001.64D1.68D7
Cost 4
Port 1(GigabitEthernet1/0/1)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0001.64D1.68D7
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface Role Sts Cost Prio.Nbr Type
----- -----
Gi1/1 Desg FWD 4 128.1 P2p
Gi1/0/2 Desg FWD 4 128.3 P2p
Gi1/0/4 Desg FWD 4 128.4 P2p
Gi1/0/3 Desg FWD 4 128.2 P2p

```

S3

```

S3#show spanning-tree
VLAN001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 0001.64D1.68D7
Cost 4
Port 3(GigabitEthernet1/0/3)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 00D0.BA0C.09CA
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface Role Sts Cost Prio.Nbr Type
----- -----
Gi1/0/1 Desg FWD 4 128.1 P2p
Gi1/0/3 Root FWD 4 128.3 P2p
Gi1/0/2 Desg FWD 4 128.2 P2p
Gi1/0/4 Altn BLK 4 128.4 P2p

```

a) Which ports are root ports on each switch (if any)?

S1: Gi1/0/1

S2: None

S3: Gi1/0/3

b) Which ports are designated ports on each switch?

S1: None

S2: Gi1/0/1, Gi1/0/2, Gi1/0/3, Gi1/0/4

S3: Gi1/0/1, Gi1/0/2

c) Which ports are showing as alternate ports on each switch (if any)?

S1: Gi1/0/2, Gi1/0/3, Gi1/0/4

S2: None

S3: Gi1/0/4

d) Is there any change of root ports on non-root switches when comparing Step 5 (j,k,l) with Step 6 (a,b,c)?

Yes, if we compare In step 5 root ports S1:Gi1/0/2 S3: Gi1/0/4 whereas, In step 6 root ports changed to S1: Gi1/0/1 S3: Gi1/0/3.

e) While selecting ports by STP, if port costs and BIDs are equal, what is used to break the tie?

Answer: The port with the lowest interface number is used to break the tie.

Lab Activity 2 – EtherChannel:

Step 1: Configure LACP between switches.

```
S1#show interfaces trunk
Port Mode Encapsulation Status Native vlan
G1/0/1 on 802.1q trunking 1
G1/0/2 on 802.1q trunking 1
G1/0/3 on 802.1q trunking 1
G1/0/4 on 802.1q trunking 1

Port Vlans allowed on trunk
G1/0/1 1-4094
G1/0/2 1-4094
G1/0/3 1-4094
G1/0/4 1-4094

Port Vlans allowed and active in management domain
G1/0/1 1
G1/0/2 1
G1/0/3 1
G1/0/4 1

Port Vlans in spanning tree forwarding state and not pruned
G1/0/1 1
G1/0/2 none
G1/0/3 none
G1/0/4 none

Port Vlans in spanning tree forwarding state and not pruned
G1/0/4 none
S1# 

S2#show interfaces trunk
Port Mode Encapsulation Status Native vlan
G1/0/1 on 802.1q trunking 1
G1/0/2 on 802.1q trunking 1
G1/0/3 on 802.1q trunking 1
G1/0/4 on 802.1q trunking 1

Port Vlans allowed on trunk
G1/0/1 1-4094
G1/0/2 1-4094
G1/0/3 1-4094
G1/0/4 1-4094

Port Vlans allowed and active in management domain
G1/0/1 1
G1/0/2 1
G1/0/3 1
G1/0/4 1

Port Vlans in spanning tree forwarding state and not pruned
G1/0/1 1
G1/0/2 1
G1/0/3 1
G1/0/4 1

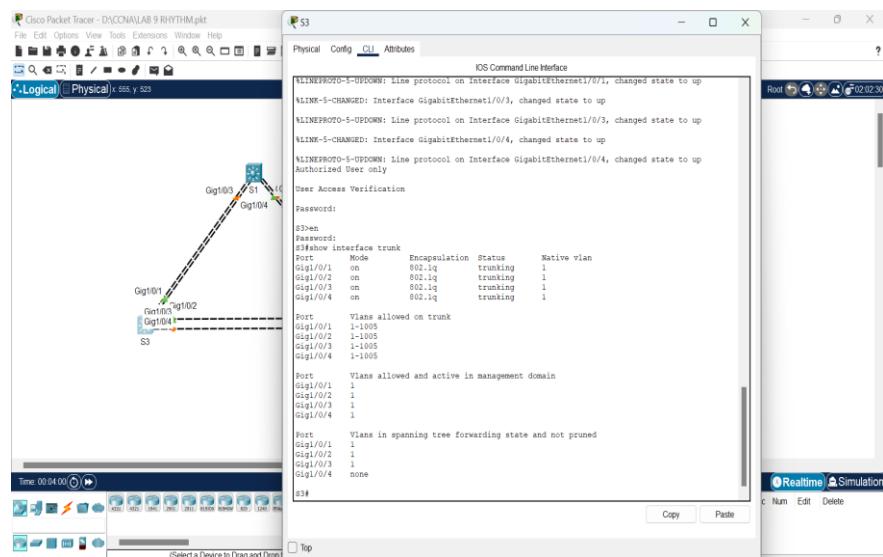
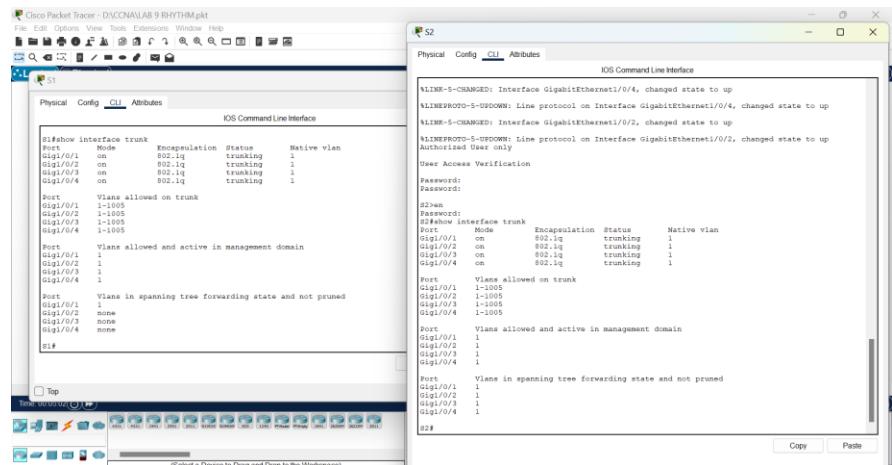
Port Vlans in spanning tree forwarding state and not pruned
G1/0/4 1
S2# 

S3#show int trunk
Port Mode Encapsulation Status Native vlan
G1/0/1 on 802.1q trunking 1
G1/0/2 on 802.1q trunking 1
G1/0/3 on 802.1q trunking 1
G1/0/4 on 802.1q trunking 1

Port Vlans allowed on trunk
G1/0/1 1-4094
G1/0/2 1-4094
G1/0/3 1-4094
G1/0/4 1-4094

Port Vlans allowed and active in management domain
G1/0/1 1
G1/0/2 1
G1/0/3 1
G1/0/4 1

Port Vlans in spanning tree forwarding state and not pruned
G1/0/1 1
G1/0/2 1
G1/0/3 1
G1/0/4 none
S3# 
```

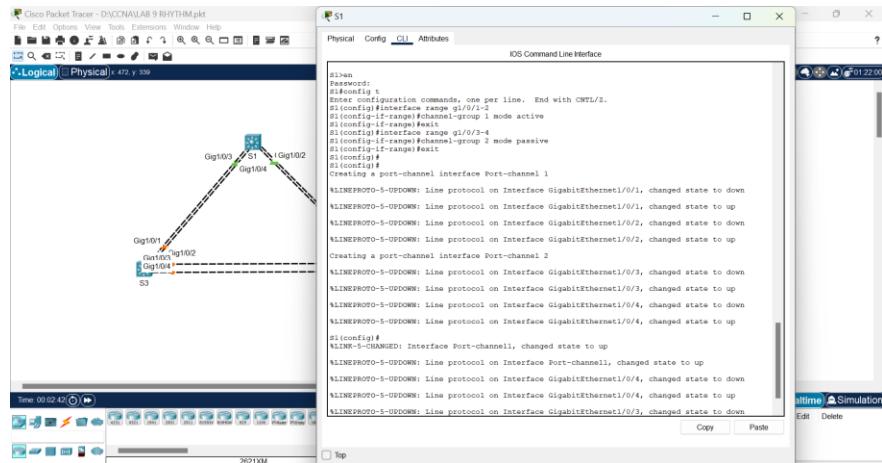


LACP is used for link aggregation and is not a proprietary protocol.

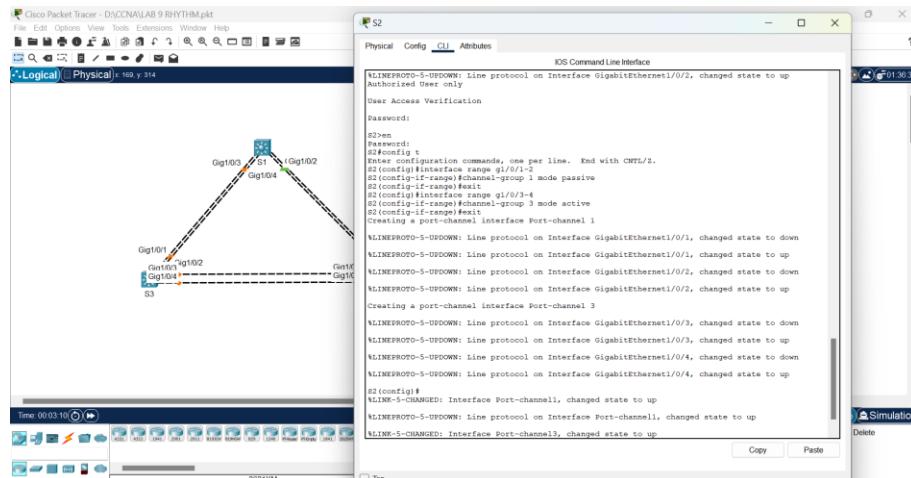
It is an open-source protocol developed by IEEE for Link aggregation. In this part, the trunk links will be aggregated using LACP as EtherChannels. For example:

- interface range g1/0/1-2
 - channel-group 1 mode active
 - exit- Active mode in LACP will initiate the negotiation when passive mode will not start or when the initiate packet negotiation responds to the LACP packets initiated by the other end. If both ends have passive mode, then the EtherChannel will not be formed/established.
 - interface range g1/0/3-4
 - channel-group 2 mode passive
 - exit

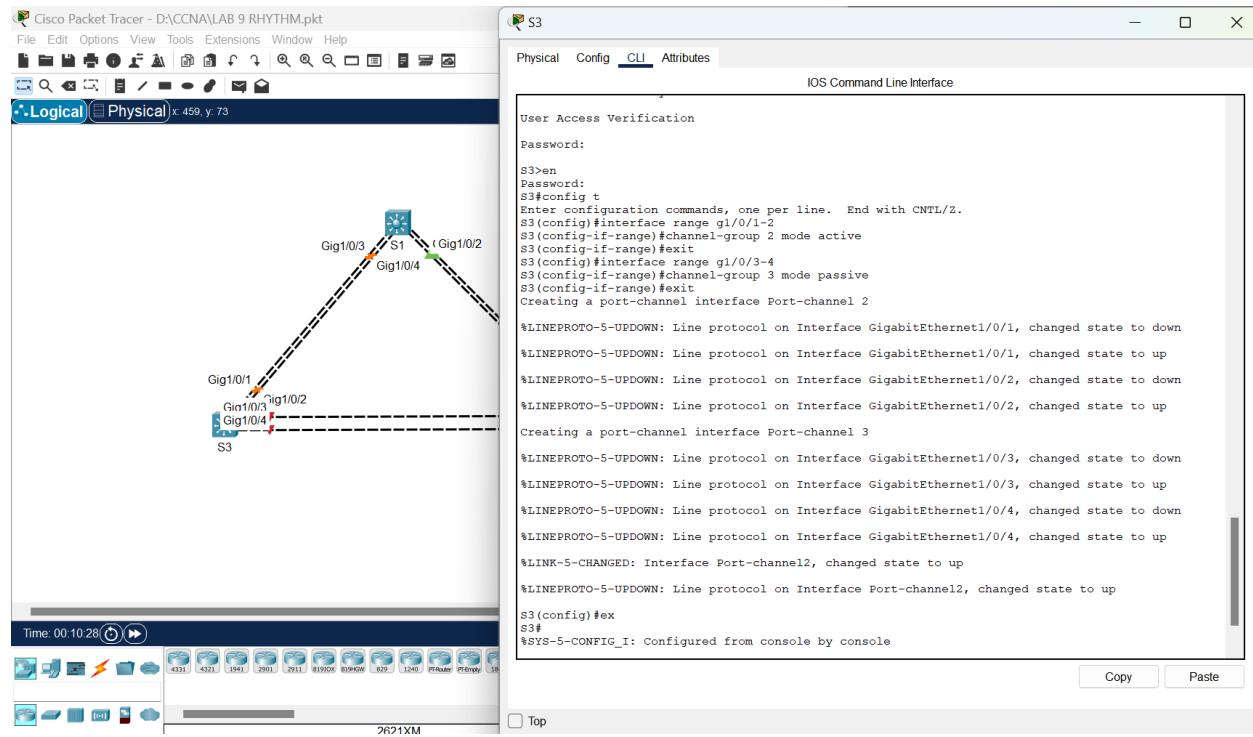
S1



S2



S3



- Once all the three port channels are established between the switches the output should be similar as below:

```
S1#show interfaces trunk
Port      Mode          Encapsulation  Status      Native vlan
Po1      on           802.1q        trunking    1
Po2      on           802.1q        trunking    1

Port      Vlans allowed on trunk
Po1      1-4094
Po2      1-4094

Port      Vlans allowed and active in management domain
Po1      1
Po2      1

Port      Vlans in spanning tree forwarding state and not pruned
Po1      1
Po2      none
S1#
```

```
S2#show int trunk
Port      Mode          Encapsulation  Status      Native vlan
Po1      on           802.1q        trunking    1
Po3      on           802.1q        trunking    1

Port      Vlans allowed on trunk
Po1      1-4094
Po3      1-4094

Port      Vlans allowed and active in management domain
Po1      1
Po3      1

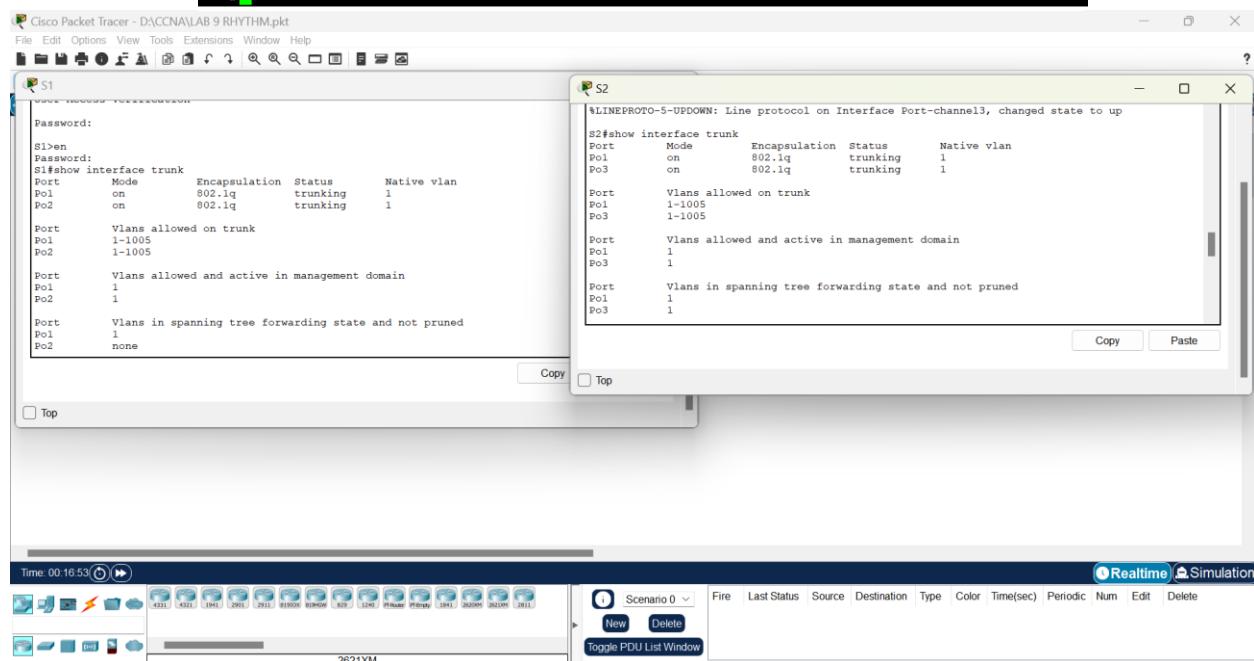
Port      Vlans in spanning tree forwarding state and not pruned
Po1      1
Po3      1
S2#
```

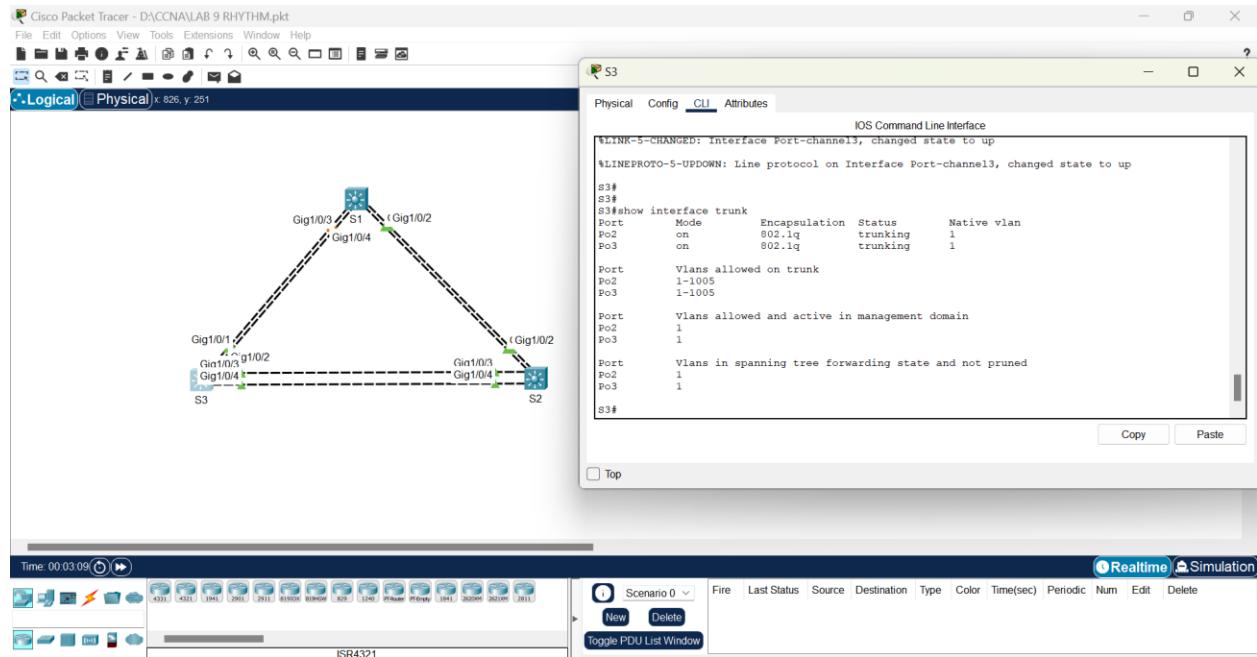
```
S3#show int trunk
Port      Mode          Encapsulation  Status      Native vlan
Po2      on           802.1q        trunking    1
Po3      on           802.1q        trunking    1

Port      Vlans allowed on trunk
Po2      1-4094
Po3      1-4094

Port      Vlans allowed and active in management domain
Po2      1
Po3      1

Port      Vlans in spanning tree forwarding state and not pruned
Po2      1
Po3      1
S3#
```





- Issue the following command on all switches to verify the EtherChannel configuration:
 - show etherchannel summary*

The output of the above-mentioned command should be similar to the screenshots below:

```

S1#show etherchannel summary
Flags: D - down P - bundled in port-channel
I - stand-alone s - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use N - not in use, no aggregation
f - failed to allocate aggregator
M - not in use, minimum links not met
m - not in use, port not aggregated due to minimum links not met
u - unsuitable for bundling
w - waiting to be aggregated
d - default port
A - formed by Auto LAG

Number of channel-groups in use: 2
Number of aggregators: 2

Group Port-channel Protocol Ports
-----+-----+-----+-----+
1   Po1(SU)    LACP   Gig1/0/1(P) Gig1/0/2(P)
2   Po2(SU)    LACP   Gig1/0/3(P) Gig1/0/4(P)
S1#

```



```

S2#show etherchannel summary
Flags: D - down P - bundled in port-channel
I - stand-alone s - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use N - not in use, no aggregation
f - failed to allocate aggregator
M - not in use, minimum links not met
m - not in use, port not aggregated due to minimum links not met
u - unsuitable for bundling
w - waiting to be aggregated
d - default port
A - formed by Auto LAG

Number of channel-groups in use: 2
Number of aggregators: 2

Group Port-channel Protocol Ports
-----+-----+-----+-----+
1   Po1(SU)    LACP   Gig1/0/1(P) Gig1/0/2(P)
3   Po3(SU)    LACP   Gig1/0/3(P) Gig1/0/4(P)
S2#

```



```

Cisco Packet Tracer - D:\CCNA\LAB 9 RHYTHM.pkt
File Edit Options View Tools Extensions Window Help
File Edit Options View Tools Extensions Window Help
Logical Physical 766, y 75
Root 03:26:30

```

```

S1
S1#show etherchannel summary
Flags: D - down P - in port-channel
I - stand-alone s - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use f - failed to allocate aggregator
u - unsuitable for bundling
w - waiting to be aggregated
d - default port

Number of channel-groups in use: 2
Number of aggregators: 2

Group Port-channel Protocol Ports
-----+-----+-----+-----+
1   Po1(SU)    LACP   Gig1/0/1(P) Gig1/0/2(P)
2   Po2(SU)    LACP   Gig1/0/3(P) Gig1/0/4(P)
S1#

```

```

S2
S2#show etherchannel summary
LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channell, changed state to up
Flags: D - down P - in port-channel
I - stand-alone s - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use f - failed to allocate aggregator
u - unsuitable for bundling
w - waiting to be aggregated
d - default port

Number of channel-groups in use: 2
Number of aggregators: 2

Group Port-channel Protocol Ports
-----+-----+-----+-----+
1   Po1(SU)    LACP   Gig1/0/1(P) Gig1/0/2(P)
3   Po3(SU)    LACP   Gig1/0/3(P) Gig1/0/4(P)
S2#

```

