Faculty of Engineering and Technology
Electrical and Computer Engineering Department
Computer Networks Laboratory ENCS4130

EXP. No. 7 Switching and VLANs 1 - Router on Stick

EXP. No. 8. Switching and VLANs 2 - Switch Virtual Interface

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Abstract

In this experiment, we will learn how to configure switches and connect different VLANs together with cisco routers via cisco packet tracer. We will also get to know how to make VLANs, how to make and configure multilayer switch, and how to make trunk and access links.

Table of Contents

Acronyms and Abbreviations

PC	Personal computer
IP	Internet protocol
VLAN	Virtual local area network
MAC	Media Access Control
VID	VLAN identifier
OSI model	Open Systems Interconnection model
WAN	Wide area network
OSPF	Open Shortest Path First

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1. Introduction

1.1 How does a switch work?

Switches are key building blocks for any network. They connect multiple devices, such as computers, wireless access points, printers, and servers; on the same network within a building or campus. A switch enables connected devices to share information and talk to each other.[1]

1.2 VLAN numbering

A VLAN represents a broadcast domain. VLANs are identified by a VLAN ID (a number between 0 – 4095), with the default VLAN on any network being VLAN 1. Each port on a switch or router can be assigned to be a member of a VLAN (i.e., to allow receiving and sending traffic on that VLAN). For example: on a switch, traffic that is sent to a port that is a member of VLAN 100, may be forwarded to any other VLAN 100 port on the switch, and it can also travel across a trunk port (connections between switches) to another switch and forwarded to all VLAN 100 ports on that switch. Traffic will not, however, be forwarded to ports that are on a different VLAN ID.[2]

1.2.1 Creating a VLAN

You can create a specific VLAN on a switch using the command;

```
Switch(config)# VLAN <VLAN-NUMBER>
```

and you can check that this VLAN is configured by this command;

```
Switch# show VLAN
```

1.3 Trunk and access ports

VLAN-enabled ports are generally categorized in one of two ways, tagged or untagged. These may also be referred to as "trunk" or "access" respectively. The purpose of a tagged or "trunked" port is to pass traffic for multiple VLAN's, whereas an untagged or "access" port accepts traffic for only a single VLAN. Generally speaking, trunk ports will link switches, and access ports will link to end devices.[3]

1.3.1 Initializing Switch Port as Trunk

By using the command; `Switch(config -if)# switchport mode trunk`

Note; when one end of a link is configured as a trunk, the other end changes automatically to trunk mode.

1.3.2 Initializing Switch Port as Access

By using the command; `switchport access VLAN <VLAN-NUMBER>`

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[1] https://www.cisco.com/c/en/us/solutions/small-business/resource-center/networking/network-switch-how.html on 19/8/2022 at 3;18 pm

[2] https://help.ui.com/hc/en-us/articles/222183968-Intro-to-Networking-Introduction-to-Virtual-LANs-VLANs-and-Tagging#:~:text=VLANs%20are%20identified%20by%20a,sending%20traffic%20on%20that%20VLAN). On 18/9/2022 at 3;21 pm

[3] https://documentation.meraki.com/General_Administration/Tools_and_Troubleshooting/Fundamentals_of_802.1Q_VLAN_Tagging#:~:text=These%20may%20also%20be%20referred,will%20link%20to%20end%20devices. On 18/9/2022 at 3;26 pm

1.4 Sub interface on Routers

A sub interface is a virtual interface created by dividing one physical interface into multiple logical interfaces. A sub-interface in a Cisco Router uses the parent physical interface for sending and receiving data.[4]

1.4.1 Initializing a sub interface

By the command; `Router(config)# interface <TYPE> <SLOT>/<PORT>.<SUB-INTERFACE-NUMBER>`

This command defines a sub-interface on the main interface.

1.4.2 Initializing IP address for a sub interface

By the following commands;

```
Router(config-subif)#encapsulation dot1Q <VLAN-ID>
Router(config-subif)#ip address <IP-ADDRESS> <SUBNET-MASK>
```

1.5 Third layer switch

A layer 3 switch combines the functionality of a switch and a router. It acts as a switch to connect devices that are on the same subnet or virtual LAN at lightning speeds and has IP routing intelligence built into it to double up as a router. It can support routing protocols, inspect incoming packets, and can even make routing decisions based on the source and destination addresses. This is how a layer 3 switch acts as both a switch and a router.[5]

1.5.1 Features of a layer 3 switch;

- Comes with 24 Ethernet ports, but no WAN interface.
- Acts as a switch to connect devices within the same subnet.
- Switching algorithm is simple and is the same for most routed protocols.
- Performs on two OSI layers — layer 2 and layer 3. [6]

1.5.2 Benefits of a layer 3 switch

- Support routing between virtual LANs.
- Improve fault isolation.
- Simplify security management.
- Reduce broadcast traffic volumes.
- Ease the configuration process for VLANs, as a separate router isn't required between each VLAN.
- Separate routing tables, and as a result, segregate traffic better.
- Simplify troubleshooting as, fixing problems in L2 layer is tedious and time-consuming.
- Support flow accounting and high-speed scalability.
- Lower network latency as a packet does not have to make extra hops to go through a router.[7]

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[4] https://www.omnisecu.com/cisco-certified-network-associate-ccna/what-is-a-subinterface-in-a-cisco-router.php#:~:text=A%20subinterface%20is%20a%20virtual,for%20a%20variety%20of%20purposes. On 19/8/2022 at 3;31 pm

[5] https://techgenix.com/layer-3-switch/ on 19/8/2022 at 3;37 pm

[6] Manual lab on 19/8/2022 at 3;40 pm

[7] Manual lab on 19/8/2022 at 3;42 pm

1.5.3 Disadvantages of layer 3 switch

- Cost
- Limited application
- Lack of WAN functionality
- Multiple tenants and virtualization
- Lack of flexibility [8]

1.6 Configuring Third Layer Switch

1.6.1 Switch to Router link

To make third layer switch works as router, use the following command and assign ip address as shown;

```
Switch(config-if)#no switchport
Switch(config-if)#ip address <IP-ADDRESS> <SUBNET-MASK>
```

1.6.2 Enable routing

We need to enable its ability to route packets, as its default configuration would not do that. By the following command;

```
Switch(config)#ip routing
```

1.6.3 Create VLANs on third layer switch

We need to make sure that the third layer switch is working as a switch not as router, in order to do that use the following command;

```
Switch(config)#switchport
```

To create VLANs use the same commands shown in section 1.2.1.

[8] Manual lab on 19/8/2022 at 3;43 pm

2. Procedure

2.1 Building the topology for exp.7

I have built the topology shown in figure 2.1.

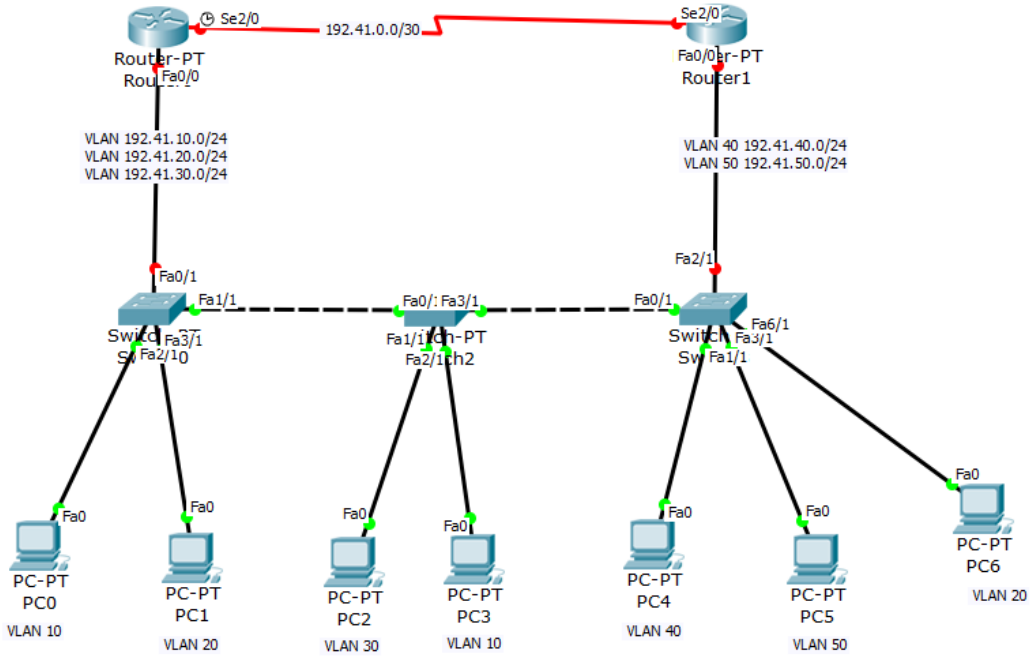

Figure 2.1 Topology on packet tracer

2.1.1 Filling router's interfaces IPs

Router0 and router1 are filled as shown in tables 2-1 and 2-2.

Router0			
Interface	IP address	Subnet mask	Wildcard mask
Fa0/0.10	192.41.10.1	255.255.255.0	0.0.0.255
Fa0/0.20	192.41.20.1	255.255.255.0	0.0.0.255
Fa0/0.30	192.41.30.1	255.255.255.0	0.0.0.255
Se2/0	192.41.0.1	255.255.255.252	0.0.0.3

Table 2-1 IPs for router0

Router1			
Interface	IP address	Subnet mask	Wildcard mask
Fa0/0.40	192.41.40.1	255.255.255.0	0.0.0.255
Fa0/0.50	192.41.50.1	255.255.255.0	0.0.0.255
Se2/0	192.41.0.2	255.255.255.252	0.0.0.3

Table 2-2 IPs for router1

Filling router0 commands; the same for router1.

```
Router(config)#int se2/0
Router(config-if)#ip add 192.41.0.1 255.255.255.252
Router(config-if)#no sh
Router(config-if)#ex
Router(config)#int fa0/0.10
Router(config-subif)#encapsulation dot1q 10
Router(config-subif)#ip add 192.41.10.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int fa0/0.20
Router(config-subif)#encapsulation dot1q 20
Router(config-subif)#ip add 192.41.20.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int fa0/0.30
Router(config-subif)#encapsulation dot1q 30
Router(config-subif)#ip add 192.41.30.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int fa0/0
Router(config-if)#no sh
```

2.1.1 Filling PCs' IPs

Each PC IP and its networks are shown in table 2-3.

Devices IPs					
PC	IP	Gateway	Subnet mask	VLAN	Network
PC0	192.41.10.2	192.41.10.1	255.255.255.0	10	192.41.10.0
PC1	192.41.20.2	192.41.20.1	255.255.255.0	20	192.41.20.0
PC2	192.41.30.2	192.41.30.1	255.255.255.0	30	192.41.30.0
PC3	192.41.10.3	192.41.10.1	255.255.255.0	10	192.41.10.0
PC4	192.41.40.2	192.41.40.1	255.255.255.0	40	192.41.40.0
PC5	192.41.50.2	192.41.50.1	255.255.255.0	50	192.41.50.0
PC6	192.41.20.3	192.41.20.1	255.255.255.0	20	192.41.20.0

Table 2-3 IPs for PCs

Filling PC0 shown in figure 2.2.

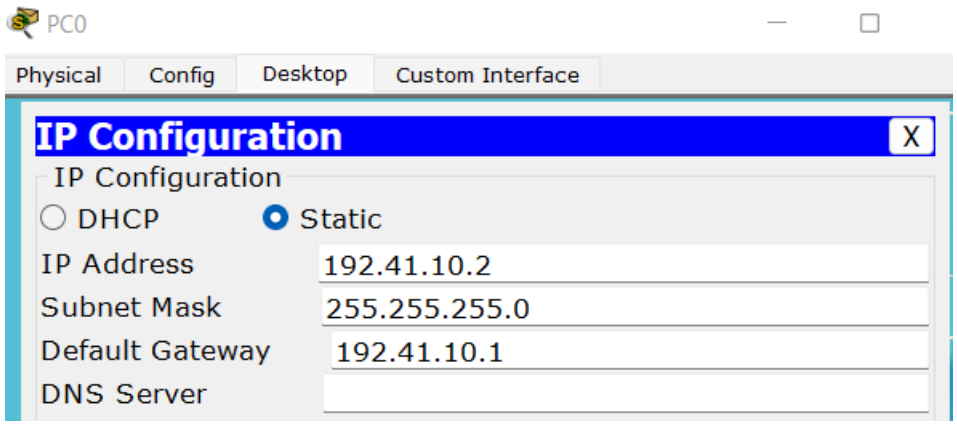

Figure 2.2 IP configuration for PC0

The same way goes for the rest of PCs.

2.2 Configuring OSPF Routing for exp.7

Configuring ospf routing for router0 and router1 as shown in the following commands;

```
Router(config)#router ospf 1
Router(config-router)#network 192.41.10.0 0.0.0.255 area 0
Router(config-router)#network 192.41.20.0 0.0.0.255 area 0
Router(config-router)#network 192.41.30.0 0.0.0.255 area 0
Router(config-router)#network 192.41.0.0 0.0.0.3 area 0
```

By adding neighbor networks to the ospf protocol as shown, the same technique goes for router1.

2.3 Configuring Switches for exp.7

2.3.1 Creating VLANs in switches

Creating all used VLANs in all switches by applying the commands shown in figure 2.3.

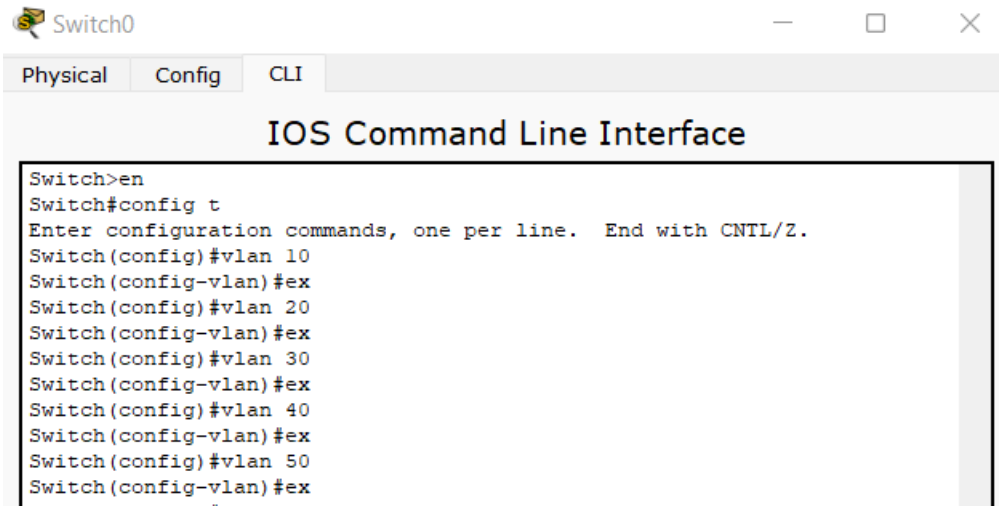

Figure 2.3 Creating VLANs in switch0

2.3.2 Configuring Switch Access and trunk

In general, between router and switch or switch or switch, use access mode. And between switch and device use trunk mode. Shown in table 2-4.

Switch	Interface	Mode
Switch0	Fa0/1	Trunk
	Fa1/1	Trunk
	Fa2/1	Access
	Fa3/1	Access
Switch1	Fa0/1	Trunk
	Fa1/1	Trunk
	Fa2/1	Access
	Fa3/1	Access
Switch2	Fa0/1	Trunk
	Fa1/1	Trunk
	Fa2/1	Trunk
	Fa3/1	Trunk
	Fa6/1	Trunk

Table 2-4 Switches ports

To enable trunk mode for switch0 as shown in figure 2.4.

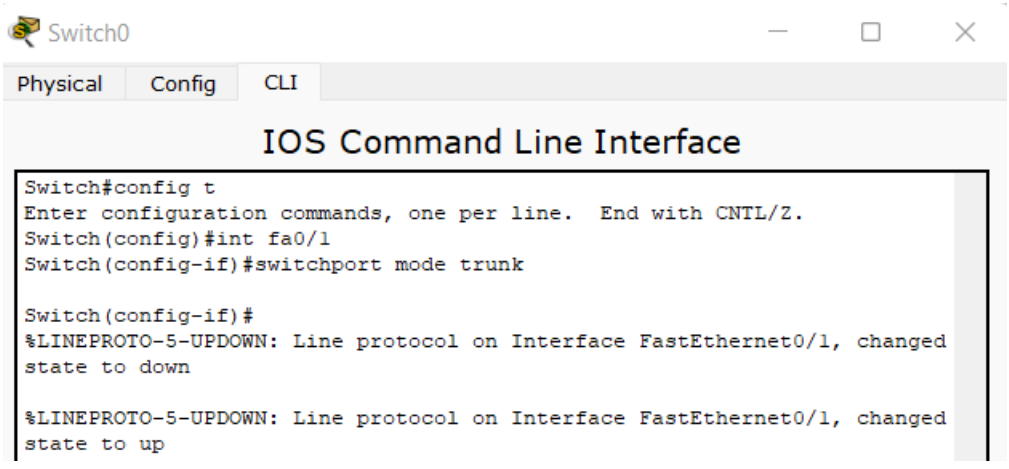

Figure 2.4 Enabling mode trunk ports in switch0

The same way for switch1 and switch2.

To enable access mode for switch0 as shown in figure 2.5.

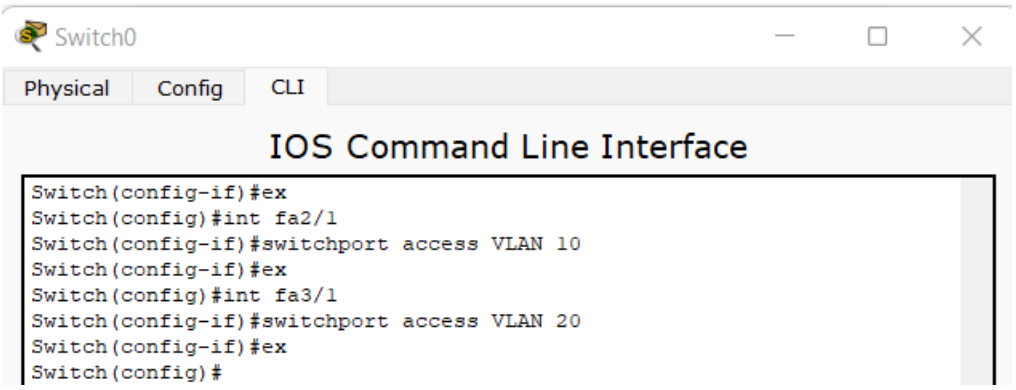

Figure 2.5 Enable accessing ports in switch0

The same way for switch1 and switch2.

2.4 Building the topology of exp.8

The same topology as exp.7 but we added multilayer switch and more pcs as shown in figure 2.6.

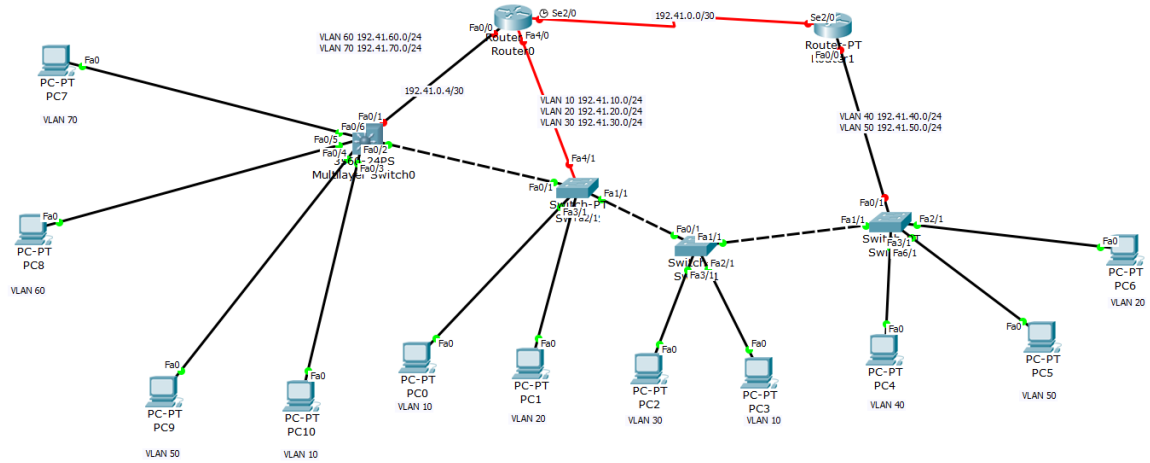

Figure 2.6 Topology of exp.8

2.4.1 Filling routers interfaces' IPs

In router1, the same IPs shown in section 2.1.1. No additions, no reduction.

2.4.2 Filling PCs' IPs

For PCs from 0 to 6, the same as section 2.1.2

However, for PCs from 7 to 10, filled as shown in table 2-6.

Devices IPs					
PC	IP	Gateway	Subnet mask	VLAN	Network
PC7	192.41.70.2	192.41.70.1	255.255.255.0	70	192.41.70.0
PC8	192.41.60.2	192.41.60.1	255.255.255.0	60	192.41.60.0
PC9	192.41.50.3	192.41.50.1	255.255.255.0	50	192.41.50.0
PC10	192.41.10.4	192.41.10.1	255.255.255.0	10	192.41.10.0

Table 2-5 IPs for PC7 to PC10

Note; the filling way is the same as shown in section 2.1.2.

2.5 Configuring switches in exp.8

This section is the same as section 2.3. Also add trunk for the connection between switch0 and multilayer switch, the way is the same as in section 2.3.

2.6 Configuring multilayer switch in exp.8

2.6.1 Multi-Layer Switch to Router link

We need to add an IP address to the switch port connected to the router, so firstly we need to change the switch port to a router port and then add an IP address. As shown in figure 2.7.

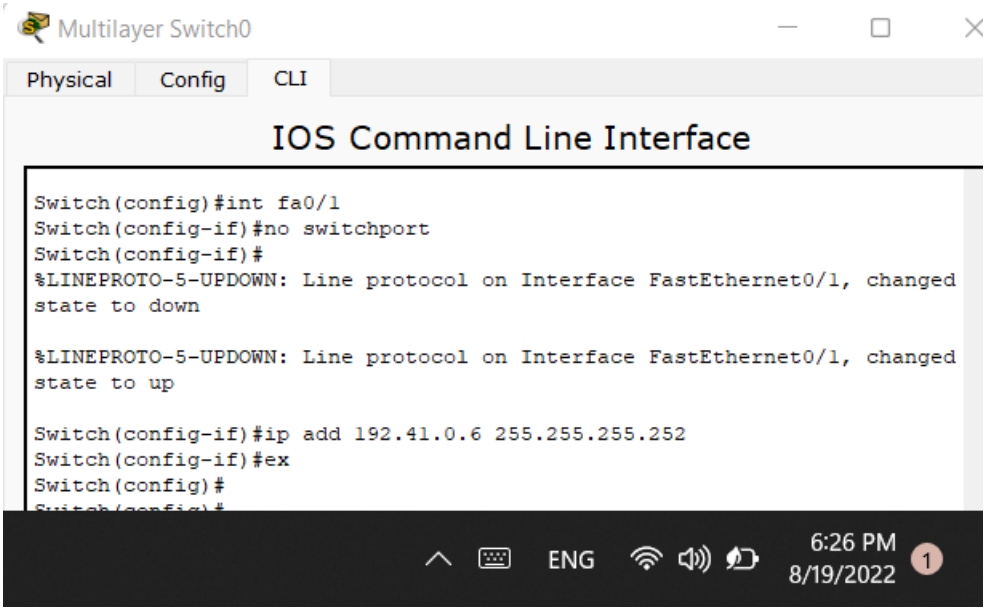

Figure 2.7 Changing to router link

Discussion; as we can see, I firstly changed interface fa0/1 into router link, then assigned the IP 192.41.0.6 into it.

2.6.2 Multi-Layer Switch Configuring VLAN Interfaces IPs (Switch Virtual Interfaces)

To make multilayer switch act as default gateways for the new VLANs, use the way as shown in figure 2.8.

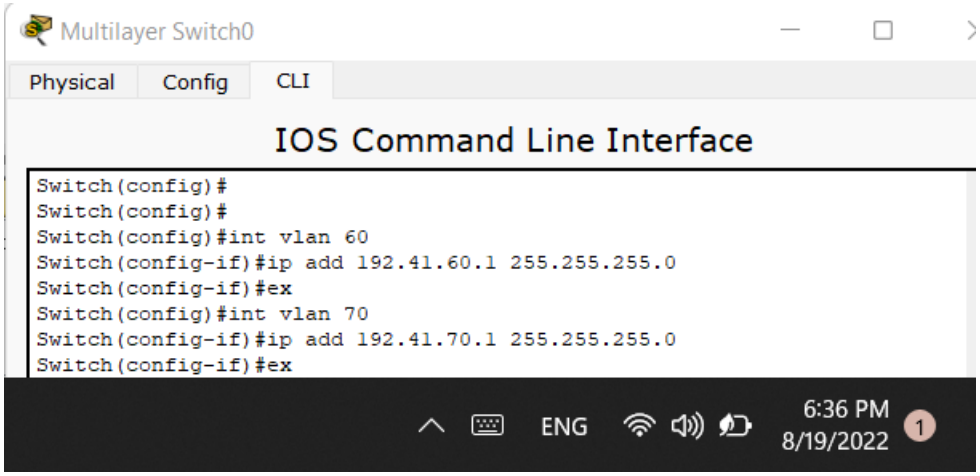

Figure 2.8 Assign gateway IPs for multilayer switch

2.6.3 Enable routing on Multi-Layer Switch and configuring OSPF

First, enable routing protocols on the switch by the following command;

```
Switch(config)#ip routing
```

Then apply ospf the same way we know as shown in figure

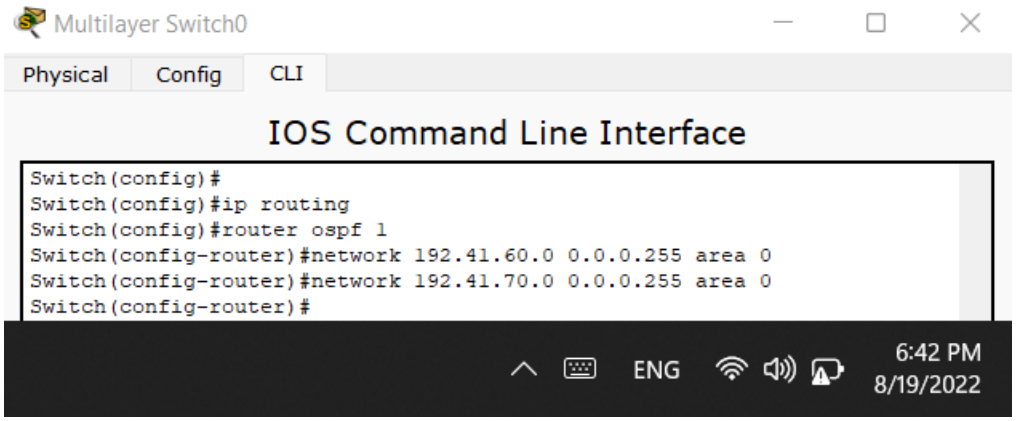

Figure 2.9 Configuring ospf routing on multilayer switch

2.6.4 Configuring VLANs on Multi-Layer Switch

The same way as in section 2.3.1. Including VLAN 60 and VLAN 70.

2.6.5 Configuring Access Ports on Multi-Layer Switch

The same way as section 2.3.2. As shown in table 2-6.

	Multilayer switch					
Interface	Fa0/6	Fa0/5	Fa0/4	Fa0/3	Fa0/2	Fa0/1
Mode	Access	Access	Access	Access	Trunk	Nothing*

Table 2-6 Trunk and access ports for multilayer switch

Note; nothing for interface fa0/1 since it is a router link.

In interface fa0/2, to make mode trunk, must apply encapsulation dot1q to it, as shown in figure 2.10.

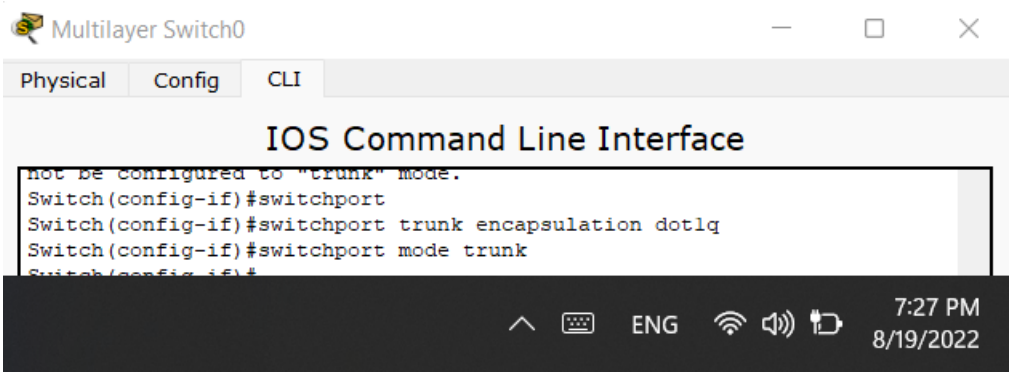

Figure 2.10 Configure mode trunk on multilayer switch

Access link is the same way as shown in section 2.3.2.

3. Results

3.1 Result for topology exp.7

After applying the same procedure, each pc must be able to ping any pc in the topology.

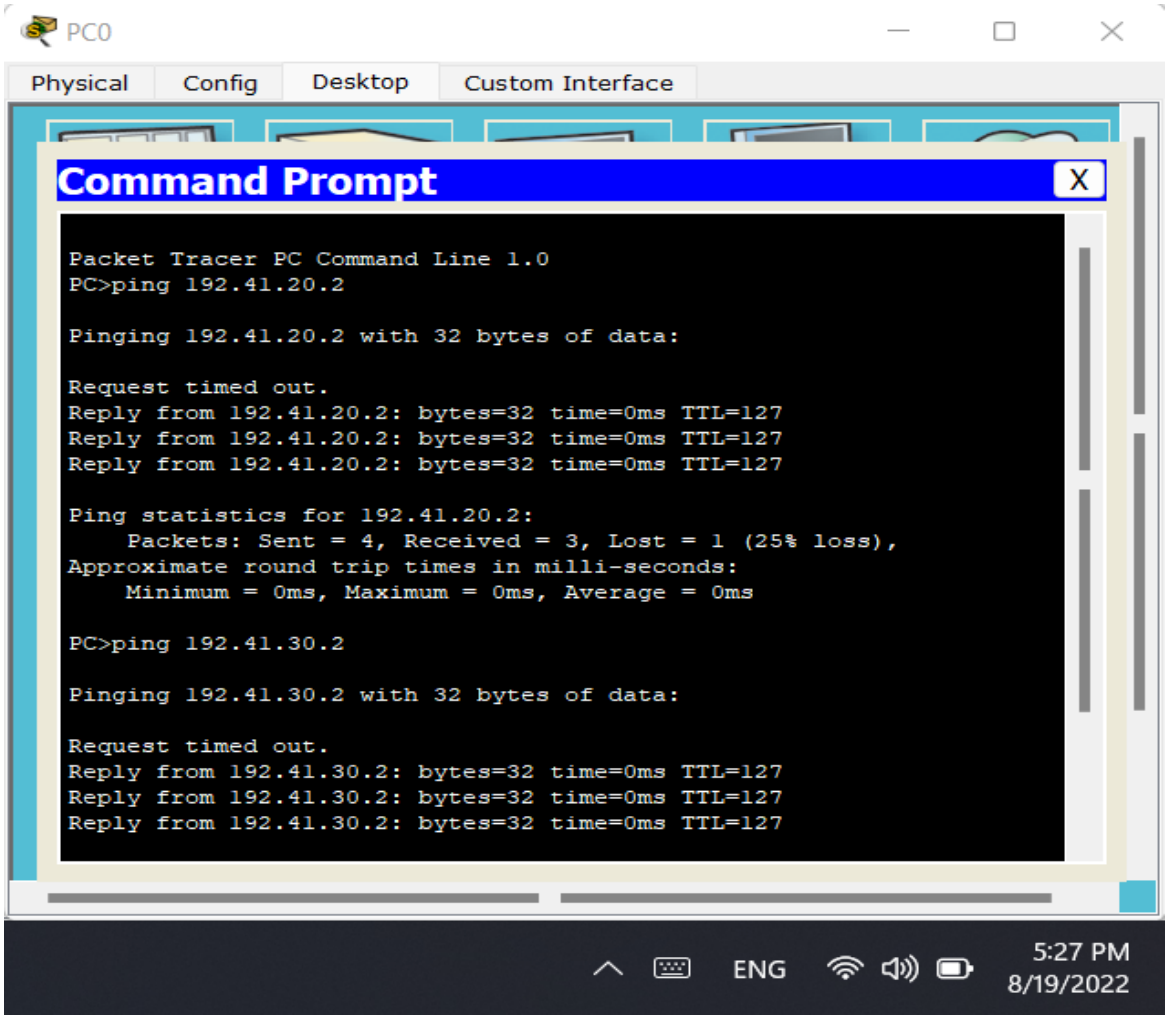

Figure 3.1 Pinging from pc0 to pc1 and pc2

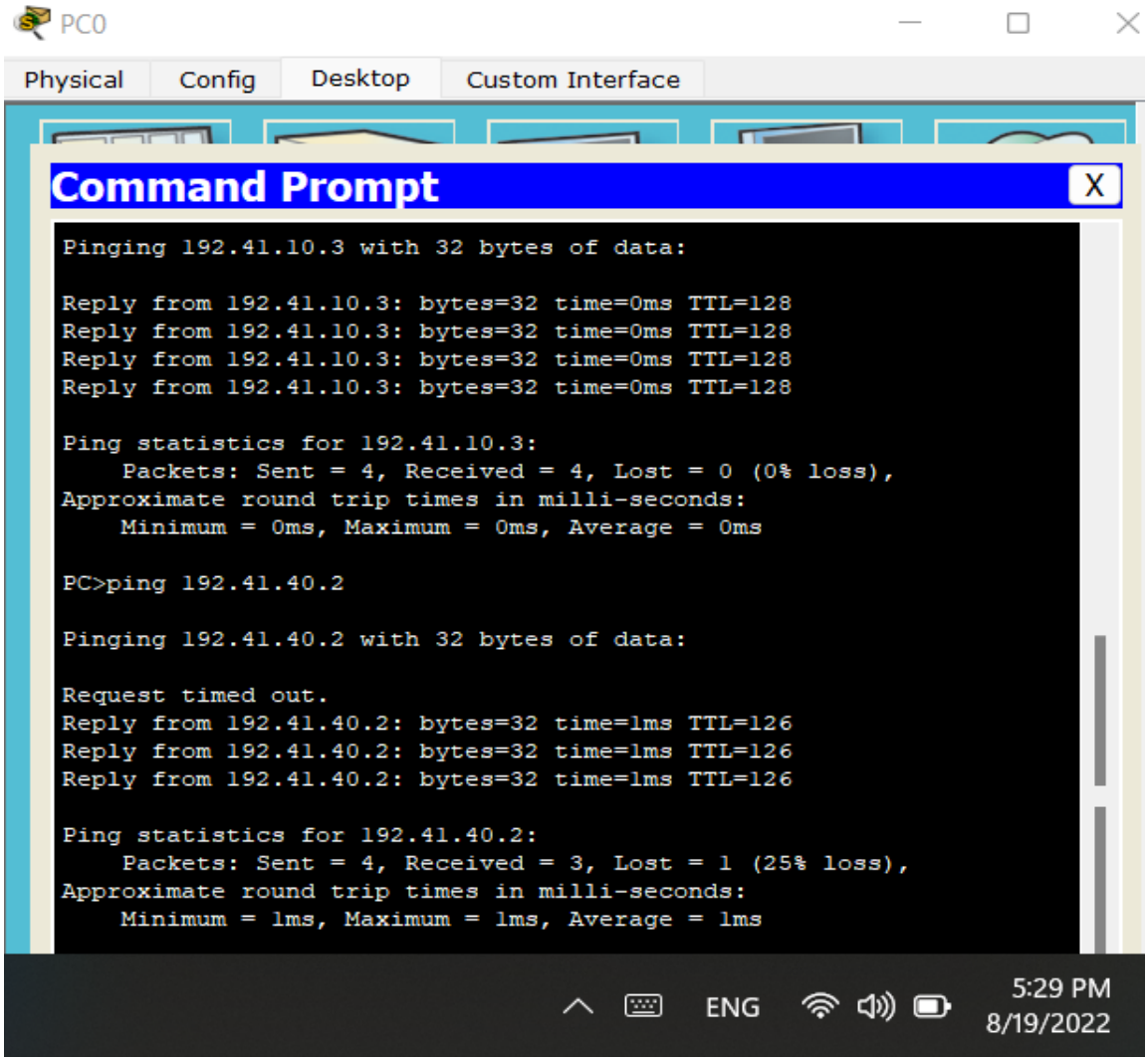

Figure 3.2 Pinging from pc0 to pc3 and pc4

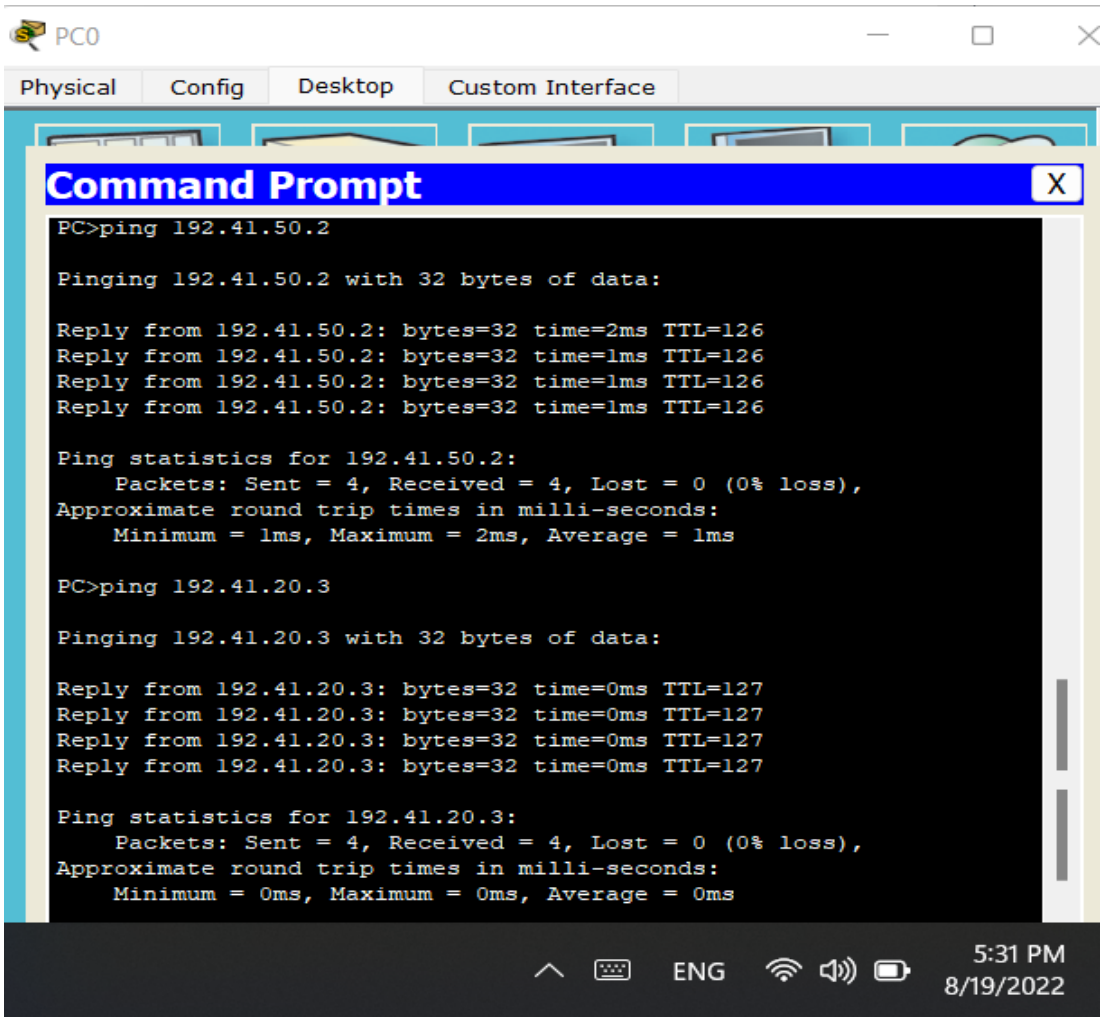

Figure 3.3 Pinging from pc0 to pc5 and pc6

Discussion; As we have seen the results in figures 3.1, 3.2 and 3.3, we now can ping from any pc to any pc through different VLANs and through different types of ports, and this is what switch do in connecting VLANs, also we can see that ospf routing also made its work perfectly. I just showed the result of pining from PC0 to all other PCs, so no need to see pining from other PCs since the result is obvious.

3.2 Result for topology of exp.8

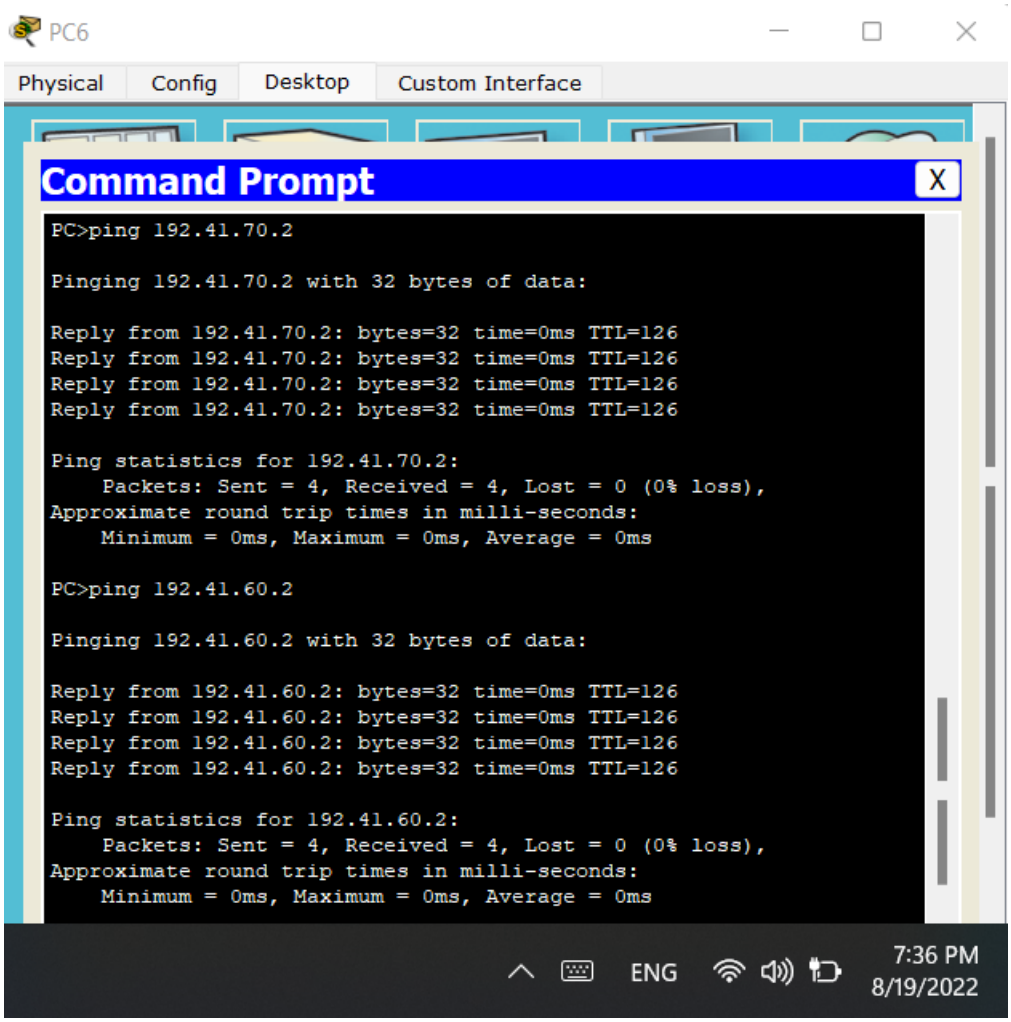

Figure 3.4 Pinging from PC6 to PC7 and PC8

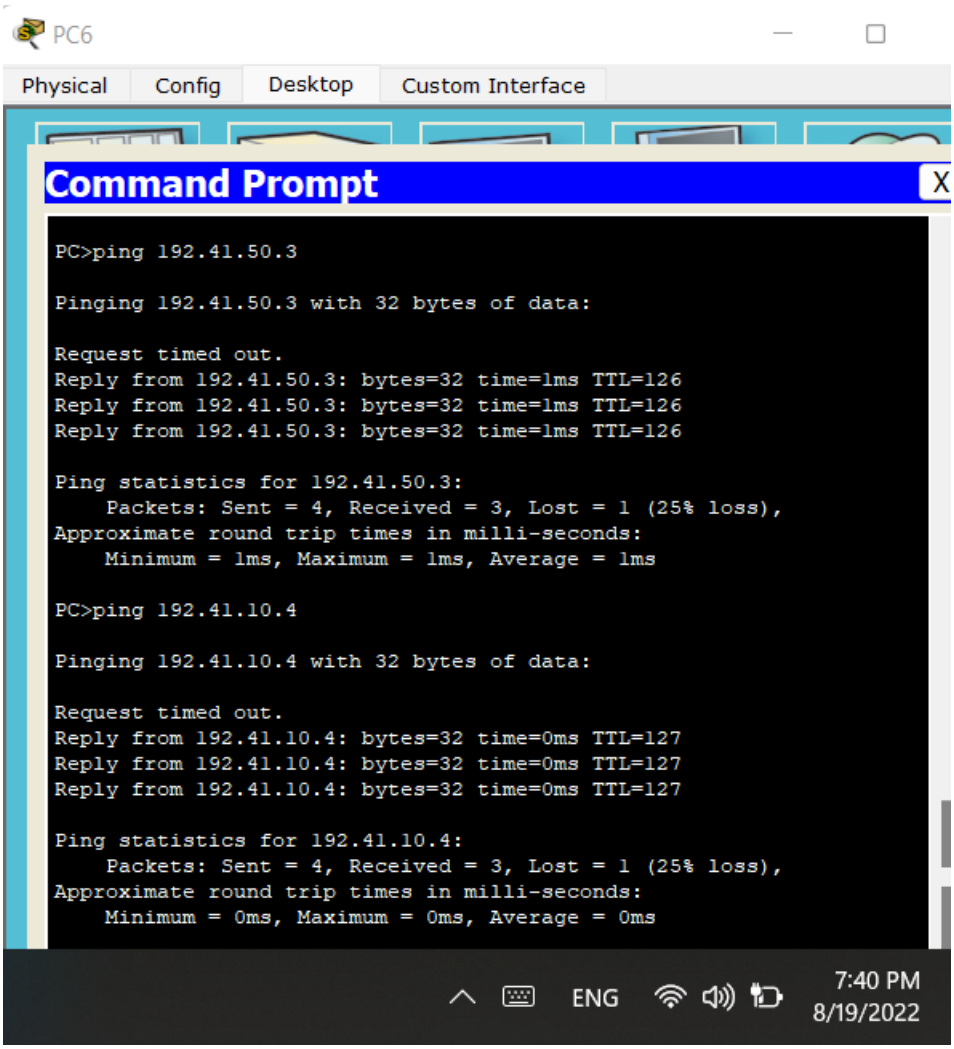

Figure 3.5 Pinging from PC6 to PC9 and PC10

Discussion; as we can see pinging from PC6 to all new PCs added and connected with multilayer switch, which plays as router and switch at the same time, router from one interface, and switch from the rest interfaces. In addition, OSPF routing is working perfectly in the multilayer switch. I did not make another pinging from other PCs since it is the same as exp.7.

4. Conclusion

In this experiment, we learnt what the meaning of VLAN is and how to configure it and how to deal with switches to connect different VLANs. In addition, we have learned about multilayer switch and what its advantages and disadvantages in its utilization. I used in this experiment cisco packet tracer, router-PT, PC-PT, switch-PT, Multilayer switch.