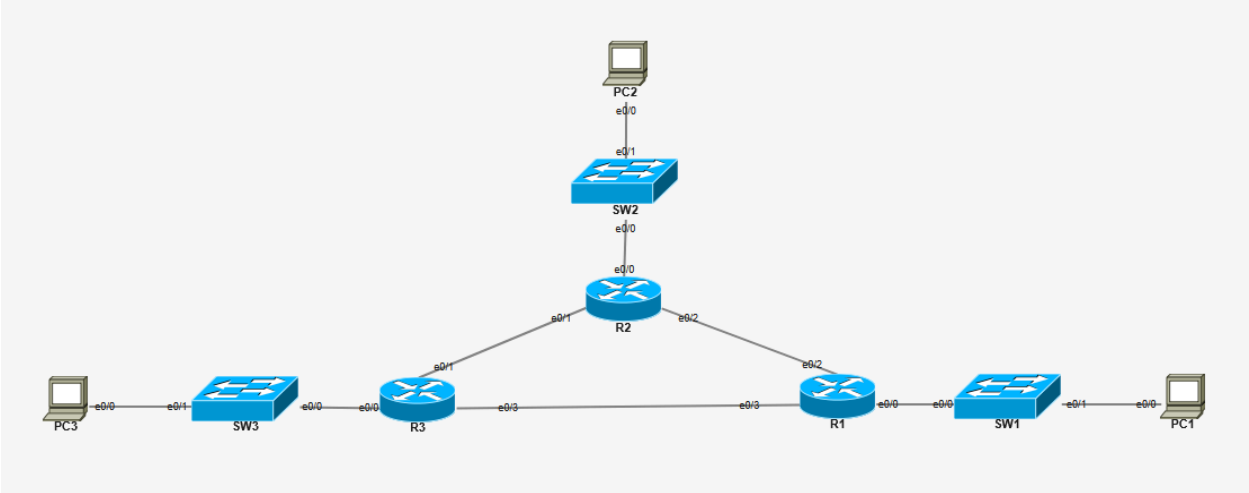
Hello! This is a tutorial regarding the setup, configuration, and troubleshooting of the network topology shown below. This is the first lab introduced in the **IT-381** class.



The lab consists of:

- Three **PCs**
- Three Cisco **Switches**
- Three Cisco **Routers**

The three routers are interconnected and each router is connected to a PC via a network switch.
The diagram also displays the interfaces, which are important to know if we are to correctly setup

The goal of this tutorial is to show and explain the proper configuration of a setup of this topology so that you may understand how to configure a similar network in a real-life situation.

This tutorial will discuss the steps required to set up the necessary VLANs, OSPF configuration, and WAN links. **By the end of this tutorial, all three PCs should be able to successfully ping each other, as well as the router loopback IP addresses.**

HQ (or Site-A) consists of PC1, SW1, and R1.
Site-B consists of PC2, SW2, and R2.

Site-C consists of PC3, SW3, and R3.

IP Addressing Table

Refer to this table when configuring your devices.

Device	Interface	IP Address	Subnet Mask	Description	Notes
PC1		142.100.64.11	255.255.255.0 (/24)	HQ host (VLAN 100)	Default Gateway: 142.100.64.1
PC2		142.100.65.21	255.255.255.0 (/24)	Site-B host (VLAN 200)	Default Gateway: 142.100.65.1
PC3		142.100.66.31	255.255.255.0 (/24)	Site-C host (VLAN 300)	Default Gateway: 142.100.66.1
R1	Loopback0	142.1.64.254	255.255.255.0 (/24)	Router ID	Advertised in OSPF
R1	e0/0.100 (subinterface)	142.100.64.1	255.255.255.0 (/24)	VLAN 100 Default Gateway	Encapsulation dot1Q 100
R1	e0/1	10.12.1.1	255.255.255.252 (/30)	R1-R2 Link	Valid hosts: .1 and .2
R1	e0/2	10.13.1.1	255.255.255.252 (/30)	R1-R3 Link	Valid hosts: .1 and .2
R2	Loopback0	142.1.65.254	255.255.255.0 (/24)	Router ID	Advertised in OSPF
R2	e0/0.200 (subinterface)	142.100.65.1	255.255.255.0 (/24)	VLAN 200 Default Gateway	Encapsulation dot1Q 200
R2	e0/1	10.12.1.2	255.255.255.252 (/30)	R2-R1 Link	Valid hosts: .1 and .2

R2	e0/2	10.23.1.1	255.255.255.252 (/30)	R2-R3 Link	Valid hosts: .1 and .2
R3	Loopback0	142.1.66.254	255.255.255.0 (/24)	Router ID	Advertised in OSPF
R3	e0/0.300 (subinterface)	142.100.66.1	255.255.255.0 (/24)	VLAN 300 Default Gateway	Encapsulation dot1Q 300
R3	e0/1	10.13.1.2	255.255.255.252 (/30)	R3-R1 Link	Valid hosts: .1 and .2
R3	e0/2	10.23.1.2	255.255.255.252 (/30)	R3-R2 Link	Valid hosts: .1 and .2

Step-by-Step Configuration

Step 1: Device Hostnames
Each device requires a hostname to be able to work properly, and for you to be able to easily tell which device is what.

On each device, access its terminal and type the following commands.
This example is for PC1:

```
enable

configure terminal

hostname PC1

end

write memory
```

Do the same for every other device in the network **(PC2, SW1, R1, etc..)**

The command **“enable”** takes you from User EXEC mode to Privileged EXEC mode, basically allowing yourself the privilege to make the necessary changes.
The command **“configure terminal”** or the quicker way **“conf t”** enters Global Configuration Mode. In this mode, you can actually change settings on the device. It is required to make the necessary changes.
The command **“write memory”** saves the configuration (Don’t forget to do this).

Step 2: PC Configurations
For each PC you’ll need to give it’s interface an IP address, a subnet mask, and a default gateway. The interfaces are the “e0/0” ports displayed on the diagram.

Execute the following commands on each PC to properly set up each PC, and change the addresses relevant to the PC you’re configuring.

The example below is specific to PC1. For the other PCs, you would change the IP and default gateway to their specified IPs (refer to the IP Addressing table).

```
enable

conf t

int e0/0

ip add 142.100.64.11 255.255.255.0

no shut

exit

ip default-gateway 142.100.64.1

end

write memory
```

The command **“int e0/0”** allows you to enter the configuration for that specific interface (int is short for interface). The information entered while in this mode will apply to the e0/0 interface for that specific PC.

The command **“no shut”** brings the interface up so that it’s “active”.

Step 3: Switch Configuration (VLANs, Ports, Trunks)
Now we’re going to configure the switches on the network. Each switch will have a VLAN (Site 1’s VLAN will be vlan 100 Site 2’s VLAN will be vlan 200 and so on) Execute the following commands on each switch, **just remember to replace the VLAN ID and name for each.**

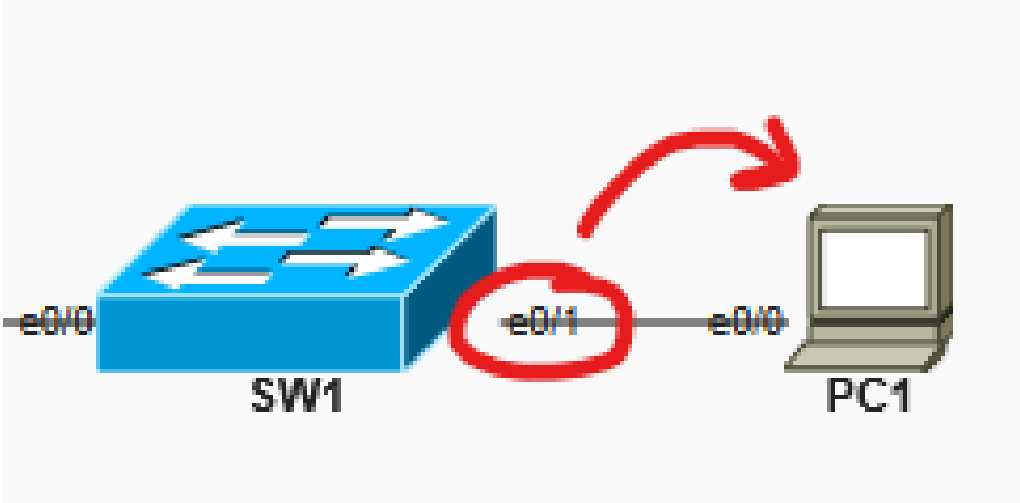
The following commands are specific to SW1.

```
enable
```

```
conf t

vlan 100

name SITE-A-VLAN

exit

wr mem
```

Now configure the access ports from the switch to the PC.

Use the switch port that connects to the PC, in this example that port is e0/1 (Refer to image below).



The following commands are specific to SW1. When configuring the other switches, change the vlan ID for that specific site (100, 200, or 300).

```
conf t

int e0/1
```

```
switchport mode access

switchport access vlan 100

spanning-tree portfast

no shut

exit

wr mem
```

Now configure the trunk ports from the switches to the routers. (Example uses e0/0).

The following commands are specific to SW1 (change the vlan Id for the other two switches (100,200,300)).

```
conf t

int e0/0

switchport trunk encapsulation dot1q

switchport mode trunk
```

```
switchport trunk allowed vlan 100

no shut

exit

wr mem
```

For brief verification on the switches to confirm they're set up correctly, run these commands:

```
show vlan brief

show interfaces trunk
```

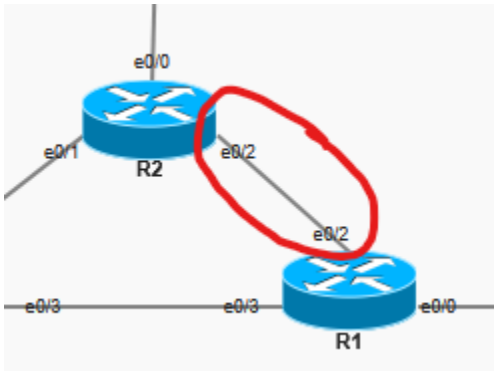
You should see the VLAN, its name, and the ports associated with it.

```
SW1>show vlan bri

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------
1    default                          active    Et0/2, Et0/3
100  VLAN1                            active    Et0/1
```

Step 4: Router Configuration (Loopbacks and Interfaces)
Now we're going to configure the routers. We'll configure each of the router's loopback addresses, LAN interfaces (Router to Switch), and WAN links (Router to Router).

The following commands are specific to Router 1 (R1). For the other routers, change the IPs relevant to the router you're working on (Refer to the IP addressing table).

- **IMPORTANT NOTE:** When providing the router-to-router link IPs, each end of the link will have a different ip address ending in either .1 or .2.
    - For example, the link address for R1 to R2 is 10.12.1.0/30. This means that one interface will need to be set to **10.12.1.1**, and the other interface will need to be set to **10.12.1.2**. This is because the subnet mask of /30 only leaves room for those two host IPs.




```
enable

conf t

# (Loopback)
int loopback0

ip add 142.1.64.254 255.255.255.0

no shut

exit
```

```
# (R1 to SW1)
int e0/0

no shut

exit

int e0/0.100

encapsulation dot1Q 100

ip add 142.100.64.1 255.255.255.0

no shut

exit

# (R1 to R2)
int e0/2

ip add 10.12.1.1 255.255.255.252

no shut

exit

# (R1 to R3)
int e0/3

ip add 10.13.1.1 255.255.255.252

no shut
```

Step 5: OSPF Configuration (on each router)

Now we'll configure the OSPF on each router. This is basically a way for each router to "advertise" the devices on their sites to other routers.

Perform the following commands on each router, this time I'll provide the commands for all three routers.

R1:

```
conf t
router ospf 1
router-id 142.1.64.254
network 142.100.64.0 0.0.0.255 area 0
network 142.1.64.0   0.0.0.255 area 0
network 10.12.1.0    0.0.0.3   area 0
network 10.13.1.0    0.0.0.3   area 0
network 10.23.1.0    0.0.0.3   area 0
exit
end
wr mem
```

R2:

```
conf t
```

```
router ospf 1
router-id 142.1.65.254
network 142.100.65.0 0.0.0.255 area 0
network 142.1.65.0   0.0.0.255 area 0
network 10.12.1.0    0.0.0.3   area 0
network 10.23.1.0    0.0.0.3   area 0
network 10.13.1.0    0.0.0.3   area 0
exit
end
wr mem
```

R3:

```
conf t
router ospf 1
router-id 142.1.66.254
network 142.100.66.0 0.0.0.255 area 0
network 142.1.66.0   0.0.0.255 area 0
network 10.13.1.0    0.0.0.3   area 0
network 10.23.1.0    0.0.0.3   area 0
network 10.12.1.0    0.0.0.3   area 0
exit
end
wr mem
```

These commands advertise all LAN networks, all point-to-point WAN links, and all loopback interfaces to every other router in the network.

Step 6: Verification

Now that everything is set up, we need to test to make sure everything is working as it should. On your routers, perform the following commands to verify and troubleshoot as needed, for the last command, change the IP relevant to the router you're working on to test connectivity between router loopbacks:

```
show ip ospf neighbor

show ip route ospf

ping 142.1.65.254 source Loopback0
```

“show ip ospf neighbor” should return two FULL neighbors per router. If there aren’t two, redo your ospf configurations on the relevant routers.

“show ip route ospf” should return the ospf routes

A successful ping from Router 1’s loopback address to Router 2’s loopback address means that full bidirectional layer 3 reachability exists between R1 and R2 (R1 knows a route to R2, and R2 knows a route back to R1 via OSPF). Perform the same test on each router to verify connectivity.

Now perform ping commands on each PC to verify connectivity across the entire network.

The order of the pings below are as follow:
PC1 ←→ PC2
PC1 ←→ PC3
PC1 ←→ R2
PC1 ←→ R3

(Perform these commands on PC1’s terminal)

```
ping 142.100.65.21
ping 142.100.66.31
ping 142.1.65.254
ping 142.1.66.254
```

If all pings succeed, the entire network is correctly configured and connected.

Troubleshooting

If something isn't working, try pinging from other devices to try and pinpoint the issue, then redo that portion of the configuration.

Always remember to end your string of commands with "**wr mem**" to save the configuration and to set each interface to "**no shut**" so that it's open for traffic.

Common Problems:

1. **PC cannot ping its own default gateway.**

If a PC can't ping it's own default gateway, check the following:

- Wrong VLAN on the switch access port connected to the PC.
    - Go to the switch and do "show vlan brief" to check if the port connected to PC1 is in VLAN 100.
- Trunk port between the switch and the router doesn't allow the VLAN.
    - On the switch, do "show interfaces trunk" and see if the VLAN is allowed.
- The router subinterface is misconfigured (e0/0.100, e0/0.200, etc..) or missing encapsulation dot1Q
    - On the router (for example R1): do "show ip interface brief | include 0.100" subint e0/0.100 should be up/up with IP 142.100.64.1.
- Forgot to do "no shut" on one of the interfaces.

2. **OSPF neighbors not forming.**

If "show ip ospf neighbor" show's nothing:

- You may have forgotten to do "no shut" on an interface.

    - Redo no shut on the interfaces
- The wrong IP addresses could be on one side of the /30 WAN link.
    - Check interfaces with “show ip int bri”
- Missing or wrong network statements in OSPF.
    - Check ospf config with “show ip ospf int bri”
- ospf not set to area 0

3. **PCs can ping local router but can’t ping remote PCs or loopbacks.**

If a PC can ping it’s own router but not other routers or PCs:

- OSPF may not be advertising the subnets.
    - Check OSPF config
- Router loopbacks aren’t being advertised.
    - Check router loopback address
- Default gateway is wrong or missing
    - Check configured default gateway.

Conclusion

Hopefully this tutorial was helpful! Your network may look different from mine so you may need to adapt accordingly, but it should go over the basics and what to do if your network is set up differently.

Final Tip: Don’t underestimate the importance of doing “no shut” on each interface. Without doing that, the interface will be shutdown allowing no traffic to go through. Also remember to advertise the loopback address on your router’s OSPF, it’s very important and easy to miss.

Thanks for reading!