Lab Manual

Computer Networking

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OBJECTIVE

1. To learn about different networking cables and devices
2. Explain network technologies and how devices access local and remote networks
3. Explain how switching operates in a small to a medium-sized business network.
4. Design an IPv4 and IPv6 addressing scheme to provide network connectivity for a small to a medium-sized business network.
5. Configure initial to advanced settings on a network device using the Cisco command-line interface (CLI)
6. Implement basic network connectivity between devices using various networking topologies.

COURSE OUTCOME

After completing this lab course, students will be able to:

CO1: Demonstrate a broad knowledge of the area of computer networking and its terminology

CO2: Design, Implement and test the operation of a basic computer network.

CO3:Demonstrate an understanding of the operations of a range of networking protocols

CO4: Able to create a network for a small organization

SL No.	Experiment
1.	Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.
2.	Study of Network Devices in Detail and IP Addressing
3.	Connect the computers in Local Area Network.
4.	Study of basic network command and Network configuration commands .
5.	Performing an Initial Router Configuration
6.	Configuring RIP
7.	Configuring OSPF
8.	Design a network with static and dynamic routing protocol.

EXPERIMENT 1

Aim: Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.

Apparatus (Components): RJ-45 connector, Climping Tool, Twisted pair Cable

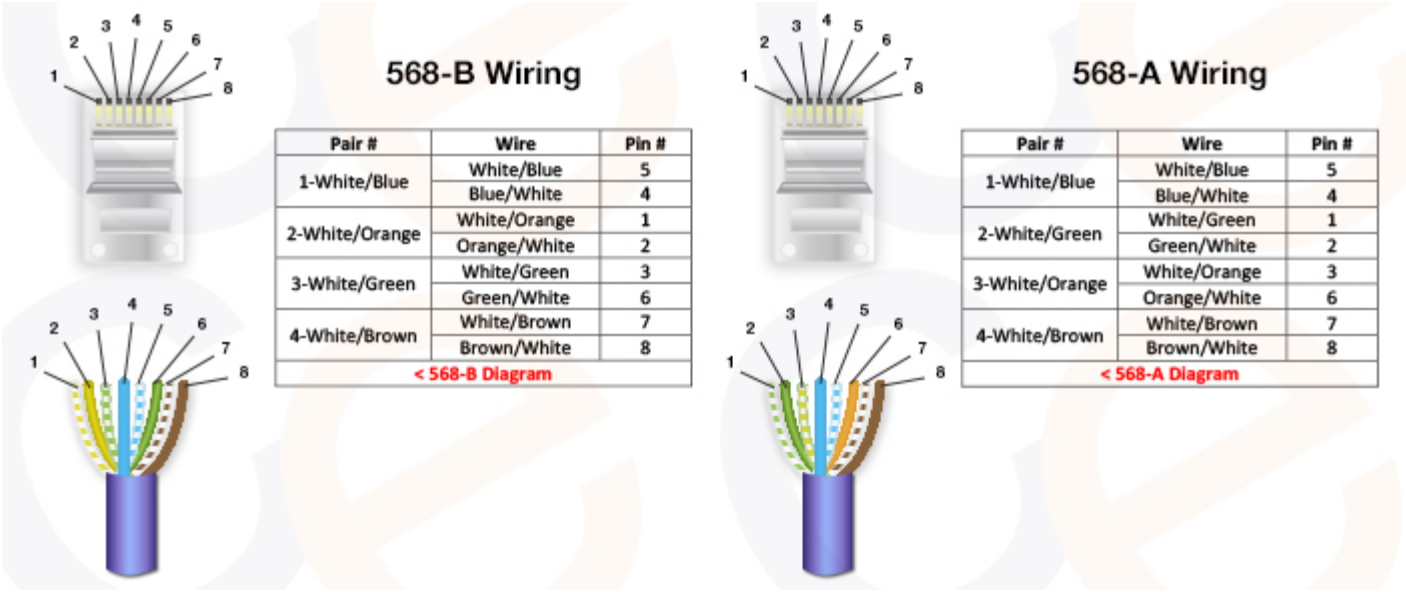
Procedure: To do these practical following steps should be done:

1. Start by stripping off about 2 inches of the plastic jacket off the end of the cable. Be very careful at this point, as to not nick or cut into the wires, which are inside. Doing so could alter the characteristics of your cable, or even worse render is useless. Check the wires, one more time for nicks or cuts. If there are any, just whack the whole end off, and start over.

2. Spread the wires apart, but be sure to hold onto the base of the jacket with your other hand. You do not want the wires to become untwisted down inside the jacket. Category 5 cable must only have 1/2 of an inch of 'untwisted' wire at the end; otherwise it will be 'out of spec'. At this point, you obviously have ALOT more than 1/2 of an inch of un-twisted wire.

3. You have 2 end jacks, which must be installed on your cable. If you are using a pre-made cable, with one of the ends whacked off, you only have one end to install - the crossed over end. Below are two diagrams, which show how you need to arrange the cables for each type of cable end. Decide at this point which end you are making and examine the associated picture below.

Diagram shows how to prepare cross-over connection

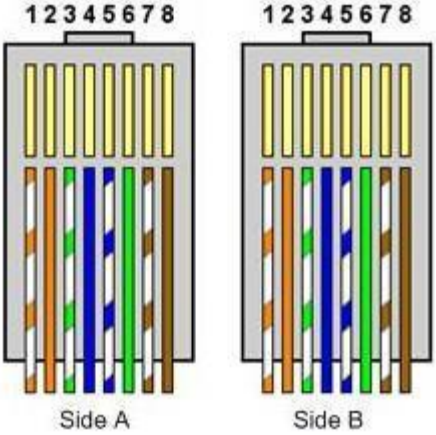


Pair #	Wire	Pin #
1-White/Blue	White/Blue	5
	Blue/White	4
2-White/Orange	White/Orange	1
	Orange/White	2
3-White/Green	White/Green	3
	Green/White	6
4-White/Brown	White/Brown	7
	Brown/White	8
< 568-B Diagram		

Pair #	Wire	Pin #
1-White/Blue	White/Blue	5
	Blue/White	4
2-White/Green	White/Green	1
	Green/White	2
3-White/Orange	White/Orange	3
	Orange/White	6
4-White/Brown	White/Brown	7
	Brown/White	8
< 568-A Diagram		

Diagram shows how to prepare straight through connection

Pin ID	Side A	Side B
1	Orange-white	Orange-white
2	Orange	Orange
3	Green-white	Green-white
4	Blue	Blue
5	Blue-white	Blue-white
6	Green	Green
7	Brown-white	Brown-white
8	Brown	Brown



EXPERIMENT 2.1

Aim: Study of following Network Devices in Detail

- Repeater
- Hub
- Switch
- Bridge
- Router
- Gate Way

Apparatus (Software): No software or hardware needed.

Procedure: Following should be done to understand this practical.

1. **Repeater:** Functioning at Physical Layer. A repeater is an electronic device that receives a signal and retransmits it at a higher level and/or higher power, or onto the other side of an obstruction, so that the signal can cover longer distances. Repeater have two ports ,so cannot be use to connect for more than two devices

2. **Hub:** An Ethernet hub, active hub, network hub, repeater hub, hub or concentrator is a device for connecting multiple twisted pair or fiber optic Ethernet devices together and making them act as a single network segment. Hubs work at the physical layer (layer 1) of the OSI model. The device is a form of multiport repeater. Repeater hubs also participate in collision detection, forwarding a jam signal to all ports if it detects a collision.

3. **Switch:** A network switch or switching hub is a computer networking device that connects network segments. The term commonly refers to a network bridge that processes and routes data at the data link layer (layer 2) of the OSI model. Switches that additionally process data at the network layer (layer 3 and above) are often referred to as Layer 3 switches or multilayer switches.

4. **Bridge:** A network bridge connects multiple network segments at the data link layer (Layer 2) of the OSI model. In Ethernet networks, the term bridge formally means a device that behaves according to the IEEE 802.1D standard. A bridge and switch are very much alike; a switch being a bridge with numerous ports. Switch or Layer 2 switch is often used interchangeably with bridge .Bridges can analyze incoming data packets to determine if the bridge is able to send the given packet to another segment of the network.

5. **Router:** A router is an electronic device that interconnects two or more computer networks, and selectively interchanges packets of data between them. Each data packet contains address information that a router can use to determine if the source and destination are on the same network, or if the data packet must be transferred from one network to another. Where multiple routers are used in a large collection of interconnected networks, the routers exchange information about target system addresses, so that each router can build up a table showing the preferred paths between any two systems on the interconnected networks.

7. **Gate Way:** In a communications network, a network node equipped for interfacing with another network that uses different protocols.
   - A gateway may contain devices such as protocol translators, impedance matching devices, rate converters, fault isolators, or signal translators as necessary to provide

system interoperability. It also requires the establishment of mutually acceptable administrative procedures between both networks.
• A protocol translation/mapping gateway interconnects networks with different network protocol technologies by performing the required protocol conversions.

EXPERIMENT 2.2

Aim: Study of network IP
- Classification of IP address
- Sub netting
- Super netting

Apparatus (Software): NA

Procedure: Following the class is required to be study under this practical.

EXPERIMENT 3

Aim: Connect the computers in Local Area Network.

Procedure: On the host computer

On the host computer

follow these steps to share the Internet connection:

1. Log on to the host computer as Administrator or as Owner.
2. Click **Start**, and then click **Control Panel**.
3. Click **Network and Internet Connections**.
4. Click **Network Connections**.
5. Right-click the connection that you use to connect to the Internet. For example, if you connect to the Internet by using a modem, right-click the connection that you want under Dial-up / other network available.
6. Click **Properties**.
7. Click the **Advanced tab**.
8. Under Internet Connection Sharing, select the **Allow other network users to connect through this computer's Internet connection** check box.
9. If you are sharing a dial-up Internet connection, select the **Establish a dial-up connection** whenever a computer on my network attempts to access the Internet check box if you want to permit your computer to automatically connect to the Internet.
10. Click **OK.** You receive the following message:
    When Internet Connection Sharing is enabled, your LAN adapter will be set to use IP address 192.168.0. 1. Your computer may lose connectivity with other computers on your network. If these other computers have static IP addresses, it is a good idea to set them to obtain their IP addresses automatically. Are you sure you want to enable Internet Connection Sharing?
11. Click **Yes.**
    The connection to the Internet is shared to other computers on the local area network (LAN). The network adapter that is connected to the LAN is configured with a static IP address of 192.168.0. 1 and a subnet mask of 255.255.255.0

On the client computer

To connect to the Internet by using the shared connection, you must confirm the LAN adapter IP configuration, and then configure the client computer.
To confirm the LAN adapter IP configuration, follow these steps:

1. Log on to the client computer as Administrator or as Owner.
2. Click **Start**, and then click **Control Panel**.
3. Click **Network and Internet Connections**.
4. Click **Network Connections**.
5. Right-click **Local Area Connection** and then click **Properties**.
6. Click the **General tab**, click **Internet Protocol (TCP/IP)** in the connection uses the following items list, and then click Properties.
7. In the Internet Protocol (TCP/IP) Properties dialog box, click **Obtain an IP address automatically** (if it is not already selected), and then click **OK**.
   Note: You can also assign a unique static IP address in the range of 192.168.0.2 to 254. For example, you can assign the following static IP address, subnet mask, and default gateway:

8. IP Address 192.168.31.202
9. Subnet mask 255.255.255.0
10. Default gateway 192.168.31.1
11. In the Local Area Connection Properties dialog box, click **OK.**
12. Quit Control Panel.

EXPERIMENT 4

Aim: Study of basic network command and Network configuration commands

Apparatus (Software): Command Prompt And Packet Tracer.

Procedure: To do this EXPERIMENT- follows these steps:

In this EXPERIMENT- students have to understand basic networking commands e.g ping, tracert etc.

All commands related to Network configuration which includes how to switch to privilege mode and normal mode and how to configure router interface and how to save this configuration to flash memory or permanent memory.

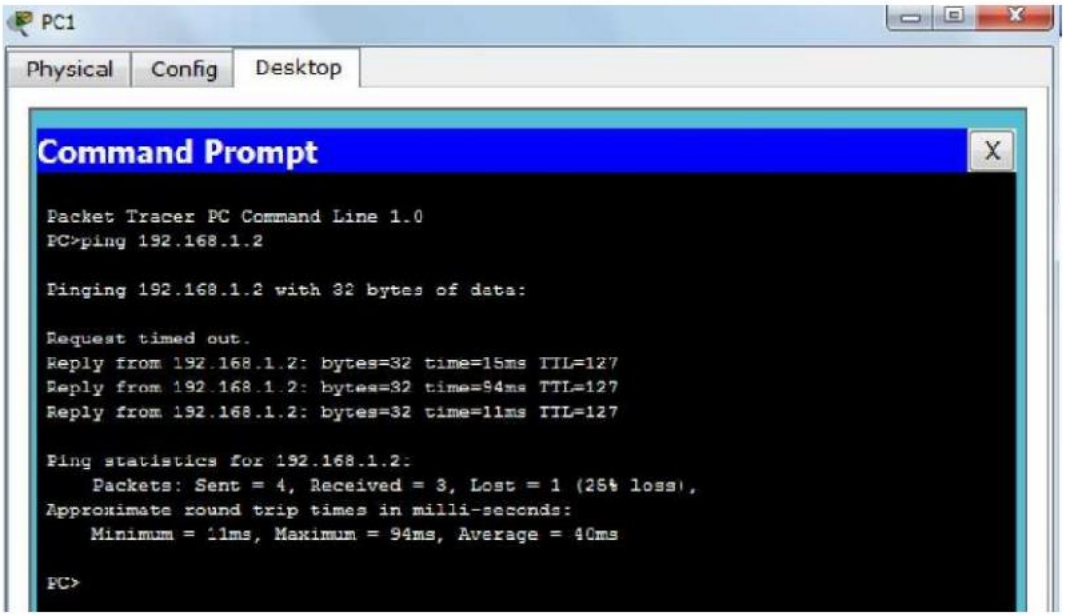
This commands includes

- Configuring the Router commands
- General Commands to configure network
- Privileged Mode commands of a router
- Router Processes & Statistics
- IP Commands •

Other IP Commands e.g. show ip route etc.

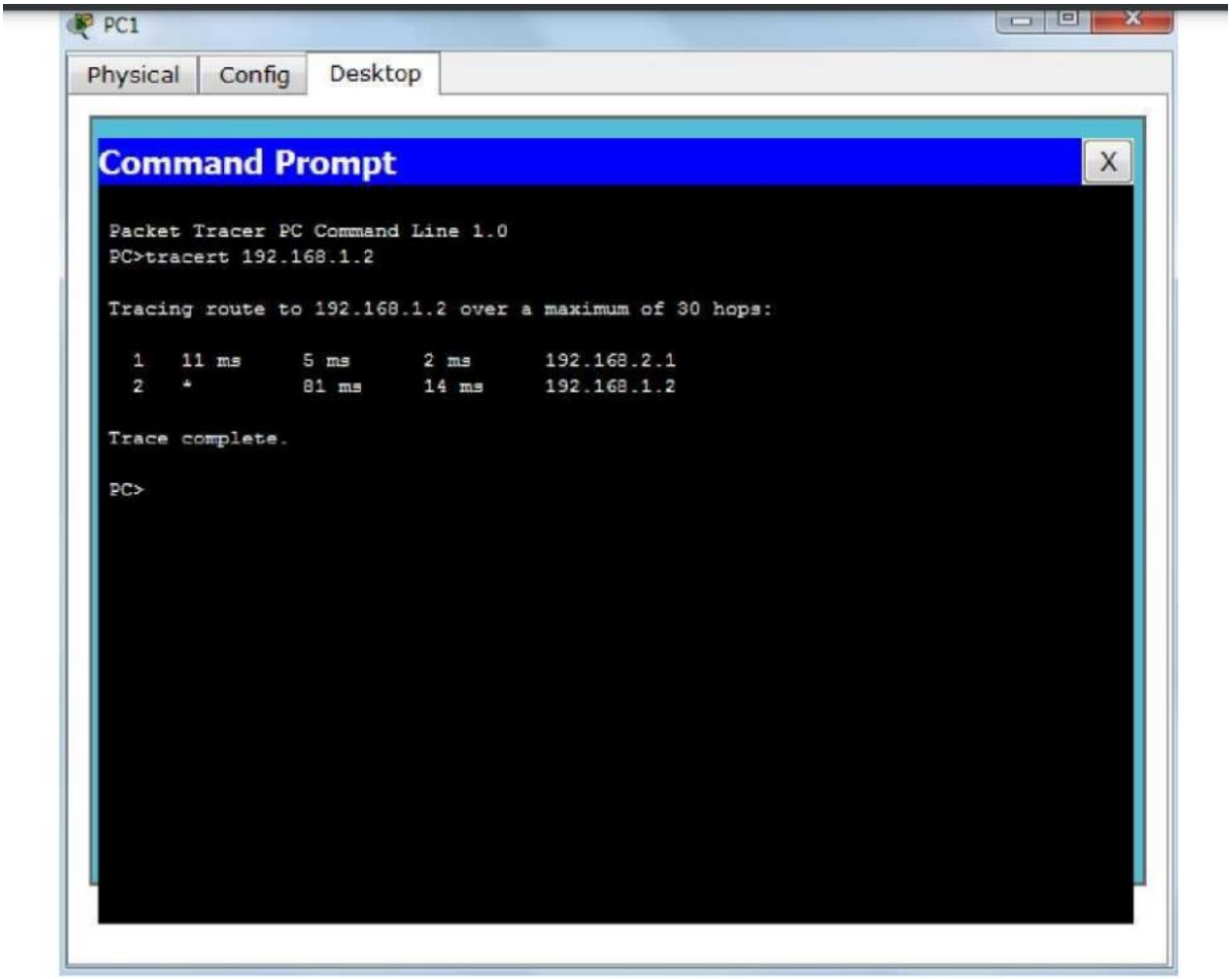
ping:

ping sends an ICMP ECHO_REQUEST packet to the specified host. If the host responds, you get an ICMP packet back. Sound strange? Well, you can "ping" an IP address to see if a machine is alive. If there is no response, you know something is wrong.



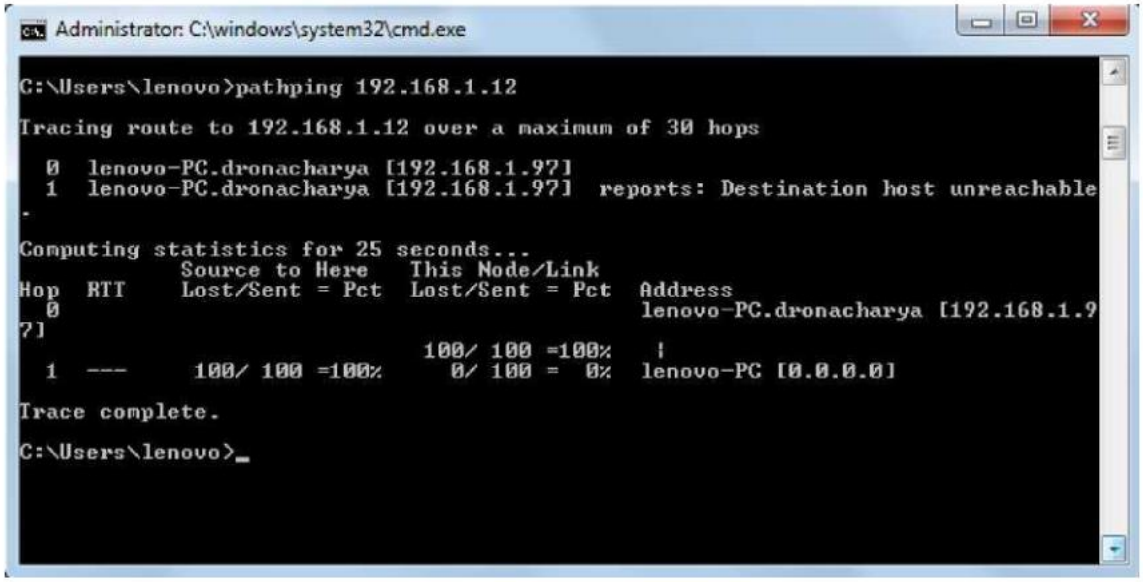
Traceroute:

Tracert is a command which can show you the path a packet of information takes from your computer to one you specify. It will list all the routers it passes through until it reaches its destination, or fails to and is discarded. In addition to this, it will tell you how long each 'hop' from router to router takes.



pathping:

A better version of tracert that gives you statics about packet lost and latency.



Getting Help:

In any command mode, you can get a list of available commands by entering a question mark (?).

Router>?

To obtain a list of commands that begin with a particular character sequence, type in those haracters followed immediately by the question mark (?).

Router#co?

configure connect copy.

To list keywords or arguments, enter a question mark in place of a keyword or argument. Include a space before the question mark.

Configuration Files:

Any time you make changes to the router configuration, you must save the changes to memory because if you do not they will be lost if there is a system reload or power outage.

There are two types of configuration files: **the running (current operating) configuration** and **the startup configuration**.

Use the following privileged mode commands to work with configuration files.

Enter the **copy running-config startup-config** command to save the current running configuration to the startup configuration file in NVRAM.

Router>enable
Router#copy running-config startup-config

To display the **startup configuration**, enter the **show startup-config command**.

Enter the **copy startup-config running-config command** to write the startup configuration to the running configuration.

Router Mode:

There are four modes to configure and access Cisco Router:

- ***user EXEC mode,***
- ***privileged EXEC mode,***
- ***global configuration mode,***
- ***interface configuration mode***
-

- ***user EXEC mode*** is the initial startup mode. A router configuration session can be initiated using terminal emulation programs such as Kermit, HyperTerminal, or telnet.

- ***privileged EXEC mode*** is the system administrator mode. In this mode configuration files can be read, the router can be rebooted, and operating parameters can be changed.

- ***global configuration mode*** is used to modify system-wide configuration parameters, such as routing tables and routing algorithms.

- ***interface configuration mode*** is used to modify the Ethernet and serial port configurations.

HOW TO CHANGE MODE:

- **user Exec mode** is entered by starting a terminal emulation program, such as **kermit** or **HyperTerminal**, or by starting a **telnet session**. The workstation must physically be connected to the console port on the router by either a rollover cable (kermit or HyperTerminal) or to an Ethernet port by a standard patch cable (telnet).

    - The user Exec mode prompt has the following form:

      RouterName>

- **privileged Exec mode** is entered from user Exec mode by typing **enable**. A password must be supplied to complete the connection.

    - The privileged Exec mode prompt has the following form:

      RouterName#

- **global configuration mode** is entered from privileged Exec mode by typing **configure terminal** or **config t**. No password is required.

- The global configuration mode prompt has the following form:

  RouterName (config)#

- **interface configuration mode** is entered from global configuration mode by typing **interface InterfaceName**, where the InterfaceName is either Ethernet0, Serial0, or Serial1.

- The interface configuration mode prompt has the following form:

  RouterName(config-if)#

EXITING FROM A MODE:

1. To exit ***interface configuration*** *mode* type ***exit***. This will return the system to *global configuration mode*.
2. To exit ***global configuration*** *mode* type ***exit***. This will return the system to *privileged Exec mode*.
3. To exit ***global configuration*** *mode* type ***disable***. This will return the system to *user Exec mode*.
4. To exit *user* ***Exec mode*** type ***logout***. This will end the session.

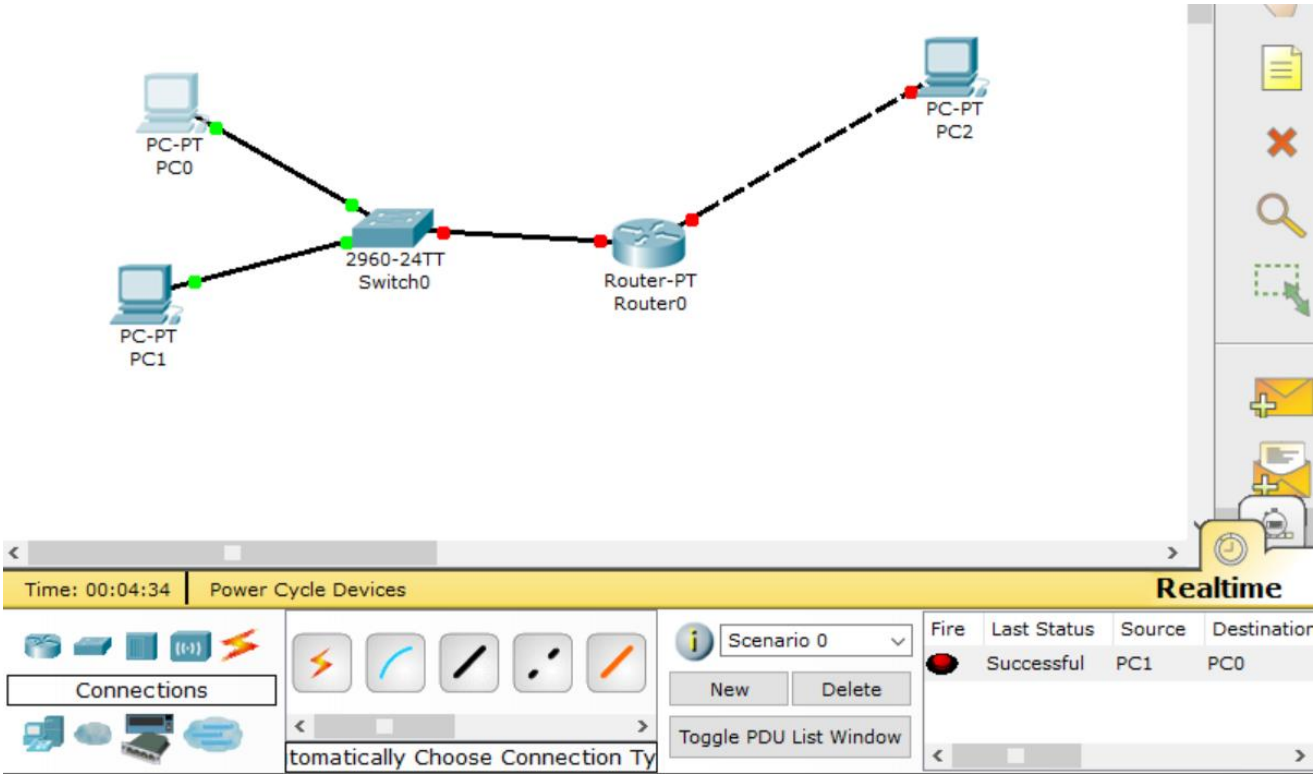
Selected Privileged Exec Mode Commands:

- **show running-config –** displays current router configuration for the router
- **show startup-config –** displays the startup configuration for the router
- **reload –** restarts the router. Discards running configuration and reloads startup configuration
- **copy running-config startup-config –** saves the current configuration to NVRAM. The new configuration takes effect after the router is rebooted.
- **show ip route –** displays the contents of the routing table
- **clear ip route –** deletes all routing table entries
- **show interfaces –** displays information about all network interfaces

Selected Global Configuration Commands:

- **ip routing –** enables IP forwarding
- **no ip routing –** disables IP forwarding and deletes content of routing table
- **ip route-cache –** enables route caching (default mode)
- **no ip route-cache –** disables route caching
- **ip route [ipDestinationAddr subnetmask gw_address]–** adds a static route to the routing table. gw_address is the IP address of the default gateway (next hop router)
  - *ip route 10.21.0.0 255.255.0.0 10.11.1.4 – this command adds a route to the routing table for network 10.21.0.0 with subnet mask 255.255.0.0. 10.11.1.4 is the default gateway (next hop router) address.*
  - *ip route 0.0.0.0 0.0.0.0 10.0.4.4 – this command adds 10.0.4.4 as a default gateway*
  - ip route [ipDestinationAddr subnetmask Interface] – similar to above, but Interface is the network interface name
- **no ip route [ipDestinationAddr subnetmask gw_address] –** deletes route table entry
- **no ip route [ipDestinationAddr subnetmask Interface] –** deletes route table entry

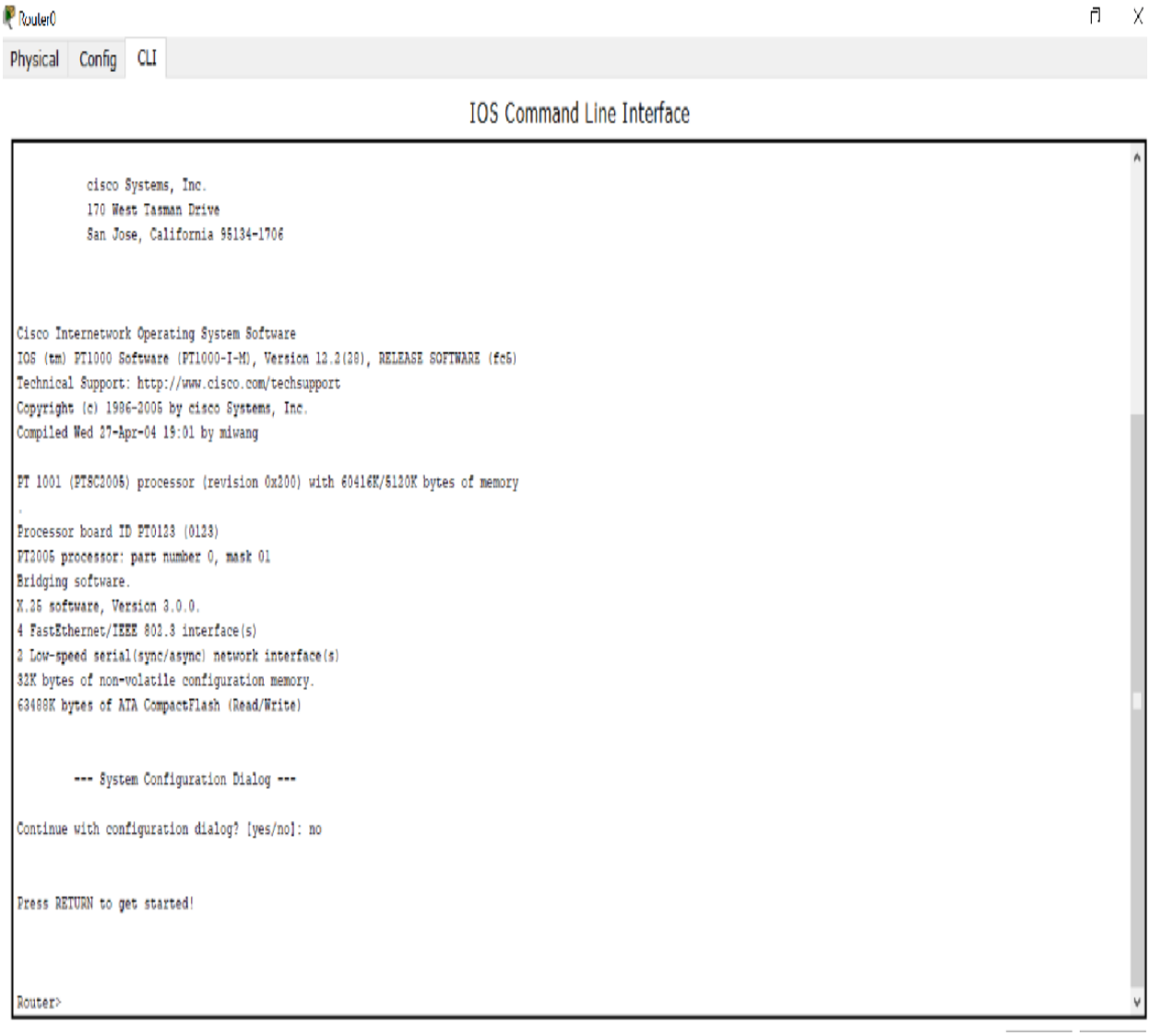
TOPOLOGY



PC NAME/INTERFACE NAME	IP ADDRESS
PC0	192.168.1.2
PC1	192.168.1.1
Fastethernet 0/0	192.168.1.3
Fastethernet 1/0	192.168.2.1
PC2	192.168.2.2

CONFIGURING THE ROUTER:

- Click on the “router” and go to “CLI” bar
- Choose “no” and enter
- When you will find “Router>” prompt write “enable” and press enter
- Then write “configure terminal” or “conf t” and press enter



CONFIGURING GLOBAL PARAMETERS:

	Command	Purpose

Step 1	**configure terminal**
	Example:
	`Router> enable`
	`Router# configure terminal`
		Enters global configuration mode, when using the console port.

Step 2	**hostname** *name* **Example:** `Router(config)# hostname Router`	Specifies the name for the router.
Step 3	**enable secret** *password* **Example:** `Router(config)# enable secret cr1ny5ho`	Specifies an encrypted password to prevent unauthorized access to the router.
Step 4	**no ip domain-lookup** **Example:** `Router(config)# no ip domain-lookup`	Disables the router from translating unfamiliar words (typos) into IP addresses.

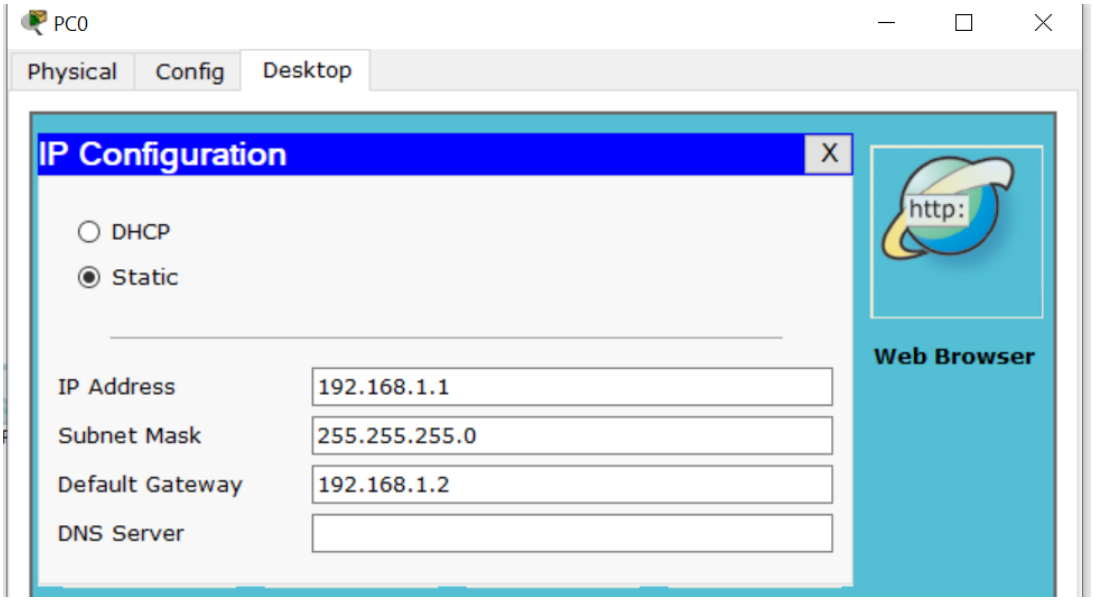
CONFIGURING FAST ETHERNET LAN INTERFACE:

COMMAND	PURPOSE
S1:**interface fastethernet** slot/port **Example:** R1(config)# interface fastethernet 0/1	Enters the configuration mode for a fast Ethernet interface on the router.
S2: **ip address ip-address mask** **Example:** R1(config-if)# **ip address** 192.168.1.3 255.255.255.0	Sets the IP address and subnet mask for the specified FE interface.
S3: **no shutdown** **Example:** R1(config-if)# **no shutdown**	Enables the FE interface, changing its state from administratively down to administratively up.

- R1(config)#interface fastethernet 0/0
- R1(config-if)#ip address 192.168.1.3 255.255.255.0
- R1(config-if)#no shutdown
- %LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
- %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
- R1(config-if)#
- R1#

CONFIGURING DEFAULT GATEWAY:

- Select a PC
- Enter on its "IP Configuration" prompt from "Desktop"
- Set the "Default Gateway" as the interface ip address of the router connected with that PC
- Repeat this process for all the PCs of the network.



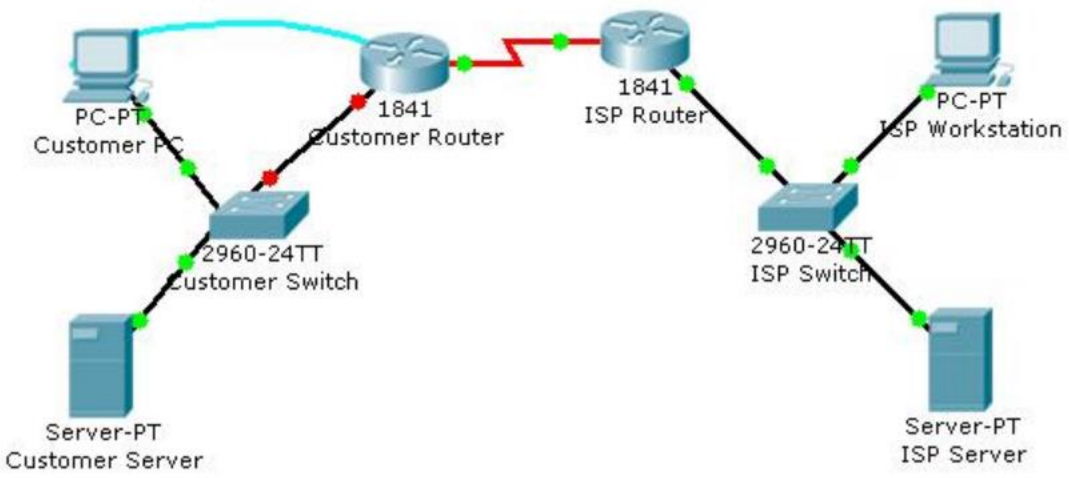
CLASS WORK:

- Configure Router fastethernet interface 1/0 in similar way with ip address 192.168.2.1
- Configure PC2 with ip address 192.168.2.2
- Ping PC2 from PC0

EXPERIMENT 5

CONFIGURING ROUTER NAME, PASSWORD AND BANNER MESSAGE

Topology Diagram



Objectives

- Configure the router host name.
- Configure passwords.
- Configure banner messages.
- Verify the router configuration.

Background / Preparation

In this activity, you will use the Cisco IOS CLI to apply an initial configuration to a router, including host name, passwords, a message-of-the-day (MOTD) banner, and other basic settings.

Note: Some of the steps are not graded by Packet Tracer.

Step 1: Configure the **router host name**

a. On Customer PC, use the terminal emulation software to connect to the console of the customer Cisco 1841 ISR.
b. Set the host name on the router to **CustomerRouter** by using these commands.

```
Router>enable
Router#configure terminal
Router(config)#hostname CustomerRouter
```

Step 2: Configure the privileged mode and secret passwords.

a. In global configuration mode, set the password to **cisco**
b. CustomerRouter(config)#enable password cisco

Step 3: Configure the console password.

a. In global configuration mode, switch to line configuration mode to specify the console line.

CustomerRouter(config)#line console 0

Set the password to **cisco123**, require that the password be entered at login, and then exit line configuration mode.

```
CustomerRouter(config-line)#password cisco123
CustomerRouter(config-line)#login
CustomerRouter(config-line)#exit
CustomerRouter(config)#
```

Step 4: Configure the vty password to allow Telnet access to the router.

a. In global configuration mode, switch to line configuration mode to specify the vty lines.

CustomerRouter(config)#line vty 0 4

Set the password to cisco123, require that the password be entered at login, exit line configuration mode, and then exit the configuration session.

```
CustomerRouter(config-line)#password cisco123
CustomerRouter(config-line)#login
CustomerRouter(config-line)#exit
CustomerRouter(config)#
```

Step 5: Configure password encryption, a MOTD banner, and turn off domain server lookup.

a. Currently, the line passwords and the enable password are shown in clear text when you show the running configuration.
b. Verify this now by entering the **show running-config command**.
c. To avoid the security risk of someone looking over your shoulder and reading the passwords, encrypt all clear text passwords.

CustomerRouter(config)#service password-encryption

Use the **show running-config** command again to verify that the passwords are encrypted.

To provide a warning when someone attempts to log in to the router, configure a **MOTD banner**.

CustomerRouter(config)#banner motd $Authorized Access Only!$

Test the banner and passwords.
Log out of the router by typing the **exit** command twice.
The banner displays before the prompt for a password.
Enter the password to log back into the router.

You may have noticed that when you enter a command incorrectly at the user or privileged EXEC prompt, the router pauses while trying to locate an IP address for the mistyped word you entered. For example, this output shows what happens when the enable command is mistyped.

CustomerRouter>**emable**

Translating "emable"...domain server (255.255.255.255)

To prevent this from happening, use the following command to stop all DNS lookups from the router CLI.

CustomerRouter(config)#no ip domain-lookup

Save the running configuration to the startup configuration.

CustomerRouter(config)#end
CustomerRouter#copy run start

Step 6: Verify the configuration.

a. Log out of your terminal session with the Cisco 1841 customer router.
b. Log in to the Cisco 1841 Customer Router. Enter the console password when prompted.
c. Navigate to privileged EXEC mode. Enter the privileged EXEC password when prompted.
d. Click the Check Results button at the bottom of this instruction window to check your work

EXPERIMENT 6

IMPLEMENTATION OF STATIC ROUTING

OBJECTIVE:

- Configure WAN Interface
- Configure Static Routing Protocol

TOPOLOGY TABLE:

DEVICE	CONNTECT TO	CONNTECTED FROM	IP ADDRESS
PC0	Switch	Fast Ethernet 0/1	192.168.1.2/24
PC1	Switch	Fast Ethernet 1/1	192.168.1.3/24
Routet1	Fast Ethernet 2/1	Fast Ethernet 0/0	192.168.1.1/24
Router2	Serial2/0	Router 2's Serial2/0	192.168.3.1/24
Router2	Fast Ethernet 0/0	PC3	192.168.2.1/24
PC3	Router2	Fast Ethernet 0/0	192.168.2.3/24

CLASS WORK:

Design the topology using the given table in your packet tracer

WHAT IS DCE AND DTE:

- The term **DTE** (Data Terminal EQUIPMENT) is used to describe the initiator or controller of the serial connection, typically the computer.
- The term **DCE** (Data Communications EQUIPMENT) describes the device that is connected to the DTE device such as a modem.
- The terms are most often used in reference to serial communications defined by the EIA RS232 standard.
- Devices that communicate over a serial interface are divided into two classes: DTE and DCE.
- The most important difference between these types of devices is that the DCE device supplies the clock signal that paces the communications on the bus.

CONFIGURING WAN INTERFACE OF ROUTER1:

STEP	COMMAND	PURPOSE
S1	configure terminal Example: Router1# configure terminal	Enters global configuration mode.
S2	interface serial slot/port Example: Router1(config)# interface serial 2/0	Enters the configuration mode for a serial interface on the router.
S3	ip address ip-address mask Example: Router1(config-if)# ip address 192.168.3.1 255.255.255.0	Sets the IP address and subnet mask for the specified serial interface.
S4	Clock rate Example: Router1(config-if)#Clock rate 56000	For DCE part need to enter clock rate which can be 64000/72000/56000 or any

		Note: if one port is DCE and given clock rate then the other port must be DTE and for that port clock rate is not required
S5	no shutdown Example: Router1(config-if)# no shutdown	Enables the GE interface, changing its state from administratively down to administratively up.
S6	Exit Example:Router1(config-if)# exit	Exits configuration mode for the serial interface and returns to global configuration mode.

CLASS WORK:

- Configure WAN interface of Router2
- Configure Fast Ethernet Interface of Both Router 1 & 2
- Configure PC0, PC1 and PC3
- Ping PC0 to PC1
- Ping PC0 to Router1
- Ping PC0 to PC3

FACING ANY PROBLEM!!!!!!!!

TROUBLESHOOTING:

- From PC0 and PC1 provide "default gateway" address as "192.168.1.1"
- From PC3 provide "default gateway" address as "192.168.2.1"
- Configure Routers with Static Routing Protocol

FOR STATIC ROUTING:

For Router1

STEP	COMMAND	PURPOSE
S1	configure terminal Example: Router1# configure terminal	
S2	ip route prefix mask {ip-address | interface-type interface-number [ip-address]} Example: Router1(config)# ip route 192.168.2.0 255.255.255.0 192.168.3.2.	Specifies the static route for the IP packets.
S3	end Example: Router(config)# end	Exits router configuration mode, and enters privileged EXEC mode.

Configure Router2 following the same steps

TO VARIFY:

To verify that you have properly configured static routing, enter the "*show ip route"* command and look for static routes signified by the "S."

CONFIGURE DEFAULT ROUTE:

- We can set a default route for internet connection or we can implement a security measurement to deal with all matched packet.
- By default, Routers are configured to drop the packet if destination address is not found in routing table.
- Default route will override this behaviour.
- If no match for destination network is found in routing table then it would be forwarded to the default route.
- Thus default route is a way to deal with all unmatched packets.

STEP	COMMAND	PURPOSE
S1	Router(config)#ip route 0.0.0.0 0.0.0.0 ip_address_of_next_hop_neigher For example: Router1(config)# ip route 0.0.0.0 0.0.0.0 192.168.3.2.	Command to set default route. Here destination network to 0.0.0.0/0 represents all networks

CLASS WORK:

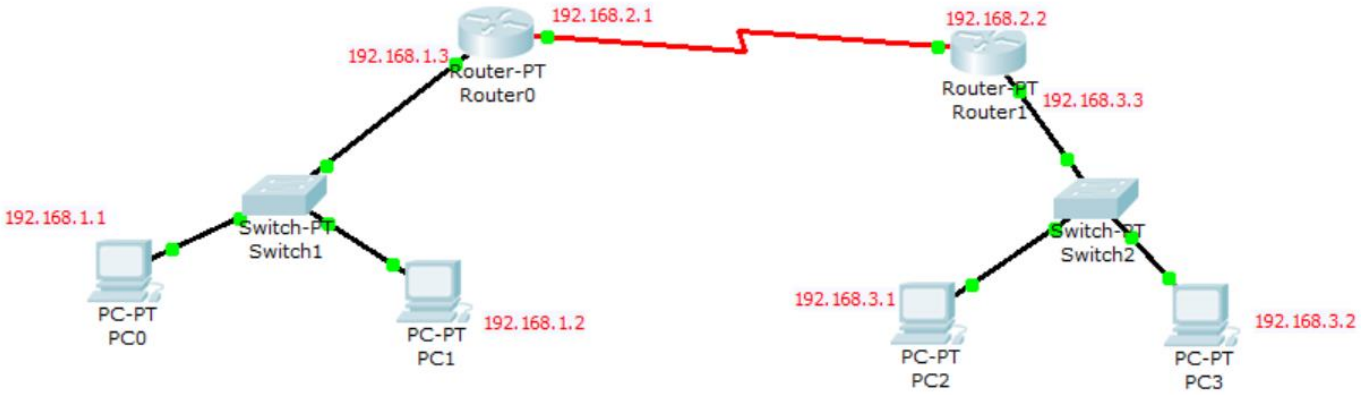
Using the following table information design the entire network and ping from any PC to any other PC.

DEVICE	CONNTECTED FROM	CONNTECTED TO	IP ADDRESS
PC0	FastEthernet0	Router's FastEthernet0/0	10.0.0.2/8
Router0	FastEthernet0/0	PC0's FastEthernet0	10.0.0.1/8
Router0	Serial 0/0/0	Router1's serial0/0/0	192.168.0.253/30
Router1	Serial0/0/0	Router0's Serial0/0/0	192.168.0.254/30
Router1	Serial0/0/1	Router2's Serial0/0/0	192.168.0.249/30
Router3	Serial0/0/0	Router2's Serial0/0/1	192.168.0.246/30
Router3	FastEthernet0/0	PC1's FastEthernet0	20.0.0.1/8
PC1	FastEthernet0	Router1's FastEthernet0/0	20.0.0.2/8

EXPERIMENT 7

DYNAMIC ROUTING PROTOCOL (RIP)

TOPOLOGY:



Do the following tasks:

- Enable each interface of each router
- Provide default gateway address to each PC
- Provide clock rate to appropriate interface
- **DO NOT ENABLE STATIC ROUTING**

CONFIGURING RIPV2

1. enabling RIP by using the ***router rip*** global configuration command
2. instructing the router to use RIPv2 by typing the ***version 2*** command
3. telling RIP which networks to advertise by using one or more *network* commands.

- With the *network* command you specify which interfaces will participate in the routing process
- This command takes a classful network as a parameter and enables RIP on the corresponding interfaces.

FOR ROUTER1

1. Router>enable
2. Router#conf t
3. Router(config)#router rip
4. Router(config-router)#version 2
5. Router(config-router)#network 192.168.2.0
6. Router(config-router)#network 192.168.3.0
7. Router(config-router)#

FOR ROUTER0

1. Router>enable
2. Router#conf t
3. Router(config)#router rip
4. Router(config-router)#version 2
5. Router(config-router)#network 192.168.1.0
6. Router(config-router)#network 192.168.2.0
7. Router(config-router)#

TO CHECK:

You can verify that router R0 have a route to the R1's directly connected subnet by typing the ***show ip route*** command as follows:

```
Router>enable
Router#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    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial2/0
R    192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:24, Serial2/0
Router#
```

CLASS WORK:

USE RIP ALONG WITH STATIC ROUTING AND SEE THE CHANGE IN "SHOW IP ROUTE" COMMAND

EXPERIMENT 8

INTRODUCTION TO OSPF

OSPF OVERVIEW:

- **OSPF (Open Shortest Path First)** is a link state routing protocol.
- It is a classless routing protocol
- It supports VLSM, CIDR, manual route summarization, equal cost load balancing
- incremental updates are supported by OSPF
- It uses only one parameter as the metric – the interface cost.
- The administrative distance of OSPF routes is, by default, 110.
- It uses multicast addresses 224.0.0.5 and 224.0.0.6 for routing updates.
- Routers running OSPF have to establish neighbour relationships before exchanging routes.
- Because OSPF is a link state routing protocol, neighbours don't exchange routing tables.
- Instead, they exchange information about network topology.
- Each OSFP router then runs SFP algorithm to calculate the best routes and adds those to the routing table.
- Because each router knows the entire topology of a network, the chance for a routing loop to occur is minimal.
- Each OSPF router stores routing and topology information in three tables:
- **Neighbor table** – stores information about OSPF neighbors
- **Topology table** – stores the topology structure of a network
- **Routing table** – stores the best routes

OSPF NEIGHBOUR:

- OSPF routers need to establish a neighbor relationship before exchanging routing updates.
- OSPF neighbours are dynamically discovered by sending Hello packets out each OSPF-enabled interface on a router.
- Hello packets are sent to the multicast IP address of 224.0.0.5.

- The following fields in the Hello packets must be the same on both routers in order for routers to become neighbours:
  - subnet
  - area id
  - hello and dead interval timers
  - authentication
  - area stub flag

    - MTU
- By default, OSPF sends hello packets every 10 second on an Ethernet network (Hello interval).
- A dead timer is four times the value of the hello interval, so if a routers on an Ethernet network doesn't receive at least one Hello packet from an OSFP neighbour for 40 seconds, the routers declares that neighbour to be down.

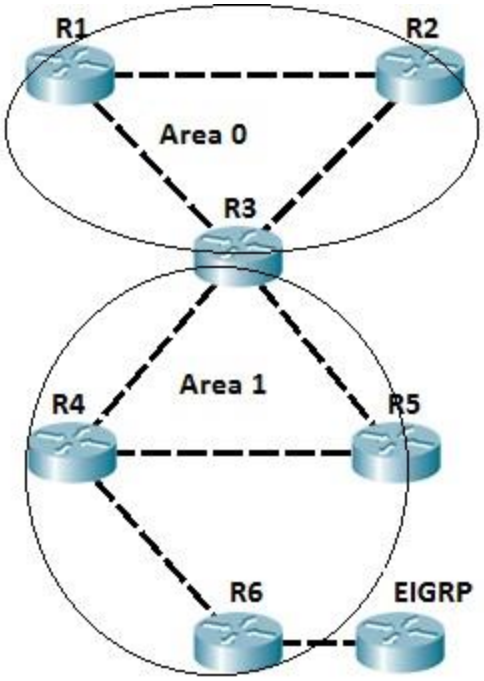
OSPF NEIGHBOUR STATE:

Before establishing a neighbour relationship, OSPF routers need to go through several state changes. These states are explained below.

1. **Init state** – a router has received a Hello message from the other OSFP router
2. **2-way state** – the neighbour has received the Hello message and replied with a Hello message of his own
3. **Exstart state** – beginning of the LSDB (Link State DataBase) exchange between both routers. Routers are starting to exchange link state information.
4. **Exchange state** – DBD (Database Descriptor) packets are exchanged. DBDs contain LSAs headers. Routers will use this information to see what LSAs need to be exchanged.
5. **Loading state** – one neighbor sends LSRs (Link State Requests) for every network it doesn't know about. The other neighbor replies with the LSUs (Link State Updates) which contain information about requested networks. After all the requested information have been received, other neighbor goes through the same process
6. **Full state** – both routers have the synchronized database and are fully adjacent with each other.

OSPF AREAS

- OSPF uses the concept of areas.
- An area is a logical grouping of contiguous networks and routers.
- All routers in the same area have the same topology table, but they don't know about routers in the other areas.
- The main benefits of creating areas is that the size of the topology and the routing table on a router is reduced, less time is required to run the SFP algorithm and routing updates are also reduced.
- Each area in the OSPF network has to connect to the backbone area (area 0).
- All router inside an area must have the same area ID to become OSPF neighbors.
- A router that has interfaces in more than one area (area 0 and area 1, for example) is called **Area Border Router (ABR)**.
- A router that connects an OSPF network to other routing domains (EIGRP network, for example) is called **Autonomous System Border Router (ASBR)**.

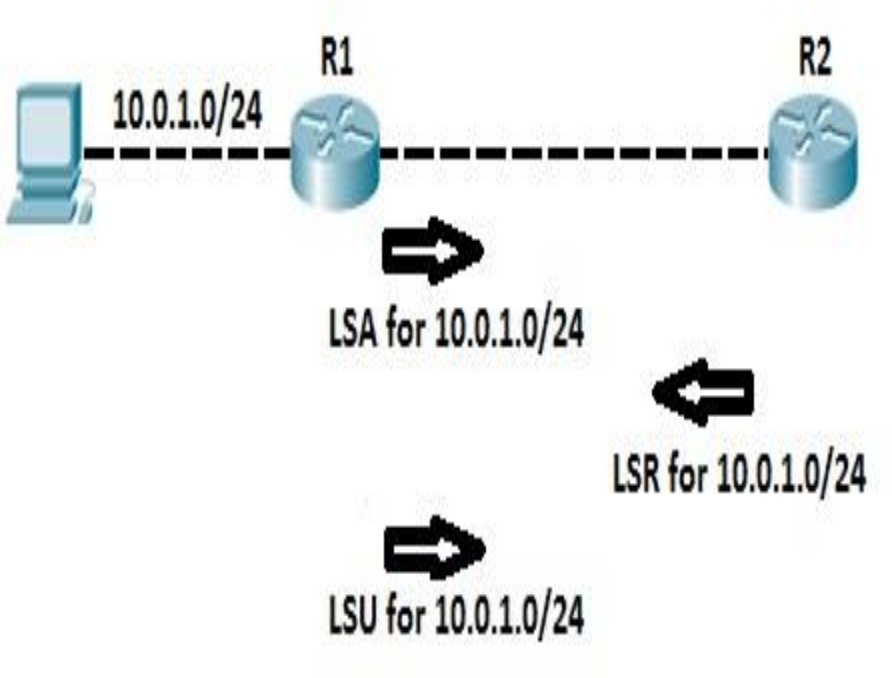


In the above figure:

- All routers are running OSPF.
- Routers R1 and R2 are inside the backbone area (area 0).
- Router R3 is an ABR, because it has interfaces in two areas, namely area 0 and area 1.
- Router R4 and R5 are inside area 1. Router R6 is an ASBR, because it connects OSFP network to another routing domain (an EIGRP domain in this case).
- If the R1's directly connected subnet fails, router R1 sends the routing update only to R2 and R3, because all routing updates all localized inside the area.
- **NOTE**
  The role of an ABR is to advertise address summaries to neighboring areas. The role of an ASBR is to connect an OSPF routing domain to another external network (e.g. Internet, EIGRP network…).

LSA, LSU & LSR

- The **LSAs (Link-State Advertisements)** are used by OSPF routers to exchange topology information.
- Each LSA contains routing and topology information to describe a part of an OSPF network.
- When two neighbours decide to exchange routes, they send each other a list of all LSAa in their respective topology database.
- Each router then checks its topology database and sends a Link State Request (LSR) message requesting all LSAs not found in its topology table.
- Other router responds with the Link State Update (LSU) that contains all LSAs requested by the other neighbour.



In the above figure:

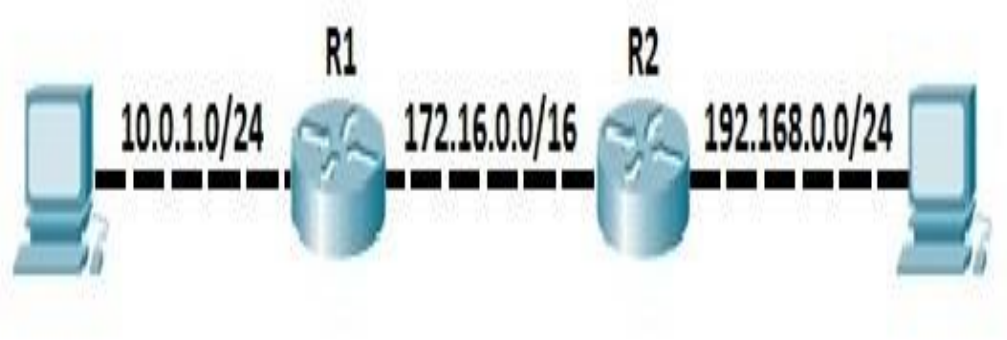
- After configuring OSPF on both routers, routers exchange LSAs to describe their respective topology database.
- Router R1 sends an LSA header for its directly connected network 10.0.1.0/24.
- Router R2 check its topology database and determines that it doesn't have information about that network.
- Router R2 then sends Link State Request message requesting further information about that network.
- Router R1 responds with Link State Update which contains information about subnet 10.0.1.0/24 (next hop address, cost…).

OSPF CONFIGURATION

- OSPF basic configuration is very simple.
- Just like with other routing protocols covered so far (RIP) first you need to enable OSPF on a router.
    - This is done by using the *router* ***ospf PROCESS-ID*** global configuration command.
- Next, you need to define on which interfaces OSPF will run and what networks will be advertised.
    - This is done by using the *network* ***IP_ADDRESS WILDCARD_MASK AREA_ID*** command from the ospf configuration mode.

NOTE

The OSPF process number doesn't have to be the same on all routers in order to establish a neighbour relationship, but the Area ID has to be the same on all neighboring routers in order for routers to become neighbours.



First, we need to enable OSPF on both routers.
Then we need to define what network will be advertised into OSPF.

This can be done by using the following sequence of commands on both routers:

```
R1(config-router)#router ospf 1
R1(config-router)#network 10.0.1.0 0.0.0.255 area 0
R1(config-router)#network 172.16.0.0 0.0.255.255 area 0
```

```
R2(config)#router ospf 1
R2(config-router)#network 192.168.0.0 0.0.0.255 area 0
R2(config-router)#network 172.16.0.0 0.0.255.255 area 0
```

The *network* commands entered on both routers include subnets directly connected to both routers.

- We can verify that the routers have become neighbors by typing the ***show ip ospf neighbors*** command on either router.
-

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.0.2       1   FULL/BDR        00:00:32    172.16.0.2      FastEthernet0/1
```

To verify if the routing updated were exchanged, we can use the ***show ip route*** command. All routes marked with the character **O** are OSPF routes. For example, here is the output of the command on R1.

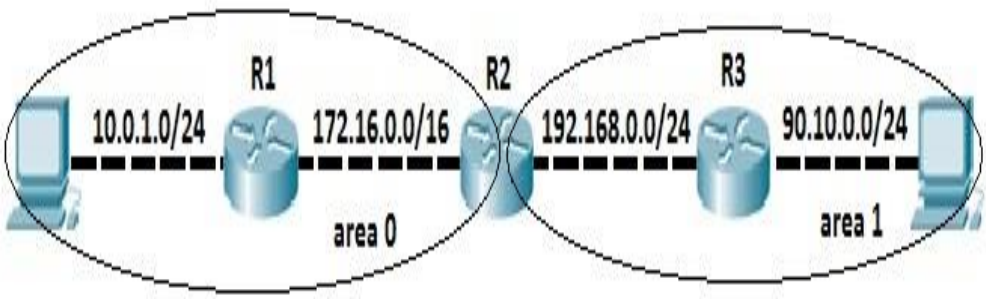
```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       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

     10.0.0.0/24 is subnetted, 1 subnets
C       10.0.1.0 is directly connected, FastEthernet0/0
C    172.16.0.0/16 is directly connected, FastEthernet0/1
O    192.168.0.0/24 [110/2] via 172.16.0.2, 00:03:44, FastEthernet0/1
```

You can see that R1 has learned about the network 192.168.0.0/24 through OSPF.

CONFIGURING OSPF in TWO AREAS



- In this example we have two OSPF areas – area 0 and area 1.
- As you can see from the network topology depicted , routers R1 and R3 are in the area 0 and area 1, respectively.
- Router 2 connects to both areas, which makes him an **ABR (Area Border Router)**.
- Our goal is to advertise the subnets directly connected to R1 and R3. To do that, the following configuration on R1 will be used:

-
```
R1(config)#router ospf 1
R1(config-router)#network 10.0.1.0 0.0.0.255 area 0
R1(config-router)#network 172.16.0.0 0.0.255.255 area 0
R1(config-router)#router-id 1.1.1.1
```

Because R1 connects only to R2, we only need to establish a neighbour relationship with R2 and advertise directly connected subnet into OSPF.

```
R1(config)#router ospf 1
R1(config-router)#network 10.0.1.0 0.0.0.255 area 0
R1(config-router)#network 172.16.0.0 0.0.255.255 area 0
R1(config-router)#router-id 1.1.1.1
```

Configuration of R3 looks similar, but with one difference, namely area number. R3 is in the area 1.

```
R3(config)#router ospf 1
R3(config-router)#network 192.168.0.0 0.0.0.255 area 1
R3(config-router)#network 90.10.0.0 0.0.0.255 area 1
R3(config-router)#router-id 3.3.3.3
```

What about R2?

Well, because R2 is an ABR, we need to establish neighbor relationship with both R1 and R3. To do that, we need to specify different area ID for each neighbor relationship, 0 for R1 and 1 for R2.
We can do that using the following sequence of commands.

```
R2(config)#router ospf 1
R2(config-router)#network 172.16.0.0 0.0.255.255 area 0
R2(config-router)#network 192.168.0.0 0.0.0.255 area 1
R2(config-router)#router-id 2.2.2.2
```

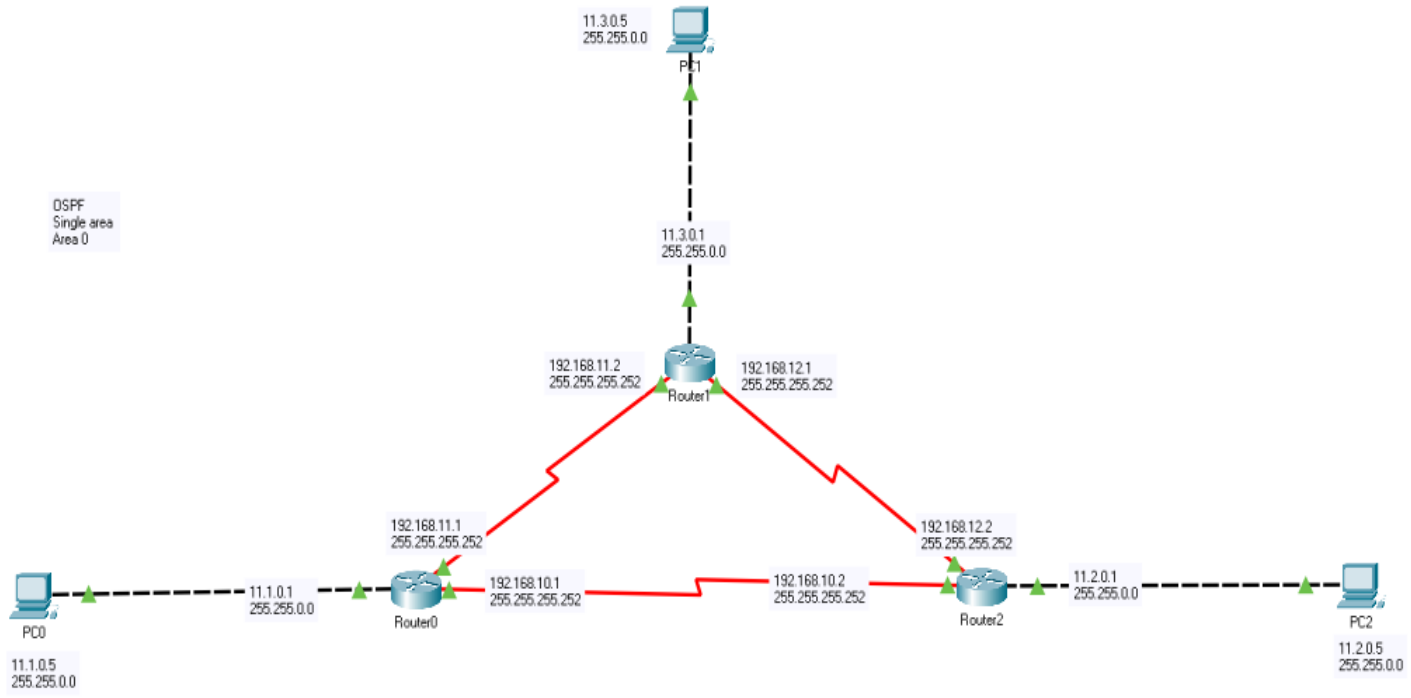
Now R2 should have neighbor relationship with both R1 and R3.
We can verify that by using the *show* ***ip ospf neighbor*** command

- To verify if directly connected subnets are really advertised into the different area, we can use the ***show ip route ospf*** command on both R1 and R3
- Characters **IA** in front of the routes indicate that these routes reside in different areas.

EXPERIMENT 9

MORE OF OSPF

DESING A NETWOKR USING FOLLOWING TOPOLOGY



DO THE FOLLOWING TASKS:

- Enable each interface of each router
- Provide default gateway address to each PC
- Provide clock rate to appropriate interface
- **DO NOT ENABLE STATIC OR RIP ROUTING**

CONFIGURING ROUTER0

- Router>enable
- Router#conf t
- Router(config)#router ospf 1
- Router(config-router)#network **11.1.0.0 0.0.255.255** area **0**
- Router(config-router)#network **192.168.11.0 0.0.0.3** area **0**
- Router(config-router)#network **192.168.10.0 0.0.0.3** area **0**
- Router(config-router)#exit

CONFIGURING ROUTER1

- Router>enable
- Router#conf t
- Router(config)#router ospf 1

- Router(config-router)#network **11.3.0.0 0.0.255.255 area 0**
- Router(config-router)#network **192.168.11.0 0.0.0.3** area **0**
- Router(config-router)#network **192.168.12.0 0.0.0.3** area **0**
- Router(config-router)#exit

CLASS WORK:

CONFIGURE ROUTER2

CONNECTION TESTING

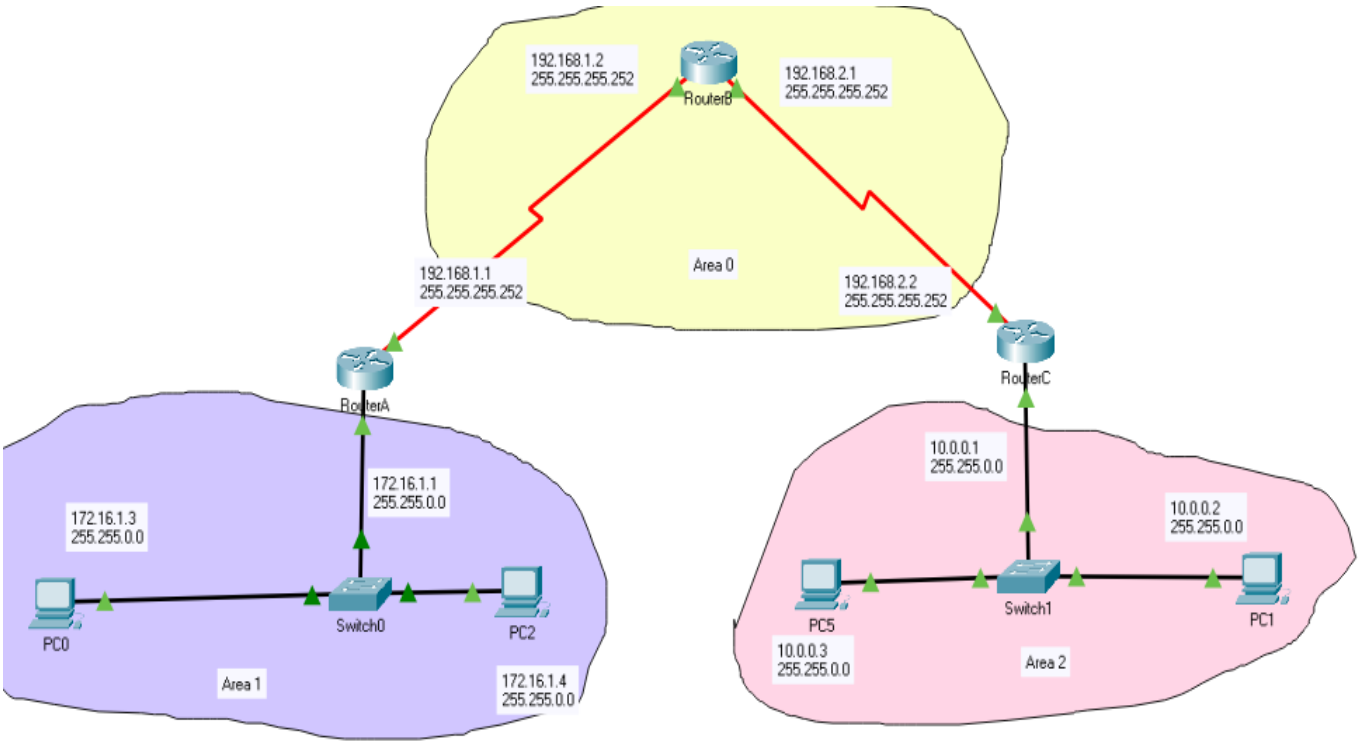
To check connection and viewing the database Use

- **show ip protocol,**
- **show ip ospf,**
- **show ip route ospf**

Commands from priviledged mode.

- Ping from one pc to another.
- Troubleshoot if there is any problem.

OSPF FOR MULTIPLE AREAS



Do the same tasks as before –

- Enable each interface of each router
- Provide default gateway address to each PC
- Provide clock rate to appropriate interface
- **DO NOT ENABLE STATIC OR RIP ROUTING**

CONFIGURING ROUTER A:

- Router>enable
- Router#conf t
- Router(config)#router ospf 1
- Router(config-router)#network **172.16.0.0 0.0.255.255 area 1**
- Router(config-router)#network **192.168.1.0 0.0.0.3 area 0**
- Router(config-router)#exit

CONFIGURING ROUTER B:

- Router>enable
- Router#conf t
- Router(config)#router ospf 1
- Router(config-router)#network **192.168.2.0 0.0.0.3 area 0**
- Router(config-router)#network **192.168.1.0 0.0.0.3 area 0**
- Router(config-router)#exit

CLASS WORK:

CONFIGURE ROUTER C

CONNECTION TESTING:

- Check connections in the same way as you did in single area OSPF.
- Remember to always set one area as **area 0,** else the ospf won't work properly.