Lab 4 and 5 Conceptual Notes: Types of Routing and Types of Routes

To forward incoming data packets, a router learns all available routes in the network and stores them in a table known as the routing table. There are two types of routes: static route and dynamic route. A router can learn these routes through two types of routing: static routing and dynamic routing, respectively.

A static route is a route that is either directly configured on an active interface of the router or manually added in the routing table by an administrator. When we configure an IP address on an interface of a router, the router automatically determines the corresponding network address and adds that network address in the routing table.

A dynamic route is a route that is neither directly configured on an active interface of the router nor manually added in the routing table by an administrator. A router learns dynamic routes by running a routing protocol. Since a router learns dynamic routes through a routing protocol, a routing protocol must be configured and activated before the router can learn any dynamic routes.

Let's take an example. In a network, two routers: router0 and router1 are connected through a serial cable. To connect both routers, the network 20.0.0.0/8 is used on serial interfaces. Network 10.0.0.0/8 is connected to the router0 and the network 30.0.0.0/8 is connected to the router1.

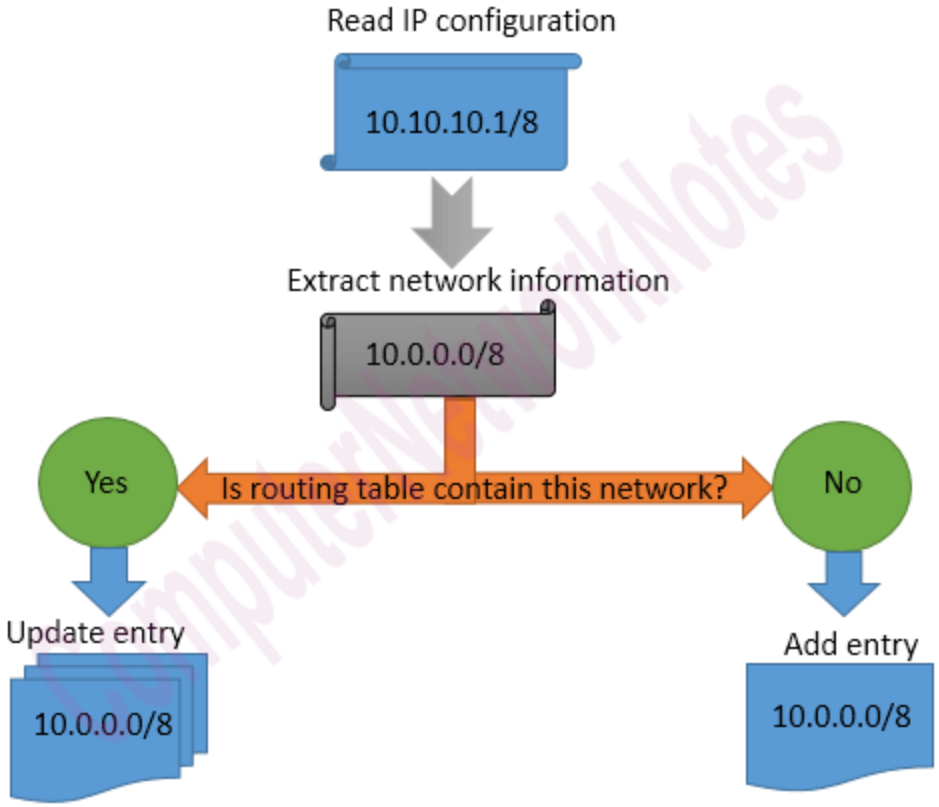
The following table shows the IP configuration of both routers.

Router 0		Router1	
Interface	IP address	Interface	IP address
FastEthernet 0/0	10.10.10.1/8	FastEthernet 0/0	30.30.30.1/8
Serial 0/0/0	20.20.20.1/8	Serial 0/0/0	20.20.20.2/8

When we activate an interface of a router, the router does the following:

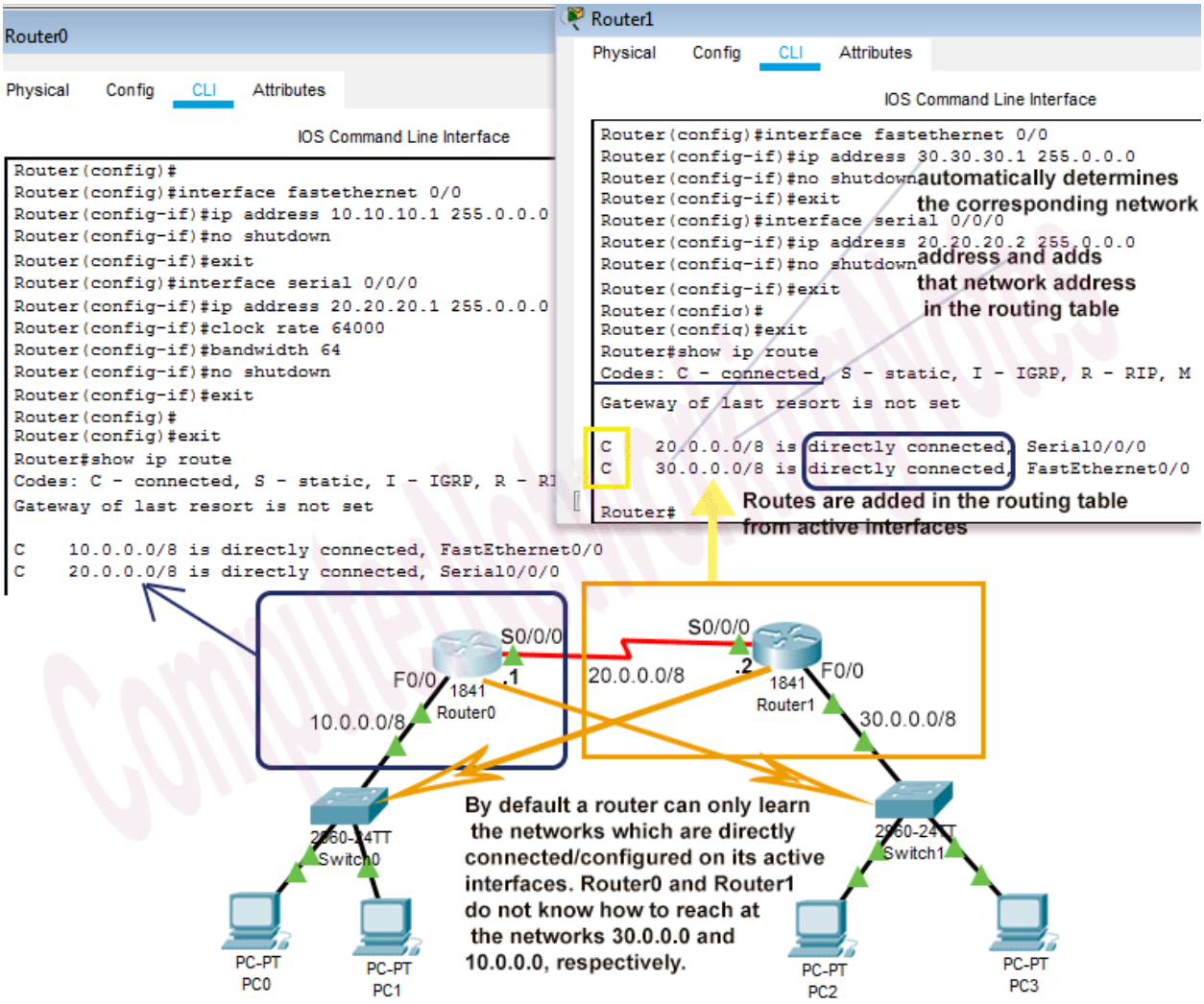
- Read the IP configuration of the interface.
- Extract network information from the IP configuration.
- Find the extracted network information in the routing table.
- If the routing table already contains an entry for the extracted network, the router updates that entry.
- If the routing table contains no entry for the extracted network, the router adds an entry for the extracted network.

The following image shows how the router0 learns the network address from the IP configuration of the FastEthernet 0/0 interface and adds that network address in the routing table.



A router can, on its own, only learn networks that are directly connected to its active interfaces. In other words, through the above-described process, a router can discover only those network paths that are directly available on its interfaces. If a network is available on the interface of another router, a router cannot learn that network on its own.

The following image shows how both routers learn and add network paths from IP configurations.



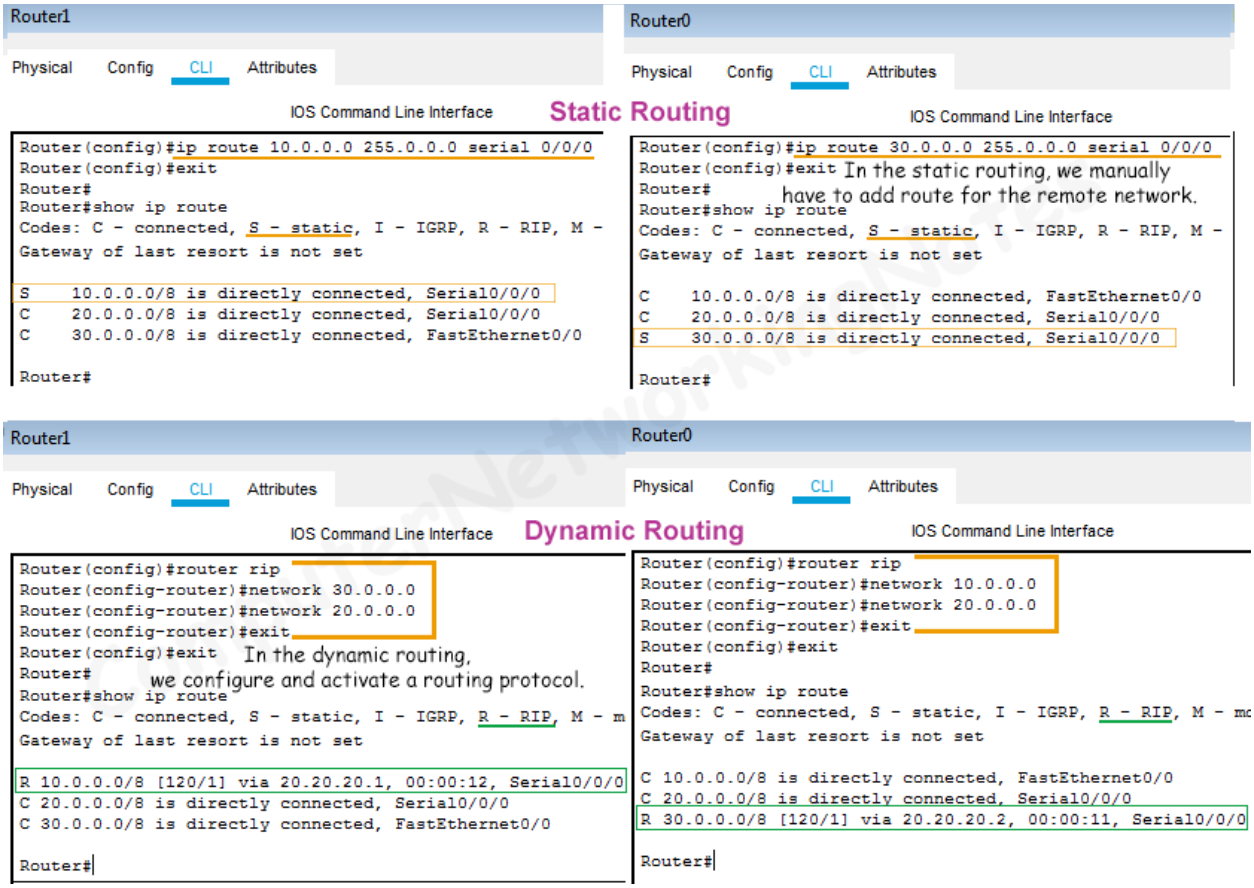
As you can see in the above image, a router neither can learn nor can populate the routing table with the networks that are not available on its interfaces. A router uses the routing table to make the packet forwarding decision.

If a router does not have an entry for a path in the routing table, it drops the incoming packets of that network.

A router can learn about the paths that are not available on its interfaces through two types of routing; static routing and dynamic routing.

In the static routing, we have to add the remote paths manually. In the dynamic routing, we configure a routing protocol and later the routing protocol automatically discovers the remote paths and adds them into the routing table.

The following image shows both types of routing in our example network.



Both types of routing have their advantages and disadvantages. The advantages of one type of routing are the disadvantages of the other types of routing.

The following table compares both types of routing with their advantages and disadvantages.

Static Routing	Dynamic Routing
Do not require any additional knowledge.	Require knowledge of the routing protocol that will be used in the network.
Any change in the path information requires a manual update on all routers.	If the path information changes, the routing protocol automatically updates all routers.
Since routes are configured manually, the static routing is considered more secure than the dynamic routing.	Since routers learn routes from the routing protocol, the dynamic routing is considered less secure than the static routing.
Do not use any additional hardware resources.	Consume CPU, memory and link bandwidth.

Which type of routing an administrator should use is depend on the size and requirement of the network. If the network is small and has only a few paths, an administrator can use static routing to save hardware resources. If the network is large and complex, an administrator can use dynamic routing to reduce the tedious job of managing paths manually.

Static Routing Configuration

Static routing is the most secure way of routing. It reduces overhead from network resources. In this type of routing we manually add routes in routing table. It is useful where numbers of route are limited. Like other routing methods static routing also has its pros and cons.

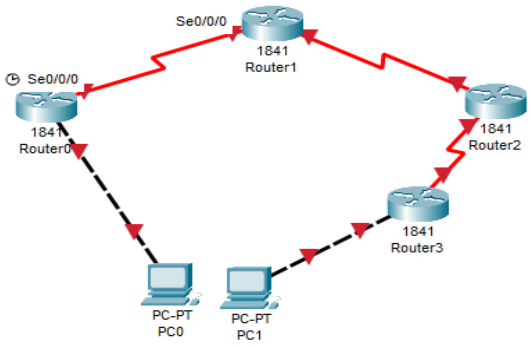
Advantage of static routing

- It is easy to implement.
- It is most secure way of routing, since no information is shared with other routers.
- It puts no overhead on resources such as CPU or memory.

Disadvantage of static routing

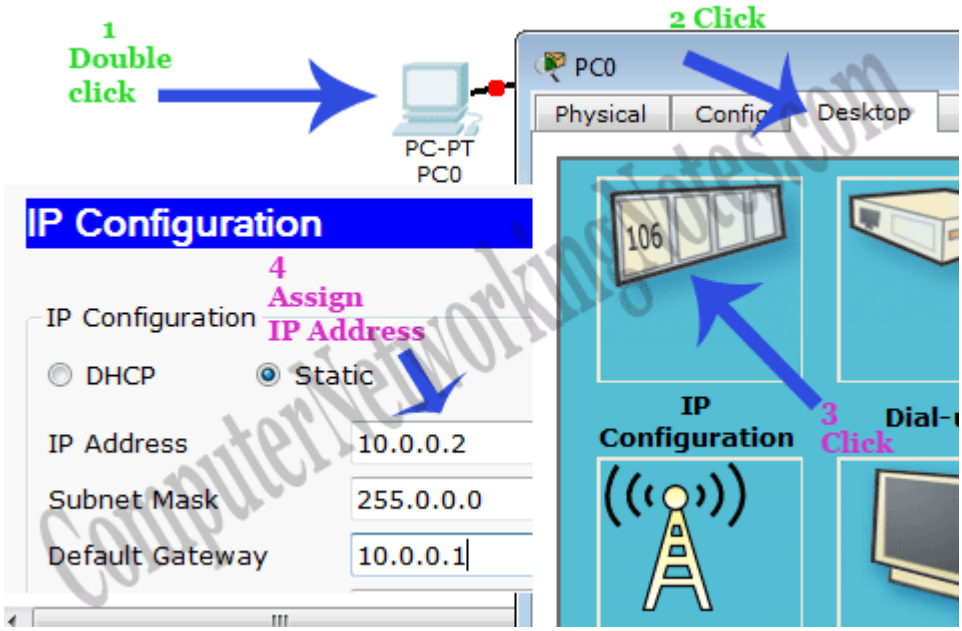
- It is suitable only for small network.
- If a link fails it cannot reroute the traffic.

Device	Connected from	Connected to	IP Address
PC0	FastEthernet0	Router0'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
Router2	Serial0/0/0	Router1's Serial0/0/1	192.168.0.250/30
Router2	Serial0/0/1	Router3's Serial0/0/0	192.168.0.245/30
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



Assign IP address to PCs

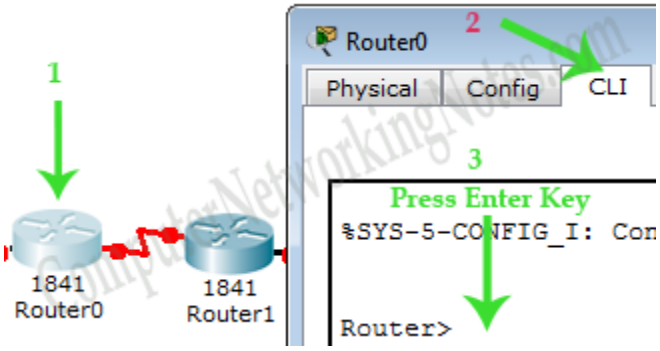
Assign IP address 10.0.0.2/8 to PC0.



Repeat same process for PC1 and assign IP address 20.0.0.2/8.

Assign IP address to interfaces of routers

Double click Router0 and click CLI and press Enter key to access the command prompt of Router0.



Two interfaces FastEthernet0/0 and Serial0/0/0 of Router0 are used in this topology. By default interfaces on router are remain administratively down during the start up.

We need to configure IP address and other parameters on interfaces before we could actually use them for routing. Interface mode is used to assign IP address and other parameters. Interface mode can be accessed from global configuration mode. Following commands are used to access the global configuration mode.

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#
```

From global configuration mode we can enter in interface mode. From there we can configure the interface. Following commands will assign IP address on FastEthernet0/0.

```
Router(config)#interface fastEthernet 0/0
Router(config-if)#ip address 10.0.0.1 255.0.0.0
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#
```

interface fastEthernet 0/0 command is used to enter in interface mode.

ip address 10.0.0.1 255.0.0.0 command will assign IP address to interface.

no shutdown command will bring the interface up.

exit command is used to return in global configuration mode.

Serial interface needs two additional parameters ***clock rate*** and ***bandwidth***. Every serial cable has two ends DTE and DCE. These parameters are always configured at DCE end.

We can use ***show controllers interface*** command from privilege mode to check the cable's end.

```
Router#show controllers serial 0/0/0
Interface Serial0/0/0
Hardware is PowerQUICC MPC860
DCE V.35, clock rate 2000000
[Output omitted]
```

Fourth line of output confirms that DCE end of serial cable is attached. If you see DTE here instead of DCE skip these parameters.

Now we have necessary information let's assign IP address to serial interface.

```
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface serial 0/0/0
Router(config-if)#ip address 192.168.0.253 255.255.255.252
Router(config-if)#clock rate 64000
Router(config-if)#bandwidth 64
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#
```

Router#configure terminal Command is used to enter in global configuration mode.

Router(config)#interface serial 0/0/0 Command is used to enter in interface mode.

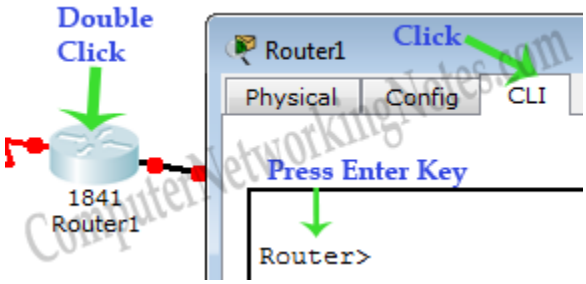
Router(config-if)#ip address 192.168.0.253 255.255.255.252 Command assigns IP address to interface. For serial link we usually use IP address from /30 subnet.

Router(config-if)#clock rate 64000 And ***Router(config-if)#bandwidth 64*** In real life environment these parameters control the data flow between serial links and need to be set at service providers end. In lab environment we need not to worry about these values. We can use these values.

Router(config-if)#no shutdown Command brings interface up.

Router(config-if)#exit Command is used to return in global configuration mode.

We will use same commands to assign IP addresses on interfaces of remaining routers. We need to provided clock rate and bandwidth only on DCE side of serial interface. Following command will assign IP addresses on interface of Router1.



```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface serial 0/0/0
Router(config-if)#ip address 192.168.0.254 255.255.255.252
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#interface serial 0/0/1
Router(config-if)#ip address 192.168.0.249 255.255.255.252
Router(config-if)#clock rate 64000
Router(config-if)#bandwidth 64
Router(config-if)#no shutdown
Router(config-if)#exit
```

Now we know how to assign IP addresses on interfaces. We will use same commands to assign IP addresses on interfaces of Router2.

Router2

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface serial 0/0/0
Router(config-if)#ip address 192.168.0.250 255.255.255.252
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#interface serial 0/0/1
Router(config-if)#ip address 192.168.0.245 255.255.255.252
Router(config-if)#clock rate 64000
Router(config-if)#bandwidth 64
Router(config-if)#no shutdown
Router(config-if)#exit
```

Repeat same process for Router3

Router3

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface fastEthernet 0/0
Router(config-if)#ip address 20.0.0.1 255.0.0.0
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#interface serial 0/0/0
Router(config-if)#ip address 192.168.0.246 255.255.255.252
Router(config-if)#no shutdown
Router(config-if)#exit
```

Now routers have information about the networks that they have on their own interfaces. Routers do not exchange network information between them on their own. We need to implement a mechanism that insists them to share this information. This mechanism is called routing.

There are two types of routing static and dynamic. In this lab we will use static method of routing.

Command to configure the static route

We have two commands to configure the static route.

```
Router(config)# ip route destination_network_# [subnet_mask] IP_address_of_next_hop_neighbor [administrative_distance] [permanent]
```

Or

```
Router(config)# ip route destination_network_# [subnet_mask] interface_to_exit [administrative_distance] [permanent]
```

ip route

This is the base command that adds new routes in routing table.

destination_network_#[subnet_mask]

This is the first parameter. It specifies the destination network address. We need to provide subnet mask if we are using sub-network. Sub-networks are the smaller network created from one large network in subnetting. If we are not using sub-network then we can omit the subnet mask value. It will parse automatically.

IP_address_of_next_hop_neighbor / interface_to_exit

This parameter provides a way to reach the destination network. Both commands use separate way to assign this value. First command provides the IP address of next hop neighbor. It tells router that if it receives a packet for destination [that we set in previous parameter], forward that packet to this next hop neighbor IP address.

Second command also do the same job but in different way. It specifies exit interface instead of next hop IP address. It tells router that if it receives a packet for the destination specified by previous parameter then exits that packet from this interface. Device attached on other end of this interface will take care of the packet.

administrative_distance

Administrative distance is the trustworthiness of route. Route with the lowest AD value will be chosen while forwarding the packet. By default static route has two AD values depending on the previous parameter. If you have used next hop neighbor IP address, then the default AD value

will be 1. If you have used exit interface, then the default AD value will be 0. This parameter allows us to create multiple static routes for the same destination. For example we can create primary and backup path for the destination network. To create backup path, we need to set AD value to higher than default, such as 2 or 3. With this configuration router will use primary path. Due to some reason if primary route fails, the router will start using backup route automatically.

permanent

When a route goes down router will remove that from routing table. Permanent parameter will keep this route in routing table even if it goes down. Its optional parameter we can omit it. If we omit it, router will remove this route from routing table if it goes down. You might use this parameter for security reason if you never want packets to take another path.

Now we are familiar with IP route command and its parameters lets implement it in our network.

Configure Static Route

By default when a packet arrives in interface, router checks destination filed in packet and compare it with routing table. If it finds a match for destination network then it will forward that packet from related interface. If it does not find a match in routing table then it will discard that packet. This is the default behavior of router. We do not need to configure directly connected networks.

Run following command from global configuration mode in routers.

Router0

```
Router(config)#ip route 20.0.0.0 255.0.0.0 192.168.0.254
```

This command instructs router that when you receive a packet for 20.0.0.0 network give it to 192.168.0.254. Network 10.0.0.0 is directly connected so we do not need to configure it here.

Router1

```
Router(config)#ip  route 10.0.0.0 255.0.0.0 192.168.0.253
Router(config)#ip  route 20.0.0.0 255.0.0.0 192.168.0.250
```

On this router both networks are reachable via other routers so we need to configure route for both networks 10.0.0.0 and 20.0.0.0.

Router2

```
Router(config)#ip  route 10.0.0.0 255.0.0.0 192.168.0.249
Router(config)#ip  route 20.0.0.0 255.0.0.0 192.168.0.246
```

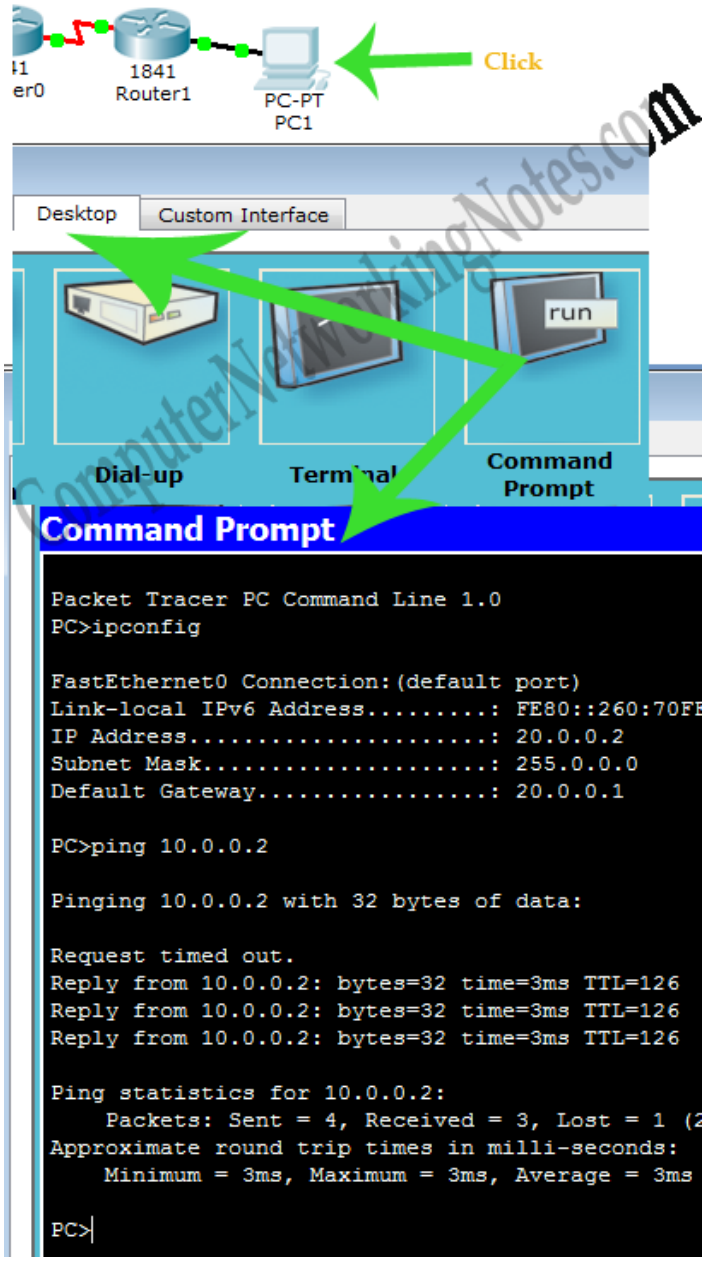
Same as Router1 again we need configure route for both networks on this router.

Router3

```
Router(config)#ip  route 10.0.0.0 255.0.0.0 192.168.0.245
```

Network 20.0.0.0 is directly connected so we only need to configure network 10.0.0.0 on this router.

To verify the result we can use ping command. Access the command prompt of PC1 and use ping command to test the connectivity from PC0.



How to Delete Static Route

In static routing we have to manage all routes manually. If any route goes down, we have to remove that manually. Removing a route in static routing is easier than you think. All you need to do is just add a keyword no before the same command that we have used to configure the static route.

no ip route command is used to remove the route from routing table. Following commands will remove the route from their respective routes.

Router0

```
Router(config)#no ip route 20.0.0.0 255.0.0.0 192.168.0.254
```

Router1

```
Router(config)#no  ip  route 10.0.0.0 255.0.0.0 192.168.0.253
Router(config)#no ip  route 20.0.0.0 255.0.0.0 192.168.0.250
```

Router2

```
Router(config)#no ip  route 10.0.0.0 255.0.0.0 192.168.0.249
Router(config)#no ip  route 20.0.0.0 255.0.0.0 192.168.0.246
```

Router3

```
Router(config)#no ip  route 10.0.0.0 255.0.0.0 192.168.0.245
```

Configure Default Route

Static routing solves one more network problem. It can redirect all unmatched packets to a certain port. This feature is extremely helpful in several situations. 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 behavior. 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.

Following command will set default route

```
Router(config)# ip route 0.0.0.0 0.0.0.0 IP_address_of_next_hop_neighbor
[administrative_distance] [permanent]
```

Or

```
Router(config)# ip route 0.0.0.0 0.0.0.0 interface_to_exit
[administrative_distance] [permanent]
```

Above command sets destination network to 0.0.0.0/0 that represents all networks.