

**ROUTERS**

### What is Router?

- Communicates between different networks
- It provides WAN connectivity
- It does routing (Selects best paths)
- It works at Layer 3
- It can read IP Header
- It maintains IP routing table which contains best paths to destination networks

### Types of Routers

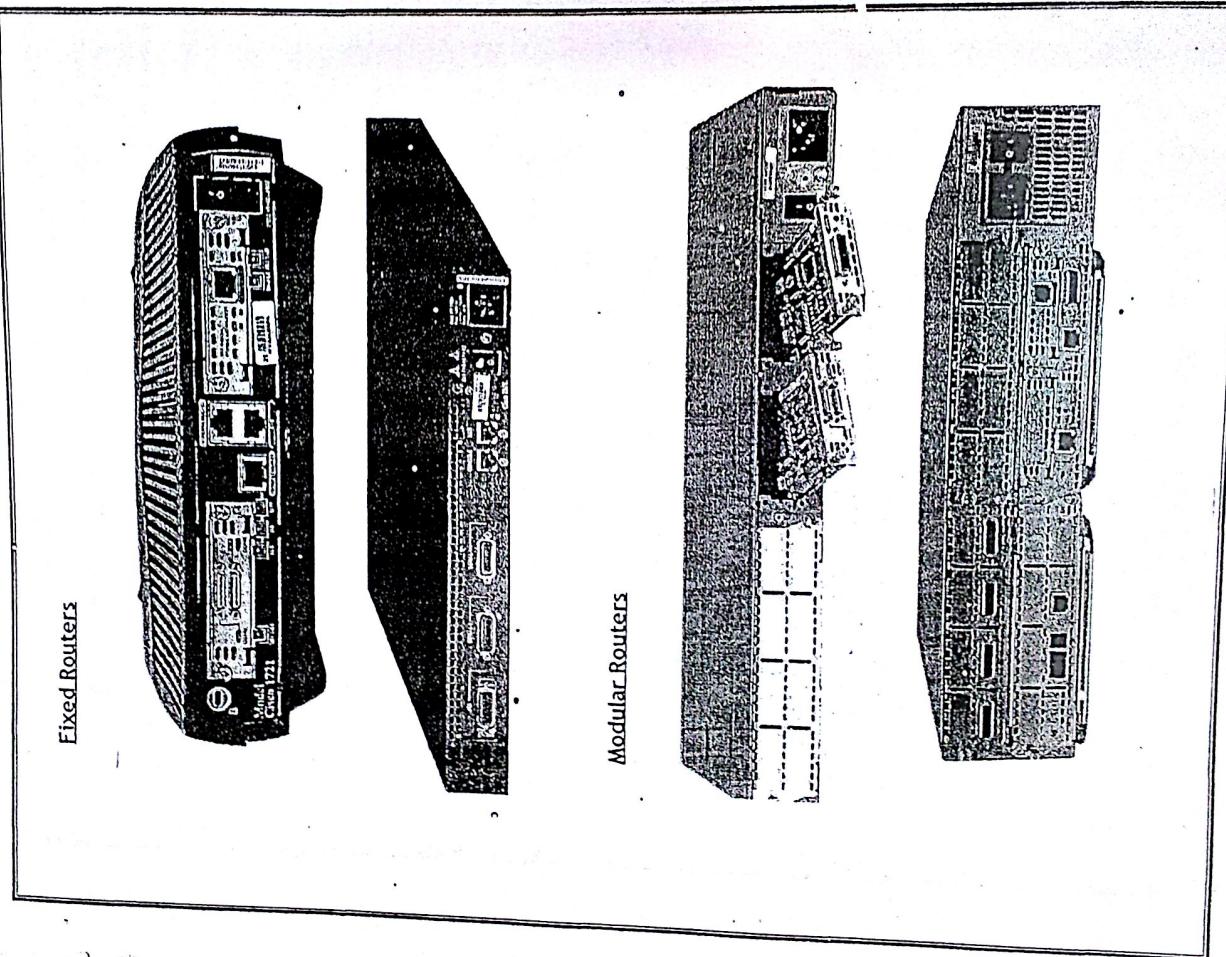
- Software Routers
  - Dual home system with routing enabled
  - Windows 2003 server, Linux Server
- Hardware Routers
  - Hardware device - Dedicated routing
  - Cisco router

### Router manufacturers

- CISCO
- DAX
- JUNIPER
- LINKSYS
- NOKIA
- D-LINK
- ZYXEL
- 3COM

### Types of Cisco Routers:

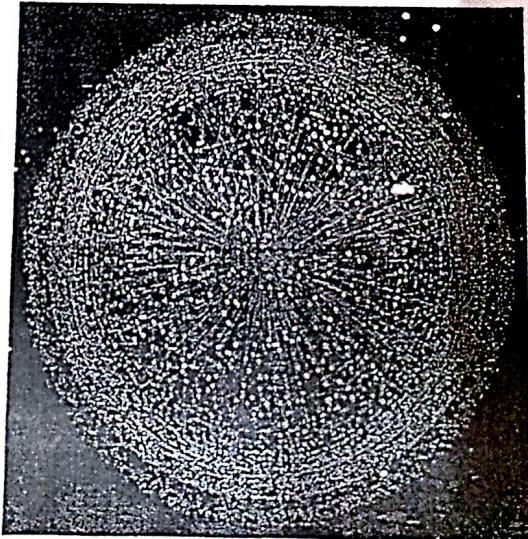
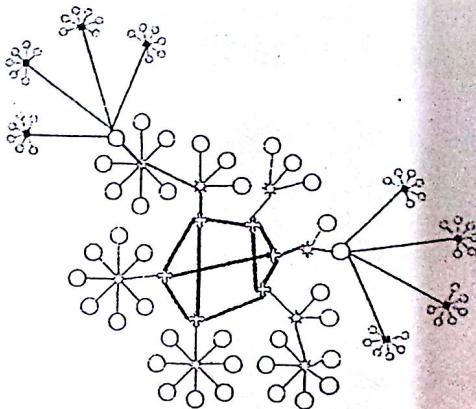
- Fixed Routers
  - Fixed No of interfaces
  - No hardware upgrade
  - Cheaper
- Modular Routers
  - No of interfaces can be increased
  - Hardware upgrade is possible
  - Costlier



### Internet Structure:

Internet centers, companies are connected to local ISPs (Internet Service Provider)  
Local ISPs are connected to Regional ISPs  
Regional ISPs are connected to National ISPs  
National ISPs are connected to Global ISPs

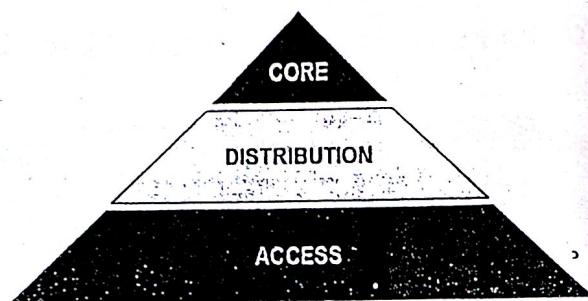
Data flow rate is low at Local ISPs and gradually increases till Global ISPs  
The devices at Global ISPs must be high end devices



### Cisco 3-Layer hierarchy

Cisco routers are divided into 3 categories based on hardware capabilities

- Access Layer
- Distribution Layer
- Core Layer



#### Access Layer:

- Used for small Organizations
- Data transfer speed is low
- Local ISPs
- 1600, 1700, 2500 series routers
- Fixed Routers

#### Distribution Layer:

- Used for medium level Organizations
- Data transfer speed is medium
- Regional ISPs, National ISPs
- 2600, 2800, 3600 series routers
- Modular Routers

#### Core Layer:

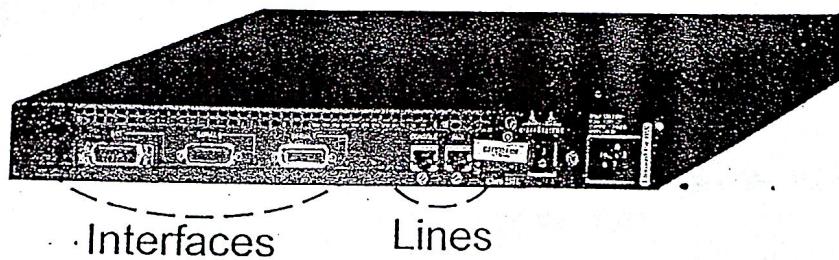
- Used for medium level Organizations
- Data transfer speed is high
- National ISPs , Global ISPs
- 6000, 7000, 10000, 12000 series routers
- Modular Routers

### Router Model Numbers:

2500 series has following models

- 2501
- 2503
- 2509
- 2511
- 2520

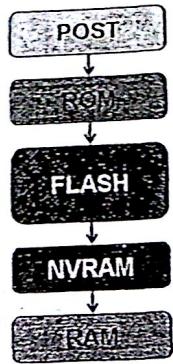
### Router Physical Structure - External Components - Cisco 2501



### Router Ports:

- **Interfaces: For data transfer**
  - ❖ LAN interfaces: For LAN connectivity
    - e 0, e 1, e 2, fa 0/0, fa 0/1
  - ❖ WAN interfaces: For WAN connectivity
    - s 0, s1, s2, s3, s 0/0, s 0/1
- **Lines: For Router management**
  - ❖ Physical lines: Exist on router
    - Console 0 (local), aux 0 (remote)
  - ❖ Logical lines: Not exist on router
    - Vty 0 4 (also called as telnet)

### Router internal Components - Boot sequence



#### POST:

- Power On Self Test
- Hardware Checkup
- RAM, CPU, Interfaces diagnosis

#### ROM:

- Read only Memory
- Bootstrap loader / Mini IOS
- Finds the location of complete IOS

#### FLASH:

- Complete IOS Image
- May have multiple IOS Images
- Router operates with single IOS
- Eg: c2500-d-l.120-7.bin

#### NVRAM:

- Non Volatile Random Access Memory
- Permanent configuration
- File name : Startup-config
- Router always uses nvram configuration when booting
- Router copies NVRAM into RAM

#### RAM:

- Random Access Memory
- Temporary configuration
- File name : Running-config
- Router copies NVRAM into RAM
- Router always works with RAM configuration only

### What is the Operating System in Router?

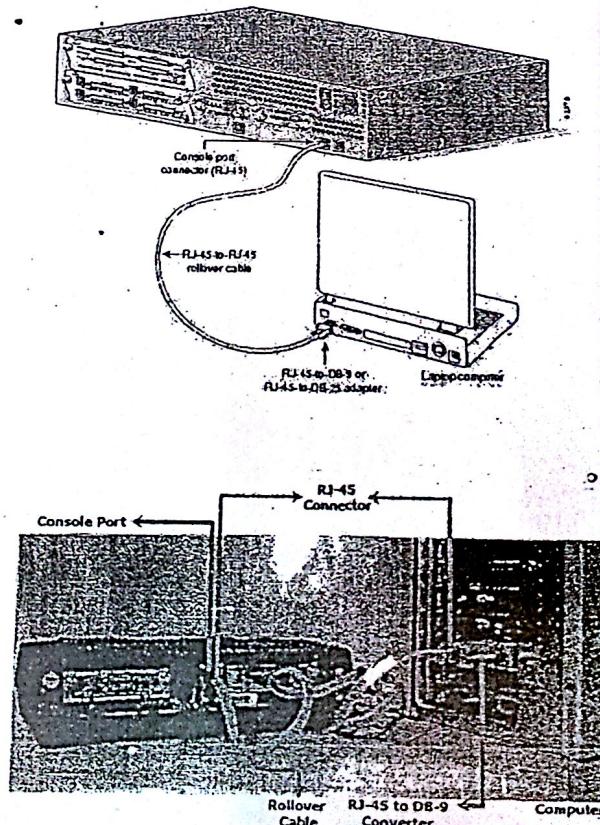
- Router works on IOS
- IOS - Internetwork Operating System
- Router works on single IOS Image File

### Router Configuration is Mandatory?

- Configuration is mandatory
- Router works if it is configured properly
- Don't connect the router without configuration
- Router is not a zero touch configuration device

### How to configure the router?

- Use console 0 to configure the router for the first time
- Connect roll over cable between console 0 on router & COM1 port on the computer/laptop



### Emulation Software:

- One application is required on the laptop/system to access IOS and to configure the router. This software is called emulation software

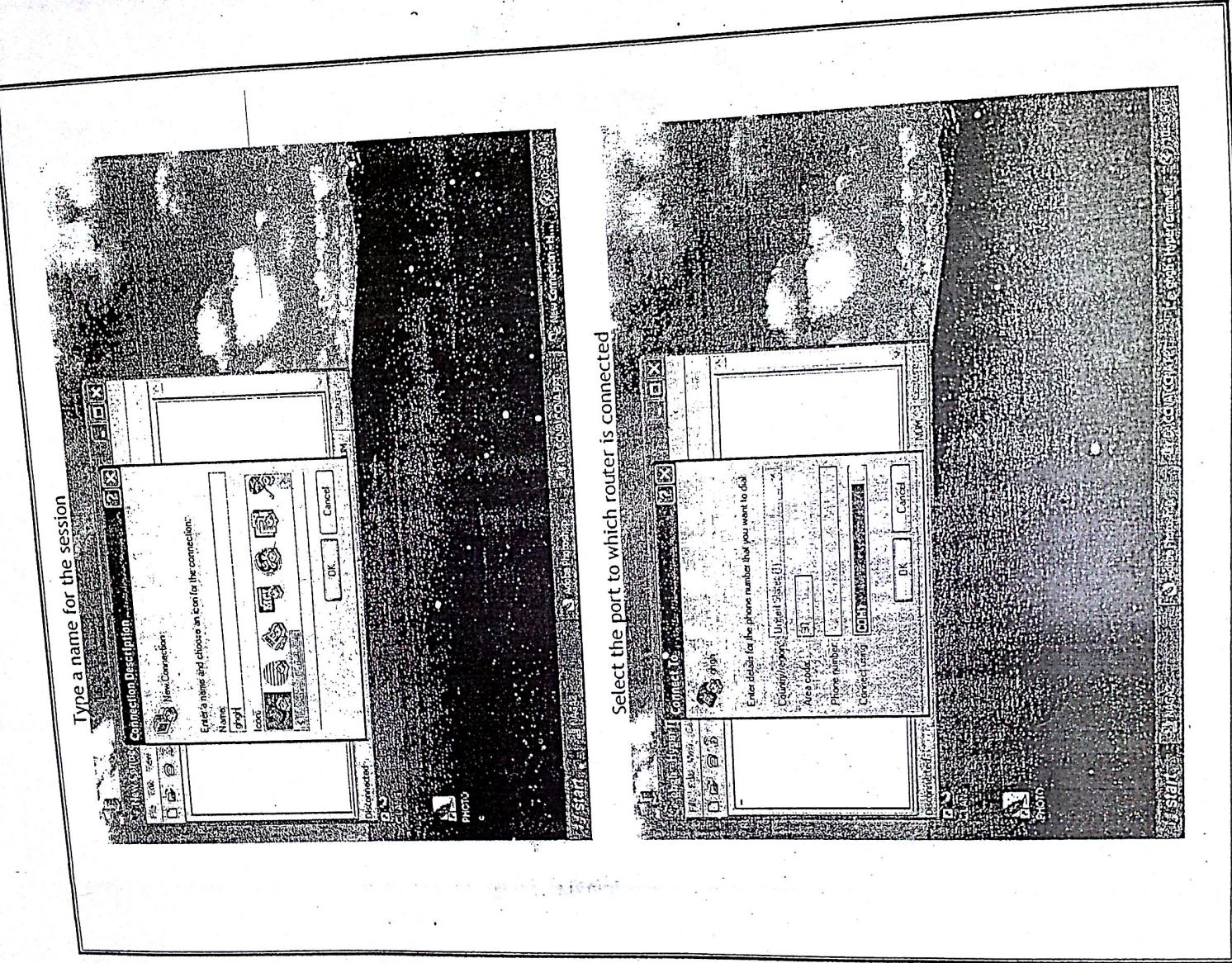
Eg: hyper terminal, Putty

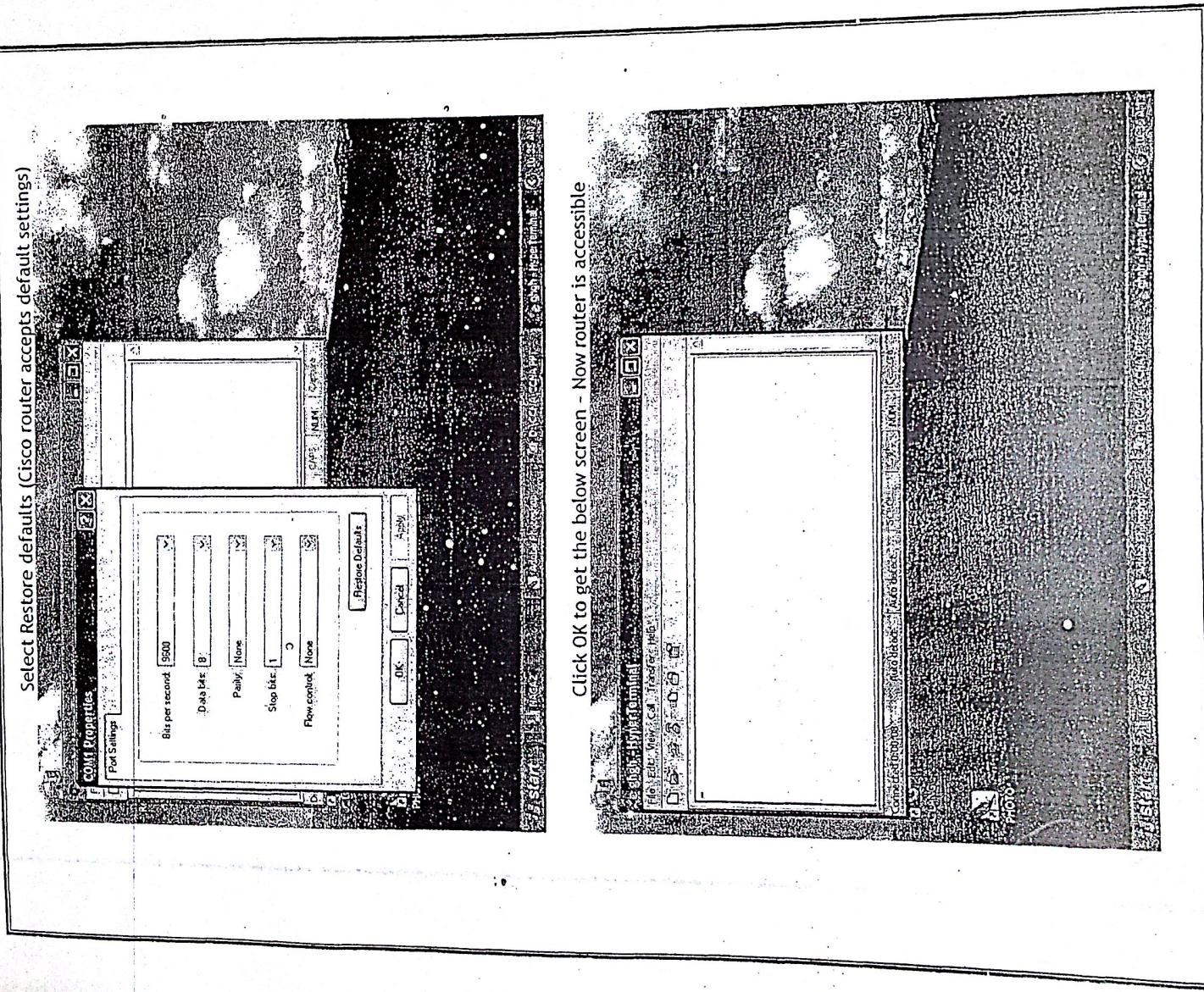
Hyper terminal is the default program in Windows XP

### How to access Hyper terminal:

- Start → Programs → Accessories → communications → hyper terminal (or)
- Type hyperterm at run prompt



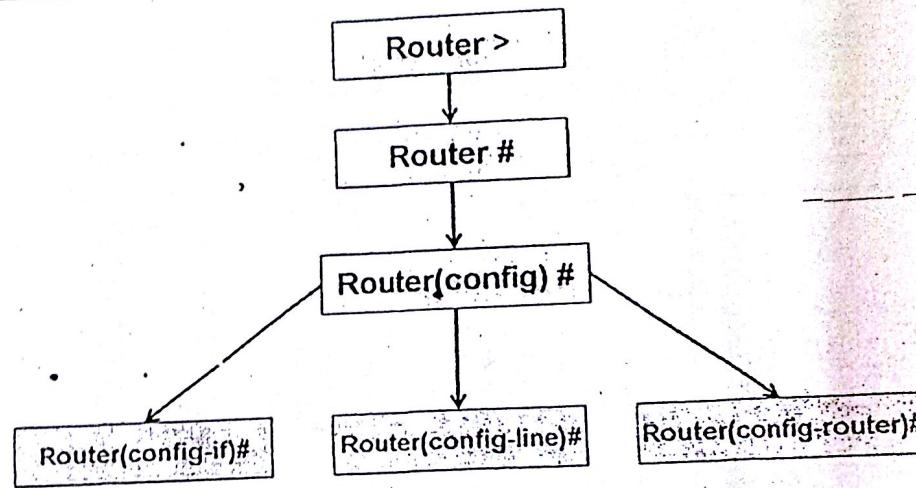




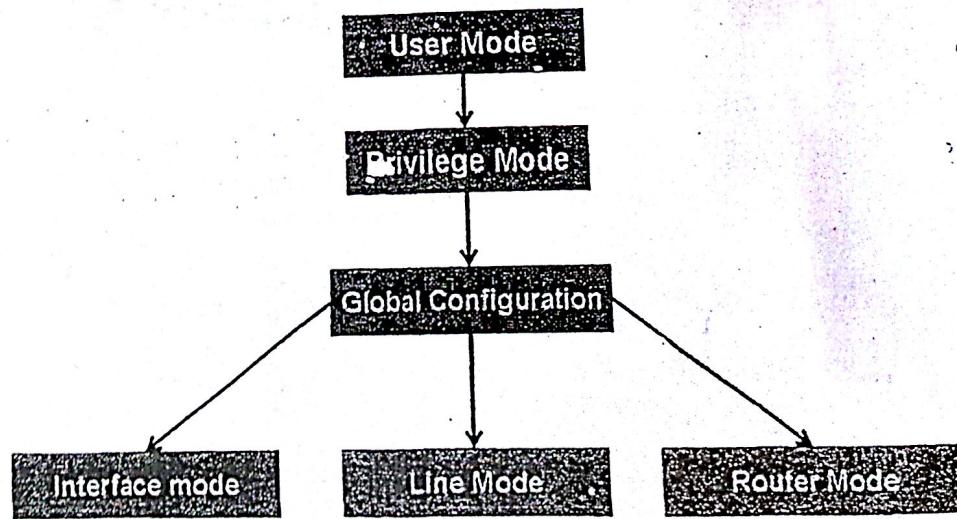
## Router Modes

- Cisco IOS has different modes
- Every mode has its own functionalities
- Cisco IOS is CLI (command line interface) based
- Commands are mode specific

### Router Modes - Prompts:

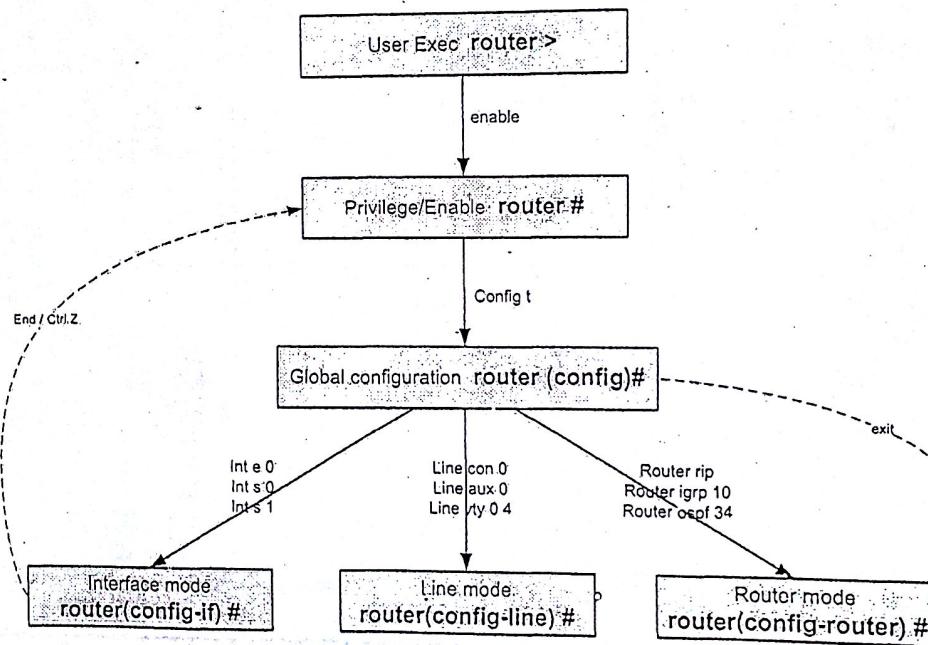


### Router Modes - Names:



## Router Modes - Navigation

### ROUTER MODES



## Router Modes - Functionalities - Commands

### 1. User mode: Router>

#### Functions:

- > To check the Connectivity
- > It has limited functionality

#### Commands:

Command	Function
telnet ip	to telnet into a device
Ping ip	to check connectivity
Traceroute ip	to trace the path
Enable	to enter privilege mode

### 2. Privilege mode: Router#

#### Functions:

- > View Entire configuration
- > Backup & Recovery

#### Commands:

Command	Function
Show run	to see temporary configuration
Show start	to see permanent configuration
Show int s 0	displays info about interface s 0
Show ip route	displays routing table
Show version	displays version, config register value
Show flash	displays flash contents /ios image
Show ip protocols	displays configured routing protocols
Show ip int brief	displays interface ip information
Show controllers serial 0	displays hardware info of s0 -DCE/DTE
Reload	restarts the router
Config t	enters into global configuration mode
Copy run start / Write	save RAM contents to NVRAM

### 3. Global configuration mode: Router (config)#

#### Functions:

- To do entire configuration of router (globally)

#### Commands:

Command	Function
No logging console	turns off logging (logging messages)
Hostname <i>hostname</i>	changes the hostname
Enable password <i>cisco</i>	set privilege mode password
Enable secret <i>cisco</i>	set secret password for privilege mode
Ip routing	Enables routing table
No ip routing	Disables routing table
Config-register 0x2102	Sets the config register value to 2102
Ip route	To configure static route
Int s 0	
Int s 1	to interface mode
Int e 0	
Line con 0	
Line aux 0	to line mode
Line vty 0 4	
Router rip	
Router eigrp 23	to router mode
Router ospf 56	

### 4. Interface mode: Router (config-if)#

#### Functions:

- Configuration of interfaces

#### Commands:

Command	Function
ip address <ip><subnetmask>	to configure ip address for interface
no shutdown	activate the interface
encapsulation hdlc	set L2 encapsulation for wan ports
clock rate 64000	set clock rate (DCE interfaces)
bandwidth 64	set interface bandwidth

### 5. Line mode: Router(config-line) #

#### Functions:

- Authentication of lines
- Configuring console 0, aux 0, vty 0 4

#### Commands:

Command	Function
Password <password>	To configure password for line
login	To set login type

### 6. Router mode: Router(config-router) #

#### Functions:

- To configure dynamic routing protocols

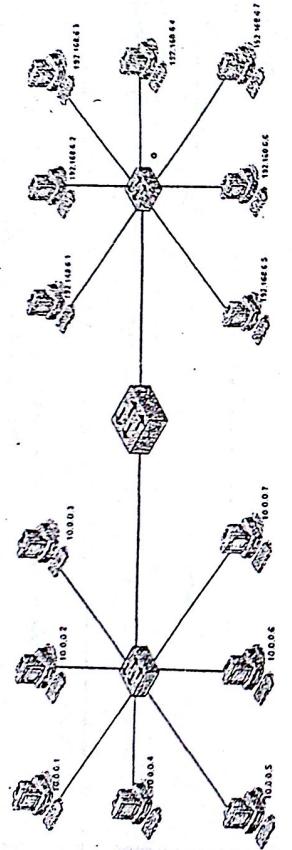
#### Commands:

Command	Function
Network <network address>	To advertise networks in routing
Auto-summary	Auto summarize networks

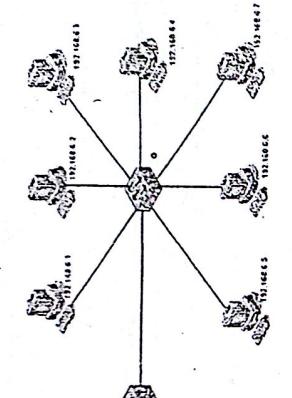
#### Tips in IOS usage:

- Use "?" to get the help
- Use "tab" to get the complete command after entering unique characters of a command
- Use "no" keyword along with the command for reverse results
- Use "q" or "Ctrl+C" to terminate output

Switch in LAN:



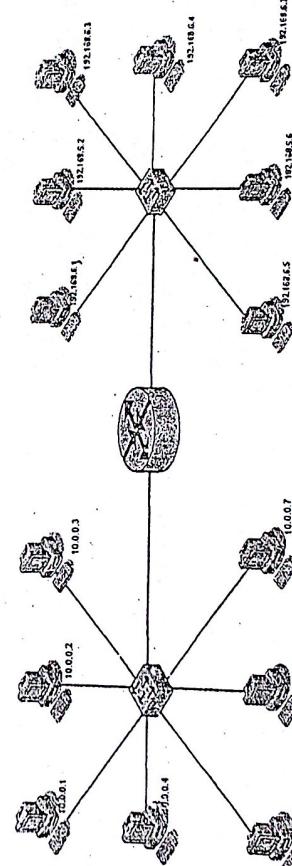
Router & Switch properties



We can talk to  
Second group  
Connected to  
Switch

We can talk to  
First group  
Connected to  
Router

Router in LAN:

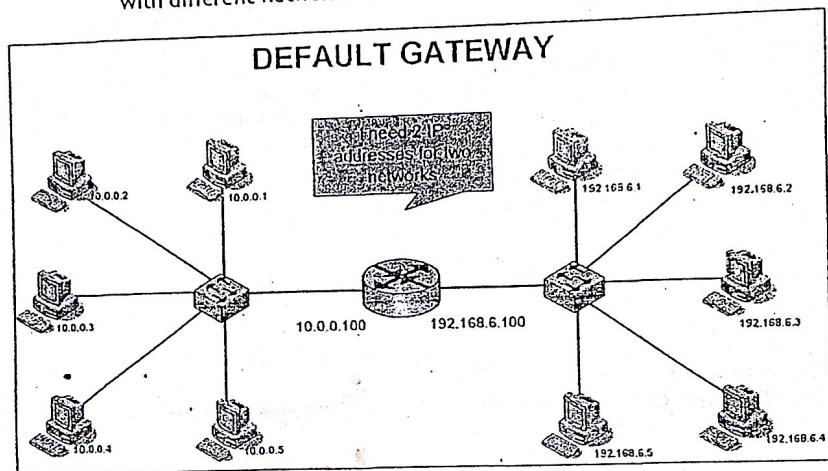


Now we can talk to  
each other  
Connected to  
Router

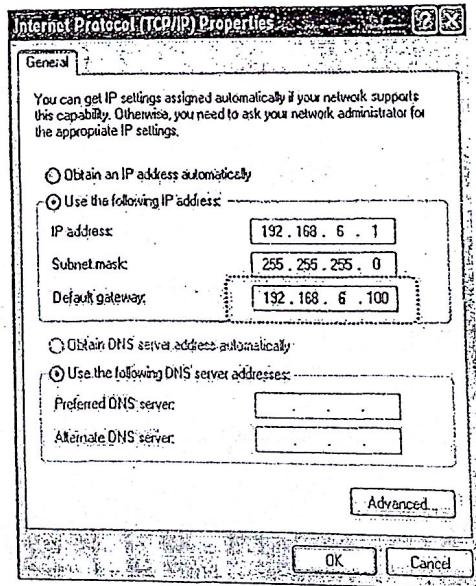
Now we can talk to  
other  
Connected to  
Router

### What is Default Gateway?

- > Entry or Exit point of a network
- > This is the IP address used to communicate with different networks
- > Default gateway is typically the ip address of router
- > Default gateway is not required within the network
- > Default gateway must be configured in every computer to communicate with different networks



### How to assign the Default Gateway?



## What is Routing Table?

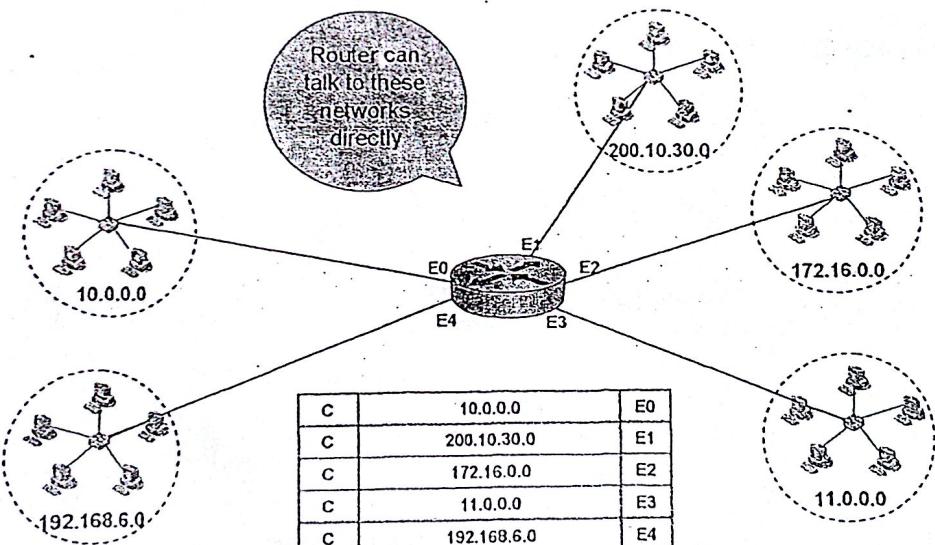
- The list of networks that router knows
- Router can reach only those networks which are presented in its routing table
- Routing table contains only the best paths to reach networks
- Routing table includes network address, exit interface, metric



This is my routing table, so I can reach these networks

C	172.17.0.0	E0
C	12.0.0.0	S0
C	11.0.0.0	S1
S	192.168.6.0	S1
S	192.168.5.0	S0

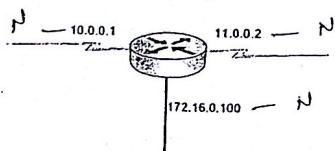
By default routing table contains directly connected networks information



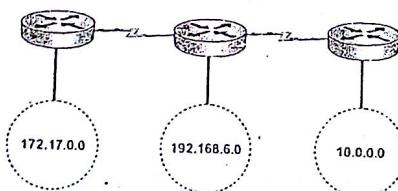
## Network design Rules

- All the connected interfaces must be different networks
- All the LANs must be different networks
- LAN and default gateway must be in same network
- Two directly connected interfaces must be same network

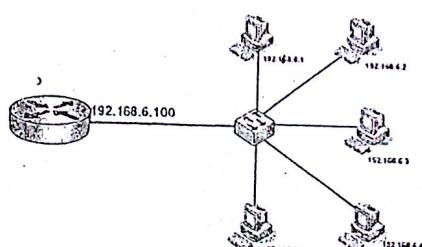
### All the connected interfaces must be different networks



### All the LANs must be Different Networks



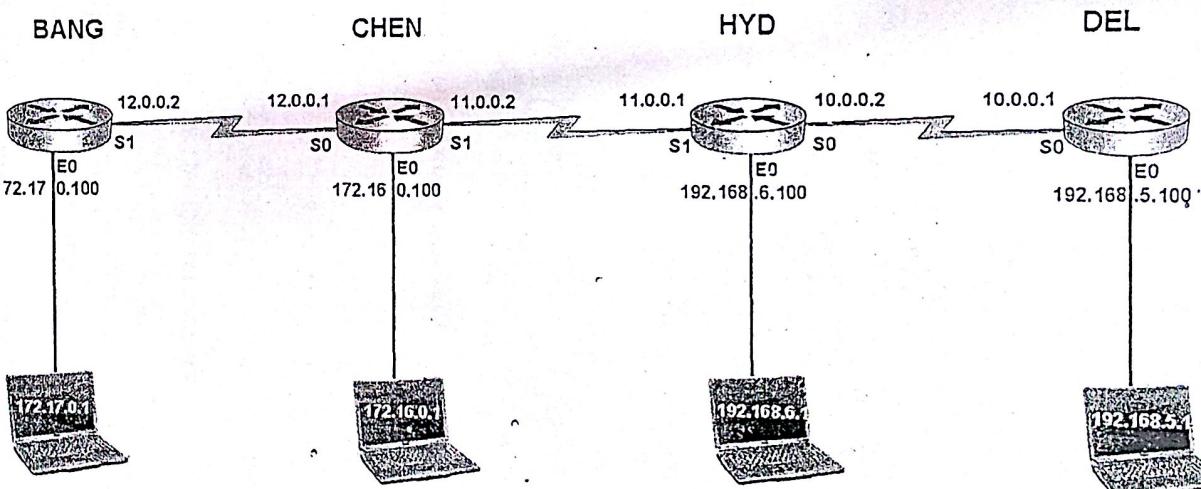
### LAN and default gateway must be in same network



### Two directly connected interfaces must be same network

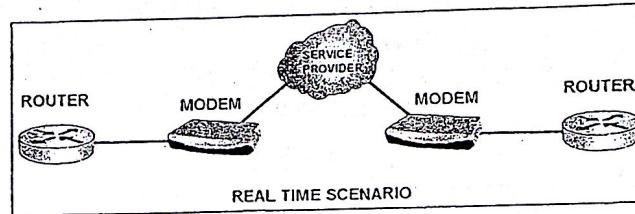


### LAB NETWORK

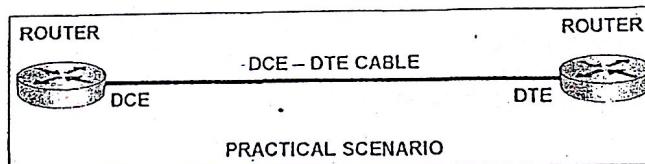


## DCE - DTE

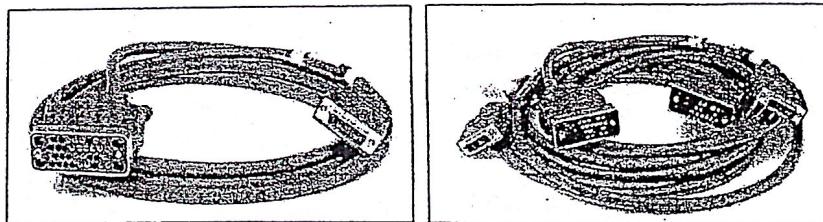
- Data synchronization is required on WAN links (on serial interfaces)
- In real time scenarios this synchronization is provided by modems connected to serial interfaces
- Modems generate clock rate to synchronize the data between WAN ports



- Because of no modems in practical scenarios, this clock rate need to be generated by one of the router in the point to point connectivity
- DCE-DTE cable is used in practical scenarios between routers
- If one router is connected to DCE end, the second router will be connected to DTE end (In point to point connectivity, if one end is DCE, other end is DTE)



### DCE- DTE cables:



### DCE- DTE differences:

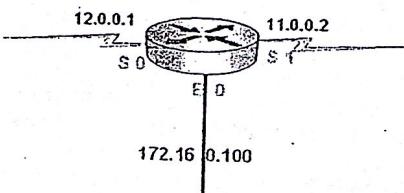
DCE	DTE
Data communication Equipment	Data terminating equipment
Master	SLAVE
Generates clock rate (64000 Hz)	Accepts clock rate
Dial up, leased line modems CSU/DSU	PC, Router

## Router Initial Configuration

> Router is not a zero-touch configuration device  
It must be configured with proper IP Addresses. If not, it won't work

### Router Configuration includes 4 steps

1. Hostname change
2. Secure router
3. Configure interfaces
4. View and Save



#### 1. Hostname Change:

```
Router> enable
Router# config t
Router(config)# hostname CHEN
```

#### 2. Secure Router:

```
CHEN(config)# enable password cisco
CHEN(config)# enable secret ccna
```

```
CHEN(config)# line con 0
CHEN(config-line)# password cisco
CHEN(config-line)# login
CHEN(config-line)# exit
```

```
CHEN(config)# line aux 0
CHEN(config-line)# password cisco
CHEN(config-line)# login
CHEN(config-line)# exit
```

```
CHEN(config)# line vty 0 5
CHEN(config-line)# password cisco
CHEN(config-line)# login
CHEN(config-line)# exit
CHEN(config)# service password-encryption
CHEN(config)# exit
```

### 3. Configure interfaces:

```
CHEN(config)# interface s 1
CHEN(config-if)# ip address 11.0.0.2 255.0.0.0
CHEN(config-if)# no shutdown
CHEN(config-if)# bandwidth 64
CHEN(config-if)# clock rate 64000
CHEN(config-if)# encapsulation hdlc

CHEN(config)# interface s 0
CHEN(config-if)# ip address 12.0.0.1 255.0.0.0
CHEN(config-if)# no shutdown
CHEN(config-if)# bandwidth 64
CHEN(config-if)# clock rate 64000
CHEN(config-if)# encapsulation ppp

CHEN(config)# interface e 0
CHEN(config-if)# ip address 172.16.0.100 255.255.0.0
CHEN(config-if)# no shutdown
CHEN(config-if)# exit
CHEN(config)# exit
```

### 4. View & Save:

```
CHEN# show ip int brief
CHEN# show run
CHEN# show ip route
CHEN# show interfaces

CHEN# copy run start
CHEN# write
```

## Routing

### What is Routing?

- Communication between two different networks
- Router can communicate with those networks presented in its Routing Table
- By default Routing table maintains connected networks Information
- If there is no information in the routing table about a destination network router drops all the packets for that destination
- So Destination networks must be added to the routing table
- This process is called ROUTING

Router(Config)# no ip routing	- To disable routing process
Router(Config)# ip routing	- To enable routing process
Router# show ip route	- To view routing table

### Routing can be done in two ways

- Static Routing
- Dynamic Routing

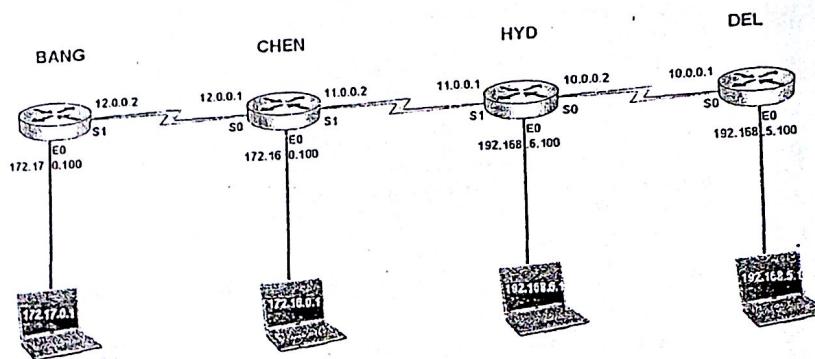
#### Static Routing:

- Manual Routing
- Administrative work is more
- It is suitable for small networks
- Suitable for Fixed networks
- Administrative distance is 1
- Single change may effect all the router configuration

#### Dynamic Routing:

- Routing happens dynamically (auto) by using routing protocols
- Administrative work is less
- It is suitable for large networks
- Suitable for Scalable networks
- Administrative distance depends on routing protocol
- Single change will not effect the remaining routers configuration
- Destination network information is obtained and updated Automatically

### Static Routing



Syntax:

```
Router(Config)# ip route <network> <subnetmask> <exit int>
```

(Or)

Syntax:

```
Router(Config)# ip route <network> <subnetmask> <nexthop>
```

Exit Interface:

Interface on the home router which forwards the data to the next router

Next hop IP address:

Interface IP Address of next immediate router towards the destination

## Static Routing configuration

Bang:

```
Bang> enable
Bang# show ip route
Bang# config t
Bang(config)# no ip routing
Bang(config)# ip routing
Bang(config)# ip route 172.16.0.0 255.255.0.0 s 1
Bang(config)# ip route 192.168.6.0 255.255.255.0 s 1
Bang(config)# ip route 192.168.5.0 255.255.255.0 s 1
Bang(config)# exit
Bang # show ip route
```

Chen:

```
Chen> enable
Chen# show ip route
Chen# config t
Chen(config)# no ip routing
Chen(config)# ip routing
Chen(config)# ip route 172.17.0.0 255.255.0.0 s 0
Chen(config)# ip route 192.168.6.0 255.255.255.0 s 1
Chen(config)# ip route 192.168.5.0 255.255.255.0 s 1
Chen(config)# exit
Chen # show ip route
```

Hyd:

```
Hyd> enable
Hyd# show ip route
Hyd# config t
Hyd(config)# no ip routing
Hyd(config)# ip routing
Hyd(config)# ip route 172.17.0.0 255.255.0.0 s 1
Hyd(config)# ip route 172.16.0.0 255.255.0.0 s 1
Hyd(config)# ip route 192.168.5.0 255.255.255.0 s 0
Hyd(config)# exit
Hyd # show ip route
```

Del:

```
Del> enable
Del# show ip route
Del# config t
Del(config)# no ip routing
Del(config)# ip routing
Del(config)# ip route 172.17.0.0 255.255.0.0 s 0
Del(config)# ip route 172.16.0.0 255.255.0.0 s 0
Del(config)# ip route 192.168.6.0 255.255.255.0 s 0
Del(config)# exit
Del # show ip route
```

## Static default Routing configuration

- It is a form of static routing
- Used when destination information is not available
- Used as the last option
- Configured at "End points" /stub network (with one exit interface)
- In default routing destination network address is 0.0.0.0
- Used in Internet configuration

### Syntax:

```
Router(Config)# ip route 0.0.0.0 0.0.0.0 <exit int>
```

0.0.0.0 Network with 0.0.0.0 subnet mask value represents all ip addresses from 0.0.0.0 to 255.255.255.255

- Bang, Del routers are the end points/stub routers in the LAB network

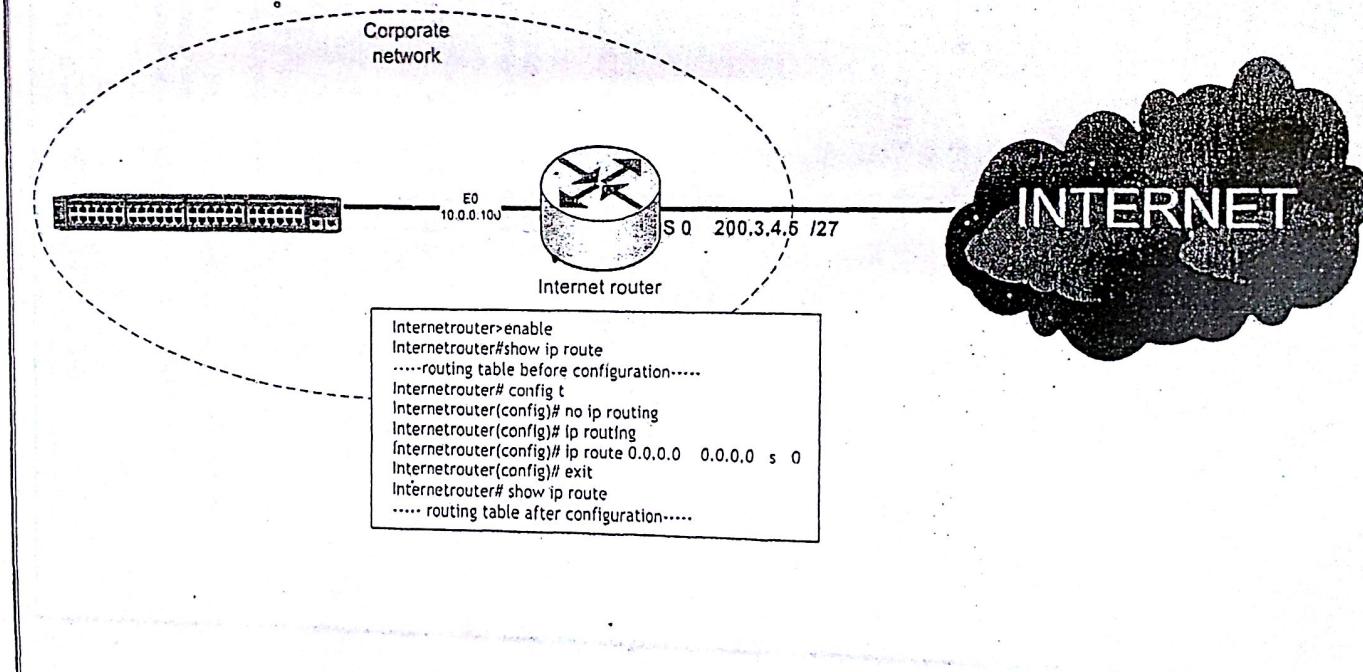
### Bang:

```
Bang> enable  
Bang# show ip route  
Bang# config t  
Bang(config)# no ip routing  
Bang(config)# ip routing  
Bang(config)# ip route 0.0.0.0 0.0.0.0 s 1  
Bang(config)# exit  
Bang # show ip route
```

### Del:

```
Del> enable  
Del# show ip route  
Del# config t  
Del(config)# no ip routing  
Del(config)# ip routing  
Del(config)# ip route 0.0.0.0 0.0.0.0 s 0  
Del(config)# exit  
Del # show ip route
```

### Internet Router Configuration (Static default Routing)

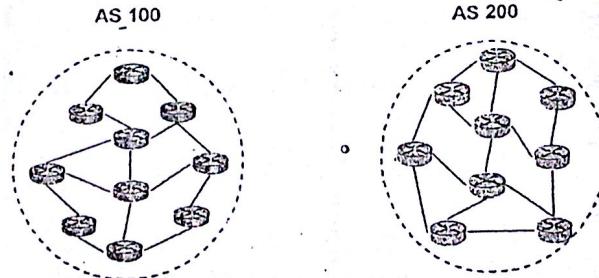


## Dynamic Routing

- Dynamic routing can be done through dynamic Routing Protocols
- Dynamic routing protocols choose the best path. Do not carry data
- Routed protocols carry the data in the chosen path
- Dynamic routing protocols are divided into two categories
  - IGP
  - EGP

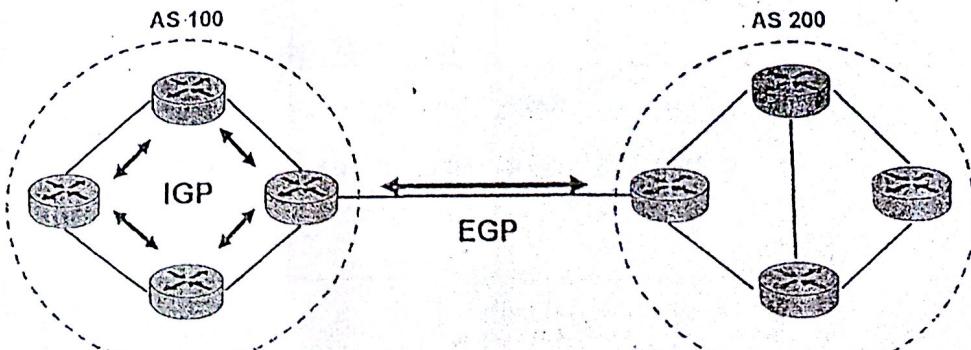
### What is Autonomous System (AS)?

- Autonomous system is the collection of networks with single Administration
- Collection of networks with common routing policies
- Autonomous system is 16 bit value
- Range is 1-65535



### IGP & EGP protocols:

- IGP category protocols work within AS
- EGP category protocols work between AS



#### Intra domain routing:

- Routing within AS
- Possible with IGP protocols

#### Inter domain routing:

- Routing between AS
- Possible with EGP protocols

### Routing Protocols

IGP		EGP	
Distance vector	RIP IGRP		
Link state	OSPF ISIS	Path vector	BGP
Hybrid	RIPv2 EIGRP		

#### IGP Routing Protocols:

- IGP protocols are used to communicate with AS
- IGP protocols are divided into 3 categories
  - Distance Vector
    - ❖ RIP, IGRP
  - Link State
    - ❖ OSPF, ISIS
  - Advanced Distance vector/ Hybrid
    - ❖ RIPv2, EIGRP
- The goal of every routing protocols is same
- That is to select the best path
- But the selection criteria is different
- Every protocol has distinct characteristics in finding best paths

Category	Protocol	Expansion
Distance vector	RIP	Routing Information protocol
	IGRP	Interior Gateway Routing Protocol
Link state	OSPF	Open Shortest Path First
	ISIS	Intermediate system to Intermediate system
Hybrid	EIGRP	Enhanced IGRP
	RIPv2	RIP version 2

#### What is Administrative Distance (AD)?

- It is trustworthiness of a protocol
- It is a value given by cisco that indicates reliability
- It is 8 Bit value : Range 0 -255
- Lesser the AD better the routing protocol

Protocol	A:D
Connected	0
Static route	1
RIP	120
IGRP	100
EIGRP	90
OSPF	110
ISIS	115
RIPV2	120
Eigrp summary	5
External BGP	20
EGP	140
ODR	160
External Eigrp	170
Internal BGP	200
Unknown	255

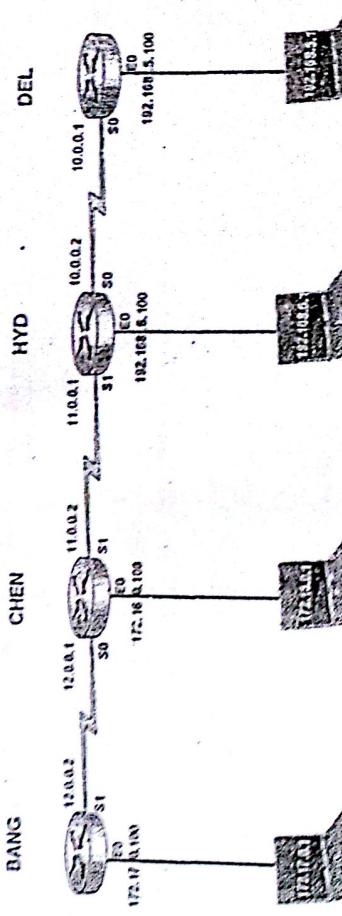
## RIPv1

### Routing Information Protocol (v1)

Ad=120 (Administrative distance)  
Metric-hop count (15=max, 16=invalid)  
Algorithm: bellman ford  
Update timer = 30 sec  
Invalid timer = 180 sec  
Hold down timer = 180 sec  
Flush timer = 240 sec  
Load balancing = 6, equal paths  
Classful routing (subnetting "not" supported)  
Open Standard

#### Syntax:

```
Router(config)# router rip  
Router(config-router)# network <network Address>
```



## RIPv1 configuration

Bang:

```
Bang> enable
Bang# config t
Bang(config)# no ip routing
Bang(config)# ip routing
Bang(config)# router rip
Bang(config-router)# version 1
Bang(config-router)# network 172.17.0.0
Bang(config-router)# network 12.0.0.0
Bang(config-router)# end
Bang # show ip route
```

Chen:

```
Chen> enable
Chen# config t
Chen(config)# no ip routing
Chen(config)# ip routing
Chen(config)# router rip
Chen(config-router)# version 1
Chen(config-router)# network 172.16.0.0
Chen(config-router)# network 12.0.0.0
Chen(config-router)# network 11.0.0.0
Chen(config-router)# end
Chen # show ip route
```

Hyd:

```
Hyd> enable
Hyd# config t
Hyd(config)# no ip routing
Hyd(config)# ip routing
Hyd(config)# router rip
Hyd(config-router)# version 1
Hyd(config-router)# network 192.168.6.0
Hyd(config-router)# network 11.0.0.0
Hyd(config-router)# network 10.0.0.0
Hyd(config-router)# end
Hyd # show ip route
```

Del:

```
Del> enable
Del# config t
Del(config)# no ip routing
Del(config)# ip routing
Del(config)# router rip
Del(config-router)# version 1
Del(config-router)# network 192.168.5.0
Del(config-router)# network 10.0.0.0
Del(config-router)# end
Del # show ip route
```

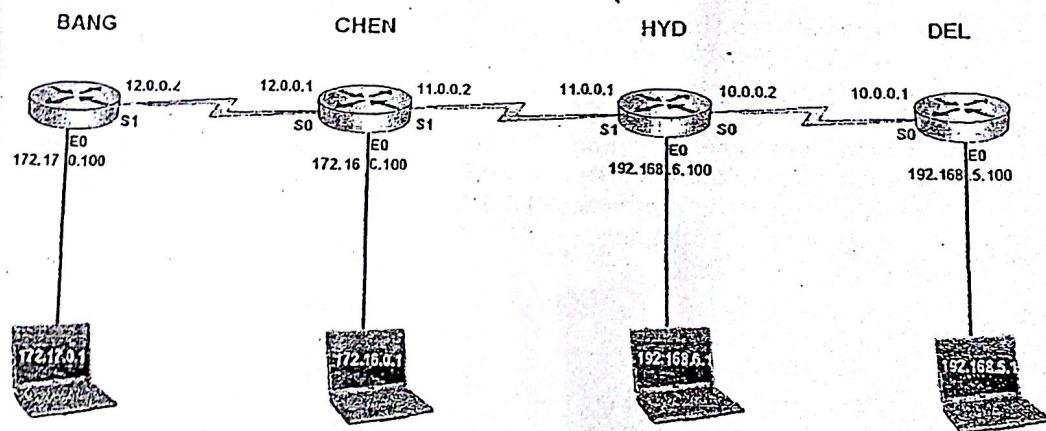
## RIPv2

### Routing Information Protocol (v2)

- AD=120 (Administrative distance)
- Metric=hop count (15=max, 16=invalid)
- Algorithm= bellman ford
- Triggered updates
- Multicast updates on 224.0.0.9
- Load balancing =6 equal paths
- Classless routing (subnetting supported)
- Open Standard

#### Syntax:

```
Router(config)# router rip  
Router(config-router)# version 2  
Router(config-router)# network <network Address>
```



### RIPv2 configuration

Bang:

```
Bang> enable
Bang# config t
Bang(config)# no ip routing
Bang(config)# ip routing
Bang(config)# router rip
Bang(config-router)# version 2
Bang(config-router)# network 172.17.0.0
Bang(config-router)# network 12.0.0.0
Bang(config-router)# end
Bang # show ip route
```

Chen:

```
Chen> enable
Chen# config t
Chen(config)# no ip routing
Chen(config)# ip routing
Chen(config)# router rip
Chen(config-router)# version 2
Chen(config-router)# network 172.16.0.0
Chen(config-router)# network 12.0.0.0
Chen(config-router)# network 11.0.0.0
Chen(config-router)# end
Chen(config-router)# show ip route
```

Hyd:

```
Hyd> enable
Hyd# config t
Hyd(config)# no ip routing
Hyd(config)# ip routing
Hyd(config)# router rip
Hyd(config-router)# version 2
Hyd(config-router)# network 192.168.6.0
Hyd(config-router)# network 11.0.0.0
Hyd(config-router)# network 10.0.0.0
Hyd(config-router)# end
Hyd # show ip route
```

Del:

```
Del> enable
Del# config t
Del(config)# no ip routing
Del(config)# ip routing
Del(config)# router rip
Del(config-router)# version 2
Del(config-router)# network 192.168.5.0
Del(config-router)# network 10.0.0.0
Del(config-router)# end
Del # show ip route
```

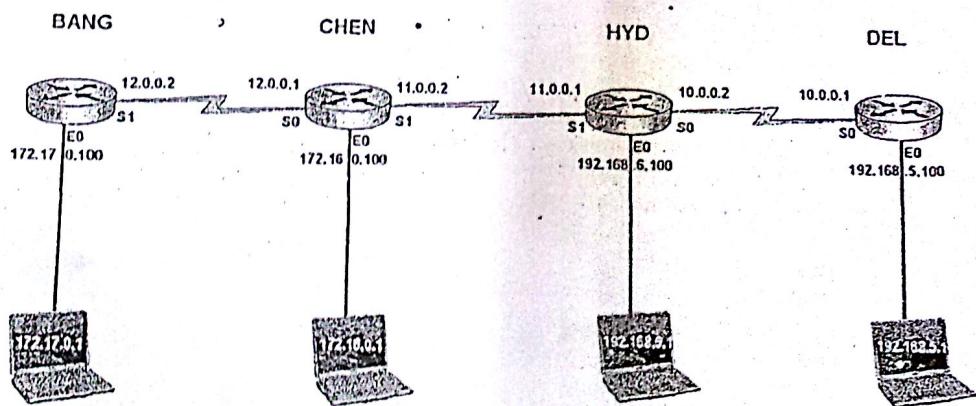
## IGRP

### Interior Gateway Routing Protocol

- AD=100
- Metric = 2<sup>24</sup> Bit Composite  
(Bandwidth+Delay+Load+Reliability+MTU)
- Algorithm = Bellman Ford
- Update timer = 90 Sec
- Invalid timer = 270 Sec
- Hold On timer = 280 Sec
- Flush timer = 630 Sec
- Load balancing = 4-6 equal /unequal paths
- Classful routing ( subnetting "not" supported )
- Cisco proprietary

#### Syntax:

```
Router(config)# router igrp <AS No>
Router(config-router)# network <network Address>
```



## IGRP configuration

Configure all routers in the same Autonomous system  
IGRP communicates within AS only

Bang:

```
Bang> enable
Bang# config t
Bang(config)# no ip routing
Bang(config)# ip routing
Bang(config)# router igrp 87
Bang(config-router)# network 172.17.0.0
Bang(config-router)# network 12.0.0.0
Bang(config-router)# end
Bang # show ip route
```

Chen:

```
Chen> enable
Chen# config t
Chen(config)# no ip routing
Chen(config)# ip routing
Chen(config)# router igrp 87
Chen(config-router)# network 172.16.0.0
Chen(config-router)# network 12.0.0.0
Chen(config-router)# network 11.0.0.0
Chen(config-router)# end
Chen # show ip route
```

Hyd:

```
Hyd> enable
Hyd# config t
Hyd(config)# no ip routing
Hyd(config)# ip routing
Hyd(config)# router igrp 87
Hyd(config-router)# network 192.168.6.0
Hyd(config-router)# network 11.0.0.0
Hyd(config-router)# network 10.0.0.0
Hyd(config-router)# end
Hyd # show ip route
```

Del:

```
Del> enable
Del# config t
Del(config)# no ip routing
Del(config)# ip routing
Del(config)# router igrp 87
Del(config-router)# network 192.168.5.0
Del(config-router)# network 10.0.0.0
Del(config-router)# end
Del # show ip route
```

## EIGRP

### Enhanced Interior Gateway Routing Protocol

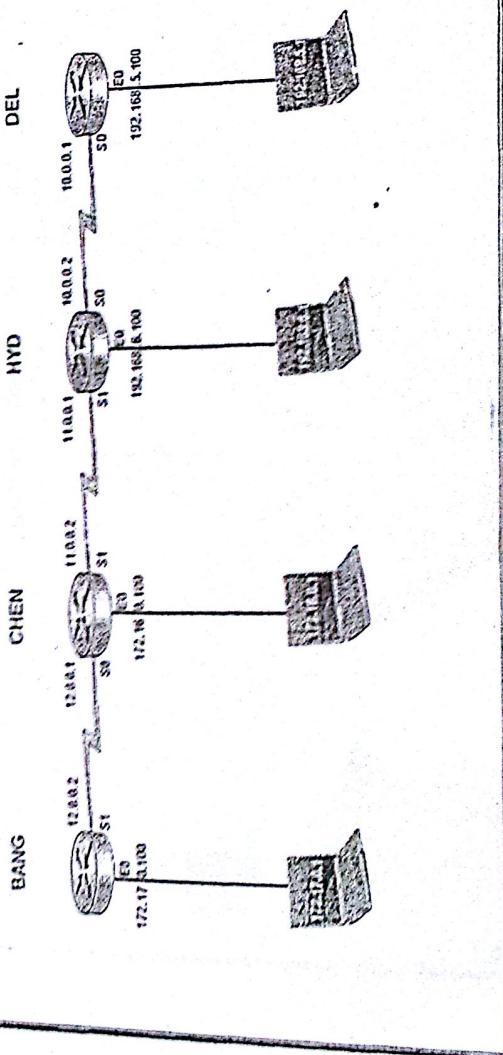
- AD=90
- Metric = 12 Bit Composite  
(Bandwidth+Delay+Load+Reliability+MTU)
- Algorithm = DUAL ( Diffused update algorithm )
- Hello timer = 5 sec
- It sends incremental, triggered updates
- Multicast updates on 224.0.0.10
- Load balancing = 4-6 equal / unequal paths
- It is Classless ( Subnetting supported )
- Cisco proprietary

#### Syntax:

```
Router(config)# router eigrp <AS No>
Router(config-router)# network <network Address> <WCM>
```

#### What is WCM?

- Wild Card Mask
- Inverse of Subnet Mask Value
- Class A WCM : 0.255.255.255
- Class B WCM : 0.0.255.255
- Class C WCM : 0.0.0.255



## EIGRP configuration

Configure all routers in the same Autonomous system

EIGRP communicates within AS only

Some older IOS versions may not support WCM for EIGRP

Bang:

```
Bang> enable
Bang# config t
Bang(config)# no ip routing
Bang(config)# ip routing
Bang(config)# router eigrp 145
Bang(config-router)# network 172.17.0.0 0.0.255.255
Bang(config-router)# network 12.0.0.0 0.255.255.255
Bang(config-router)# end
Bang # show ip route
```

Chen:

```
Chen> enable
Chen# config t
Chen(config)# no ip routing
Chen(config)# ip routing
Chen(config)# router eigrp 145
Chen(config-router)# network 172.16.0.0 0.0.255.255
Chen(config-router)# network 12.0.0.0 0.255.255.255
Chen(config-router)# network 11.0.0.0 0.255.255.255
Chen(config-router)# end
Chen # show ip route
```

Hyd:

```
Hyd> enable
Hyd# config t
Hyd(config)# no ip routing
Hyd(config)# ip routing
Hyd(config)# router eigrp 145
Hyd(config-router)# network 192.168.6.0 0.0.0.255
Hyd(config-router)# network 11.0.0.0 0.255.255.255
Hyd(config-router)# network 10.0.0.0 0.255.255.255
Hyd(config-router)# end
Hyd # show ip route
```

Del:

```
Del> enable
Del# config t
Del(config)# no ip routing
Del(config)# ip routing
Del(config)# router eigrp 145
Del(config-router)# network 192.168.5.0 0.0.0.255
Del(config-router)# network 10.0.0.0 0.255.255.255
Del(config-router)# end
Del # show ip route
```

## OSPF

### Open Shortest Path First

- AD=110
- Metric = cost ( $10^3/\text{bandwidth in bps}$ )
- Algorithm = DIJKSTRA or SPF
- Hello timer = 10 sec
- Dead timer = 40 sec
- Flush timer = 30 min
- Multicast updates on 224.0.0.5, 224.0.0.6
- It is Classless ( Subnetting supported )
- Open Standard

#### Syntax:

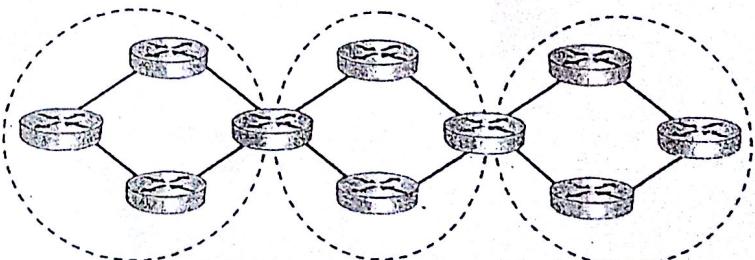
```
Router(config)# router ospf <Process id No>
Router(config-router)# network <network> <WCM> area <area id>
```

#### What is WCM?

- Wild Card Mask
- Inverse of Subnet Mask Value
- Class A WCM : 0.255.255.255
- Class B WCM : 0.0.255.255
- Class C WCM : 0.0.0.255

#### What is Area?

- Ospf maintains Link state information of every router to run SPF algorithm
- Router consumes more resources if more routers present in the network
- Areas are used to limit the link state database handled by router
- Area is a logical boundary for OSPF routers
- OSPF routers handle the link state information of all routers belong to same area
- Area Border Routers(ABR) route the data between different areas

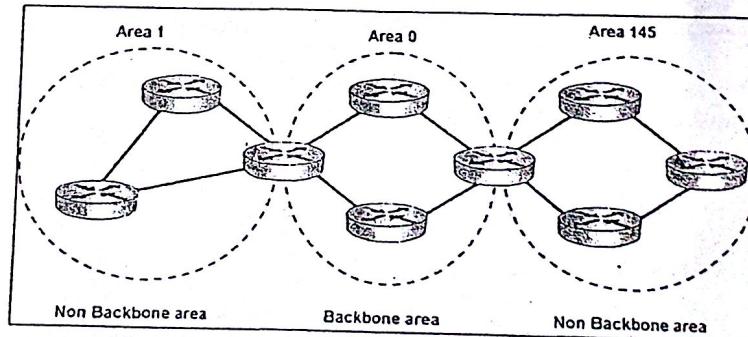


### What is Process id?

- OSPF can be configured as multiple instances on the same router
- Process id is used to identify the instance of OSPF
- It need not be the same on all routers
- Process id is 16 bit value
- Range : 1 - 65535

### OSPF areas:

- OSPF areas are basically two types
  - ❖ Backbone area
    - Area 0 is called as backbone area
    - Transit area between different areas
  - ❖ Non Backbone area
    - Areas other than Backbone area
    - All non backbone areas must be directly connected to area 0



### OSPF Router Types:

- ❖ Backbone routers
- ❖ Internal routers
- ❖ ABR
- ❖ ASBR

#### Backbone routers

Routers in Back bone area (area 0).

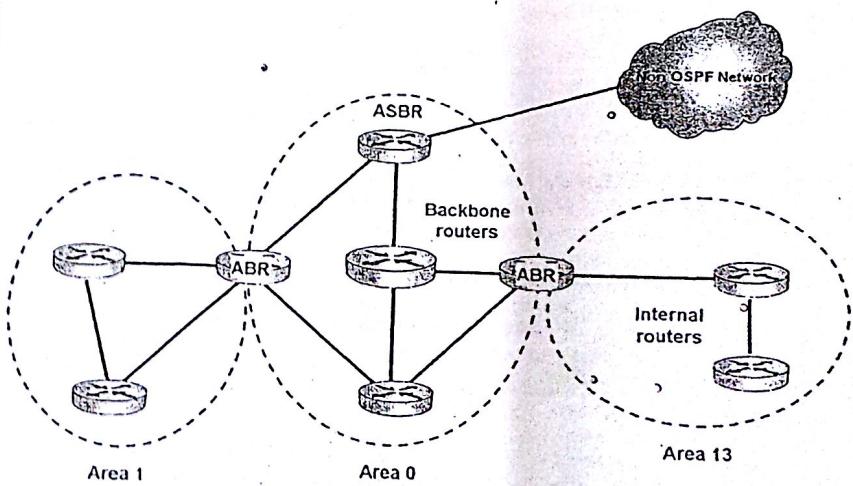
#### Internal routers

Routers belong to same area (backbone or non back bone).  
Back bone routers are internal routers

#### ABR - Area Border Router

Router belongs to multiple areas.  
For ABR, at least one interface must be in Back bone area

**ASBR - Autonomous system boundary router**  
OSPF router that is connected to non OSPF network  
ASBR is generally placed in area 0



#### OSPF area Types:

- ❖ Backbone area
- ❖ Stub Area
- ❖ Totally stub area
- ❖ NSSA (Not so stubby area)

#### LSA Types:

- LSA - Link state Advertisement
- It contains Link state information and networks available on that link

LSA Types	Name
1	Router LSA
2	Network LSA
3	Summary LSA
4	ASBR summary
5	AS external LSA
6	Multicast OSPF
7	NSSA LSA

## OSPF configuration

**Configure all routers in single area (Area 0)**  
Process id can be different from router to router

Bang:

```
Bang> enable
Bang# config t
Bang(config)# no ip routing
Bang(config)# ip routing
Bang(config)# router ospf 14
Bang(config-router)# network 172.17.0.0 0.0.255.255 area 0
Bang(config-router)# network 12.0.0.0 0.255.255.255 area 0
Bang(config-router)# end
Bang # show ip route
```

Chen:

```
Chen> enable
Chen# config t
Chen(config)# no ip routing
Chen(config)# ip routing
Chen(config)# router ospf 1456
Chen(config-router)# network 172.16.0.0 0.0.255.255 area 0
Chen(config-router)# network 12.0.0.0 0.255.255.255 area 0
Chen(config-router)# network 11.0.0.0 0.255.255.255 area 0
Chen(config-router)# end
Chen # show ip route
```

Hyd:

```
Hyd> enable
Hyd# config t
Hyd(config)# no ip routing
Hyd(config)# ip routing
Hyd(config)# router ospf 258
Hyd(config-router)# network 192.168.6.0 0.0.0.255 area 0
Hyd(config-router)# network 11.0.0.0 0.255.255.255 area 0
Hyd(config-router)# network 10.0.0.0 0.255.255.255 area 0
Hyd(config-router)# end
Hyd # show ip route
```

Del:

```
Del> enable
Del# config t
Del(config)# no ip routing
Del(config)# ip routing
Del(config)# router ospf 25696
Del(config-router)# network 192.168.5.0 0.0.0.255 area 0
Del(config-router)# network 10.0.0.0 0.255.255.255 area 0
Del(config-router)# end
Del # show ip route
```

## Router Backup & Recovery

- It is always better to take back up of router startup-configuration and IOS Image periodically
- If something happens to router/configuration, or if the router is replaced with a new one, it won't take much time to bring the router online (if backup is already taken)

### **Requirements for Backup & Recovery:**

- TFTP server is required for backup & Recovery operations
- TFTP (Trivial FTP) is used to transfer the files
  - o from router to system(Backup)
  - o from system to router (Recovery)
- TFTP server is a small free software
- Install TFTP server program in the computer/laptop
- Always ensure TFTP server has connectivity with router while performing backup and recovery operations

### How to take Backup?

#### Startup-configuration Backup:

```
Router# copy startup-config tftp
```

#### Running-configuration Backup:

```
Router# copy running-config tftp
```

#### IOS image /Flash Backup:

```
Router# copy flash tftp
```

### How to Recovery?

#### Startup-configuration recovery:

```
Router# copy tftp startup-config
```

#### Eflash recovery (or) IOS Image upgrade:

```
Router# copy tftp flash
```

```
Router(boot)# copy tftp flash
```

For backup and recovery operations router requires some information such as IOS image name, startup-config name, address of tftp server etc.  
Enter the required information correctly

## Router Password Recovery (2500 series)

Restart the router (power cycling / force restart)

Press ctrl+Break within one minute

> o/r 0x141 - setting config register value to 0x141  
> i - Initialize

--- Router restarts---

Router(boot)> enable  
Router(boot)# copy start run

Router(boot)# config t

Router(boot)(config)# no enable secret  
Router(boot)(config)# no enable password

Router(boot)(config)# line con 0  
Router(boot)(config-line)# no password  
Router(boot)(config-line)# login  
Router(boot)(config-line)# exit

Router(boot)(config)# config-register 0x2102  
Router(boot)(config)# exit

Router(boot)# write  
Router(boot)# reload

----- Router restarts-----

Router>enable  
Router#

Some routers display Rommon> prompt instead of >. Then use these commands

Rommon> confreg 0x141 (similar to > o/r 0x141)  
Rommon> reset (similar to > i)

### Config - register values:

Config-register value	Purpose
0x2102	normal boot sequence
0x141	bootstrap loader/ boot mode