Komutacioni sistemi

Ruteri i rutiranje (1/3)

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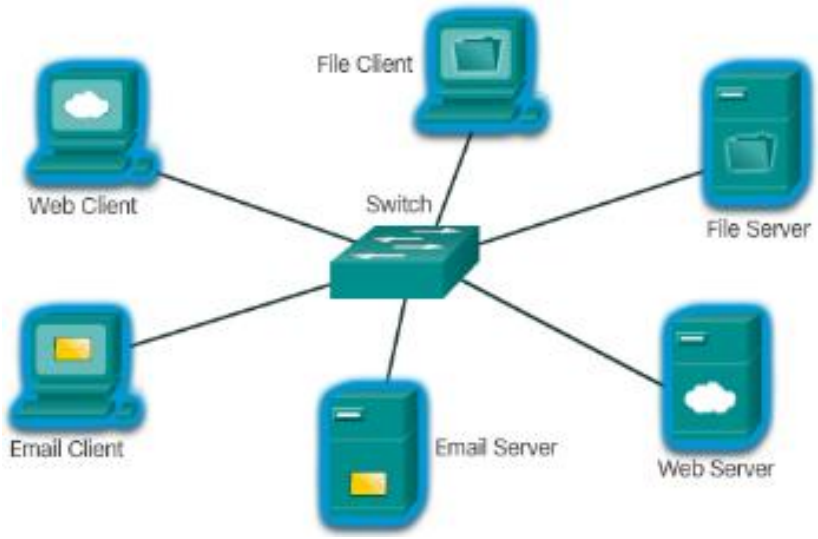
Networking Today - Globally Connected

- Network has no boundary and supports the way we:
  - Learn
  - Communicate
  - Work
  - Play

Providing Resources in a Network

- Networks of Many Sizes
  - Small Home / Office Networks
  - Medium to Large Networks
  - World Wide Network
- Clients and Servers
  - Clients request and display information
  - Servers provide information to other devices on the network
- Peer-to-Peer
  - Computers can be both server and client at the same time.

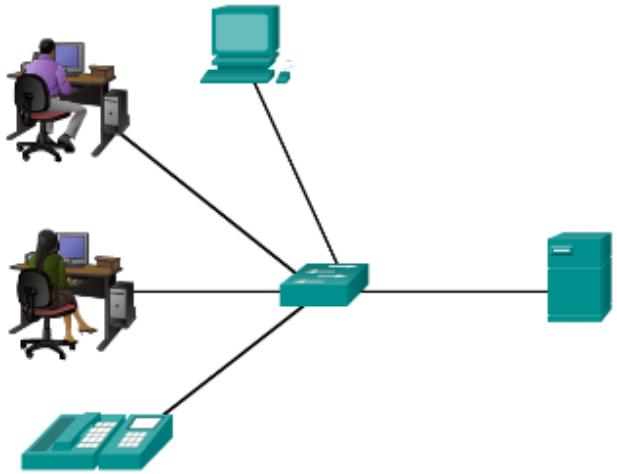


Network Components

- End Devices
  - Either the source or destination of a message
- Intermediary Network Devices
  - Connect multiple individual networks to form an internetwork
  - Connect the individual end devices to the network
  - Ensure data flows across the network
  - Provide connectivity
- Network Media
  - Provide the pathway for data transmission
  - Interconnect devices
  - Coper, fiber optic and wireless

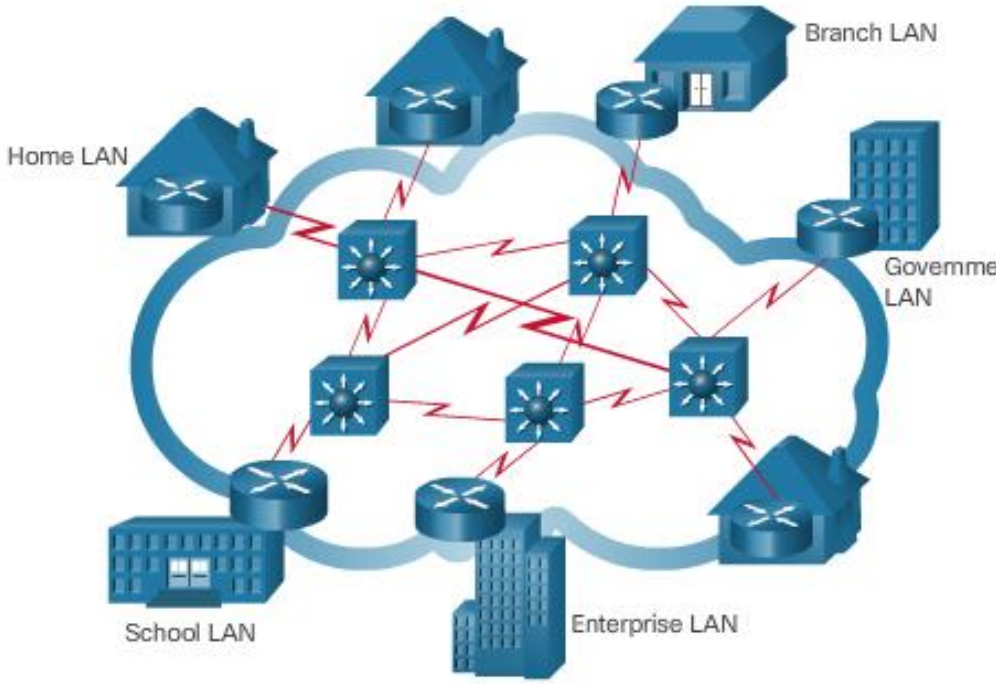
LANs and WANs

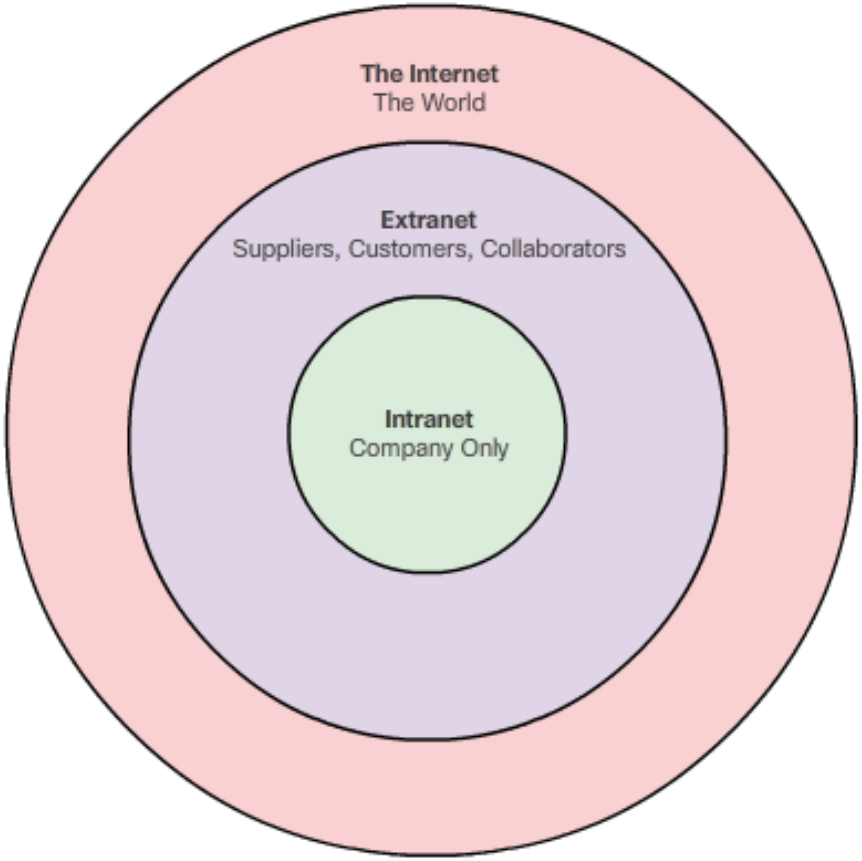
- Local Area Networks
  - Spans across small geographical area
  - Interconnects end devices
  - Administrated by a single organization
  - Provide high speed bandwidth to internal devices
- WAN Area Networks
  - Interconnects LAN
  - Administrated by multiple service providers
  - Provide slower speed links between LANS



The Internet, Intranets, and Extranets

- The Internet
  - Worldwide collection of interconnected networks
  - Not owned by any individual or group
- Intranets and Extranets



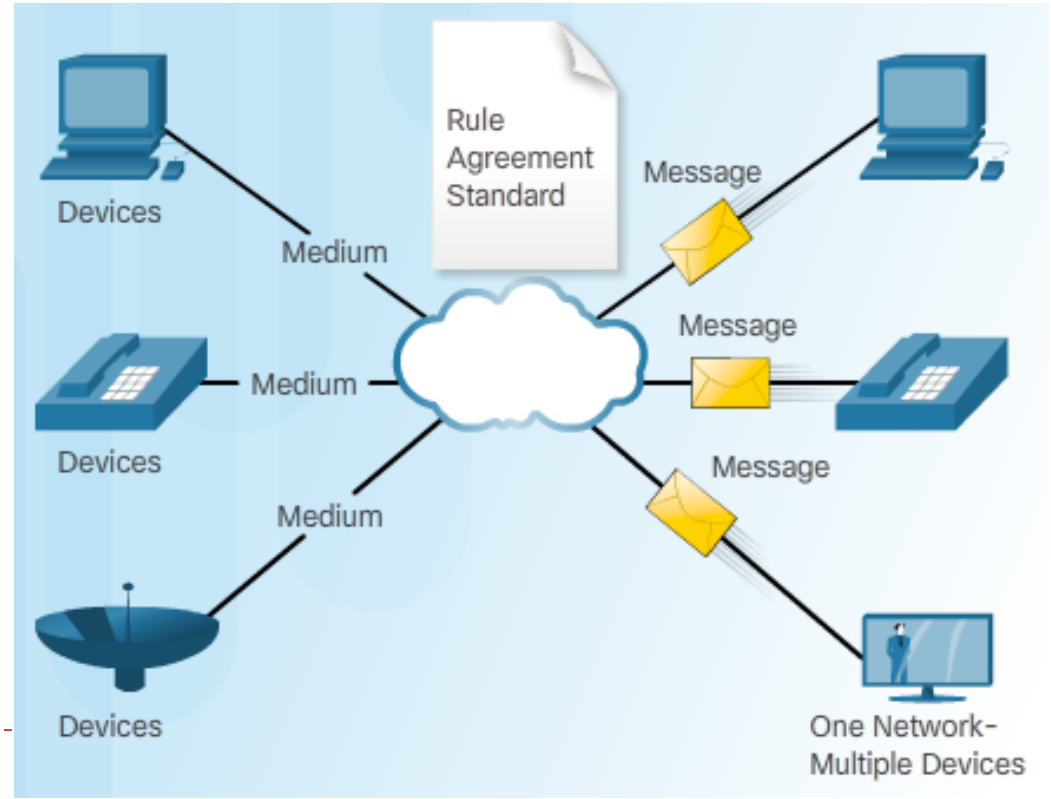


Internet Connections

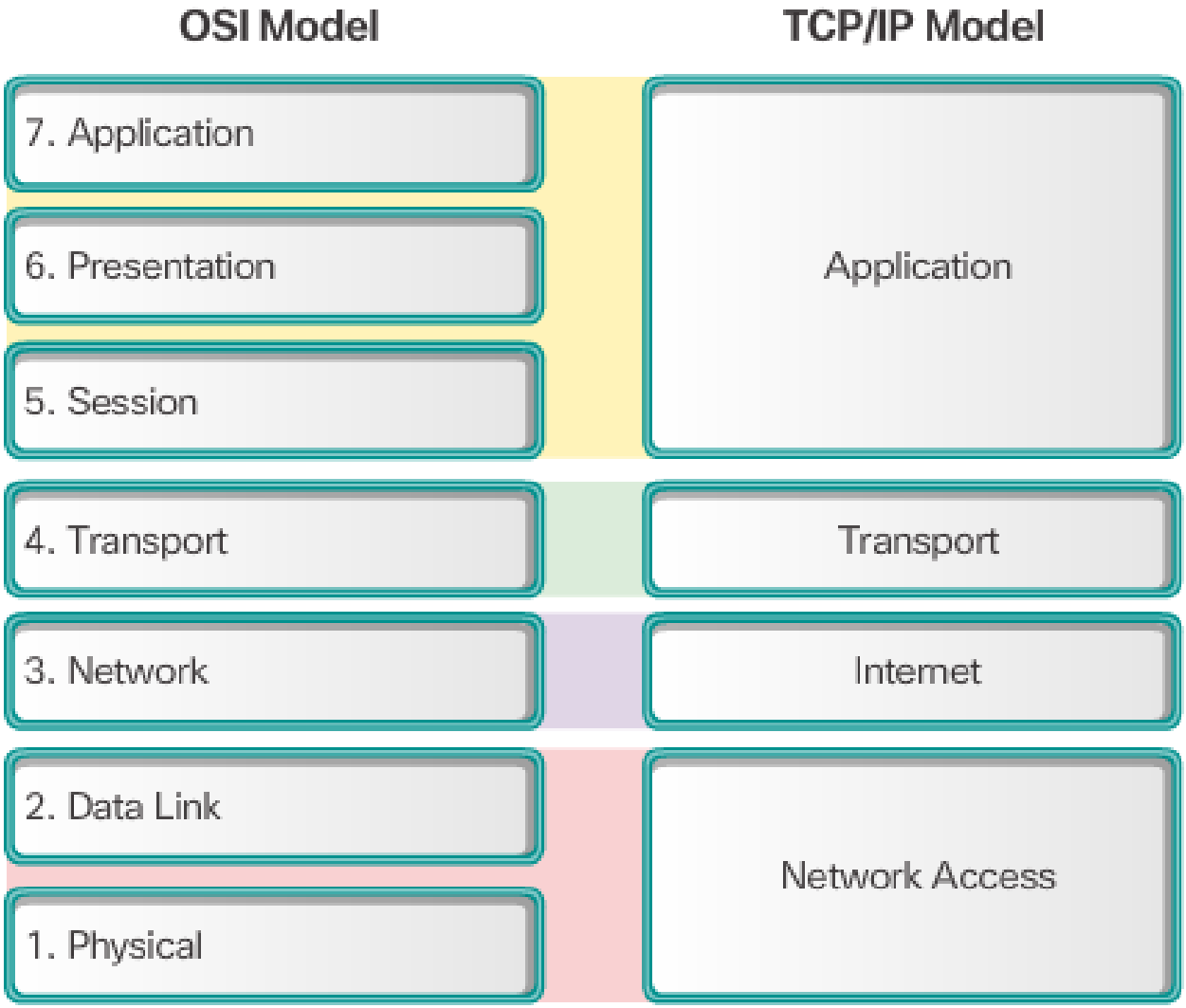
- Internet Access Technologies
  - Internet Service Provider (ISP)
  - Broadband cable
  - Broadband Digital Subscriber Line (DSL)
  - Wireless WANs
  - Mobile Services
  - Business DSL
  - Leased Lines
  - Metro Ethernet
- Types of Internet Connections
  - Home and Small Office
  - Business

Converged Networks

- Traditional Separate Networks
  - Each network with its own rules and
- The Converging Network
  - Capable of delivering data, voice, and video over the same network infrastructure

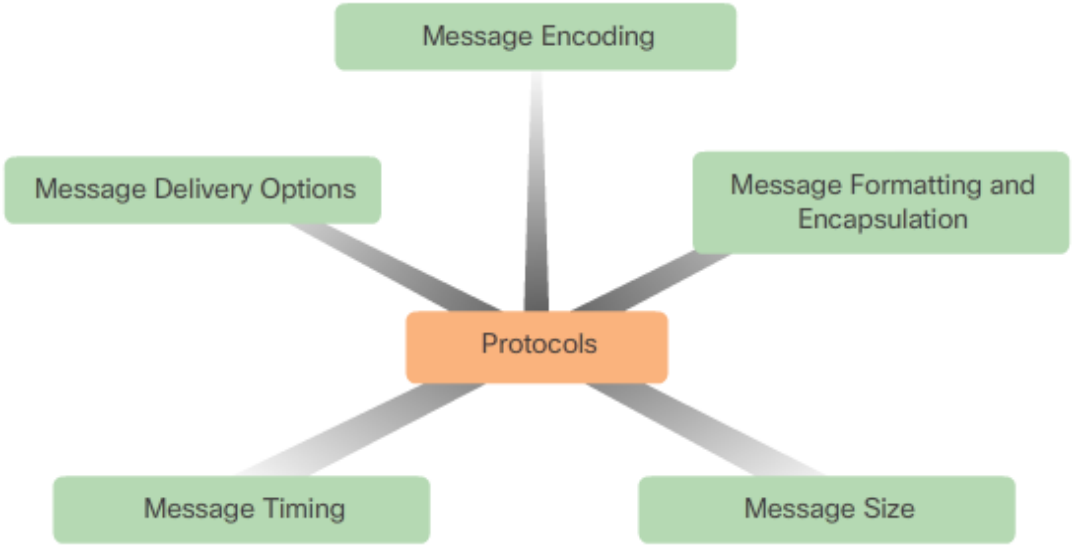


Reference Models



The Rules

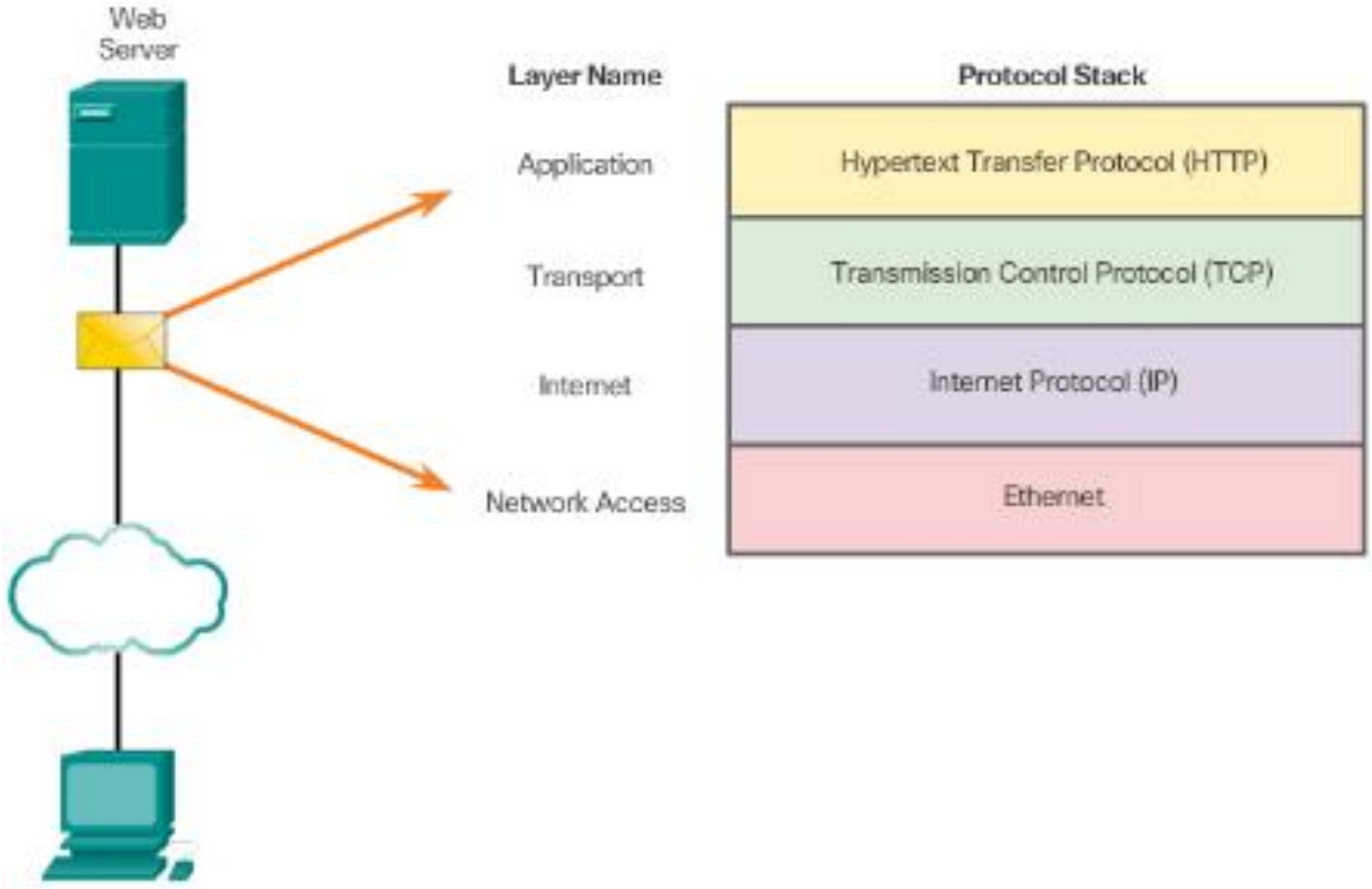
- Rule Establishment
  - Identified sender and receiver
  - Common language and grammar
  - Speed and timing of delivery
  - Confirmation or acknowledgment requirements
- Message Encoding
  - Process of converting information into another acceptable form
- Message Formatting and Encapsulation
- Message Size
- Message Timing
  - Access method
  - Flow control
  - Response timeout
- Message Delivery Options
  - Unicast
  - Multicast
  - Broadcast



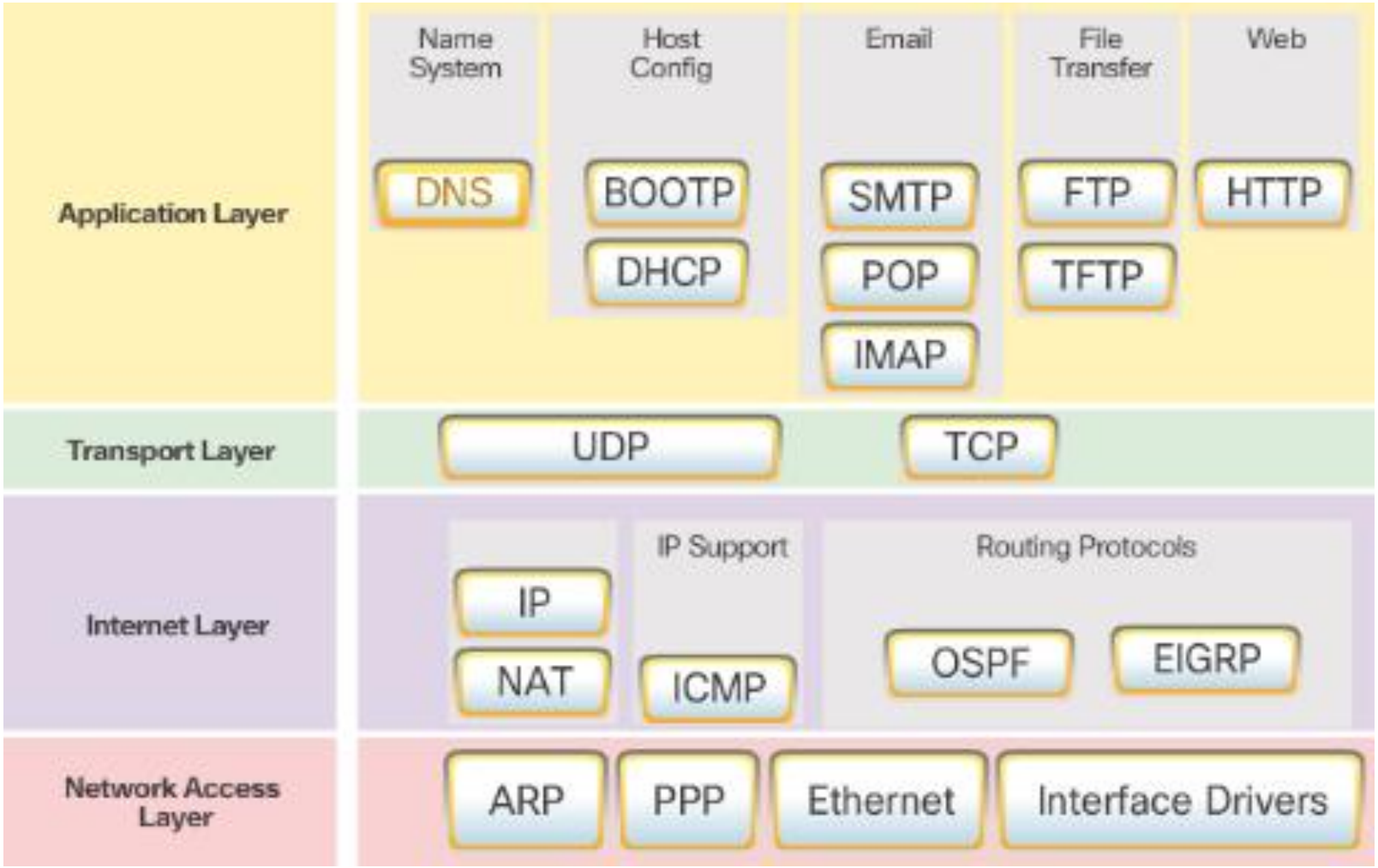
Protocols

- Rules that Govern Communications
- Network Protocols
  - The role of protocols
  - How the message is formatted or structured
  - The process by which networking devices share information about pathways with other networks
  - How and when error and system messages are passed between devices
  - The setup and termination of data transfer sessions
- Protocol Interaction
  - Example: web server and client

Example: web server and client

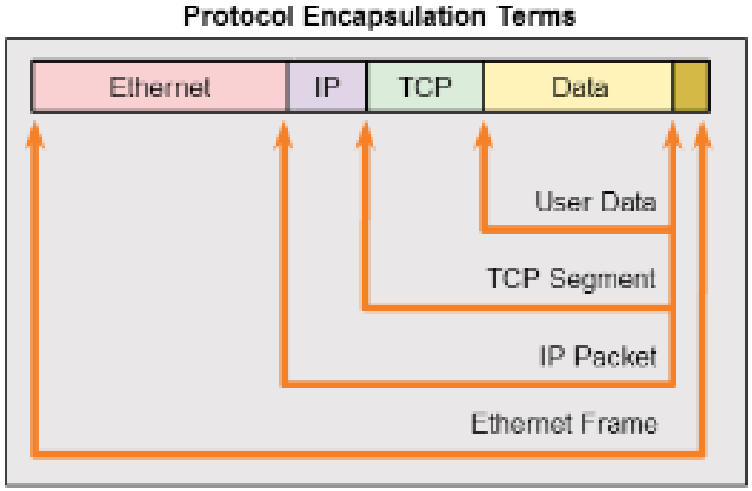


Protocol Suite TCP/IP



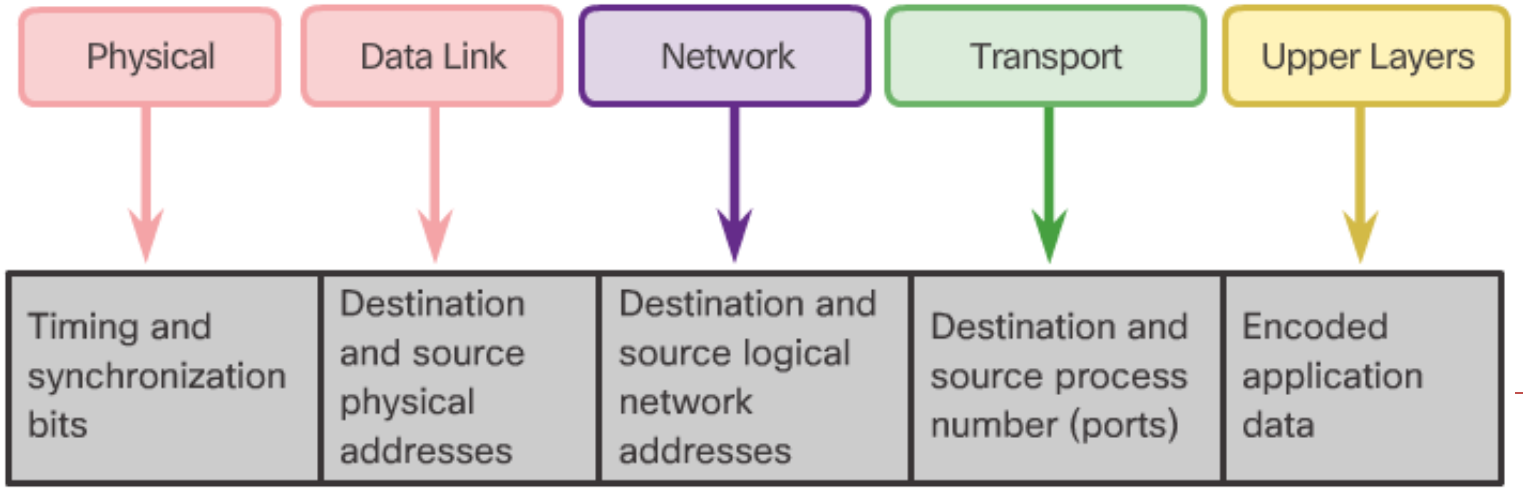
Data Encapsulation

- Message Segmentation
  - Segmentation - Break communication into pieces
  - Multiplexing – interleaving the pieces
- Protocol Data Units
- Encapsulation and de-encapsulation process

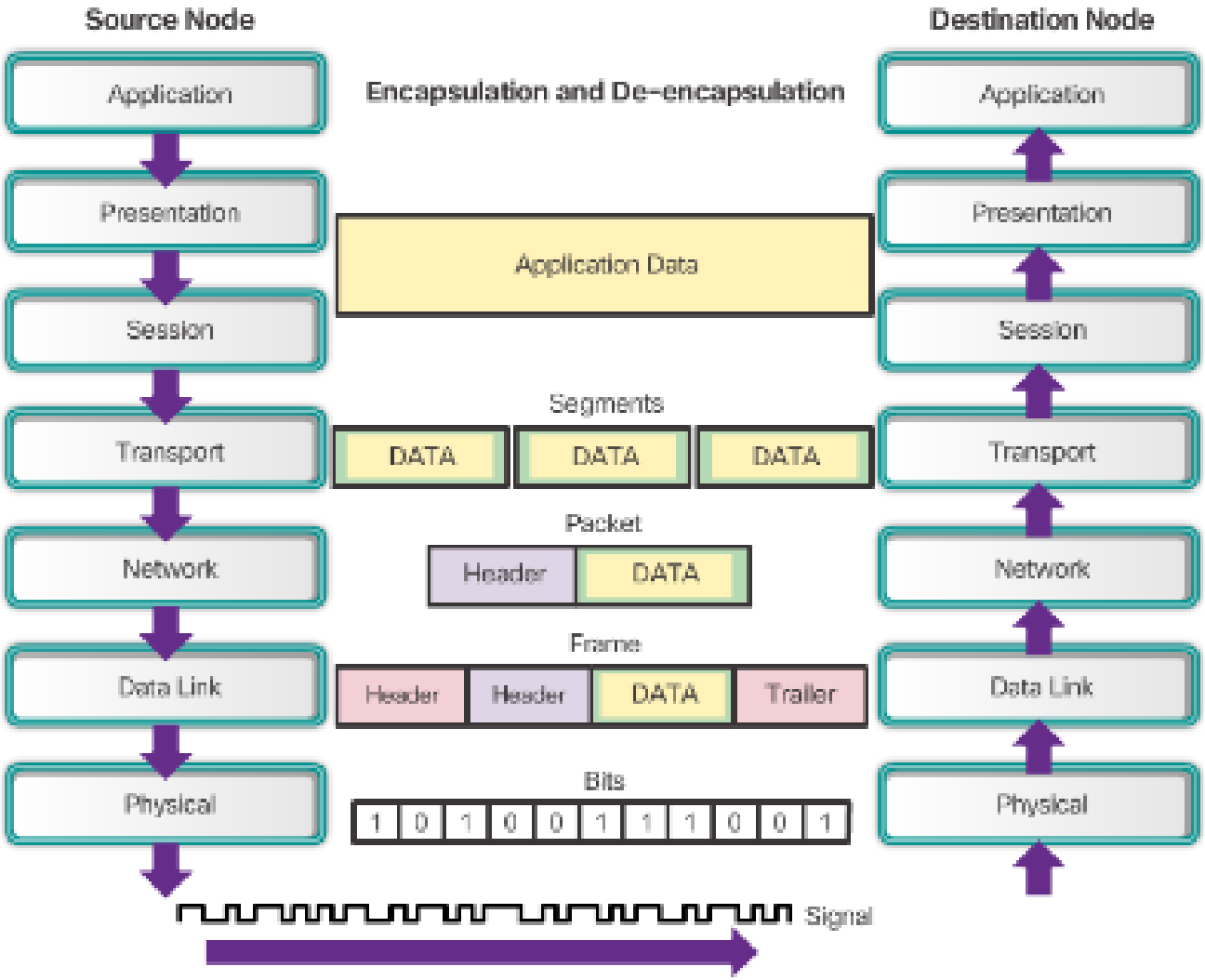


Data Access

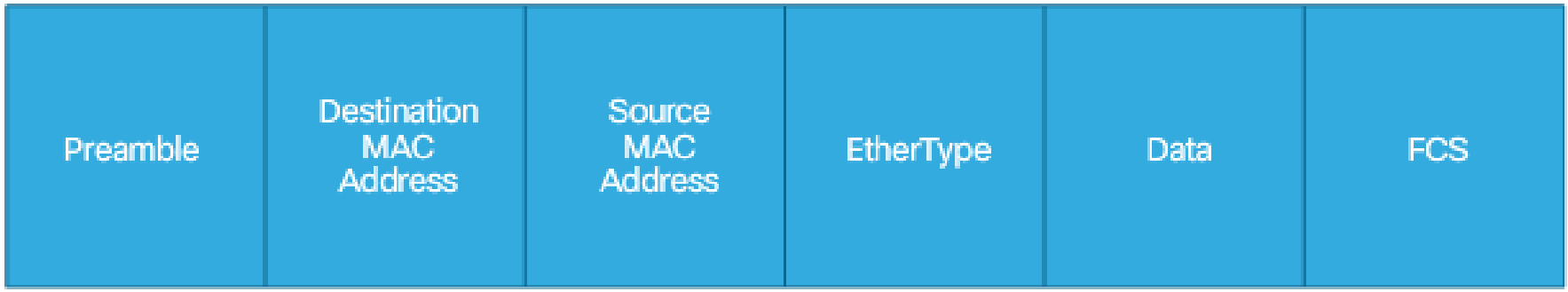
- Network Addresses
  - Source IP address and Destination IP address
  - Deliver the IP packet from the original source to the final destination, either on the same network or to a remote network.
- Data Link Addresses
  - Source data link address and Destination data link address
  - Deliver the data link frame from one network interface card (NIC) to another NIC

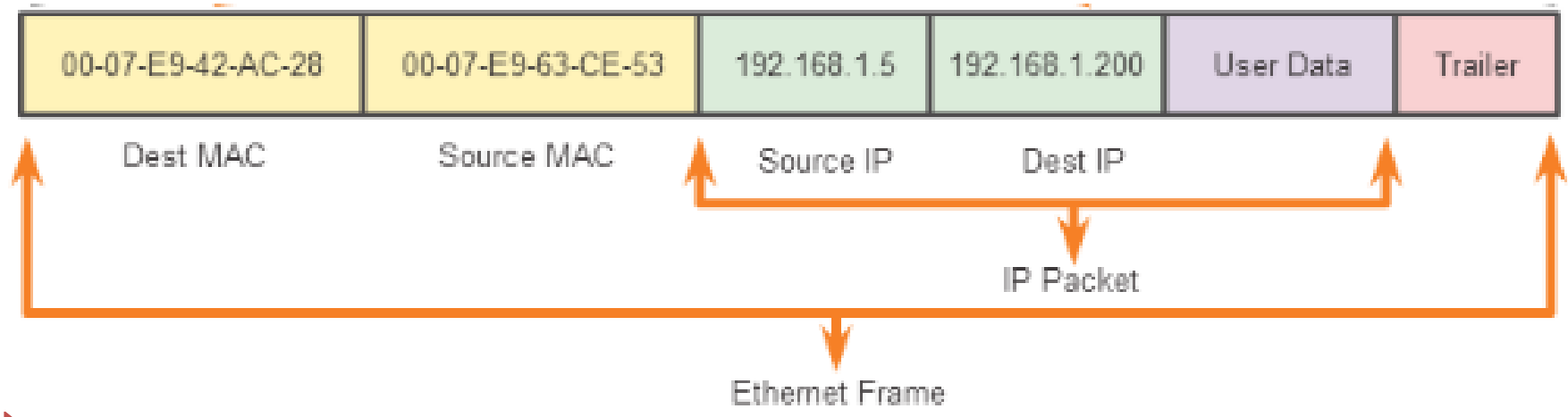


Purpose of the Physical Layer



Ethernet Protocol

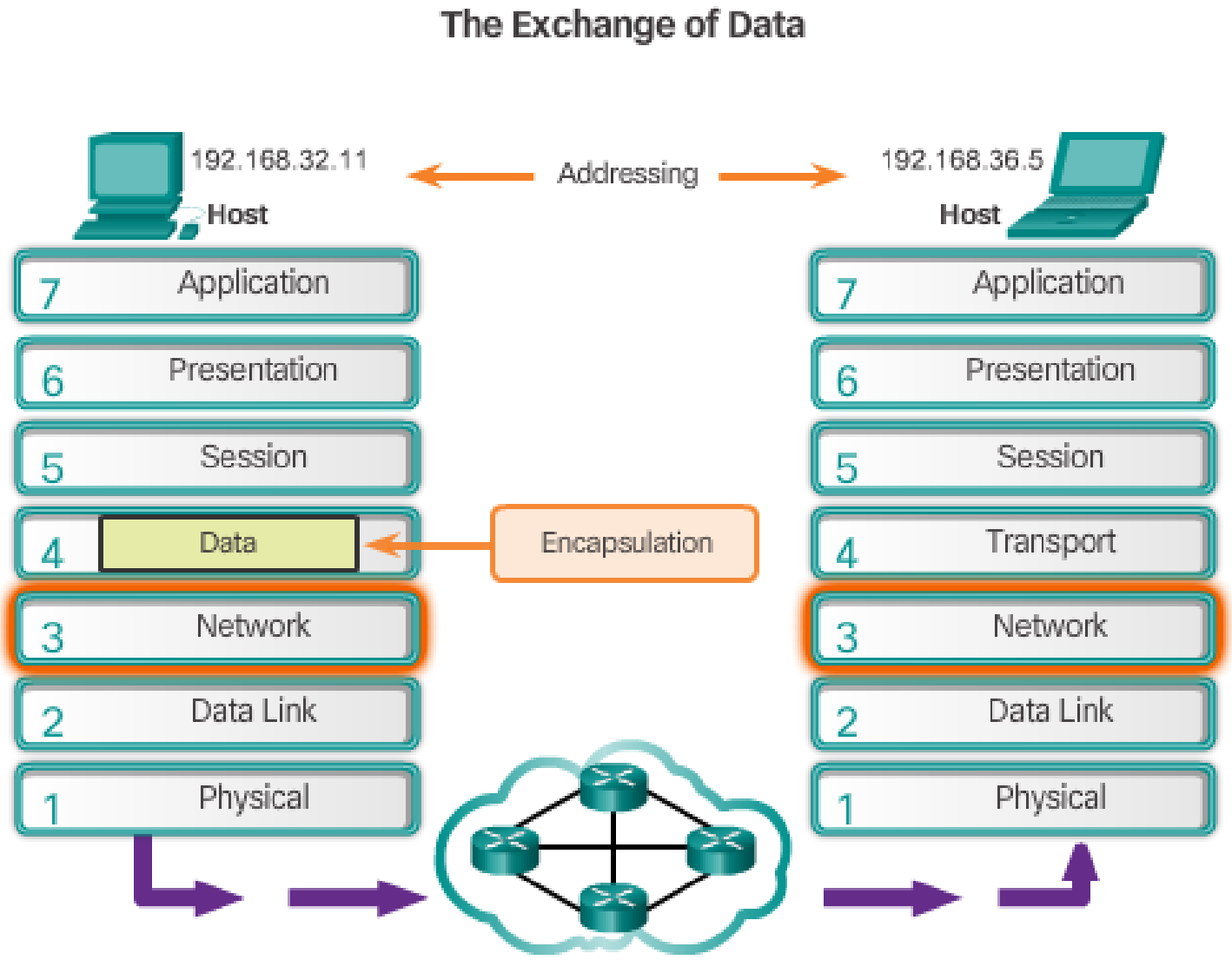




Address Resolution Protocol

- Introduction to ARP
  - ARP allows the source to request the MAC address of the destination.
  - The request is based upon the layer 3 address of the destination (known by the source).
- ARP Functions
  - Resolving IPv4 addresses to MAC addresses
  - Maintaining a table of mappings
  - ARP uses ARP Request and ARP Reply to perform its functions.
- Removing Entries from an ARP Table
  - Entries are removed from the device's ARP table when its cache timer expires.
  - Cache timers are OS dependent.
  - ARP entries can be manually removed via commands.
- ARP Tables
  - On IOS: show ip arp
  - On Windows PCs: arp -a

Network Layer in Communications



Network layer protocols forward transport layer PDUs between hosts.

Characteristics of the IP Protocol

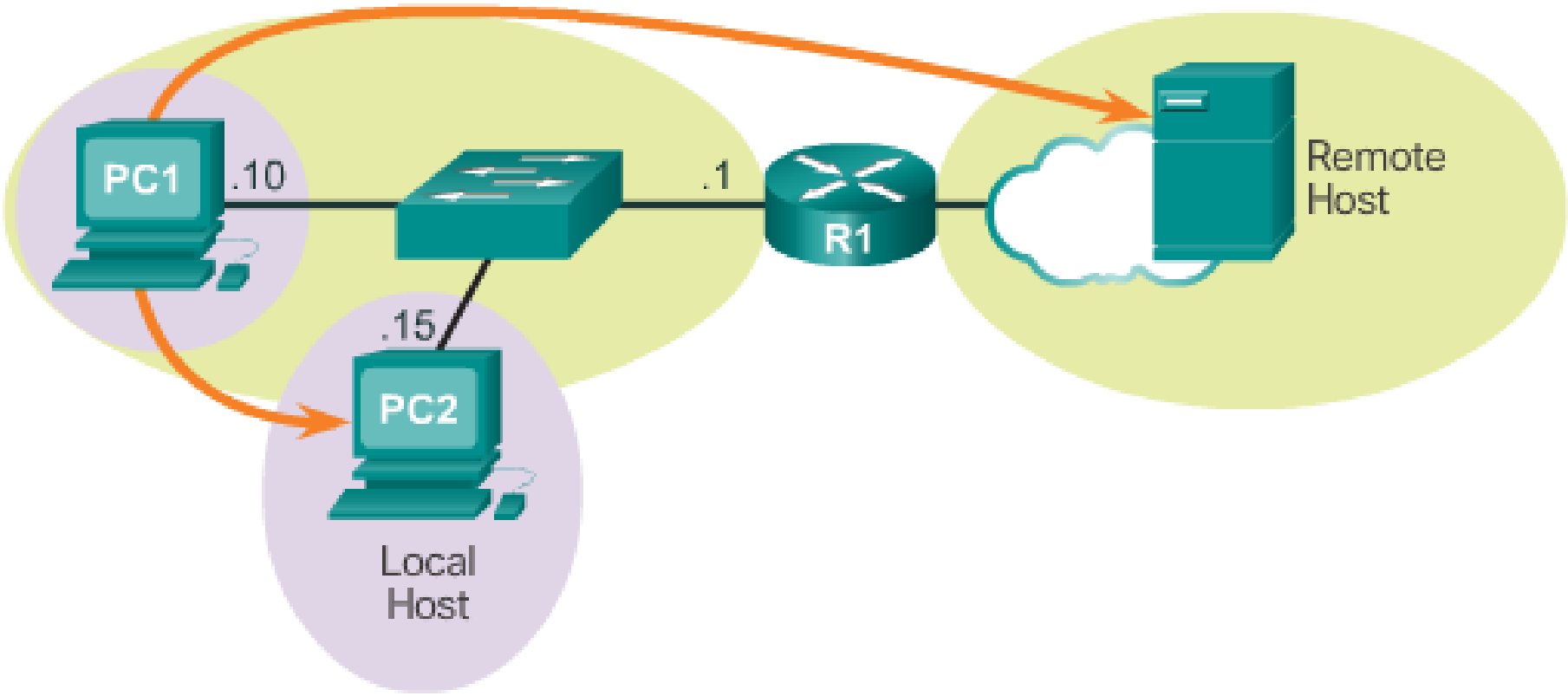
- Encapsulating IP
  - Segments are encapsulated into IP packets for transmission.
  - The network layer adds a header so packets can be routed to the destination.
- IP - Connectionless
  - Sender doesn’t know if the receiver is listening or the message arrived on time.
  - Receiver doesn’t know data is coming.
- IP – Best Effort Delivery
  - No guarantees of delivery are made.
- IP – Media Independent
  - IP can travel over different types of media.

How a Host Routes

- Host Forwarding Decision
  - Three types of destination: itself, local host, remote host.
- Default Gateway
  - Routes traffic to other networks
  - Has a local IP address in the same address range as other hosts on the network
  - Can take data in and forward data out
- Using the Default Gateway
  - Hosts will use the default gateway when sending packets to remote networks.
- Host Routing Tables
  - Use the **netstat –r** command to display the

host routing table on a Windows machine.

How a Host Routes



How a Host Routes

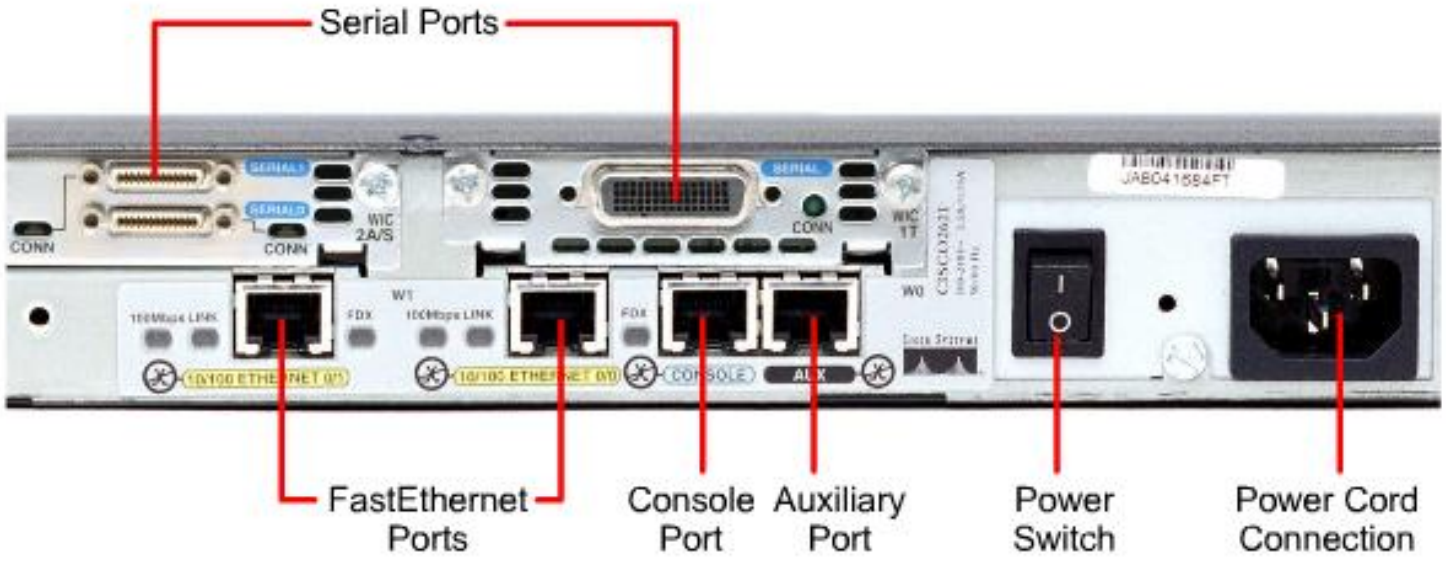
IPv4 Routing Table for PC1

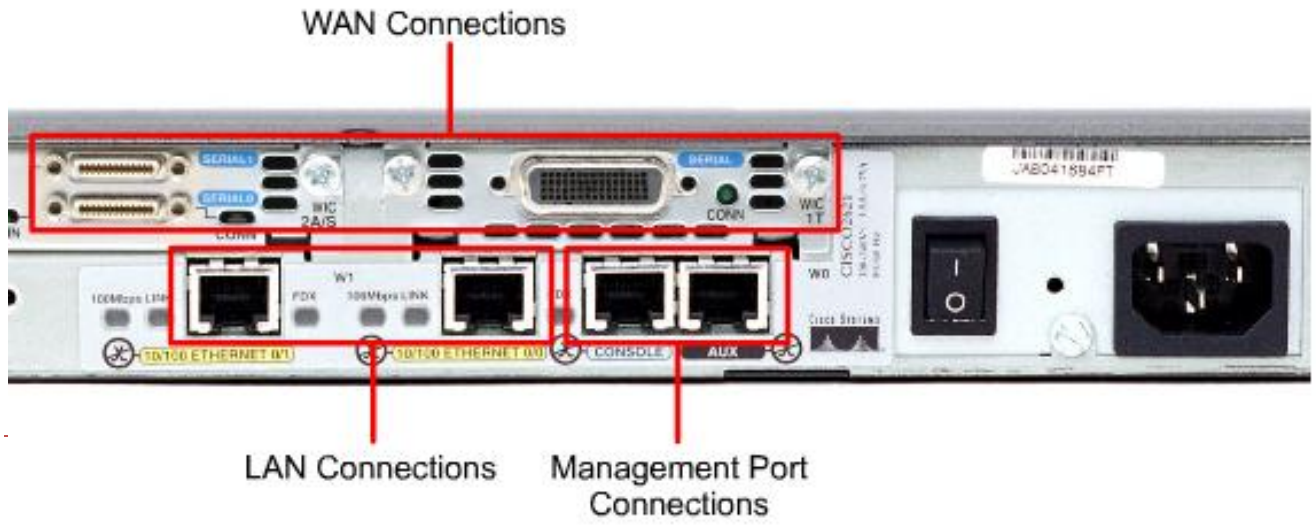

```
C:\Users\PC1>netstat -r

<output omitted>

IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0     192.168.10.1   192.168.10.10     25
        127.0.0.0        255.0.0.0         On-link         127.0.0.1    306
        127.0.0.1  255.255.255.255         On-link         127.0.0.1    306
  127.255.255.255  255.255.255.255         On-link         127.0.0.1    306
    192.168.10.0    255.255.255.0         On-link    192.168.10.10    281
   192.168.10.10  255.255.255.255         On-link    192.168.10.10    281
  192.168.10.255  255.255.255.255         On-link    192.168.10.10    281
        224.0.0.0        240.0.0.0         On-link         127.0.0.1    306
        224.0.0.0        240.0.0.0         On-link    192.168.10.10    281
  255.255.255.255  255.255.255.255         On-link         127.0.0.1    306
  255.255.255.255  255.255.255.255         On-link    192.168.10.10    281
===========================================================================

<output omitted>
```

Anatomy of a Router

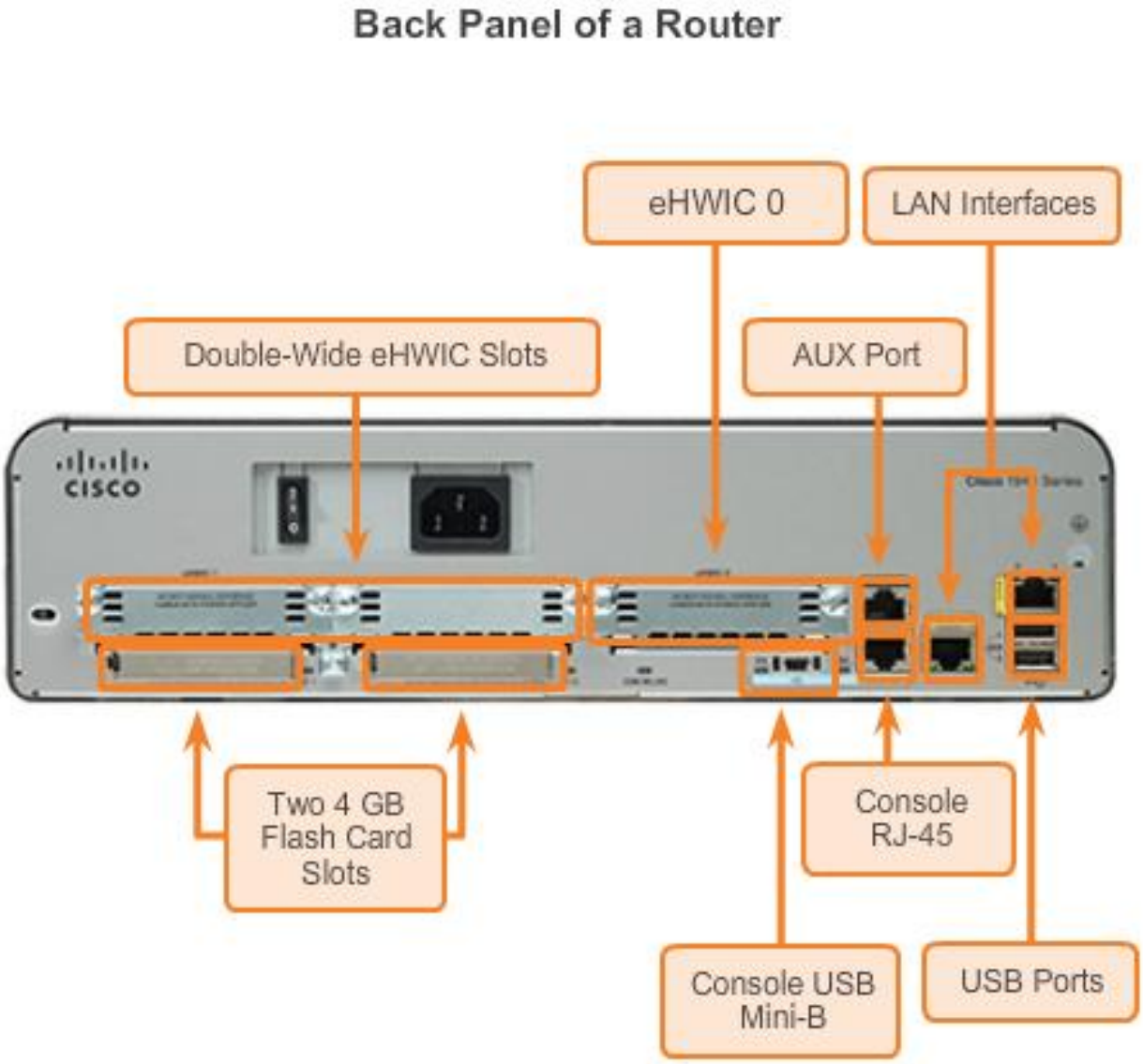
- A Router is a Computer
  - Routers have CPU, memory and I/O devices
  - Cisco routers use IOS as their operating system.
- Router Memory
  - Just as a computer, routers have memory.
  - Routers contain RAM, ROM, NVRAM and Flash memory.
- Inside a Router
  - Routers have the same general structure.
- Connect to a Router
  - Routers have may ports to support connections.
- LAN and WAN Interfaces
  - Routers have LAN and WAN ports.
  - Different models ship with different ports.
  - Ethernet is very common on different router models.

Anatomy of a Router



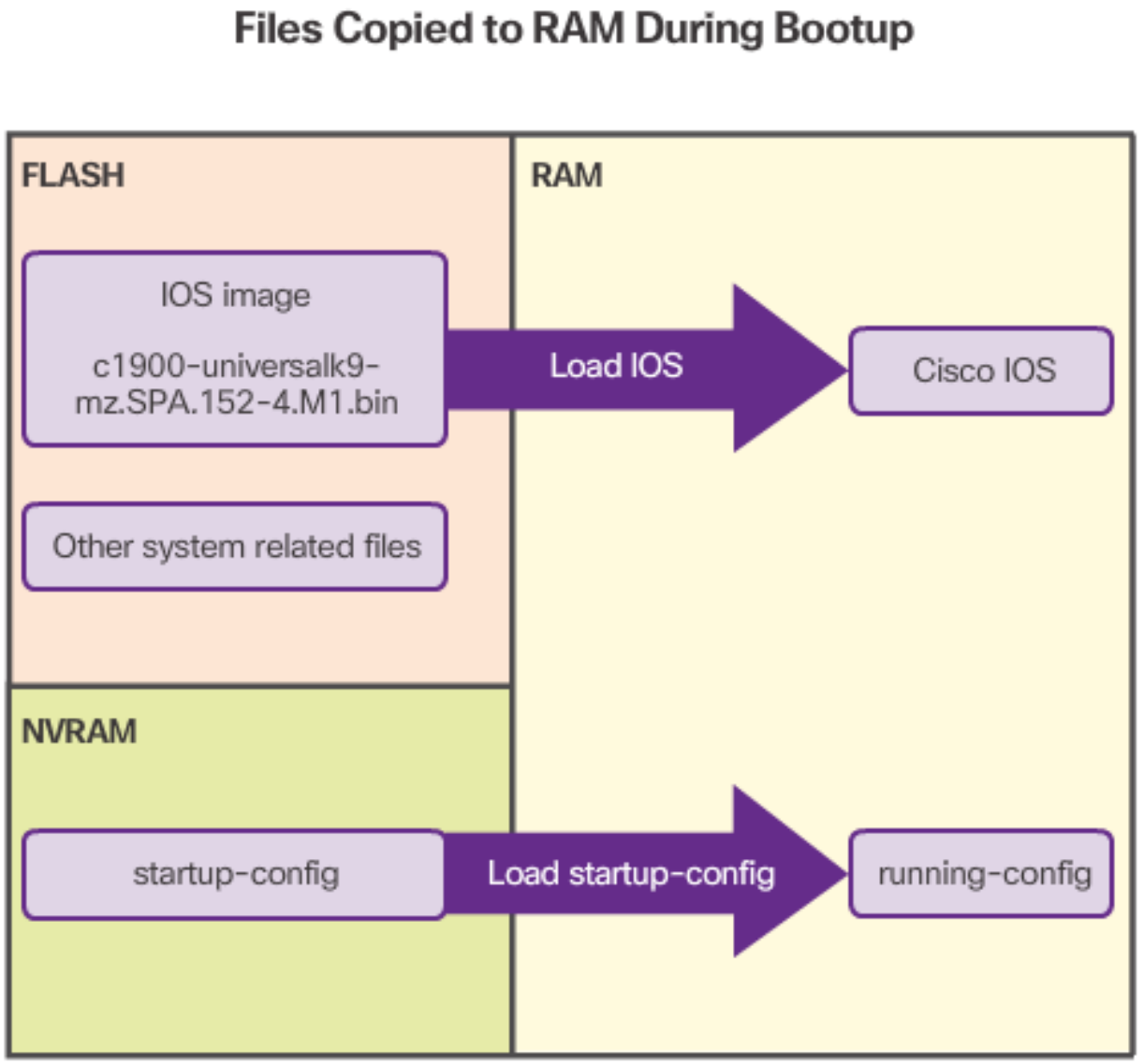


Anatomy of a Router



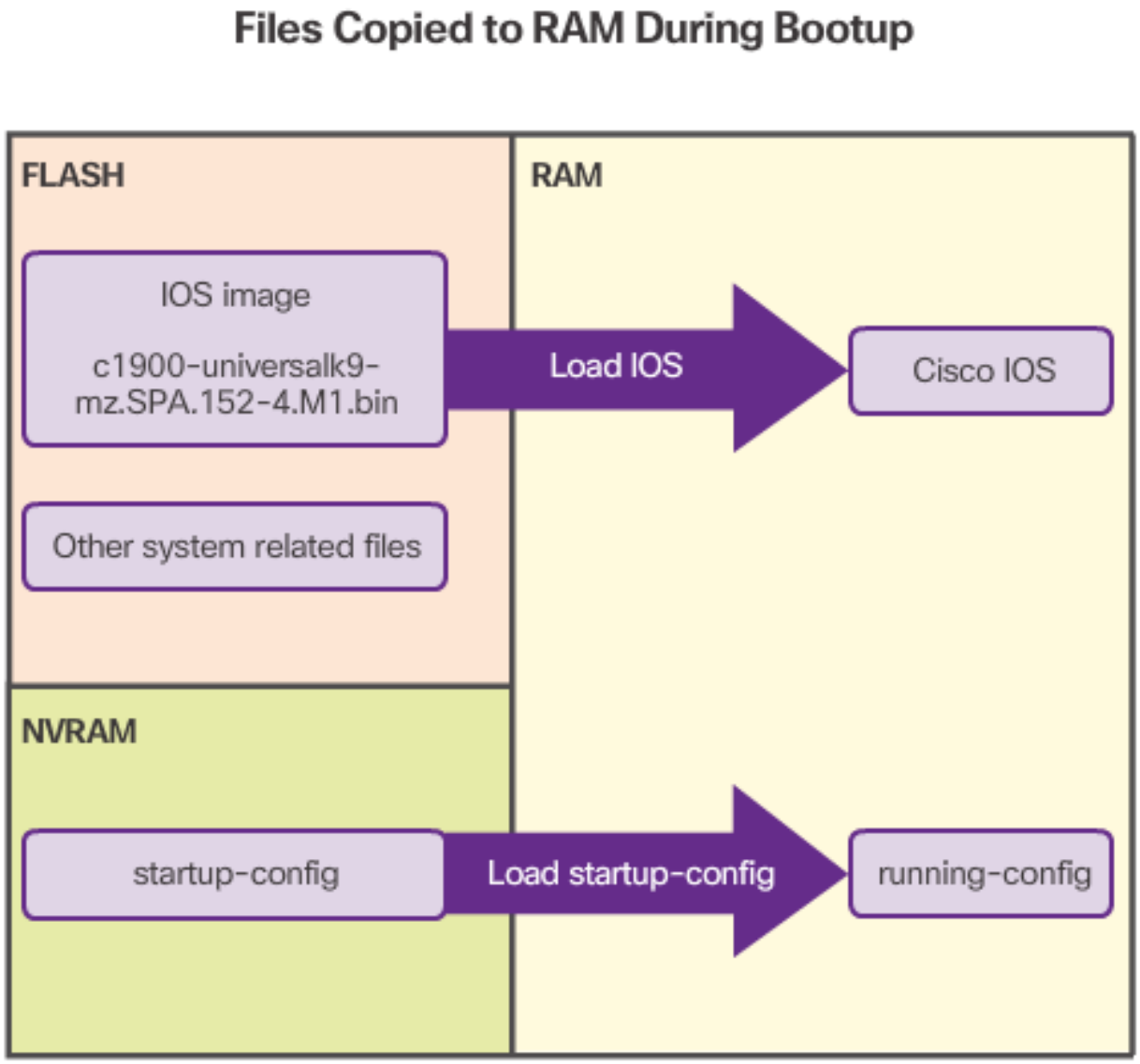
Anatomy of a Router

- Bootset Files
  - IOS image file, stored in the Flash, contains the IOS.
  - The Flash also stores other system files.
  - The NVRAM stores configuration parameters.
- Router Bootup Process
  1. Perform the POST and load the bootstrap program.
  2. Locate and load the Cisco IOS software.
  3. Locate and load the startup configuration file or enter setup mode



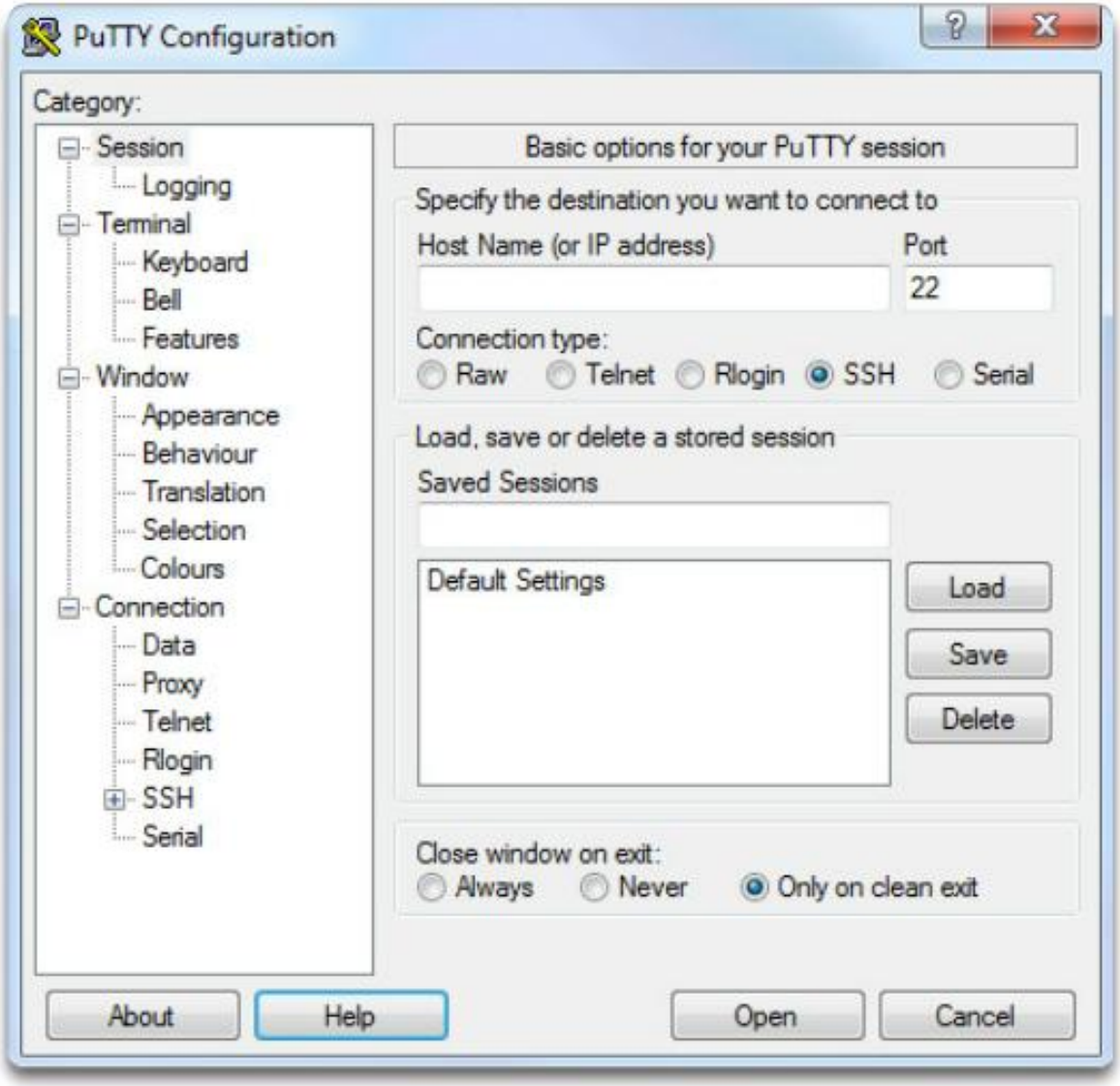
Anatomy of a Router

- Show Version Output
  - The show version command is very useful.
  - It provides information on the amounts of memory installed, what IOS images was loaded during boot and more.

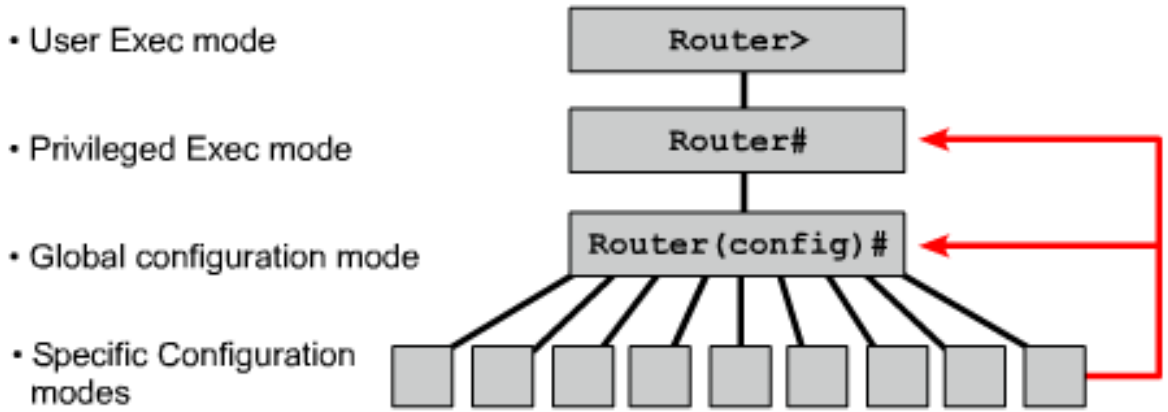


Cisco IOS Access

- Access Methods
  - Console
  - Auxiliar
  - Virtual Terminal (Telnet / SSH)
- Terminal Emulation Programs
  - PuTTY
  - Tera Term
  - SecureCRT

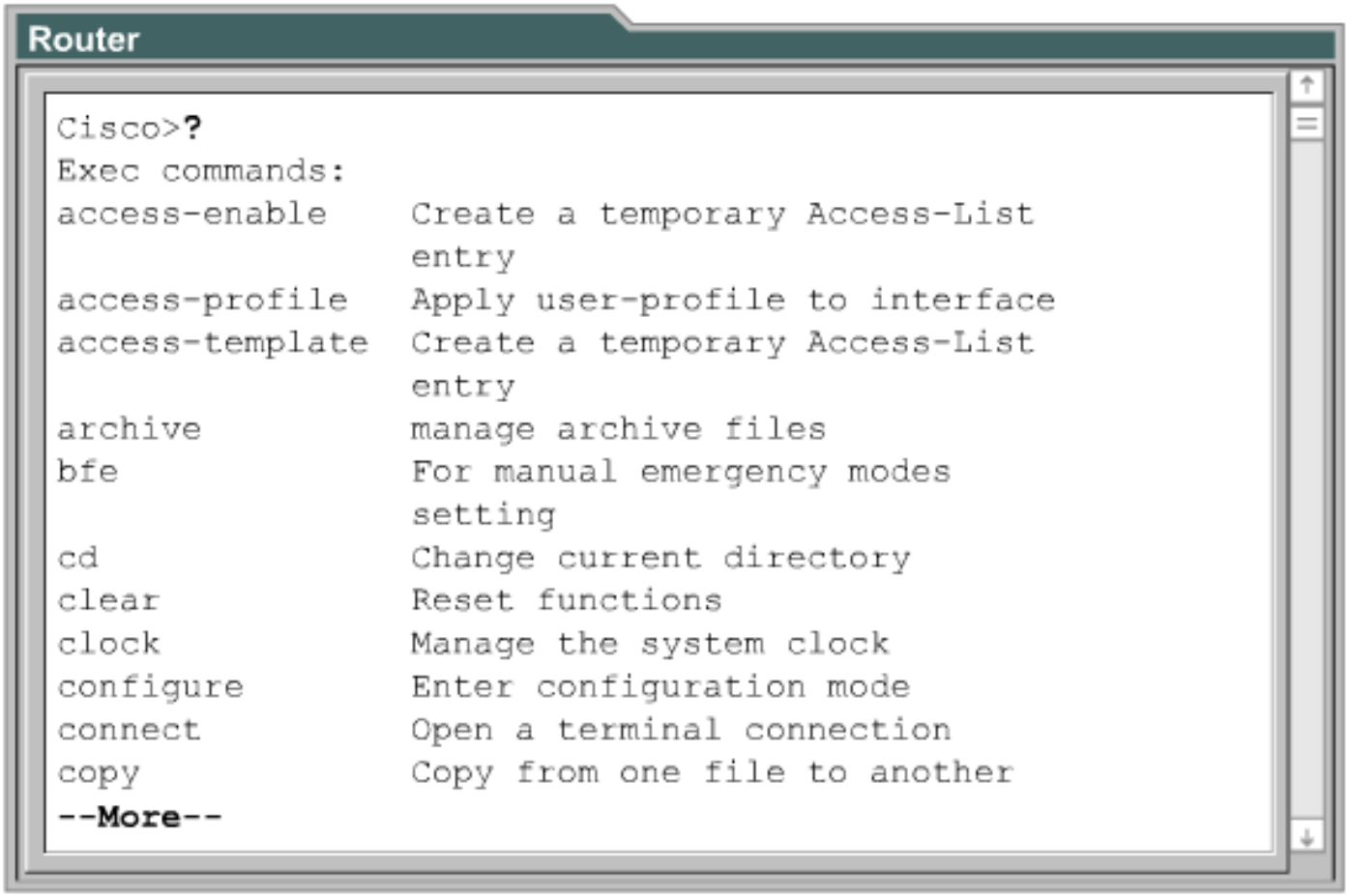


Router Routing Tables



Configuration Mode	Prompt
Interface	`Router(config-if)#`
Subinterface	`Router(config-subif)#`
Controller	`Router(config-controller)#`
Map-list	`Router(config-map-list)#`
Map-class	`Router(config-map-class)#`
Line	`Router(config-line)#`
Router	`Router(config-router)#`
IPX-router	`Router(config-ipx-router)#`
Route-map	`Router(config-route-map)#`

User Mode Commands



clock set Command

Router

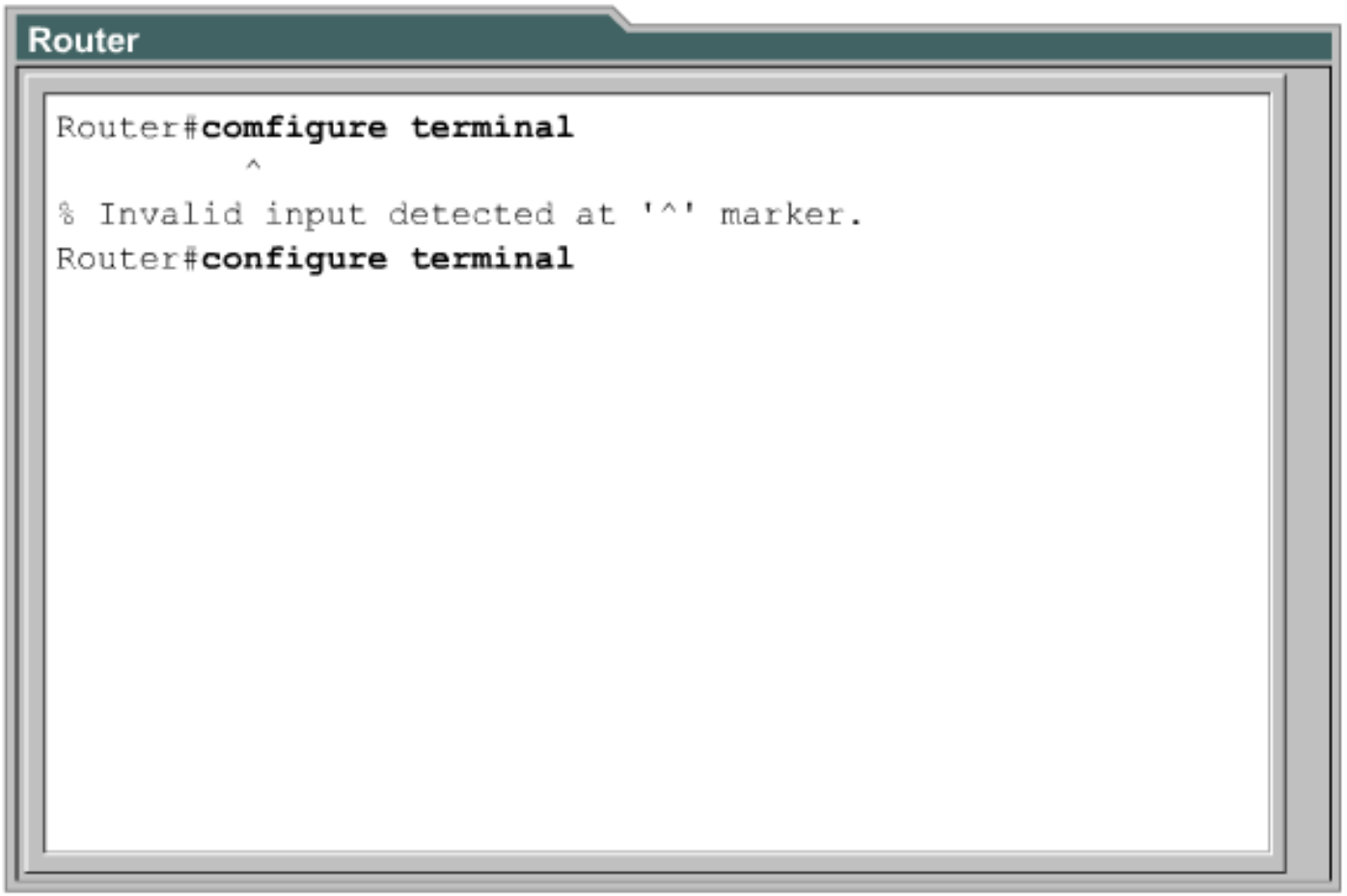
```
Cisco#cl?
clear  clock
Cisco#clock
% Incomplete command.
Cisco#clock ?
  set  Set the time and date
Cisco#clock set
% Incomplete command.
Cisco#clock set ?
  hh:mm:ss  Current Time
```

Using IOS Command `history`

Command	Description
Ctrl-P or up arrow key	Recalls last (previous) command
Ctrl-N or down arrow key	Recalls most recent command in the history buffer
Router>**show history**	Shows command buffer
Router>**terminal history size** *number-of-lines*	Sets the command history buffer size*
Router>**terminal no editing**	Disables advanced editing features
Router>**terminal editing**	Re-enables advanced editing
<Tab>	Completes the entry

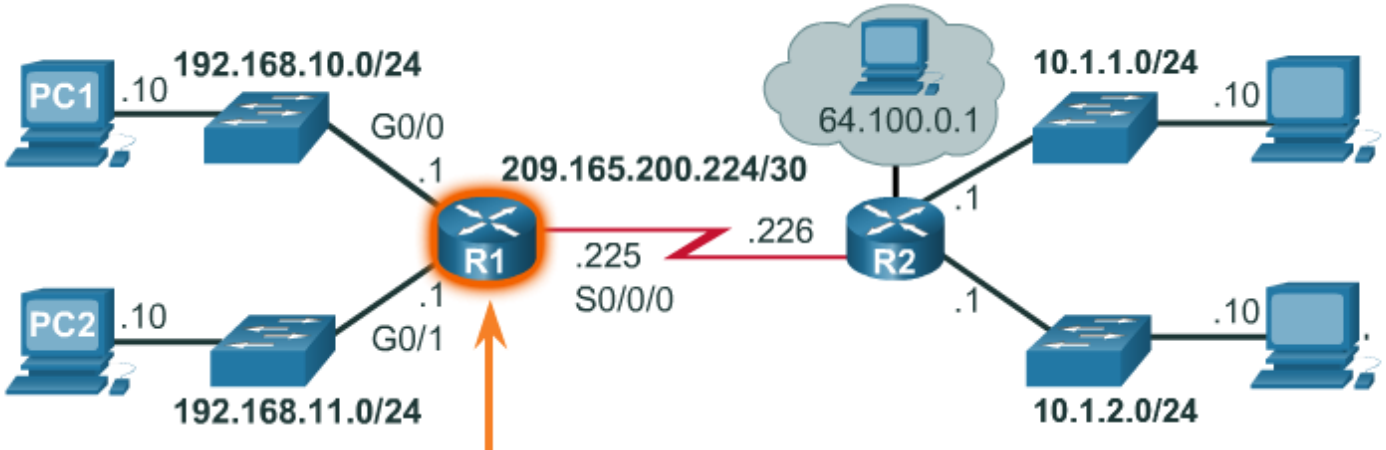
*The number will vary depending on what is displayed on the user's screen

The User Interface Error Indicator



Configure Initial Settings

- Basic Router Configuration Steps
  - Configure device name
  - Secure EXEC mode
  - Secure VTY lines
  - Secure privilege EXEC mode
  - Secure all passwords
  - Provide legal notification
  - Configure the management SVI
  - Save the configuration



Configuring a Router Name

Configuring Router Passwords

Console Password

```
Router(config)#line console 0
Router(config-line)#password cisco
Router(config-line)#login
```

Virtual Terminal Password

```
Router(config)#line vty 0 4
Router(config-line)#password cisco
Router(config-line)#login
```

Enable Password

```
Router(config)#enable password san-fran
```

Perform Password Encryption

```
Router(config)#service password-encryption
Router(config)#enable secret <password>
```

Interface Configuration Commands

In the following commands, the *type* argument includes serial, ethernet, fastethernet, token ring, and others:

```
Router(config)#interface type port
Router(config)#interface type slot/port
```

The following command is used to administratively turn off the interface:

```
Router(config-if)#shutdown
```

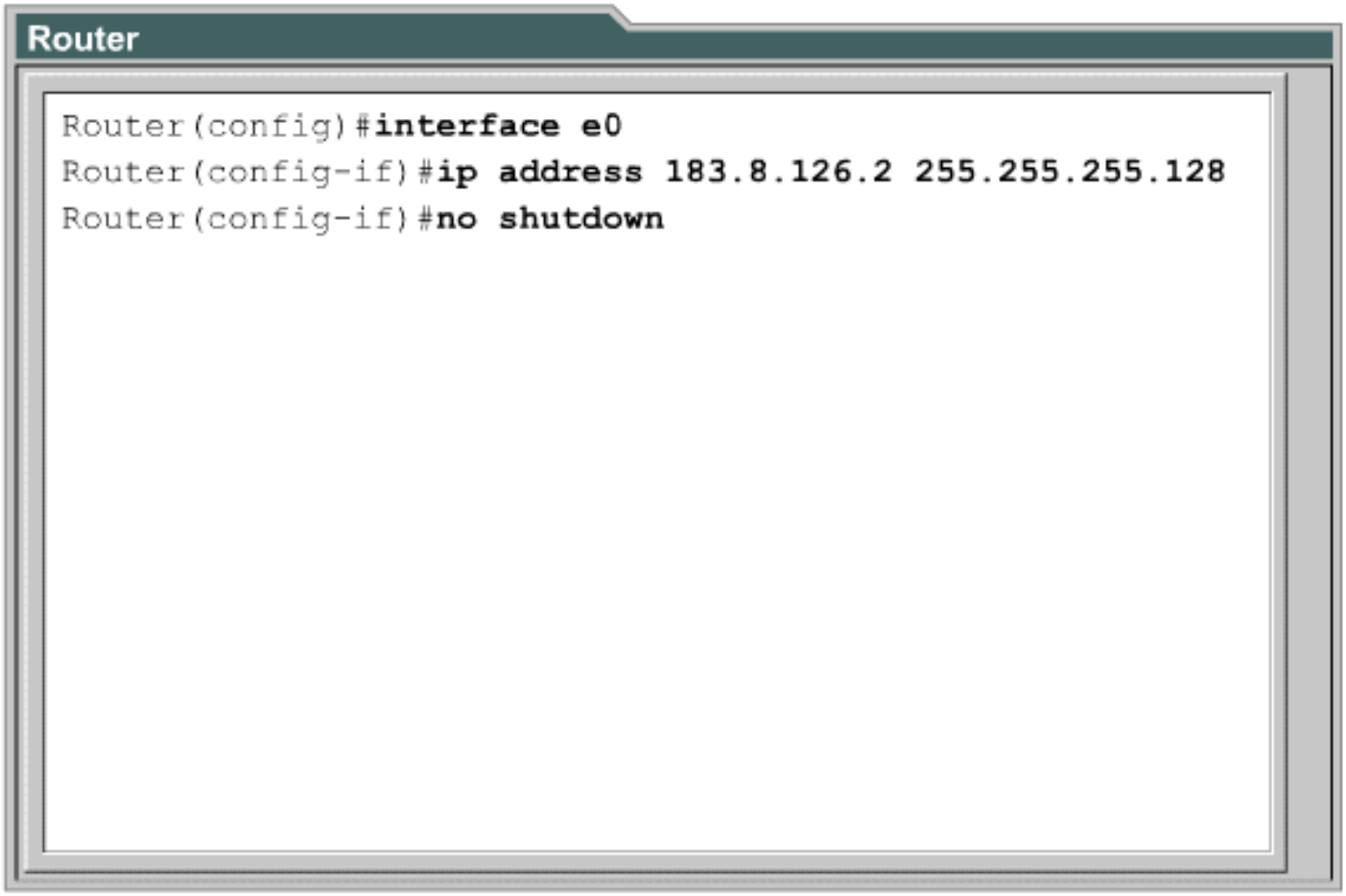
The following command is used to turn on an interface that has been shut down:

```
Router(config-if)#no shutdown
```

The following command is used to quit the current interface configuration mode:

```
Router(config-if)#exit
```

Configuring an Ethernet Interface



Configuring an Serial Interface

Router(config)#interface serial 0/0

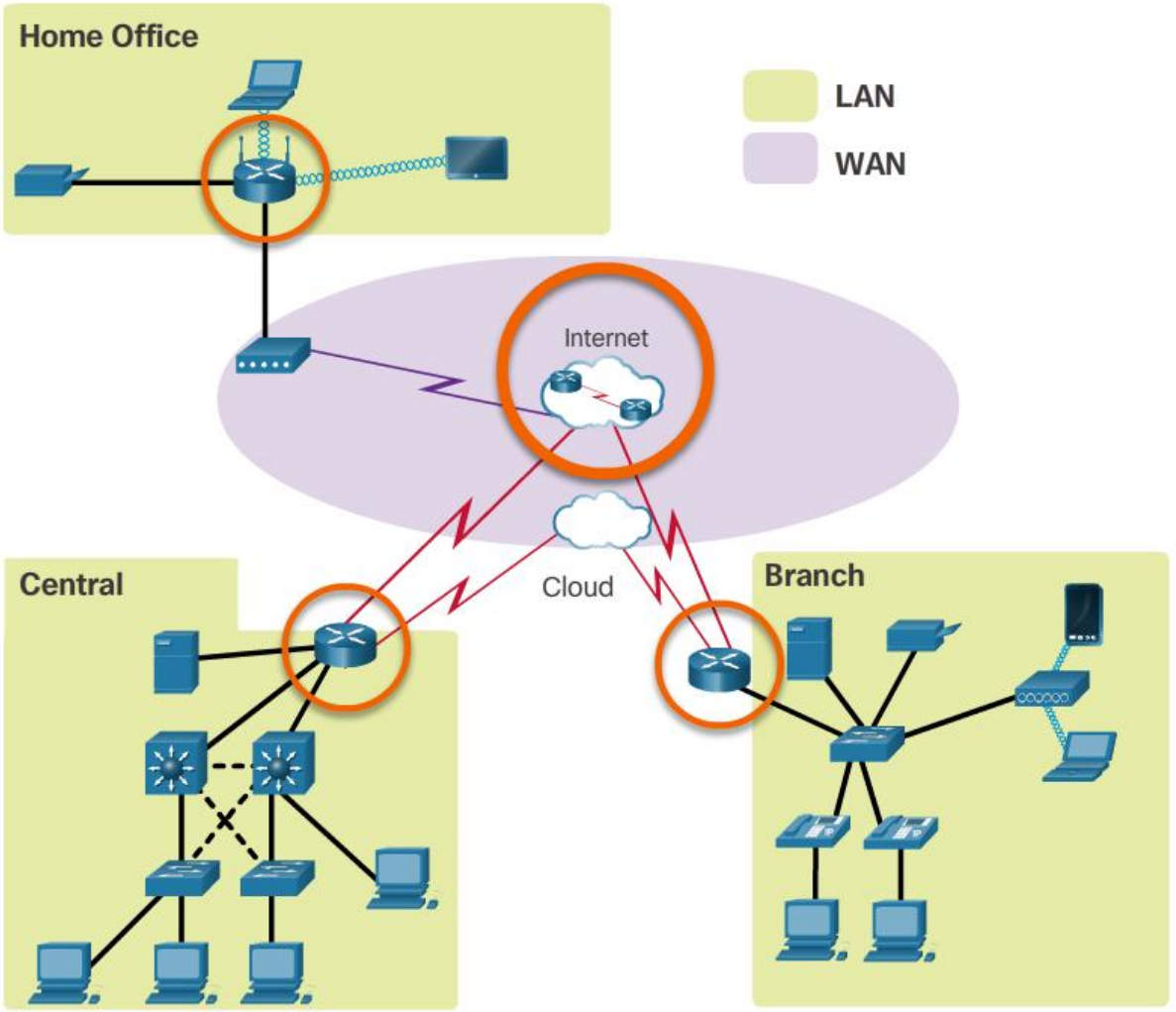
Router(config-if)#ip address <*ip address* > <*netmask* >

Router(config-if)#clock rate 56000 (only for DCE)

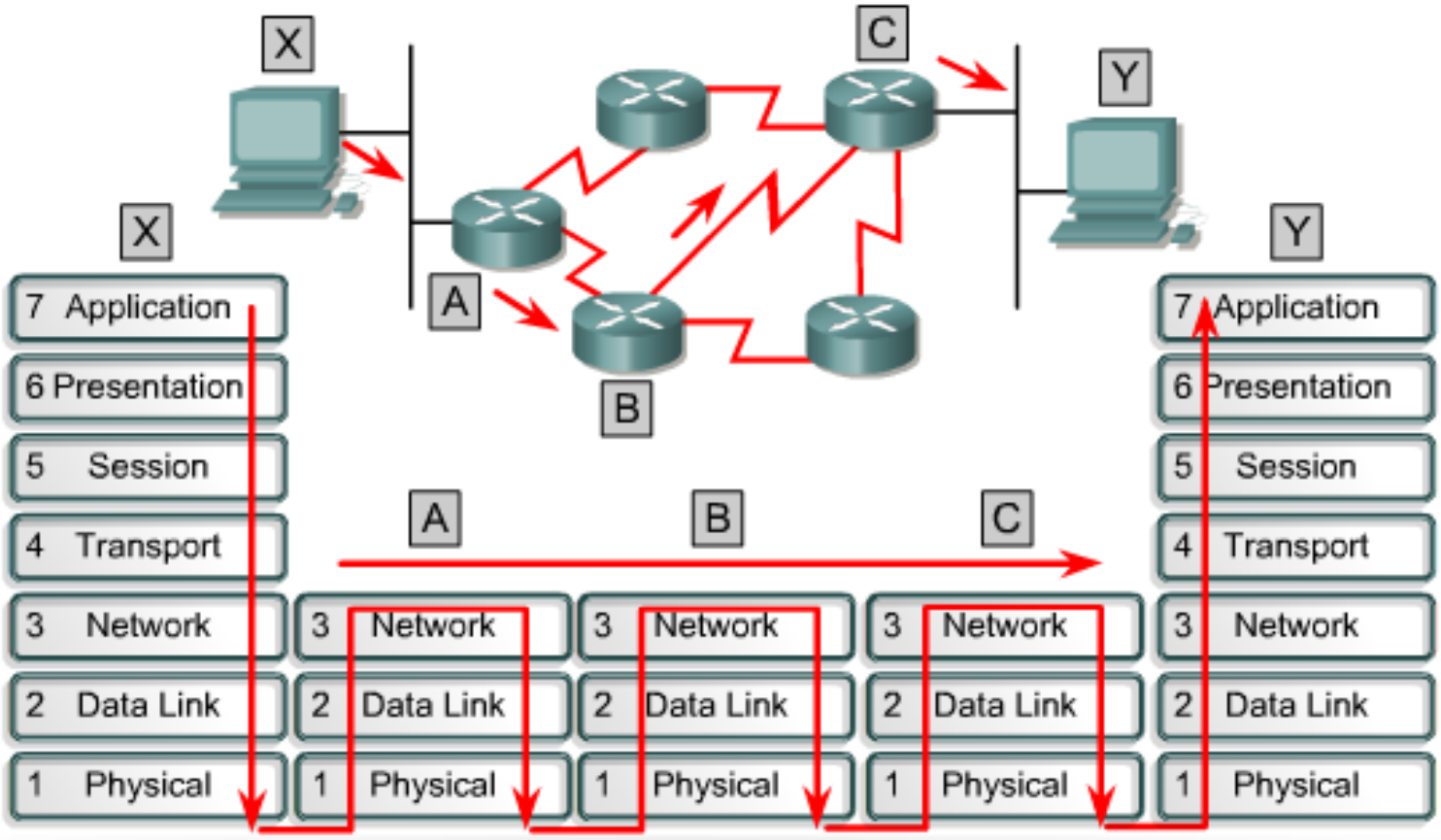
Router(config-if)#no shutdown

Routing

- The router is responsible for the routing of traffic between networks.



Routing



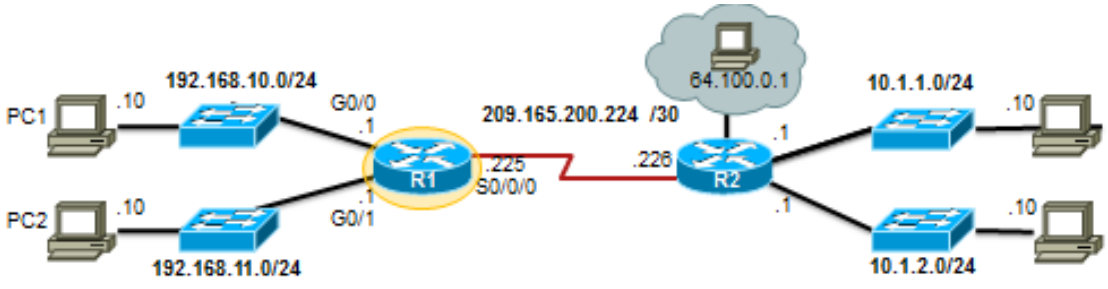
Each router provides its services to support upper-layer functions.

Router Routing Tables

- Router Packet Forwarding Decision
  - Routers and hosts forward packets in a similar fashion.
  - The main difference is that routers have more interfaces while hosts often have only one.
  - Devices on directly connected networks can be reached directly.
  - Devices on remote networks are reached through gateway.
- IPv4 Router Routing Table
  - The router routing table stores network routes the router knows about.
  - Use the **show ip route** command to display the routing table on a Cisco router.
  - The router routing table also has information on: how the route was learned, its trustworthiness and rating.
  - It also contains which interface to use to reach that specifc destination.
- Directly Connected Routing Table Entries
  - C - Identifies a directly-connected network, automatically created when an interface is configured with an IP address and activated.
  - L - Identifies that this is a local interface. This is the IPv4 address of the interface on the router.

Router Routing Tables

- Remote Network Routing Table Entries
  - Remote destinations can't be reached directly.
  - Remote routes contain the address of the intermediate network device to be used to reach the destination.
- Next-Hop Address
  - Next-Hop address is the address of the intermediate device used to reach a specifc remote destination.




```
D    10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05, Serial0/0/0
```

A	Identifies how the network was learned by the router.
B	Identifies the destination network.
C	Identifies the administrative distance (trustworthiness) of the route source.
D	Identifies the metric to reach the remote network.
E	Identifies the next hop IP address to reach the remote network.
F	Identifies the amount of elapsed time since the network was discovered.
G	Identifies the outgoing interface on the router to reach the destination network.

Configure Interfaces

- Configure Router Interfaces
  - Enter the interface sub-configuration mode.
  - Add a description to the Interface (optional)
  - Configure an IPv4 or IPv6 address.
  - Activate the interface with a **no shutdown** command
- Verify Interface Configuration
  - **show ip route** - Displays the contents of the IPv4 routing table stored in RAM.
  - **show interfaces** - Displays statistics for all interfaces on the device.
  - **show ip interface** - Displays the IPv4 statistics for all interfaces on a router.

Configure Interfaces

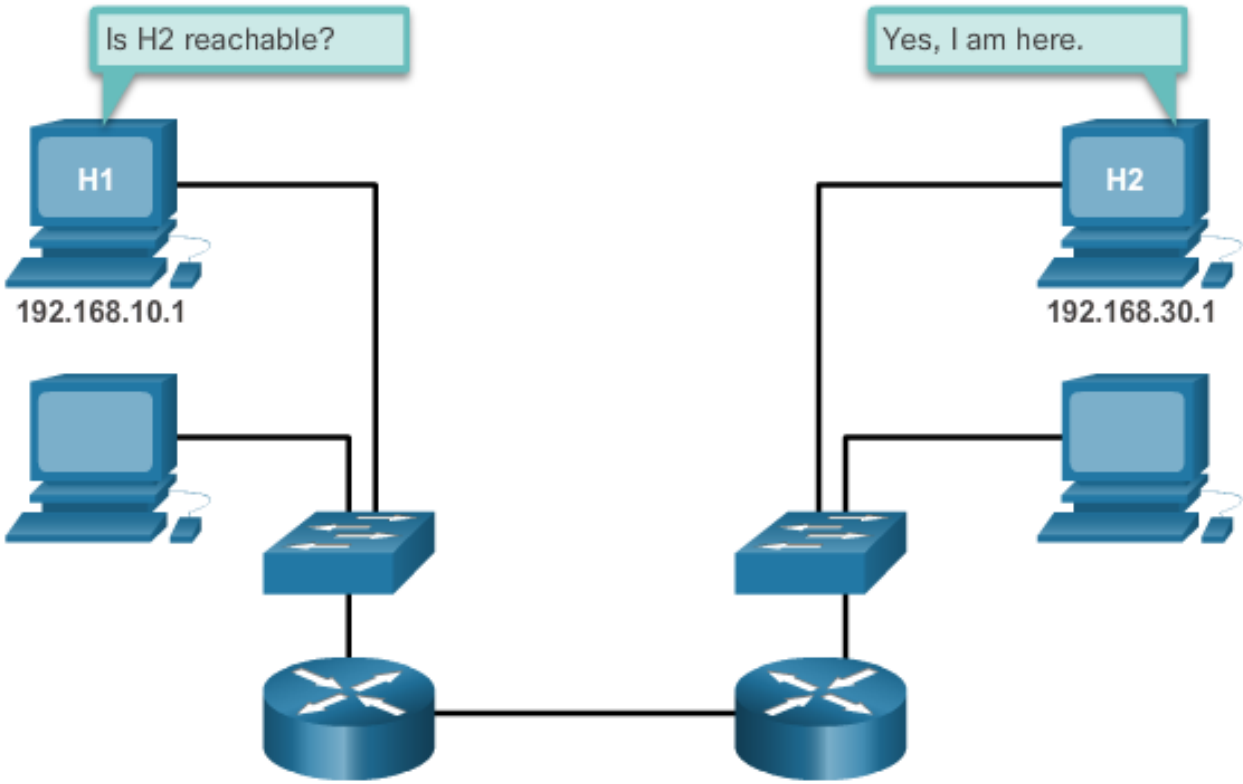
```
R1#conf t
Enter configuration commands, one per line.
End with CNTL/Z.
R1(config)#
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.10.1 255.255.255.0
R1(config-if)#description Link to LAN-10
R1(config-if)#no shutdown
%LINK-5-CHANGED: Interface GigabitEthernet0/0,
changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0,changed state to up
```

Verifying Configuration

- The command `copy running-config startup-config` is used to save active configuration in NVRAM.
- The command `show running-config` is used to view the active configuration in RAM.

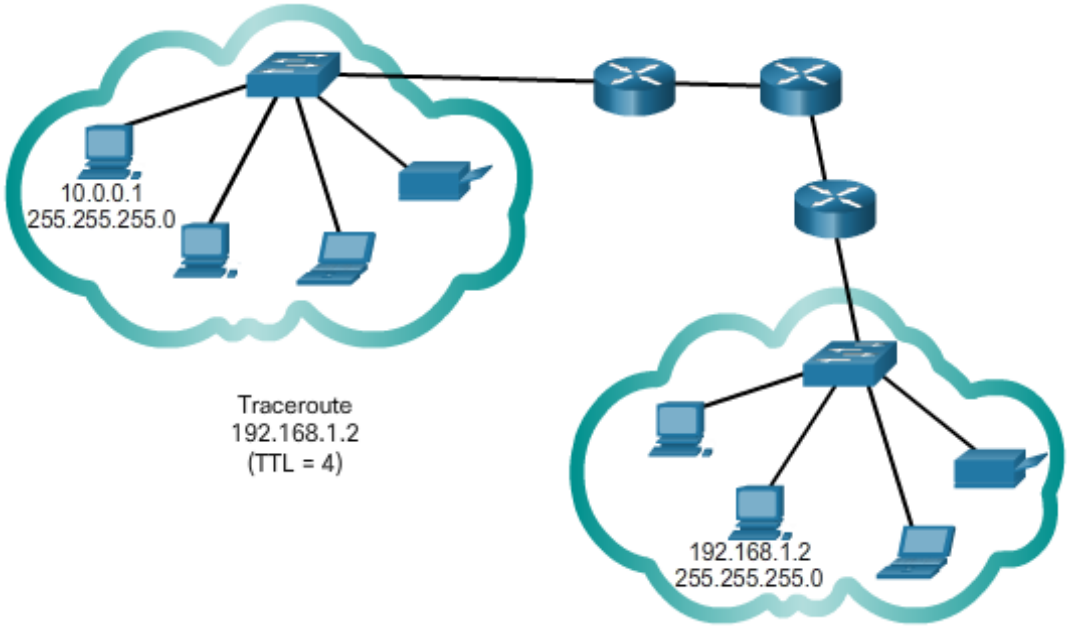
Connectivity Verification

- ICMPv4
  - Host Confirmation
  - Destination or Service Unreachable
  - Time Exceeded
  - Router Redirection

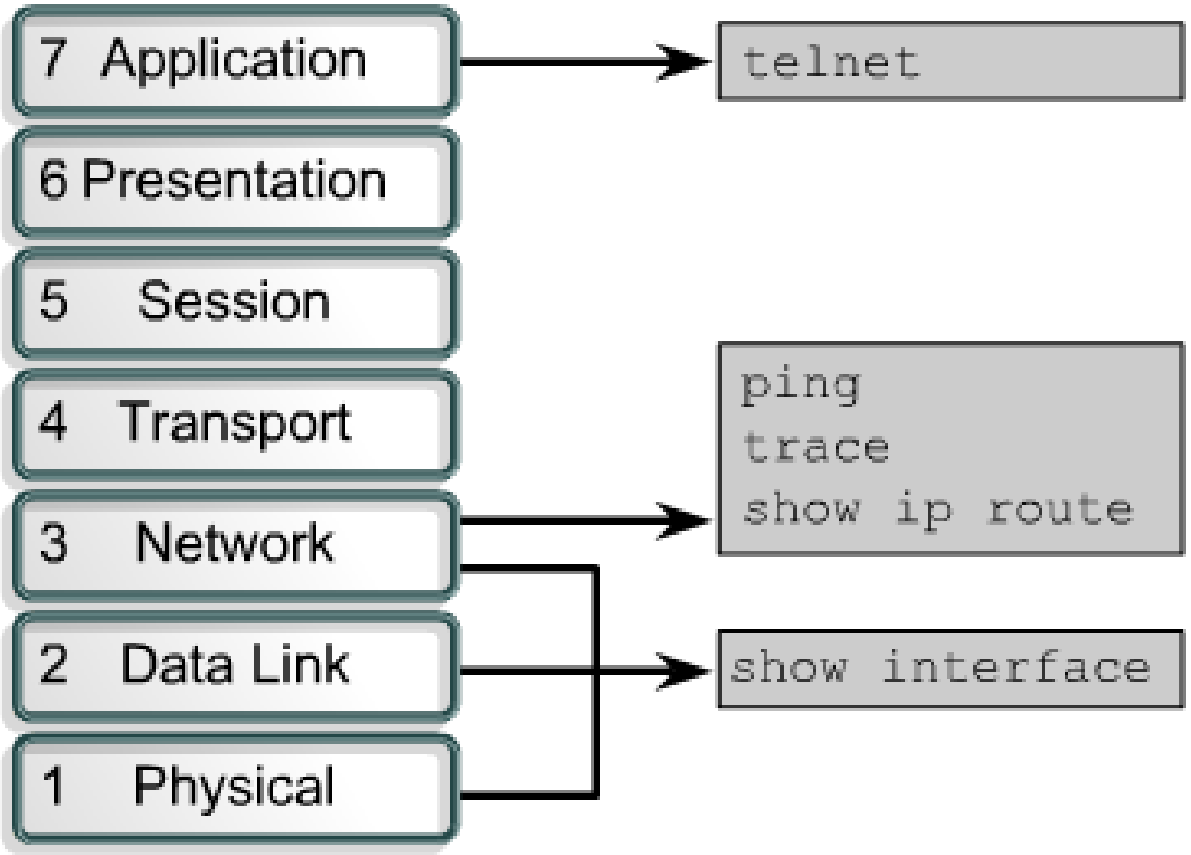


Connectivity Verification

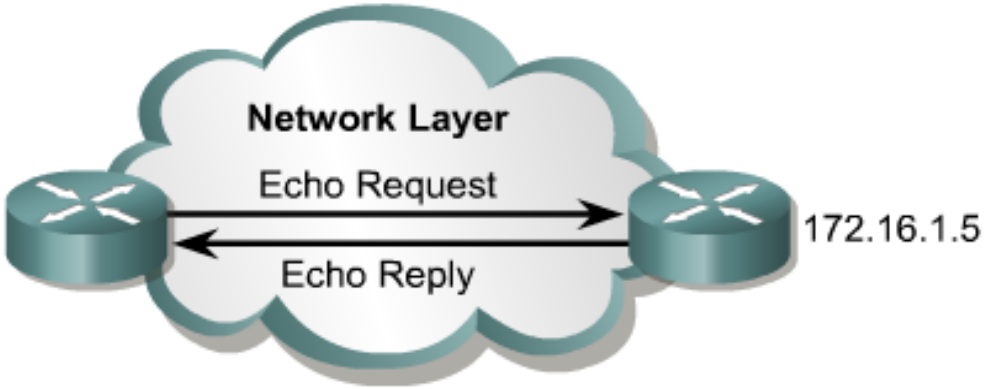
- Ping
  - Testing the Local Stack
    - 127.0.0.1 (IPv4)
  - Testing Connectivity to the Local LAN
  - Testing Connectivity to Remote
- Traceroute
  - Testing the Path
    - Round Trip Time (RTT)
    - IPv4 TTL



Test


7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical
telnet
ping
trace
show ip route
show interface

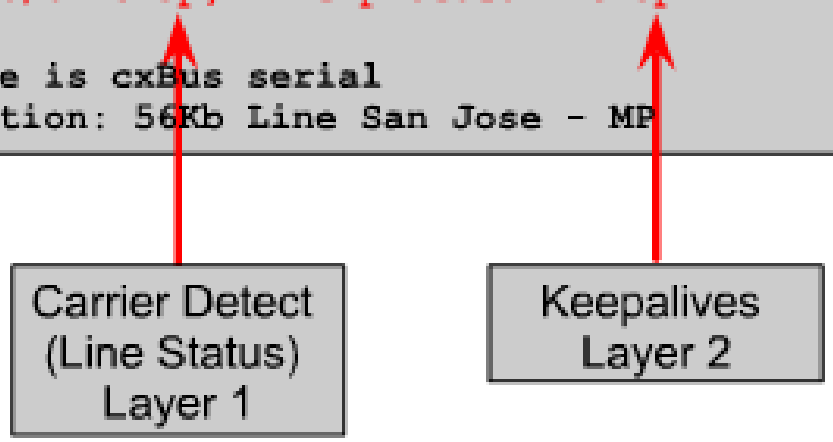
Testing with the `ping` Command




```
Router>ping 172.16.1.5
Type escape sequence to abort.
Sending 5, 100 byte ICMP Echos to 172.16.1.5,
timeout is 2 seconds:
!!!!!
Success rate is 100 percent,
round-trip min/avg/max = 1/3/4 ms
Router>
```

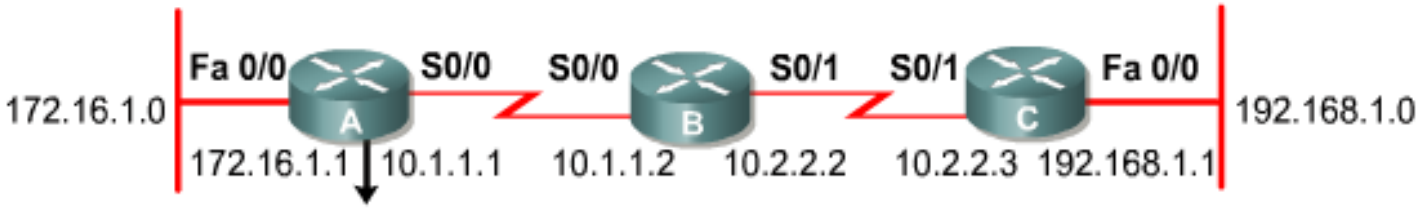
Show interface Command

```
Router#show interface serial 0/0

Serial 0/0 is up, line protocol is up

Hardware is cxBus serial
Description: 56Kb Line San Jose - MP
```



Serial 0/0 is up, line protocol is up	Operational.
Serial 0/0 is up, line protocol is down	Connection Problem
Serial 0/0 is down, line protocol is down	Interface Problem
Serial 0/0 is administratively down, line protocol is down	Disabled

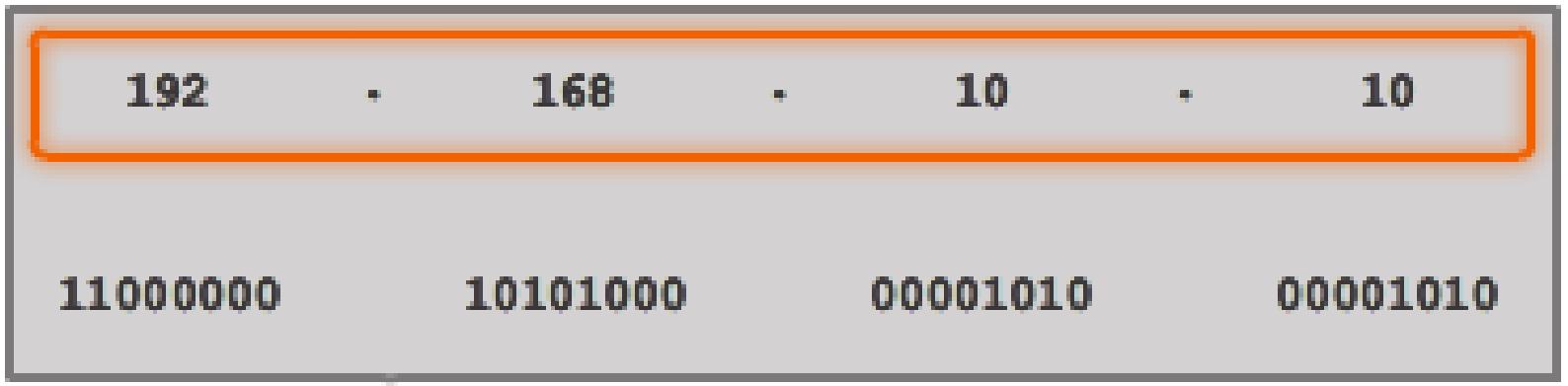
Displaying the IP Routing Table




```
RouterA#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, * - candidate
      default
       U - Per-user static route, 0 = CCR
       T - Traffic engineered route

Gateway of last resort is not set
   172.16.0.0/24 is subnetted, 1 subnets
C     172.16.1.0 is directly connected, Ethernet0
   10.0.0.0/24 is subnetted, 2 subnets
R     10.2.2.0 (120/1) via 10.1.1.2, 00:00:07, Serial 0/0
C     10.1.1.0 is directly connected, Serial 0/0
R   192.168.1.0/24 (120/2) via 10.1.1.2, 00:00:07, Serial 0/0
```

IPv4 Addressing

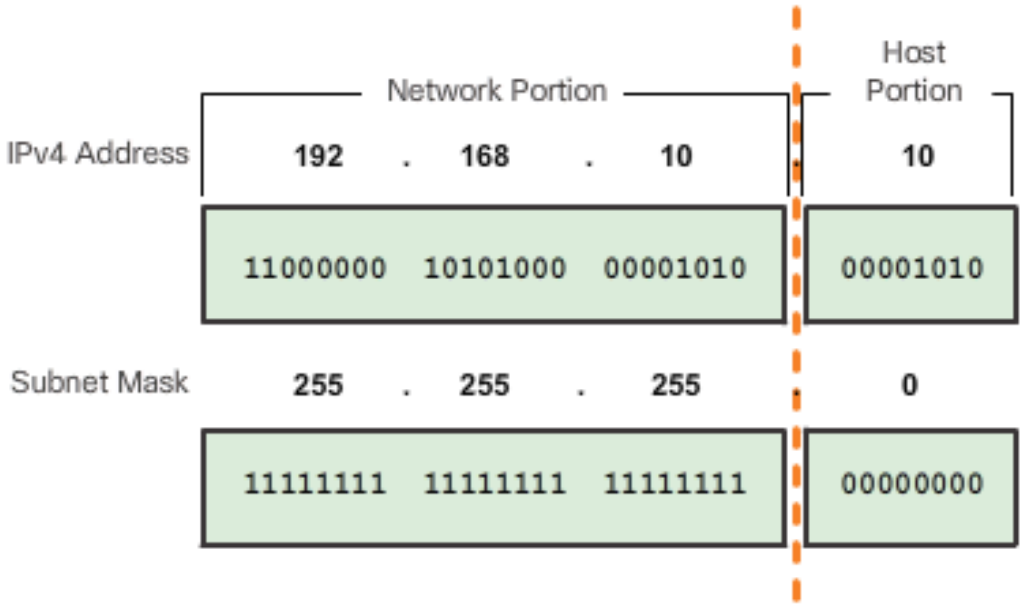
- IPv4 Addresses
  - consists of a string of 32 bits, divided into four sections called *octets*.
  - Each octet contains 8 bits (or 1 byte) separated with a dot.



192.168.10.10 is an IP address that is assigned to a computer.

IPv4 Address Structure

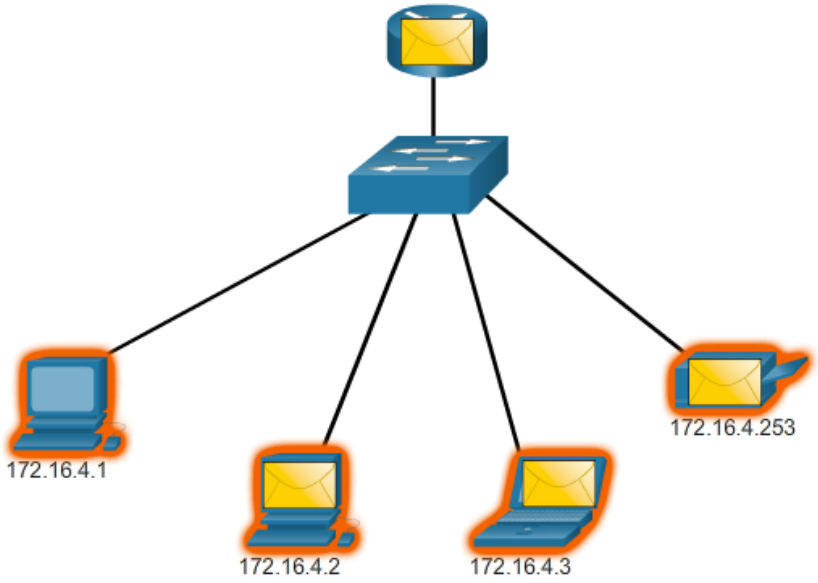
- Network and Host Portions
- The Subnet Mask
- Logical AND
- Prefix Length
- Network, Host, and Broadcast Addresses
  - Network Address
  - Range of Valid Hosts
  - Broadcast Address

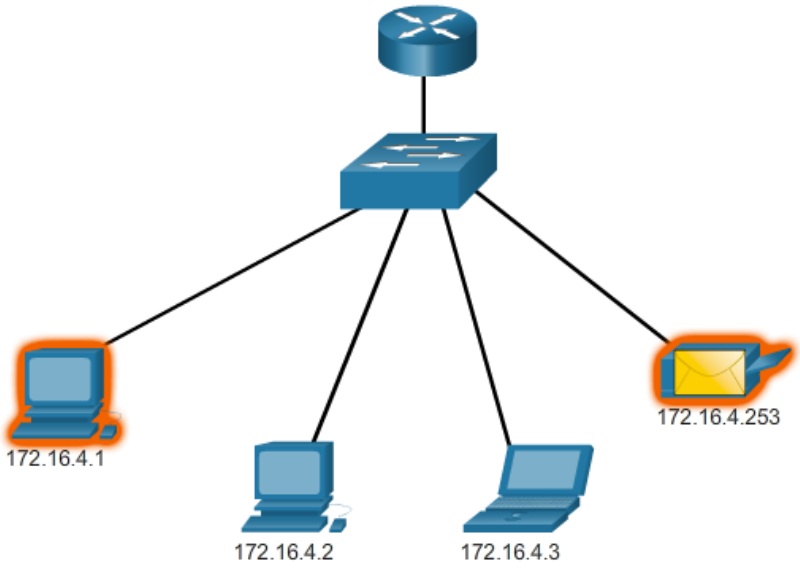


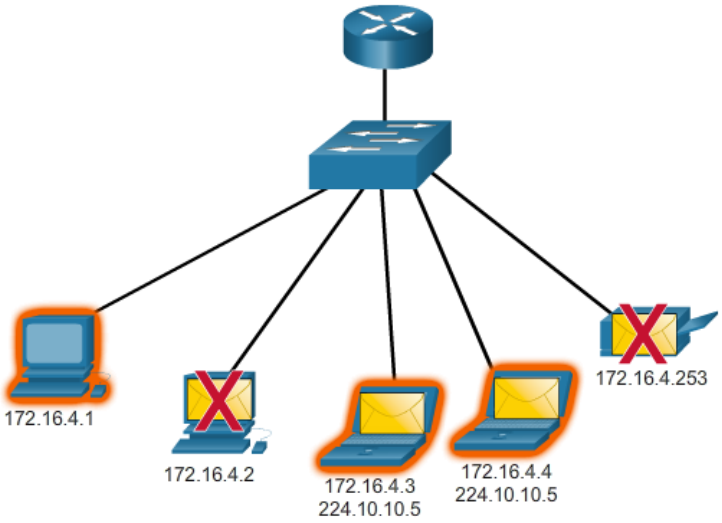
IPv4 Unicast, Broadcast, and Multicast

- IPv4 Addressing Assignment to a Host
  - Static – Type in manually
  - Dynamic - Dynamic Host Configuration Protocol (DHCP)
- IPv4 Communication
  - Unicast - send packets from one host to an individual host
  - Broadcast - send packets from one host to all the hosts in the network
  - Multicast - send a packet from one host to a selected group of hosts in the same or different network
  - Which types of communication are the graphics on the right?

IPv4 Unicast, Broadcast, and Multicast







Types of IPv4 Addresses

- Public and Private IPv4 Addresses
  - Private addresses are not routed over the Internet
  - Private Addresses:
    - 10.0.0.0/8 or 10.0.0.0 to10.255.255.255
    - 172.16.0.0 /12 or 172.16.0.0 to 172.31.255.255
    - 192.168.0.0 /16 or 192.168.0.0 to 192.168.255.255
- Classless Addressing
  - CIDR
  - Allocated IPv4 addresses based on prefix length

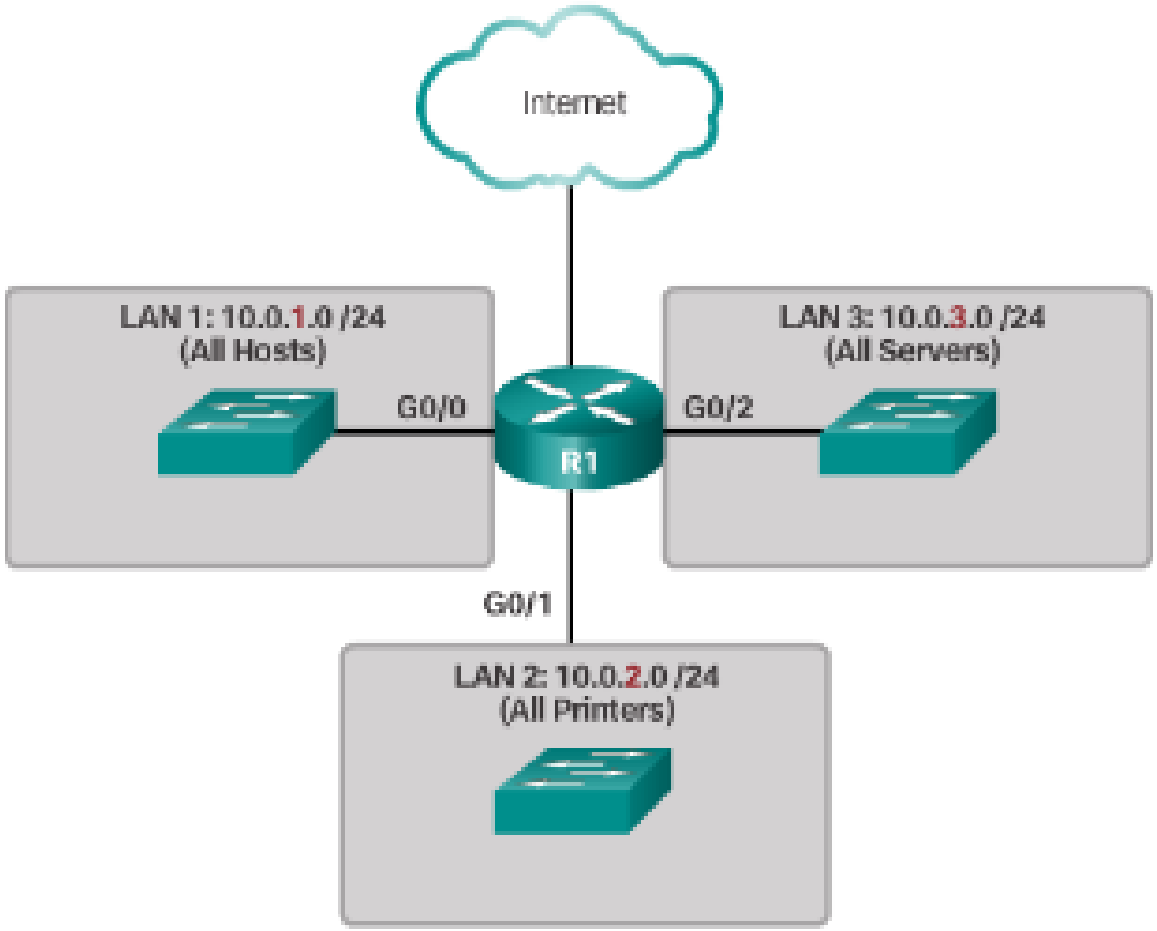
Types of IPv4 Addresses

- Special User IPv4 Addresses
  - Loopback addresses
    - 127.0.0.0 /8 or 127.0.0.1 to 127.255.255.254
  - Link-Local addresses or Automatic Private IP Addressing (APIPA) addresses
    - 169.254.0.0 /16 or 169.254.0.1 to 169.254.255.254
  - TEST-NET addresses
    - 192.0.2.0/24 or 192.0.2.0 to 192.0.2.255

Network Segmentation

- Broadcast Domains
  - Each router interface connects a broadcast domain.
  - Broadcasts are only propagated within its broadcast domain.
- Problems with Large Broadcast Domains
  - Slow network operations due to the significant amount of broadcast traffic.
  - Slow device operations because a device must accept and process each broadcast packet.
- Reasons for Subnetting
  - Solution: reduce the size of the network to create smaller broadcast domains.
  - Because each broadcast domain connects to a different router interface, each domain needs its own network address space.
  - The process of breaking an address range into smaller address spaces is called subnetting.
  - Network administrators can group devices into subnets that are determined by location, organizational unit or device type.

Network Segmentation



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