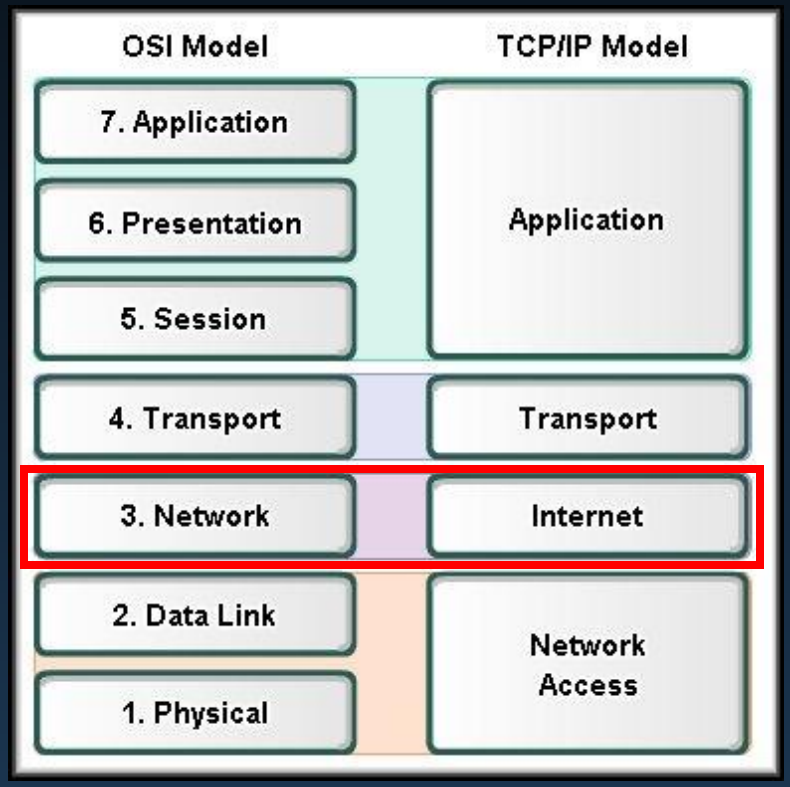
Chapter 6

Addressing the Network - IPV4

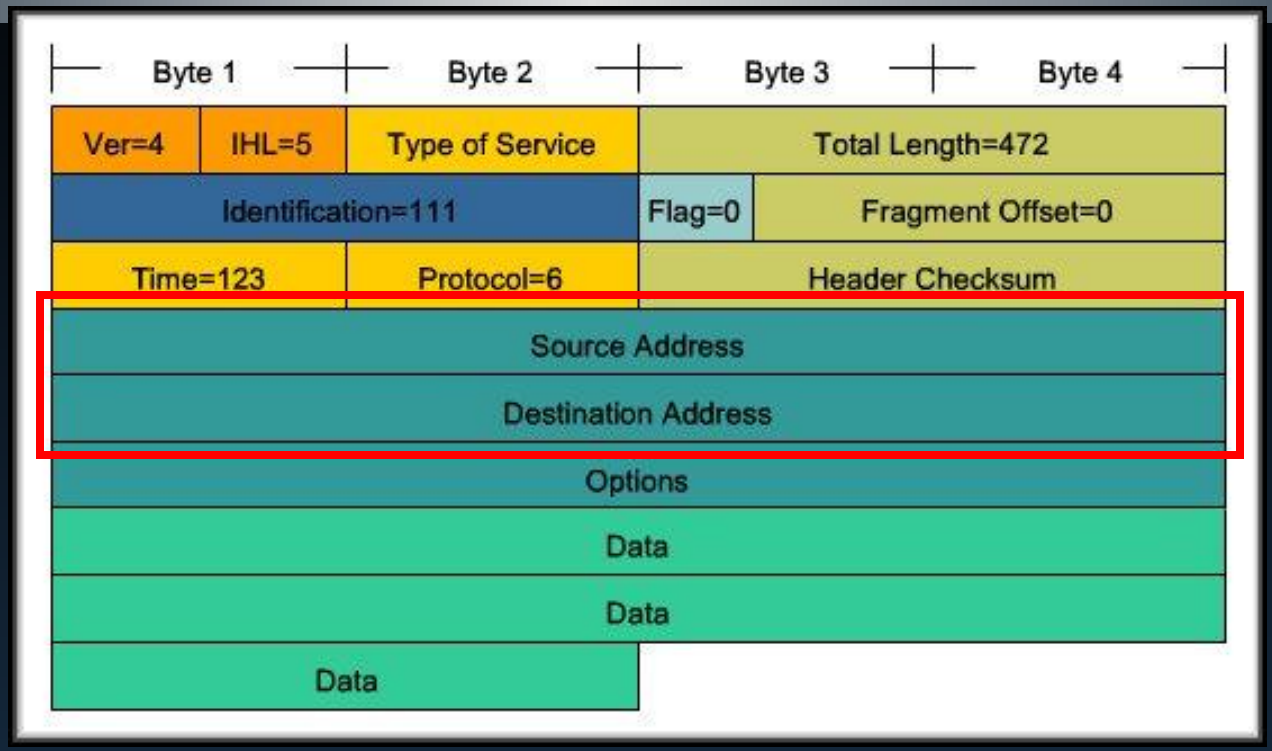
Part I

Addressing the Network: IPv4

IPv4 Addresses

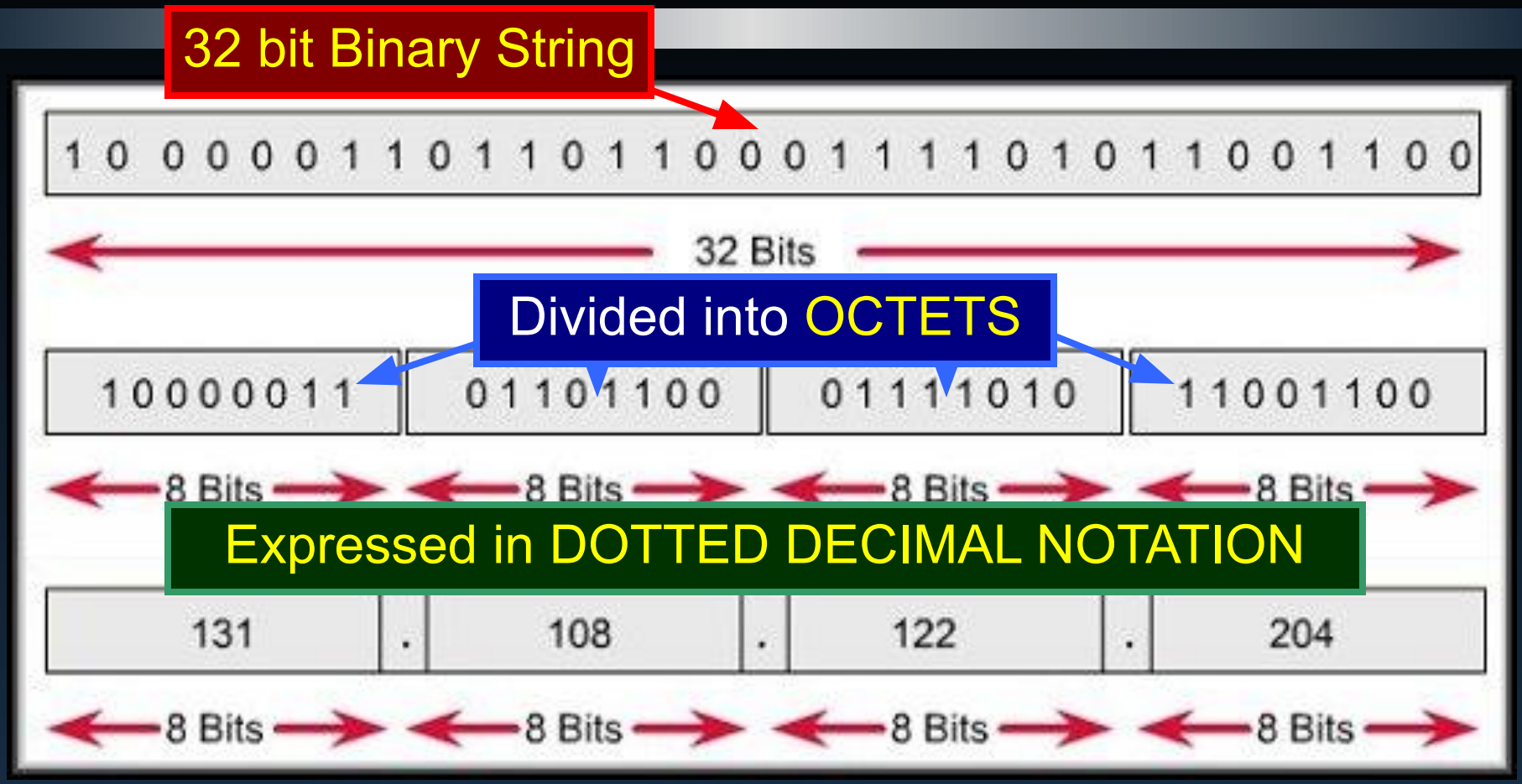


Anatomy of an IPv4 Address



- Each device on a network must be uniquely identified at the Network layer.
- For IPv4, a 32 bit source and destination address is contained in each packet.

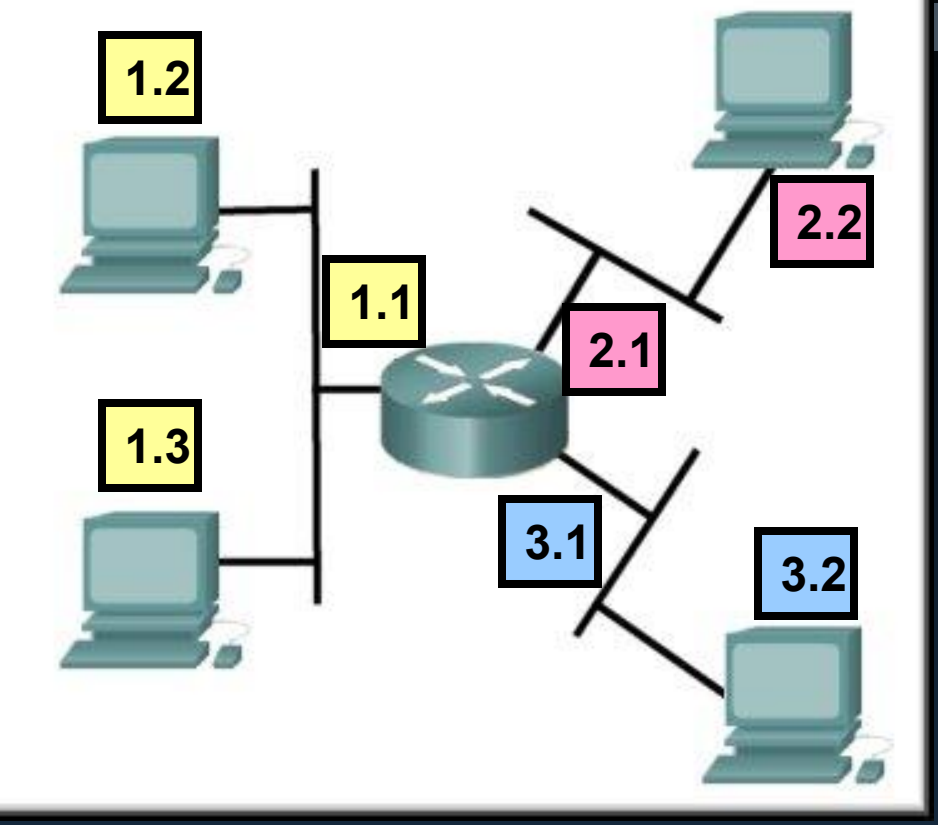
Anatomy of an IPv4 Address



- Devices use binary logic and work with strings of binary numbers. For us, the decimal equivalent is much easier to use and remember.

Anatomy of an IPv4 Address

Network	Host
1	1
	2
	3
2	1
	2
3	1
	2



- To identify a path or "route" through a network, the address must be composed of two parts:
  - Network portion
  - Host portion

Anatomy of an IPv4 Address

IP Address	192.	168.	1.	2
Binary IP Address	11000000	10101000	00000001	00000010

- Network Portion:
  - Some portion of the high-order bits represents the network address.
  - At Layer 3, we define a network as a group of hosts that have identical bit patterns in the network address portion of their addresses.

192.168.1.2	**11000000**	**10101000**	**00000001**	00000010
192.168.1.67	**11000000**	**10101000**	**00000001**	01000011
192.168.1.204	**11000000**	**10101000**	**00000001**	11001100

Anatomy of an IPv4 Address

IP Address	192.	168.	1.	2
Binary IP Address	11000000	10101000	00000001	00000010

- Host Portion:
  - There are a variable number of bits that are called the host portion of the address.
  - The number of bits used in this host portion determines the number of hosts that we can have within the network.

192.168.1.2	11000000	10101000	00000001	00000010
192.168.1.67	11000000	10101000	00000001	01000011
192.168.1.204	11000000	10101000	00000001	11001100

Binary to Decimal Conversion

- In all number systems, the digits start with 0.
- A Base-n number system has n number of digits:
  - Decimal:
    - Base-10 has 10 digits
      - 9, 8, 7, 6, 5, 4, 3, 2, 1, 0
  - Binary:
    - Base-2 has 2 digits
      - 1, 0
  - Hexadecimal:
    - Base-16 has 16 digits
      - F, E, D, C, B, A, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0

Binary to Decimal Conversion

- Positional Notation (Decimal Number System):
  - Means that a digit represents different values depending on the position it occupies.
  - The value that a *digit represents* is that value multiplied by the power of the base according to the *position* the digit occupies.

Position	3	2	1	0
Base	10^3	10^2	10^1	10^0
Value	**1,000**	**100**	**10**	**1**
String	**2**	**1**	**3**	**4**

$$(2x10^3) + (1x10^2) + (3x10^1) + (4x10^0) = 2,134$$

Binary to Decimal Conversion

- Computers react only to electrical impulses.
  - They work with and store data using electronic switches that are either on (1) or off (0).
  - They can only understand and use data that is in this two state format.
  - These 1's and 0's are called binary digits or bits.

Binary to Decimal Conversion

- Positional Notation (Binary Number System):
  - Means that a digit represents different values depending on the position it occupies.
  - The value that a *digit represents* is that value multiplied by the power of the base according to the *position* the digit occupies.

Position	7	6	5	4	3	2	1	0
Base	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Value	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
String	**0**	**1**	**1**	**0**	**1**	**1**	**0**	**0**

$$(1x2^6) + (1x2^5) + (1x2^3) + (1x2^2)$$
$$64 + 32 + 8 + 4 = 108$$

Binary to Decimal Conversion

Position	7	6	5	4	3	2	1	0
Base	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Value	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
String	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
String	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
String	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**

Range: 0 to 255

String	1	1	1	1	1	1	1	1

Binary to Decimal Conversion

IP Address: 11001001000100010001110100000100

11001001	00010001	00011101	00000100
201	17	29	4

IP Address: 201.17.29.4

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	**64**	**32**	**16**	**8**	**4**	**2**	**1**
0	0	0	0	0	1	0	0

Binary to Decimal Conversion

	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Dec.	128	64	32	16	8	4	2	1
21	0	0	0	1	0	1	0	1
50	0	0	1	1	0	0	1	0
101	0	1	1	0	0	1	0	1
150	1	0	0	1	0	1	1	0
206	1	1	0	0	1	1	1	0

Decimal to Binary Conversion

IP Address: 201.17.29.4

201
- 128
73
- 64
9
- 8
1
- 1
0

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	0	0	1	0	0	1

Decimal to Binary Conversion

IP Address: 201.17.29.4

201

11001001

17
- 16
1
- 1
0

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	**64**	**32**	**16**	**8**	**4**	**2**	**1**
0	0	0	1	0	0	0	1

Decimal to Binary Conversion

IP Address: 201.17.29.4

29
- 16
13
- 8
5
- 4
1
- 1
0

201	17
11001001	00010001

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	1	1	1	0	1

Decimal to Binary Conversion

IP Address: 201.17.29.4

4
- 4
0

201	17	29	4
11001001	00010001	00011101	00000100

Binary String: 11001001000100010001110100000100

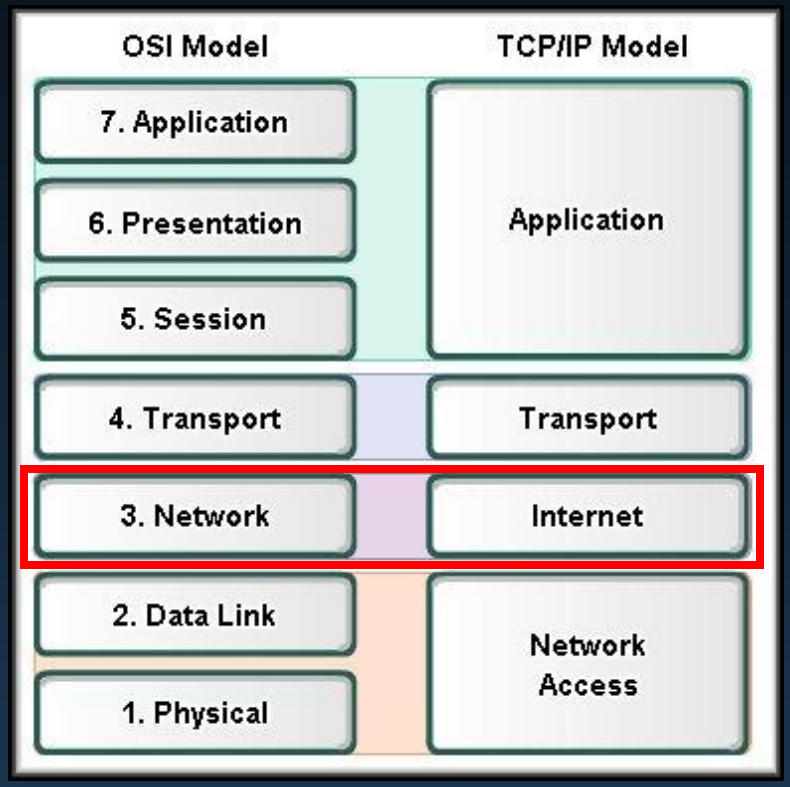
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	0	0	1	0	0

Decimal to Binary Conversion

	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Dec.	128	64	32	16	8	4	2	1
2	0	0	0	0	0	0	1	0
10	0	0	0	0	1	0	1	0
17	0	0	0	1	0	0	0	1
130	1	0	0	0	0	0	1	0
252	1	1	1	1	1	1	0	0

Addressing the Network: IPv4

IPv4 Addresses for Different Purposes



Types of Addresses in an IPv4 Network Range

- Three types:

  Network: A special address that refers to the network as an entity.

  Broadcast: A special address used to send data to all hosts in a network.

  Host: The unique address assigned to each host in a network.

Network and Broadcast addresses
CANNOT
be assigned to a host.

Network Address

			Network Address
192	168	10	0
11000000	10101000	00001010	00000000
			Broadcast Address
192	168	10	255
11000000	10101000	00001010	11111111
			Host Address
192	168	10	1
11000000	10101000	00001010	00000001

- Standard way to reference a network (Lowest Address).
- All hosts in the network will have the same network bits.
- Cannot be assigned to a device.
- Each host bit in this address will be 0.

Broadcast Address

			Network Address
192	168	10	0
11000000	10101000	00001010	00000000
			Broadcast Address
192	168	10	255
11000000	10101000	00001010	11111111
			Host Address
192	168	10	1
11000000	10101000	00001010	00000001

- The destination address of a single packet used to communicate to all hosts in a network (Highest Address)
- Cannot be assigned to a device.
- Each host bit in this address will be 1.

Host Address

Network Address			
192	168	10	0
11000000	10101000	00001010	00000000
Broadcast Address			
192	168	10	255
11000000	10101000	00001010	11111111
Host Address			
192	168	10	1
11000000	10101000	00001010	00000001

- The unique address assigned to each device on the network.
- Assign any address between the network address (192.168.10.0) and the broadcast address (192.168.10.255).
- Addresses 192.168.10.1 through 192.168.10.254.

Types of Communication in an IPv4 Network

- Three types:

  Unicast: The process of sending a packet from one host to an individual host.

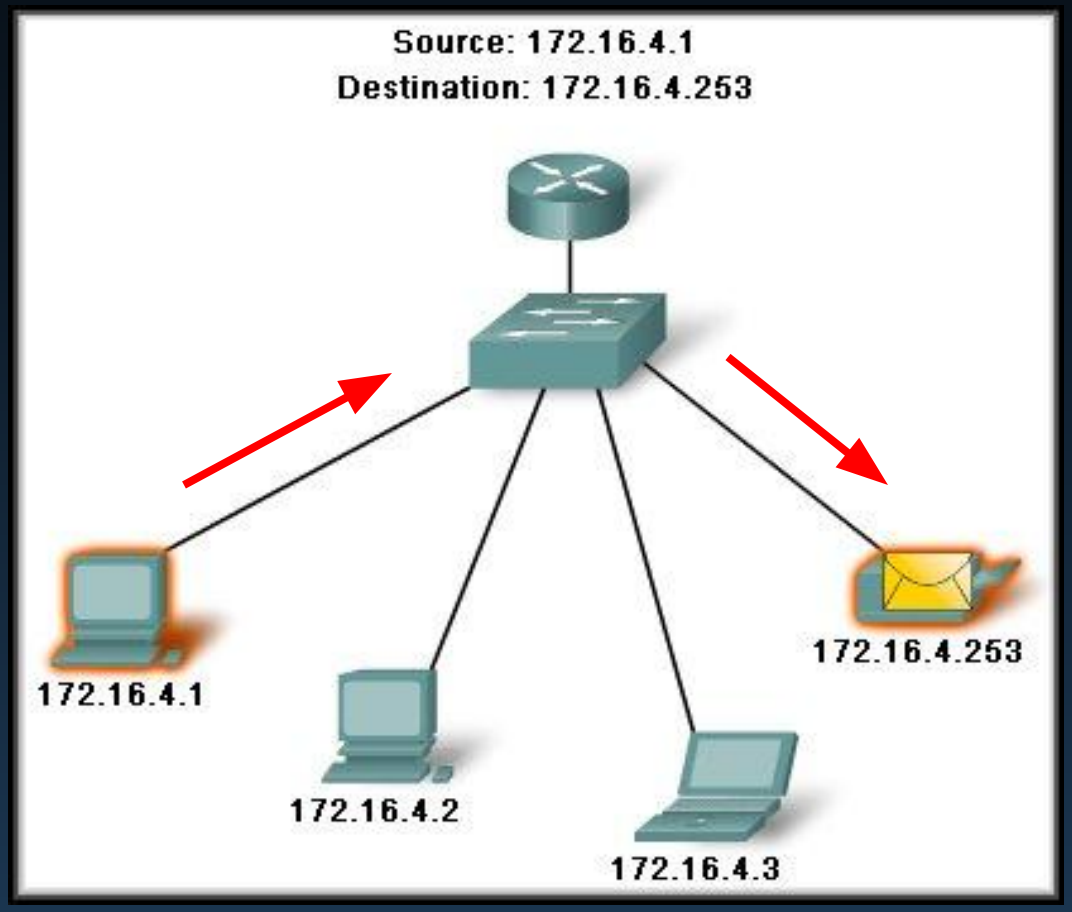
  Broadcast: The process of sending a packet from one host to all hosts in the network.

  Multicast: The process of sending a packet from one host to a selected group of hosts.

  - In all three types, the address of the originating host is used as the source address in the packet.

Unicast Communications

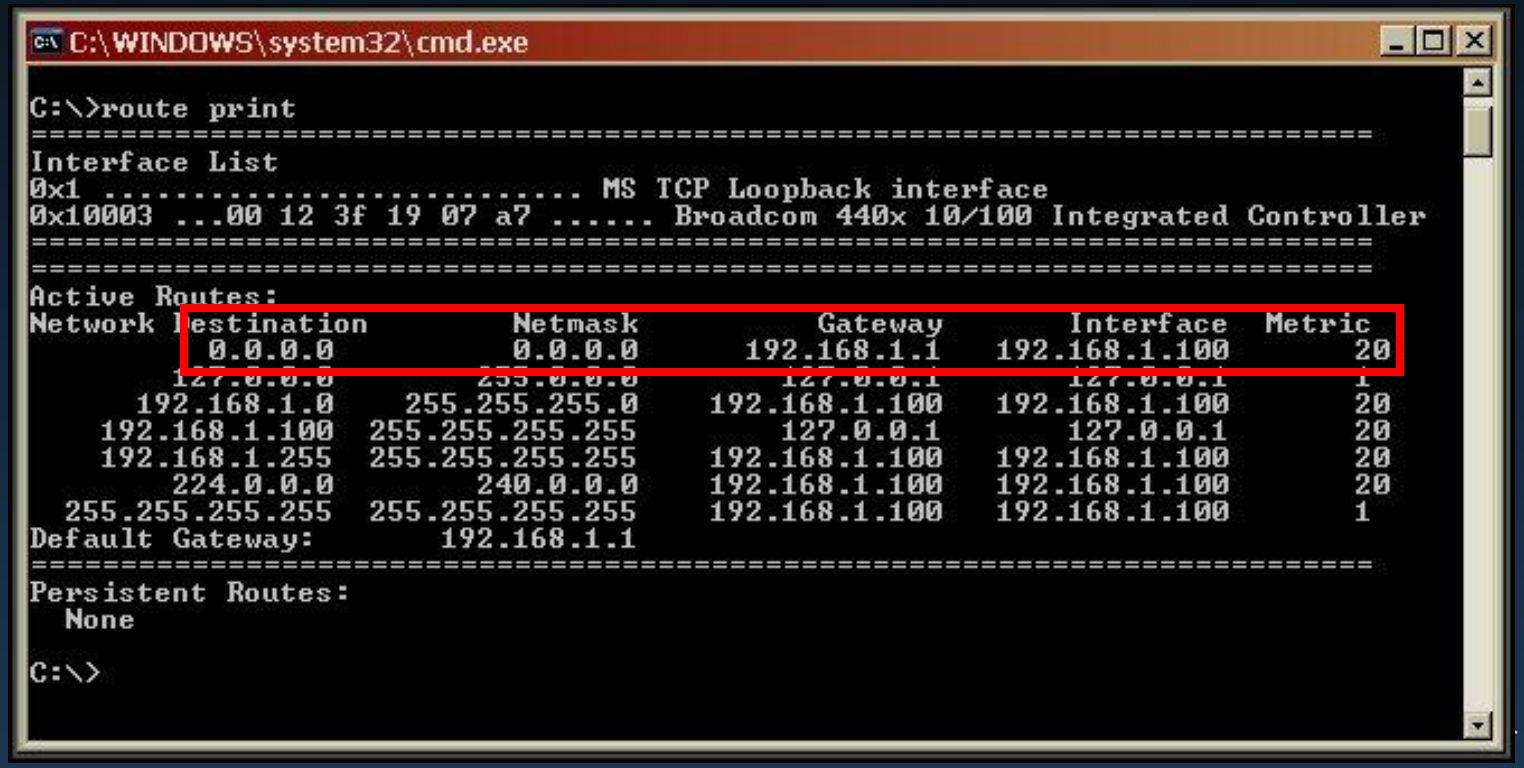
- The process of sending a packet from one host to an individual host.



Special Unicast Addresses

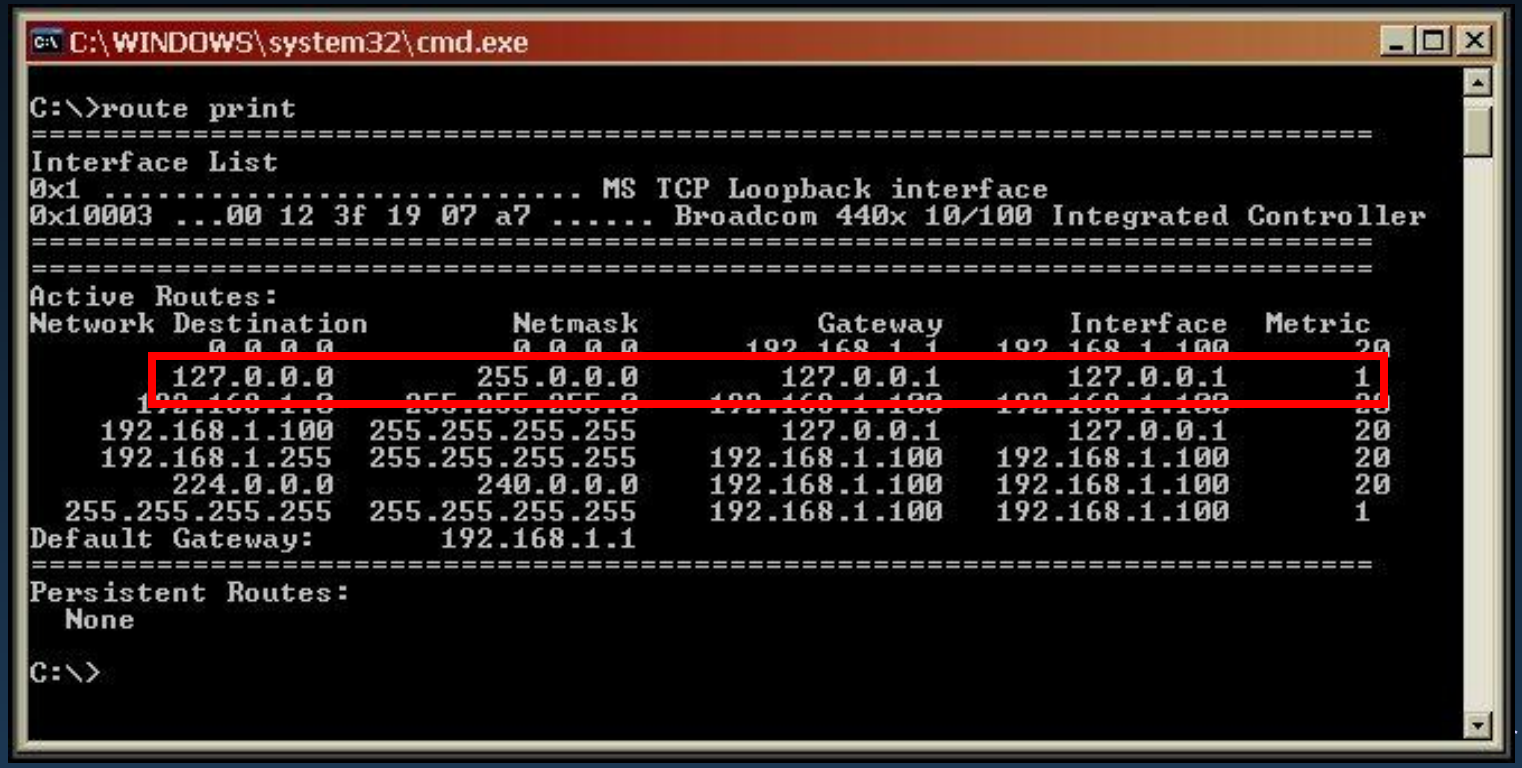
- Default Route:
  - Address - 0.0.0.0 Subnet Mask – 0.0.0.0
  - When configured, it tells the device….

If you don't know where to send the frame, send it here.



Special Unicast Addresses

- Loopback:
  - Address - 127.0.0.1
  - Host applications use it to communicate with each other.
  - Test TCP/IP configuration on a PC – ping 127.0.0.1



Special Unicast Addresses

- Link Local Addresses:
  - Address Range 169.254.0.0 to 169.254.255.255
  - Can be automatically assigned by the operating system where no IP configuration is available.

Special Unicast Addresses

- Test-Net Addresses:
  - Address Range 192.0.2.0 to 192.0.2.255
  - Used for teaching and learning purposes.
    - Appear in documentation and network examples.
    - Will be accepted by a network device.
    - Used to provide examples in RFCs and vendor and protocol documentation.
    - Should not appear on the Internet.

Your best bet…..

STAY AWAY FROM THEM….

Special Unicast Addresses

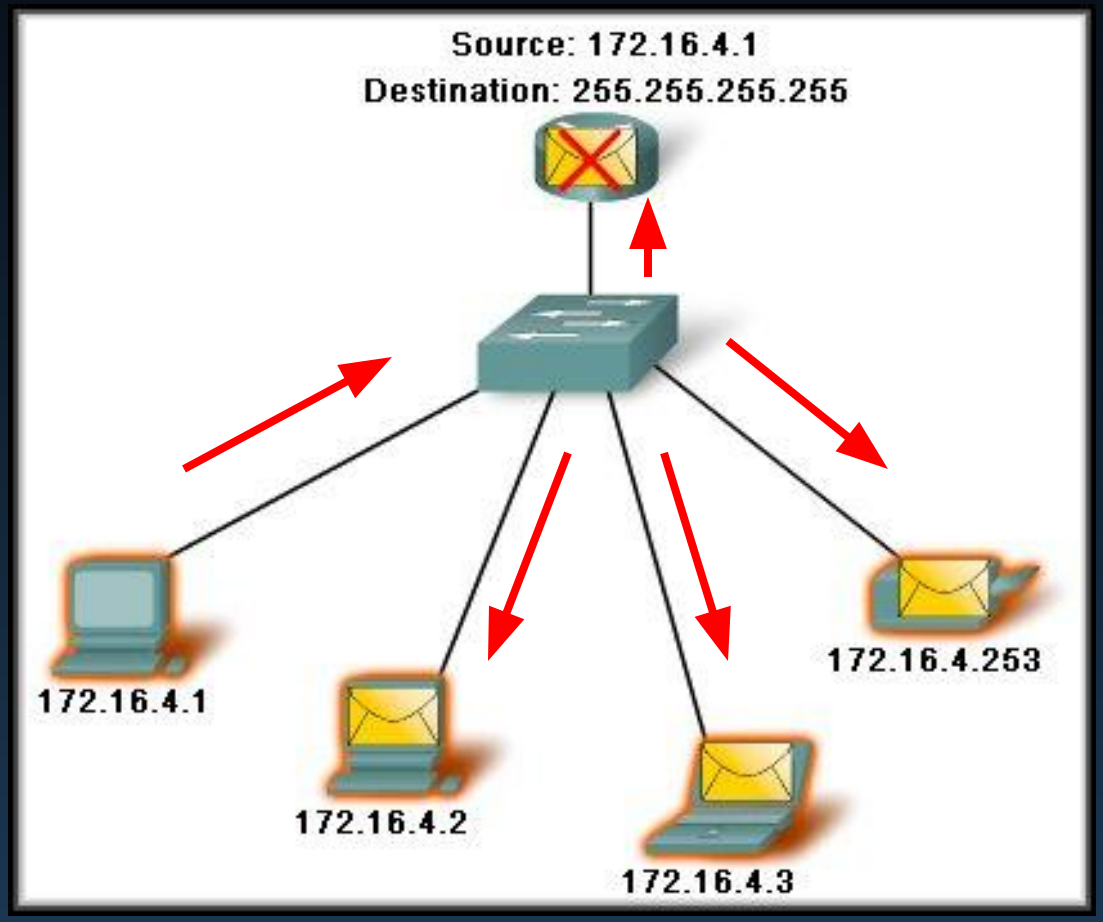
- Experimental Address Range:
  - Address Range 240.0.0.0 to 255.255.255.254
    - Reserved for future use.
    - Cannot be used on IPv4 networks.
    - Used for research and experimentation.

Special Unicast Addresses

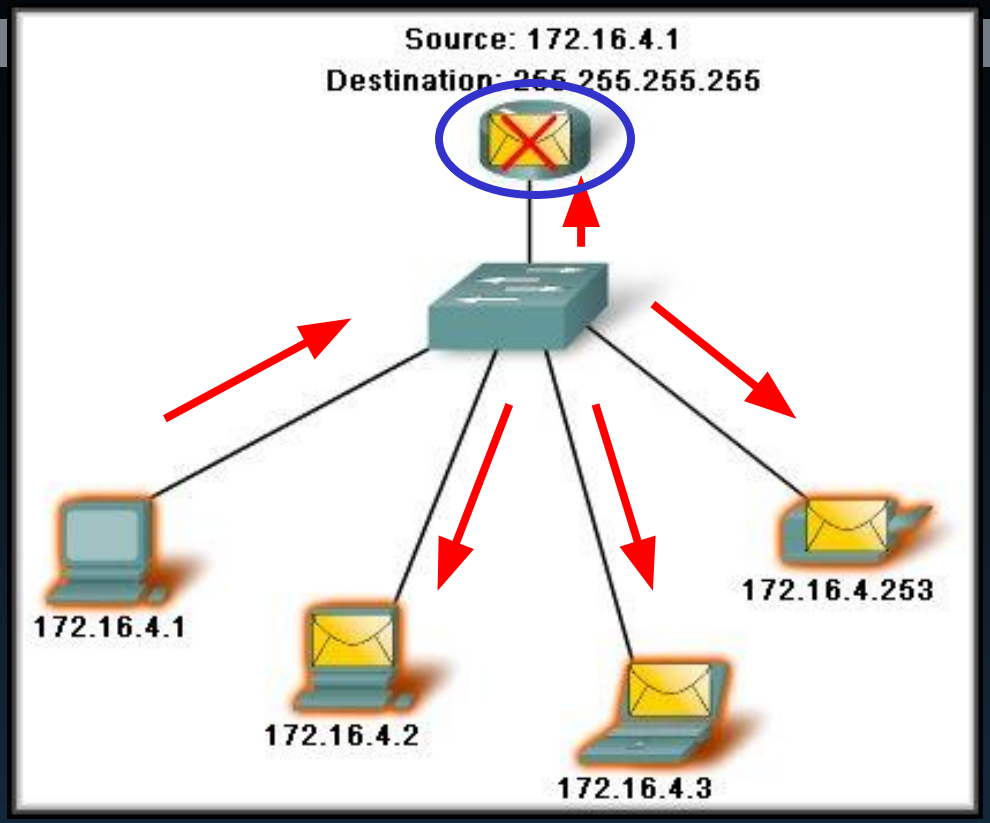
- Public and Private Addresses:
  - Most IPv4 addresses are public addresses.
    - A public address is one that is designated for use in networks that are accessible on the Internet.
  - Networks that require limited or no Internet access, use private addresses.
    - Private addresses are assigned from blocks of private address space set aside for that purpose.
      - 10.0.0.0/8 (10.0.0.0 to 10.255.255.255)
      - 172.16.0.0/12 (172.16.0.0 to 172.31.255.255)
      - 192.168.0.0/16 (192.168.0.0 to 192.168.255.255)

Broadcast Communications

- The process of sending a packet from one host to all hosts in the network.



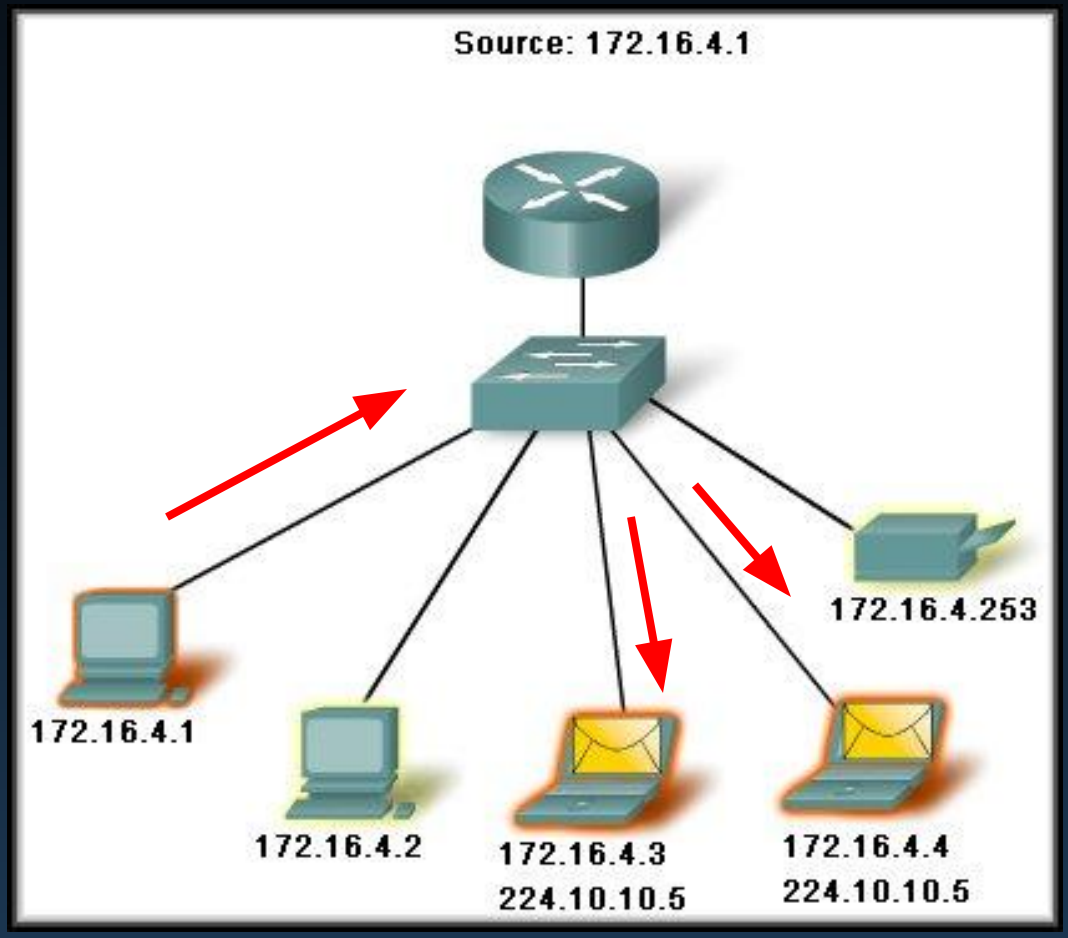
Broadcast Communications



- Broadcasts are not forwarded by a router unless specifically configured to do so.
- The bits in the host portion of a broadcast address will be all 1s.

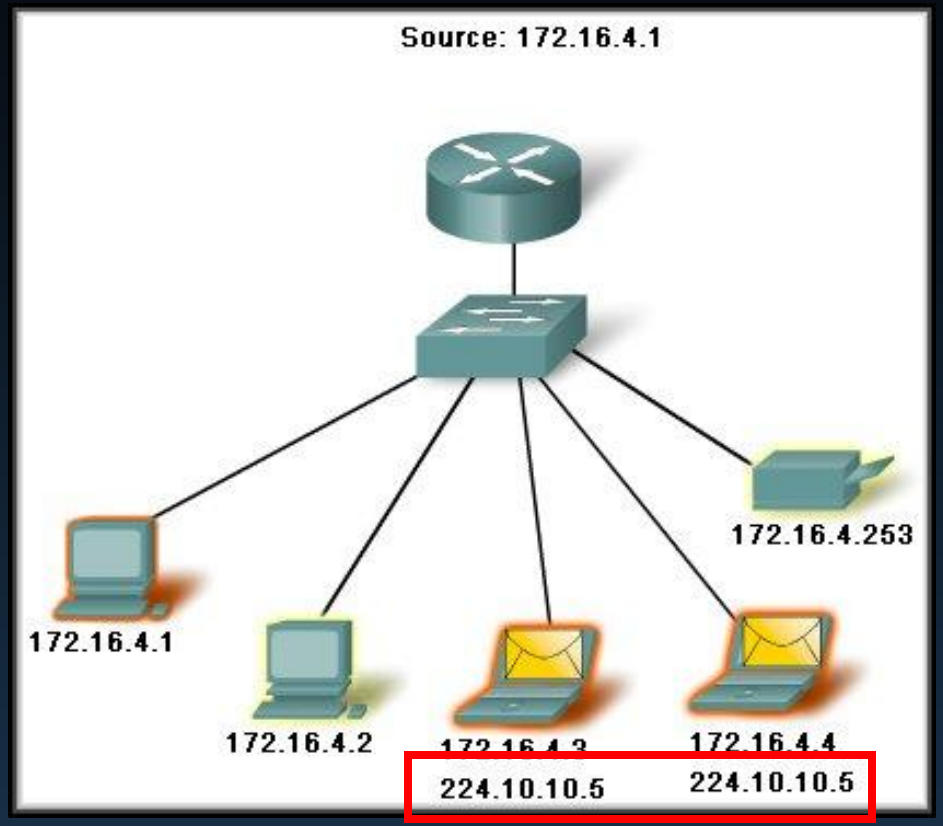
Multicast Communications

- The process of sending a packet from one host to a selected group of hosts.



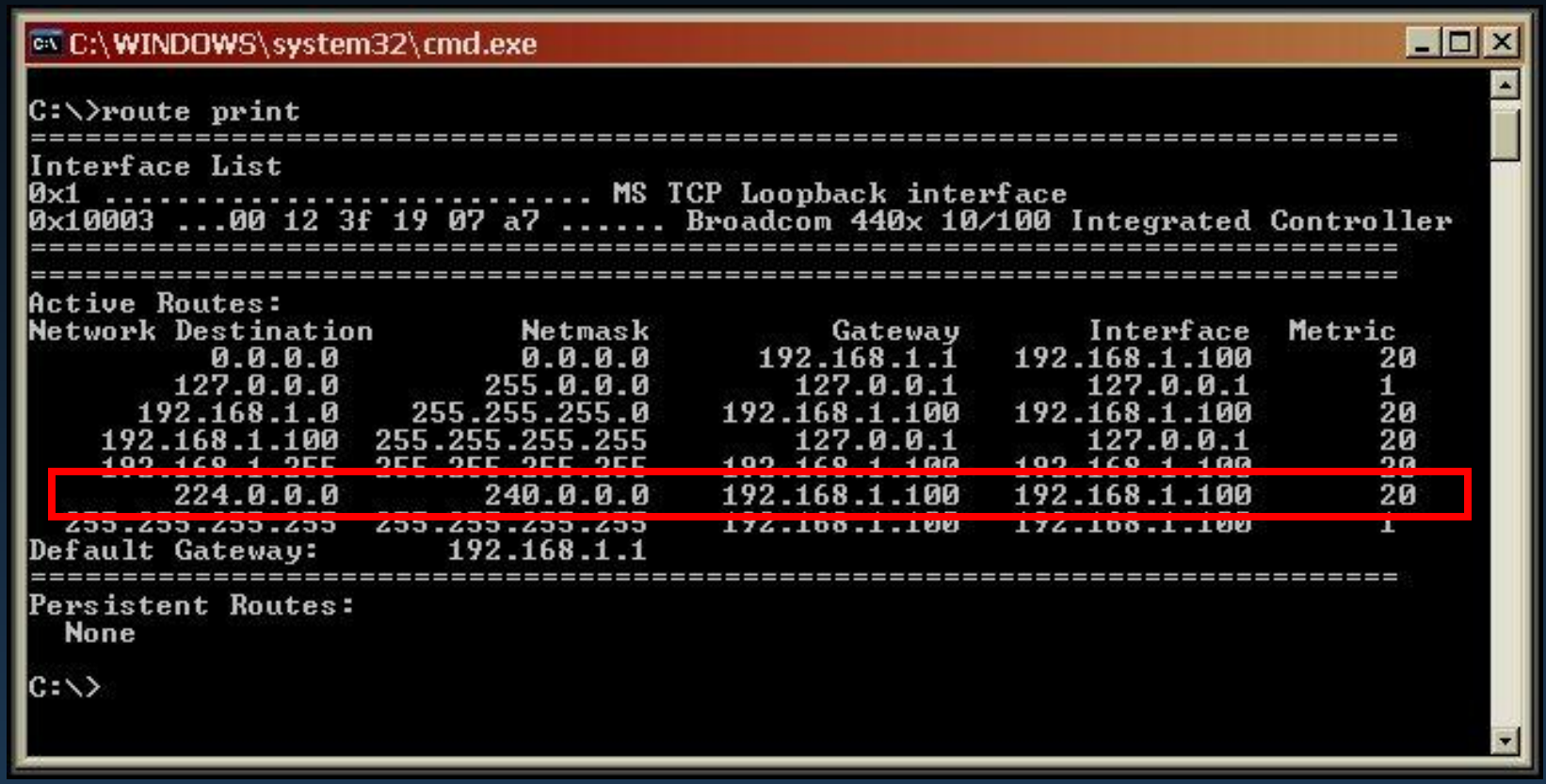
Multicast Communications

- Multicasting involves the use of a reserved network of IP Addresses (224.0.0.0).
- Each host that is to participate in a multicast session first joins the multicast group controlled by the router.
- When the packet from the source arrives at the router, it is forwarded to all members of the multicast group.



Multicast Communications

- The reserved multicast network or specific multicast addresses will be displayed in the routing table of a device.
- The following is from a PC.

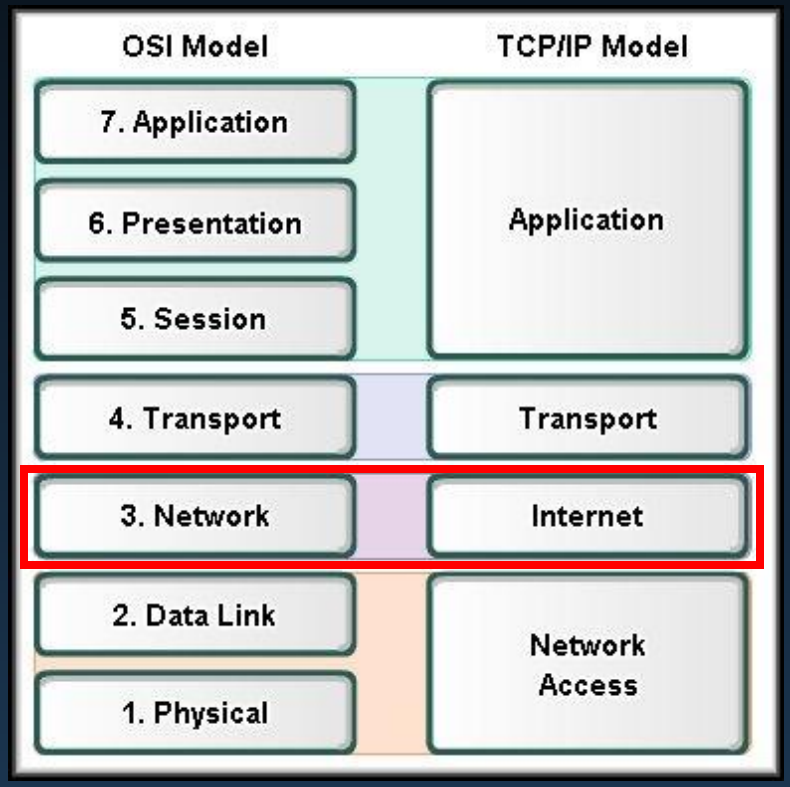


Reserved and Special Purpose Addresses

Type	Block	Range
Network		**1 per network**
Broadcast		**1 per network**
Multicast	**224.0.0.0/4**	**224.0.0.0 – 239.255.255.255**
Default Route	**0.0.0.0/8**	**0.0.0.0 – 0.255.255.255**
Loopback	**127.0.0.0/8**	**127.0.0.0 – 127.255.255.255**
Link-local	**169.254.0.0/16**	**169.254.0.0 – 169.254.255.255**
Test-net	**192.0.2.0/24**	**192.0.2.0 – 192.0.2.255**
Private	**10.0.0.0/8** **172.16.0.0/12** **192.168.0.0/16**	**10.0.0.0 – 10.255.255.255** **172.16.0.0 – 172.31.255.255** **192.168.0.0 – 192.168.255.255**

Addressing the Network: IPv4

IANA and ISPs



Internet Assigned Numbers Authority (IANA)

- To have hosts accessible from the Internet, an organization must have a block of public addresses assigned to them.
- IANA is a global organization responsible for the assignment of IPv4, IPv6 and Multicast addresses.

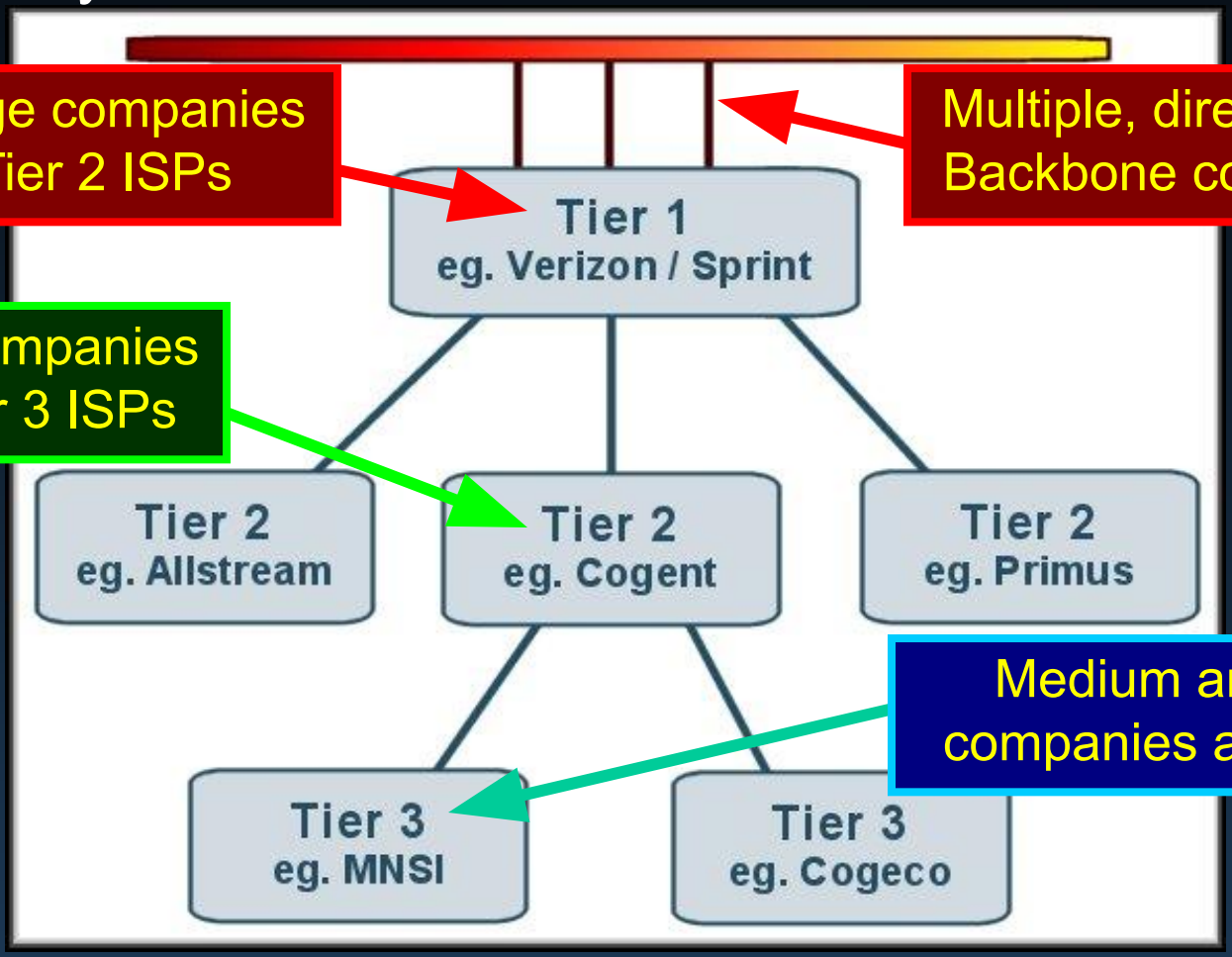
Global IANA					
Regional Internet Registries	AfriNIC	APNIC	LACNIC	ARIN	RIPE NCC
	Africa Region	Asia / Pacific Region	Latin America and Caribbean Region	North America Region	Europe, Middle East, Central Asia Region

Internet Service Provider (ISP)

- Most companies or organizations obtain their IPv4 address blocks from an ISP.
  - The ISP loans or rents these addresses to the organization.
  - If we move our Internet connectivity, the new ISP will provide us with addresses from the address blocks that have been provided to them.
  - Our previous ISP will loan the returned addresses to other customers.
  - ISPs have their own set of internal data networks to manage Internet connectivity and to provide related services (DNS, e-mail, website).

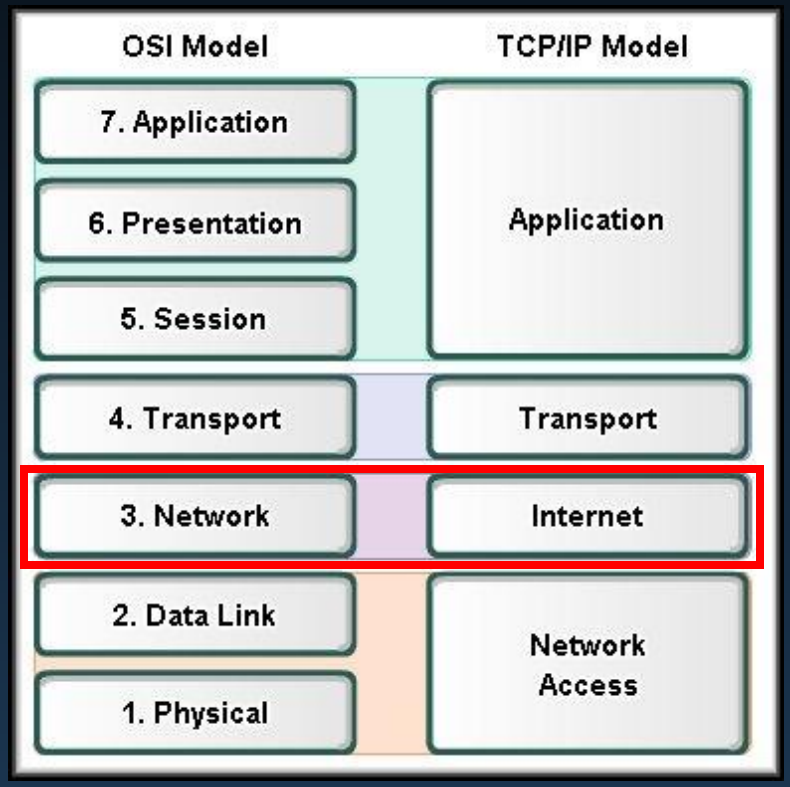
Internet Service Provider (ISP)

- ISPs are designated by a hierarchy based on their level of connectivity to the Internet backbone.



Addressing the Network: IPv4

Assigning Addresses



Planning to Address the Network

- Planning and documentation is an important part of IP Address assignment.
  - Preventing duplication of addresses.
    - Each host on a network MUST have a unique address.
  - Providing and controlling access.
    - Some servers provide services for both internal and external users.
    - Filters and access control can be done at Layer 3.
  - Monitoring security and performance.
    - Examining network traffic and troubleshooting requires a good knowledge of the addressing scheme.

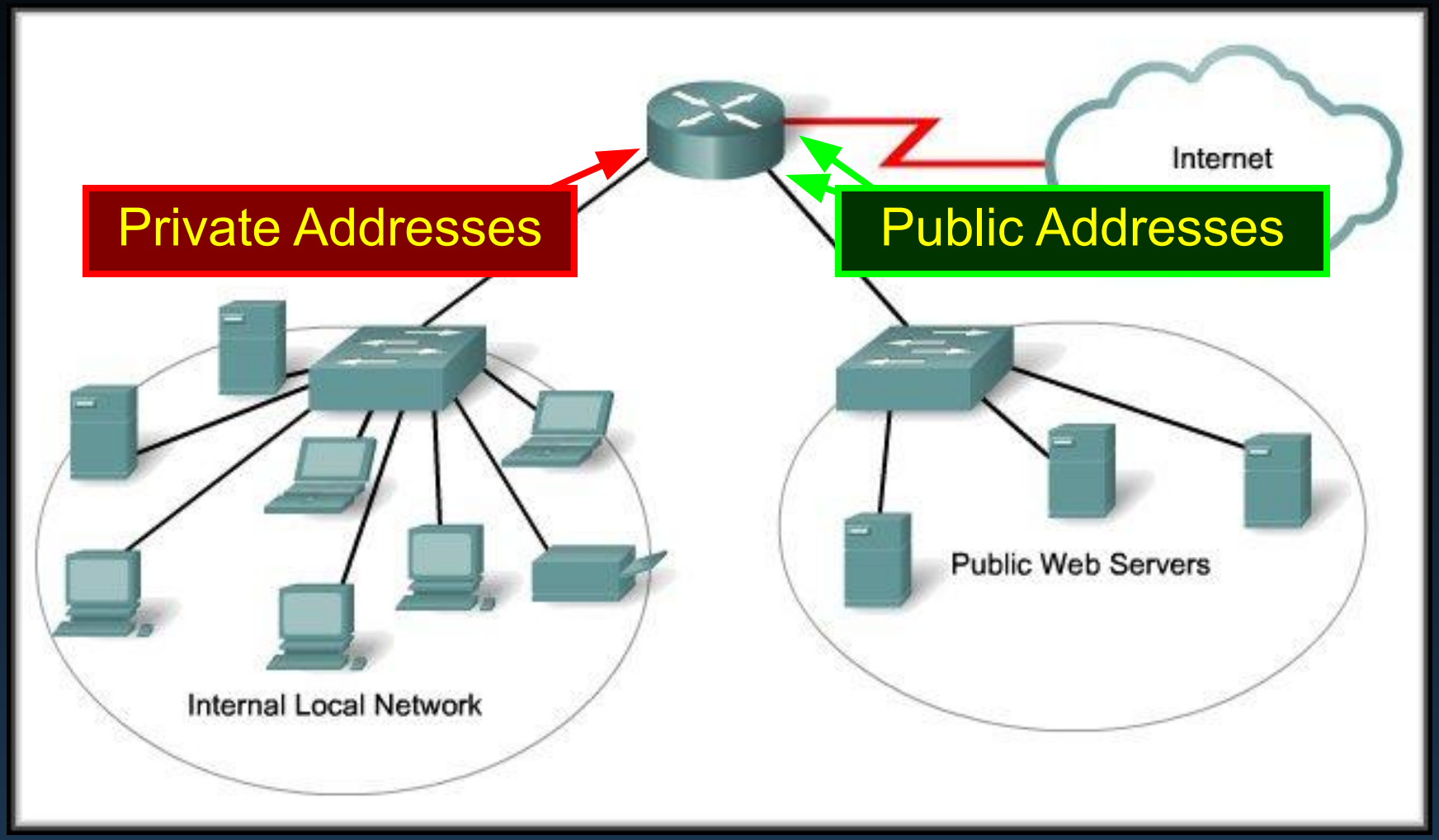
Assigning Addresses Within a Network

- The IP Addresses for hosts on a common network segment must all have the same network portion.
  - Desktop Workstations
  - Laptops
  - Internal Servers
  - External Internet Servers
  - Printers
  - Routers
  - Switches
- Each of these should be assigned a logical block of addresses within the address range of the network.

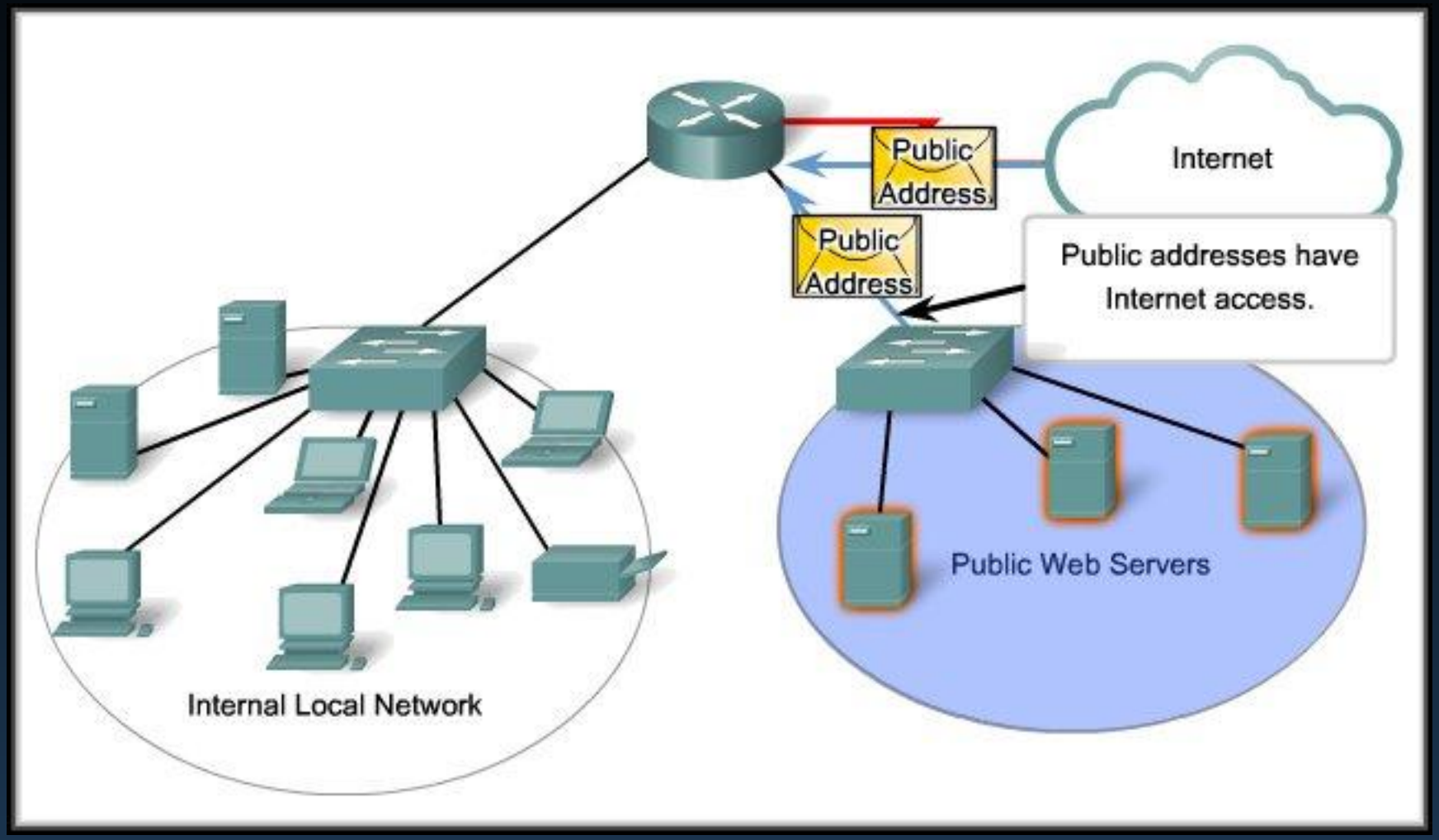
Assigning Addresses Within a Network

- Considerations – Private and Public addresses.
  - Will there be more devices connected to the network than public addresses allocated by the network's ISP?
  - Will the devices need to be accessed from outside the local network?
  - If devices that may be assigned private addresses require access to the Internet, is the network capable of providing a Network Address Translation (NAT) service?

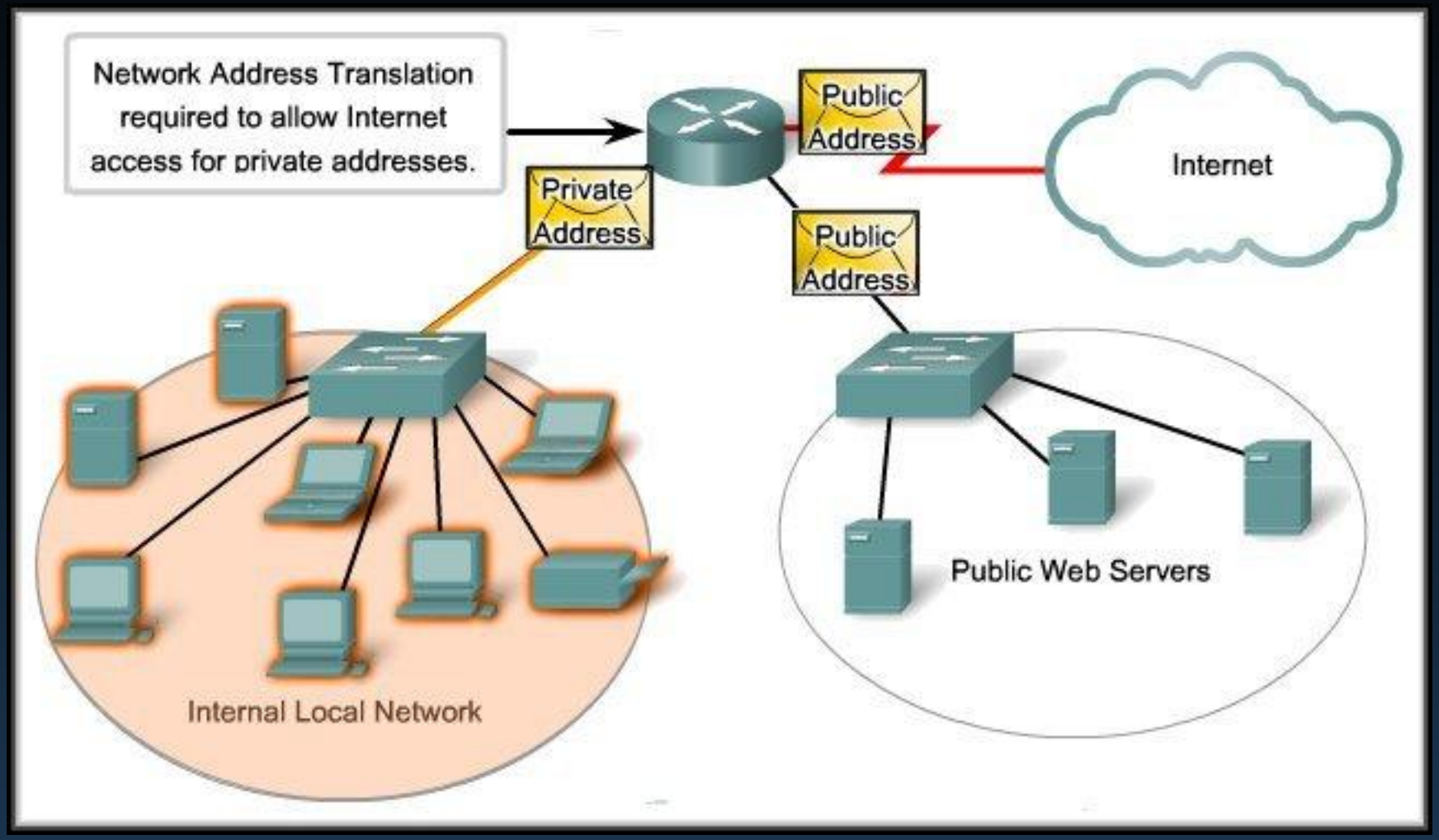
Assigning Addresses Within a Network



Assigning Addresses Within a Network

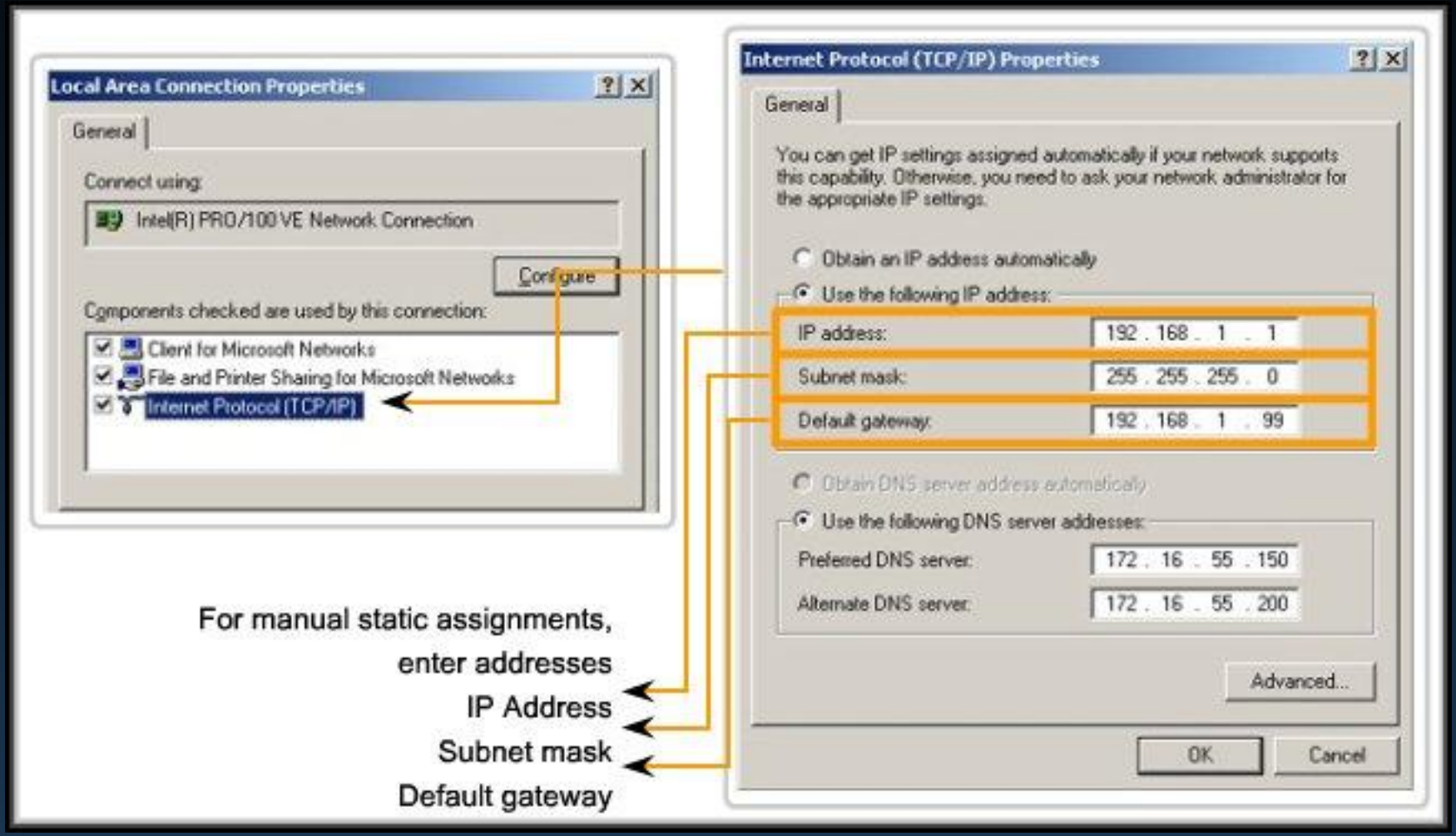


Assigning Addresses Within a Network



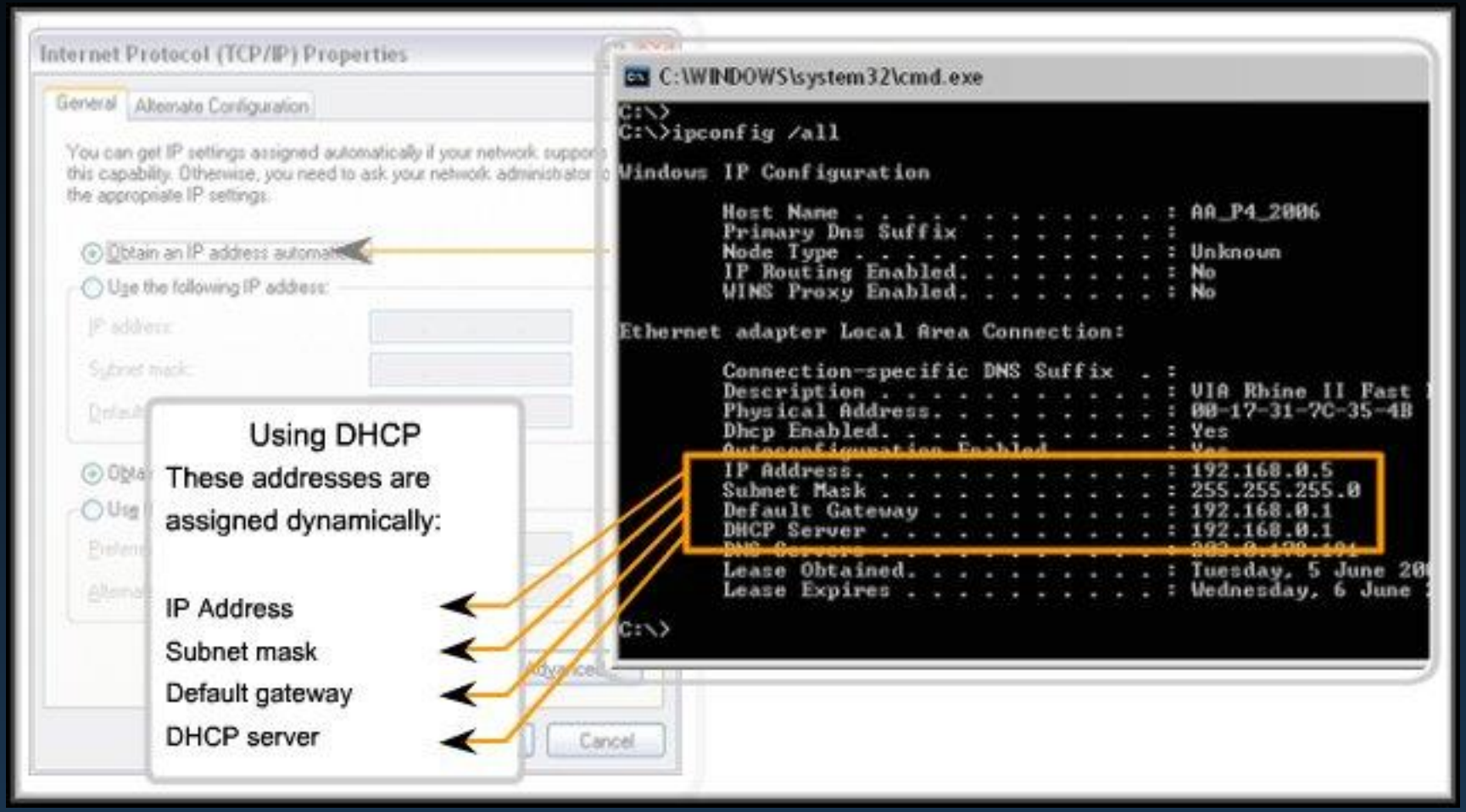
Static or Dynamic Addressing

Static Address Assignment

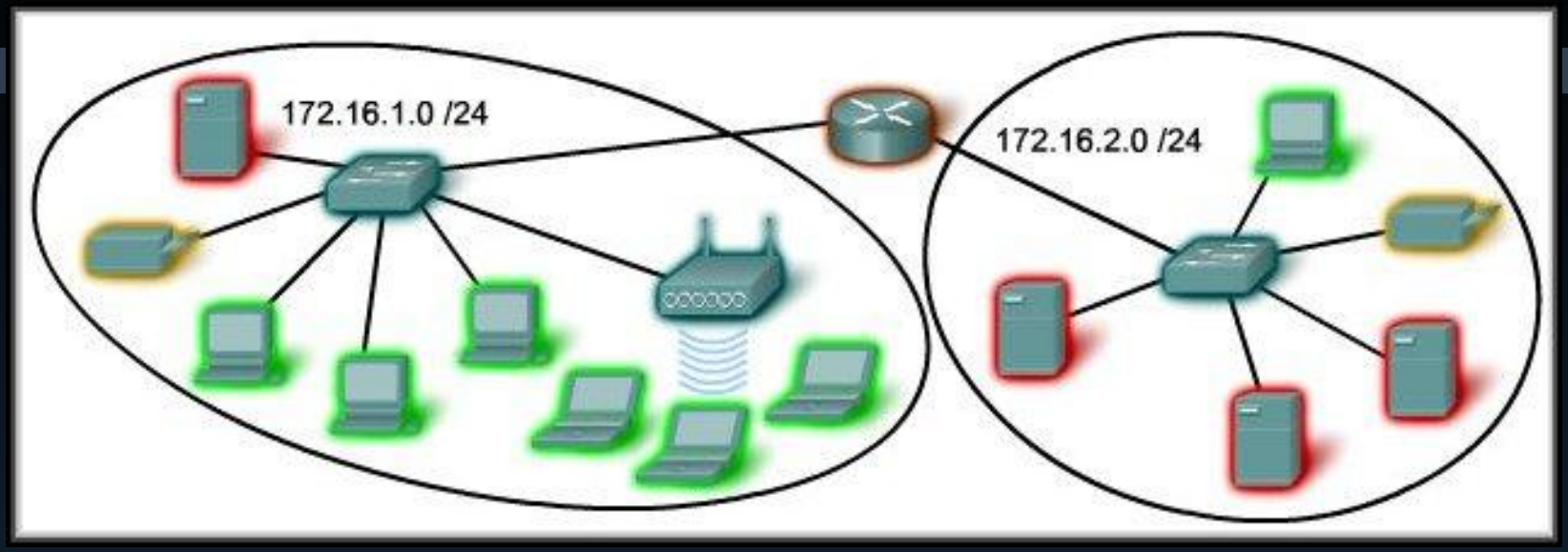


Static or Dynamic Addressing

Dynamic Address Assignment - DHCP



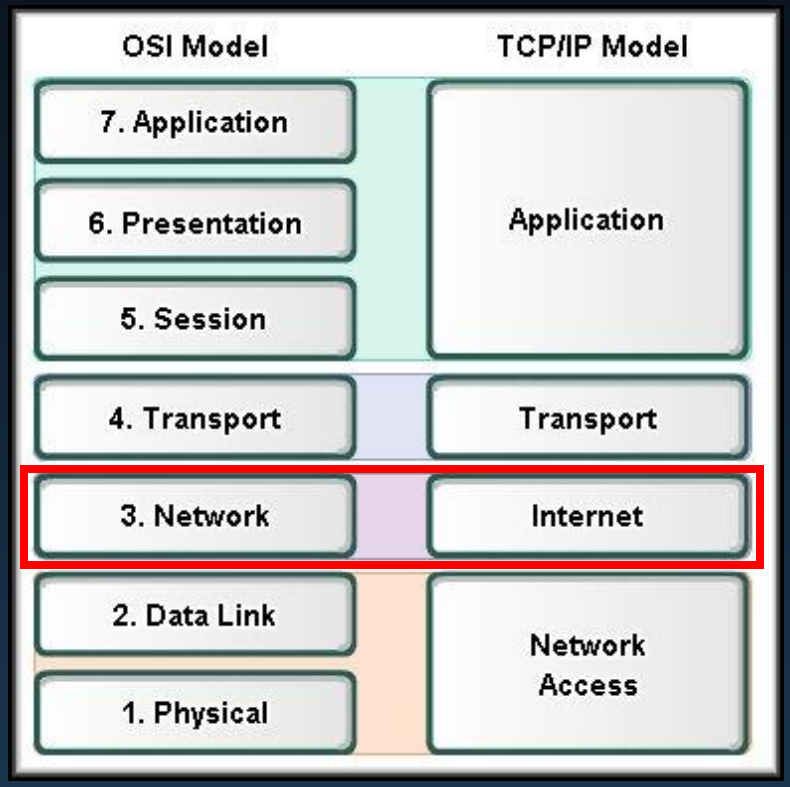
Selecting Device Addresses



Use	First Address	Last Address
Network Address	172.16.x.0	
User Hosts (DHCP Pool)	172.16.x.1	172.16.x.127
Servers	172.16.x.128	172.16.x.191
Peripherals	172.16.x.192	172.16.x.223
Networking Devices	172.16.x.224	172.16.x.253
Router	172.16.x.254	
Broadcast	172.16.x.255	

Addressing the Network: IPv4

IPv4 Addresses
Prefix and Subnet Mask



Network Prefixes

- *How do you know the number of bits assigned to the network and the number of bits assigned to the host?*
  - Prefix Mask:
    - The address is followed by a number that represents the number of bits (prefix length), beginning from the left, that apply to the network.
    - A slash (/) is used to separate the address and the prefix length.

192.168.10.2/24

Means that the first 24 bits are the network portion.
The last 8 bits are the host portion.

Network Prefixes

- Networks are not always assigned a /24 prefix.
  - Depending on the number of hosts on the network, the prefix can be different.
  - Having a different prefix changes the host range and the broadcast address.

Network	Network Address	Host Range	Broadcast Address
172.16.4.0/24	172.16.4.0	172.16.4.1 – 172.16.4.254	172.16.4.255
172.16.4.0/25	172.16.4.0	172.16.4.1 – 172.16.4.126	172.16.4.127
172.16.4.0/26	172.16.4.0	172.16.4.1 – 172.16.4.62	172.16.4.63
172.16.4.0/27	172.16.4.0	172.16.4.1 – 172.16.4.30	172.16.4.31

Subnet Mask

- *How do the network devices know how many bits are the network portion and how many bits are the host portion?*
  - Subnet Mask:
    - A 32 bit value, expressed in dotted decimal notation, that specifies the number of network bits and the number of host bits.
    - *The Prefix Mask and the Subnet Mask are different ways of representing the same information.*
    - Prefix Mask of /24 or a subnet mask of 255.255.255.0
      - First 24 bits are the network portion.
      - The remaining 8 bits are the host portion.

Subnet Mask

- *There is a direct, one-to-one relationship between the bits of the IP Address and the bits of the subnet mask.*
  - The subnet mask uses 1 and 0 bits to indicate that the corresponding bit of the IP address is either the network (1) or the host (0) portion.

IP Address: 172.16.4.35 / 24

Dotted Decimal		Binary Octets			
Host	172.16.4.35	10101100	00010000	00000100	00100011
Mask	255.255.255.0	11111111	11111111	11111111	00000000

Subnet Mask

Subnet Mask Values Within an Octet			
Mask (Decimal)	Mask (Binary)	Network Bits	Host Bits
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

Subnet Mask

IP Address:	10.24.36.2 / 8	Subnet Mask?
IP Address:	10.24.36.2 / 12	Subnet Mask?
IP Address:	10.24.36.2 / 16	Subnet Mask?
IP Address:	10.24.36.2 / 23	Subnet Mask?

IP Address:	10.24.36.2	255.255.224.0	Prefix Mask?
IP Address:	10.24.36.2	255.255.255.192	Prefix Mask?
IP Address:	10.24.36.2	255.255.255.252	Prefix Mask?
IP Address:	10.24.36.2	255.254.0.0	Prefix Mask?
IP Address:	10.24.36.2	255.255.240.0	Prefix Mask?

Is the Host on My Network?

- To send a broadcast, a network device must be able to divide the IP Address into the network and host portion.
  - It uses a process called ANDing.
    - The IP Address is converted to binary.
    - The Binary AND Truth Table is used to compare the bits strings of the address with the subnet mask.

A	B	Result
0	0	0
1	0	0
0	1	0
1	1	1

Is the Host on My Network?

- IP Address 135.15.2.1 255.255.0.0

A	B	Result
0	0	0
1	0	0
0	1	0
1	1	1

	Decimal	Binary
IP Address	135.15.2.1	10000111 00001111 00000010 00000001
Subnet Mask	255.255.0.0	11111111 11111111 00000000 00000000
Network	135.15.0.0	10000111 00001111 00000000 00000000

Reasons to Use AND

- *Routers use the ANDing process to determine the route a packet will take.*
  - The network number of the destination address is used to find the network in the routing table.
  - The router determines the best path for the frame.

	Decimal	Binary			
IP Address	135.15.2.1	10000111	00001111	00000010	00000001
Subnet Mask	255.255.0.0	11111111	11111111	00000000	00000000
Network	135.15.0.0	10000111	00001111	00000000	00000000

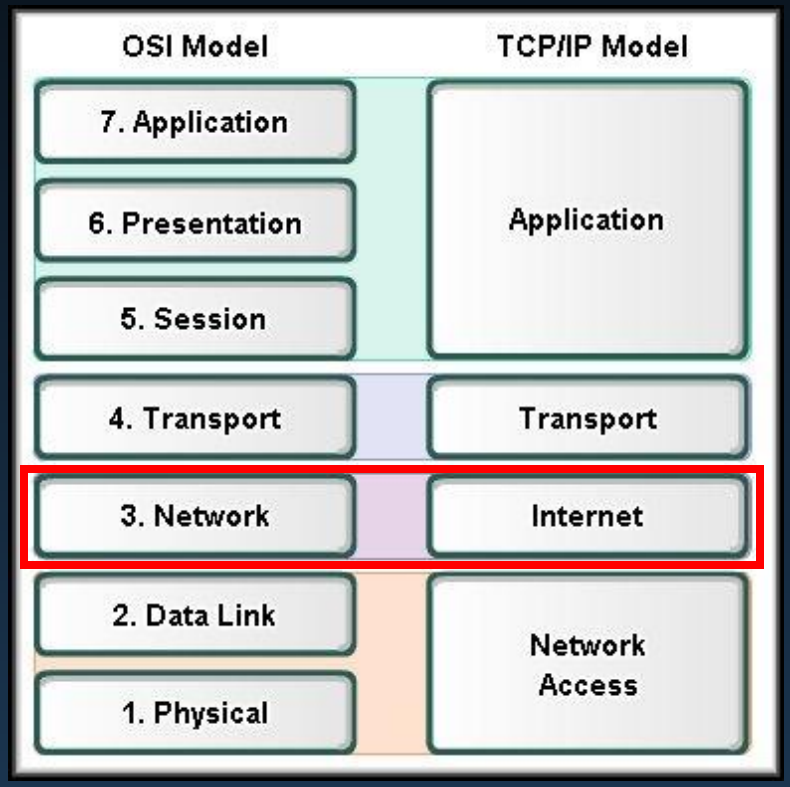
Reasons to Use AND

- *The source device uses the ANDing process to determine if the packet is to be sent to the default gateway.*
  - A PC will use it to determine the destination network.
  - If the destination network is the same as the network where the PC resides, the packet is sent directly to that host.
  - If the destination network is different, the packet is sent to the default gateway.

	Decimal	Binary			
IP Address	135.15.2.1	10000111	00001111	00000010	00000001
Subnet Mask	255.255.0.0	11111111	11111111	00000000	00000000
Network	135.15.0.0	10000111	00001111	00000000	00000000

Addressing the Network: IPv4

Testing the Network Layer

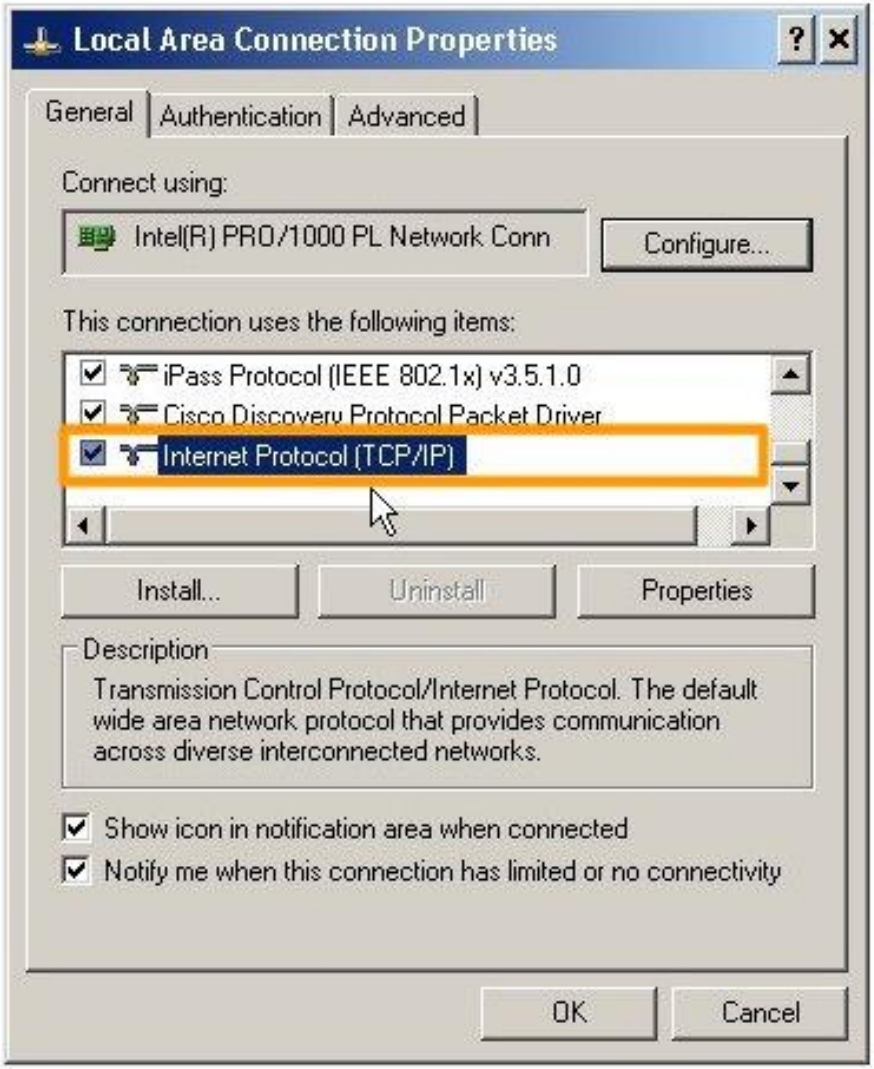


Testing the Network Layer

Testing Local TCP/IP Stack

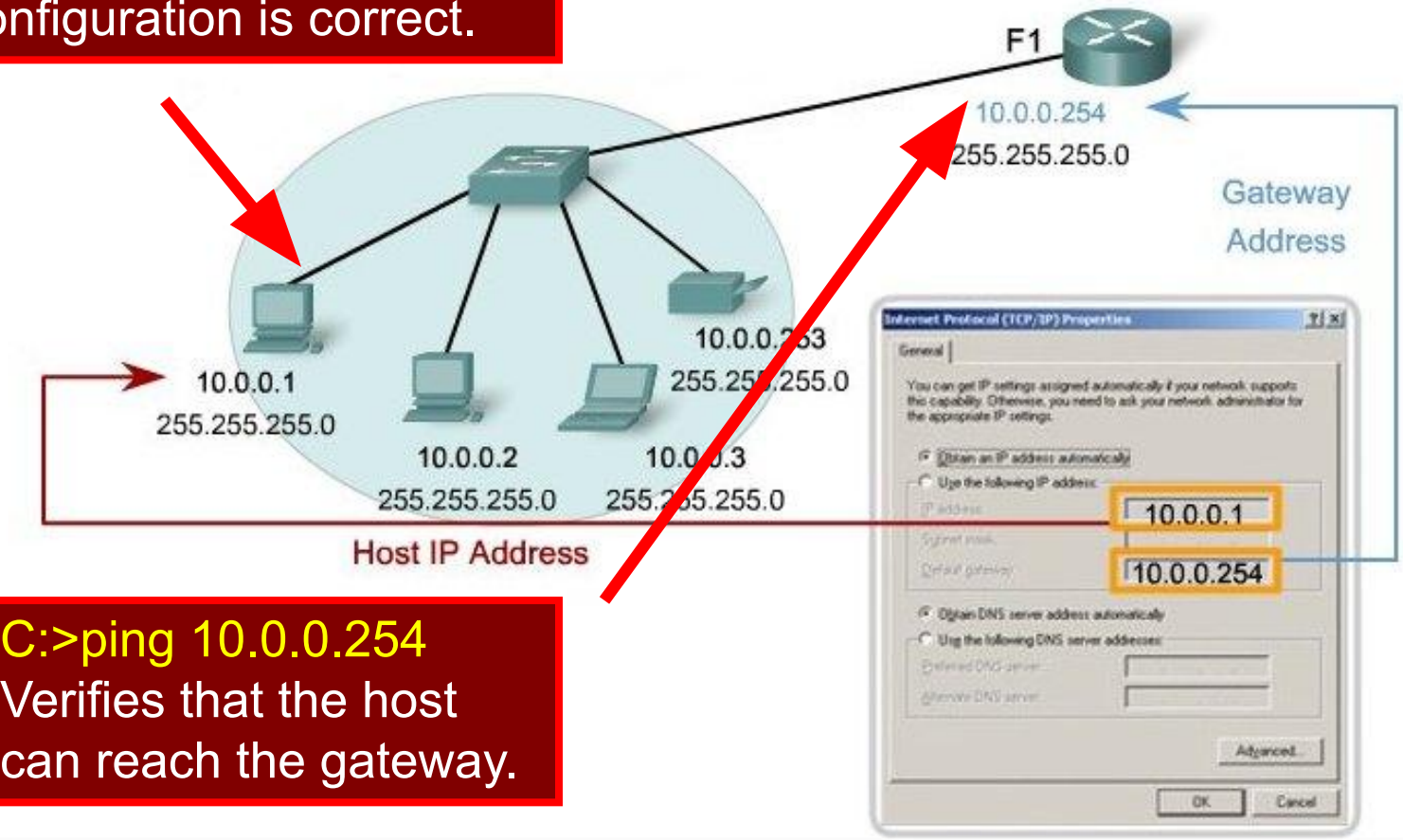
Pinging the local host confirms that TCP/IP is installed and working on the local host.

Pinging 127.0.0.1 causes a device to ping itself.



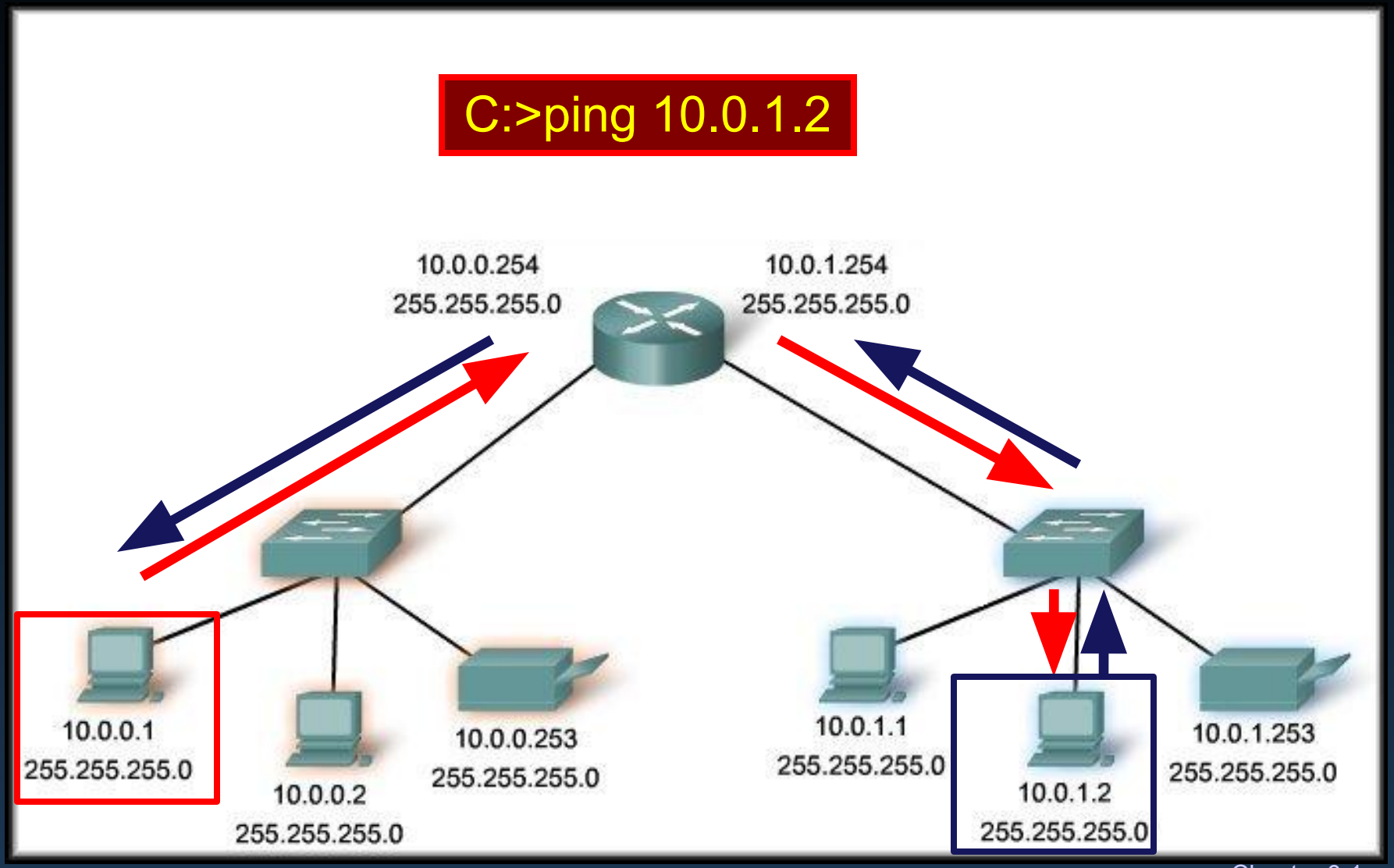
Testing the Network Layer

C:>ping 10.0.0.1
Verifies that the local IP configuration is correct.

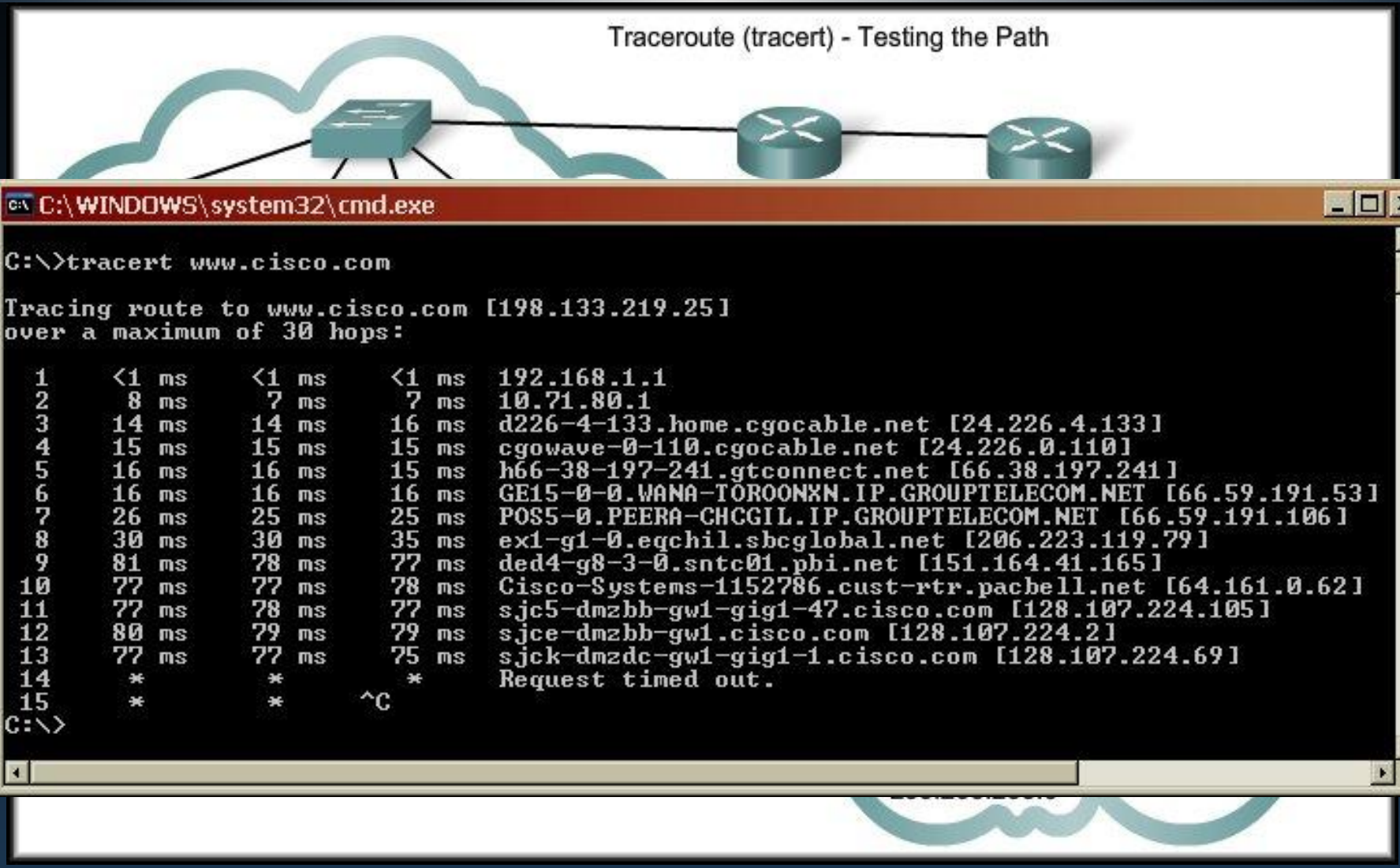


C:>ping 10.0.0.254
Verifies that the host can reach the gateway.

Testing the Network Layer



Testing the Network Layer



Testing the Network Layer

- ICMPv4: Protocol for Testing and Messaging.
  - Provides control and error messages and is used by ping and traceroute.
    - Host confirmation
    - Unreachable destination or service
    - Time exceeded
    - Route redirection
    - Source quench

There's that truck again…….

Your turn to do stuff!