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Network Layer: IP Addressing

Lecture 6 | CSE421 – Computer Networks

Department of Computer Science and Engineering
School of Data & Science

Objectives

- Anatomy of IPv4 Address
  - Subnet/Prefix Mask
- Types of Address
  - Network
  - Host
  - Broadcast
- Specific Address
  - Unicast
  - Multicast
  - Broadcast
- Classful IP Addressing

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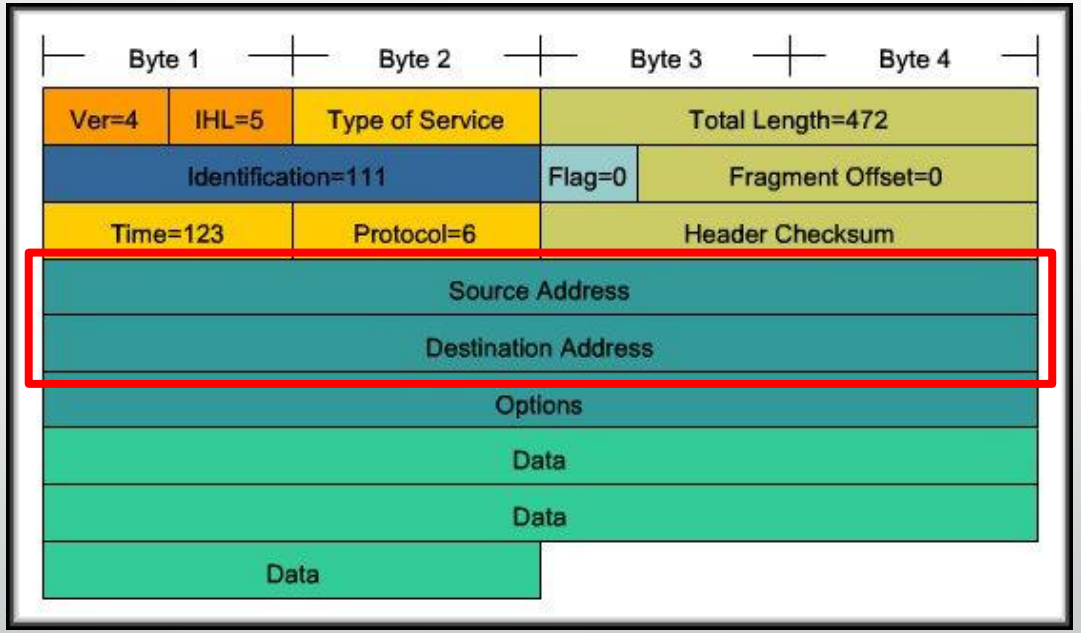
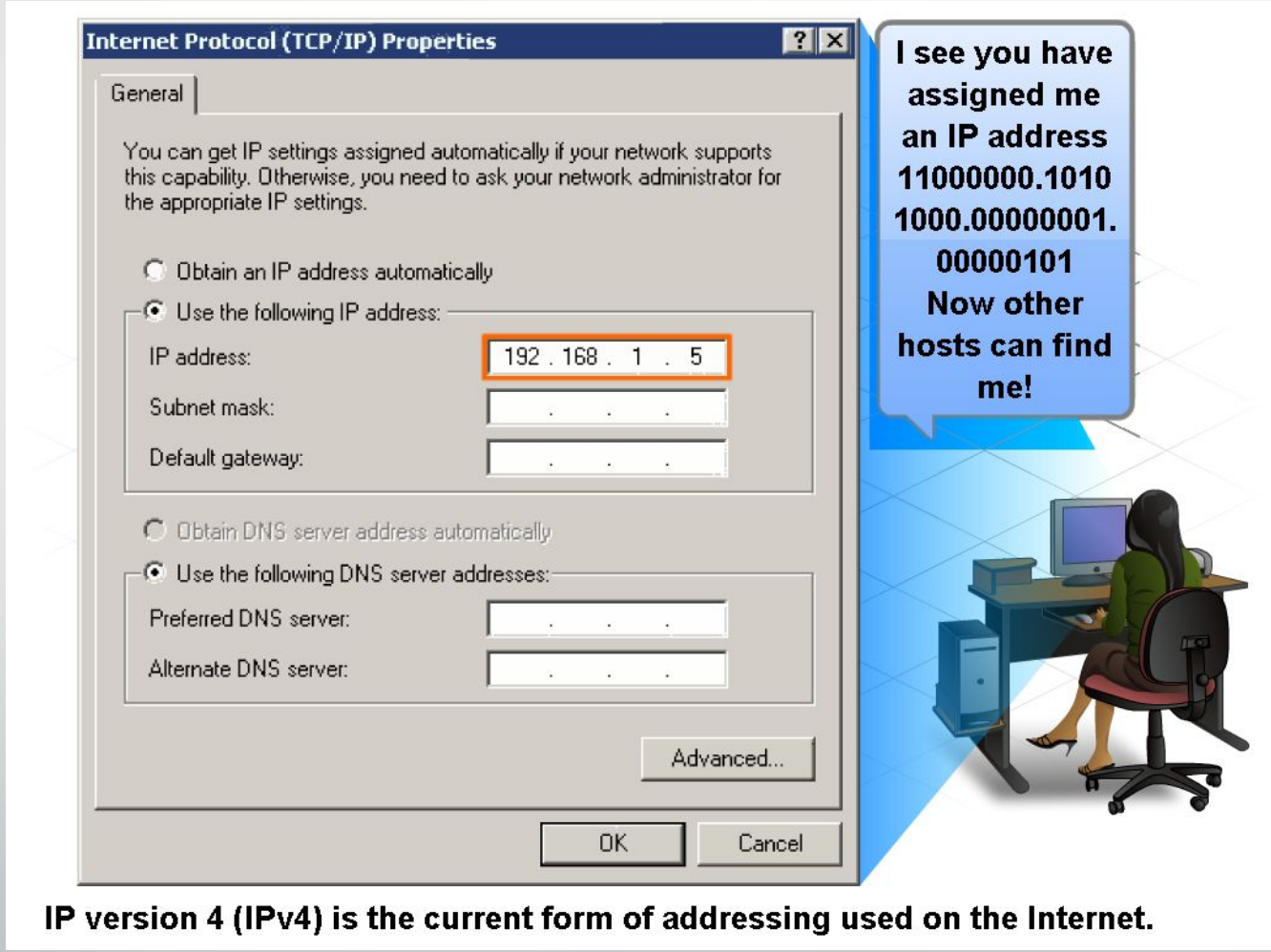
Anatomy of IPv4

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.

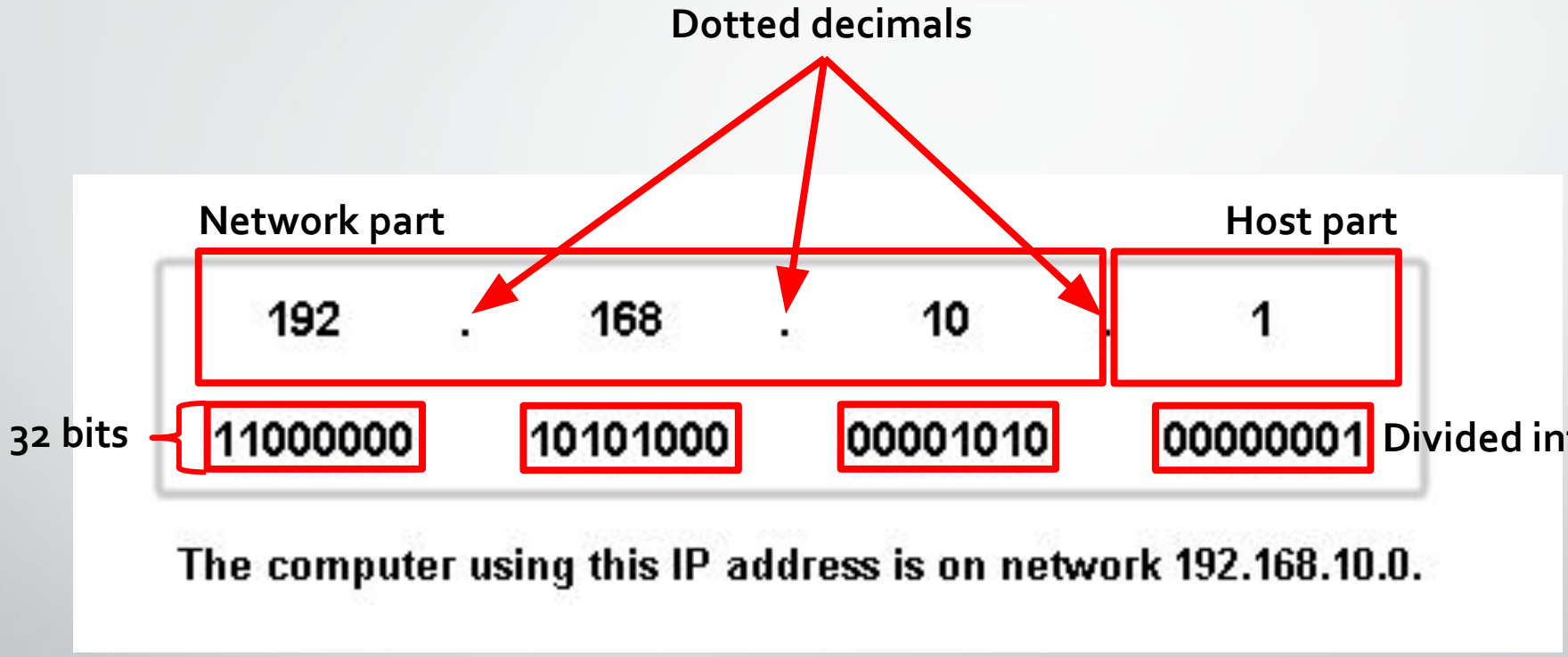


IPv4 Addressing Structure

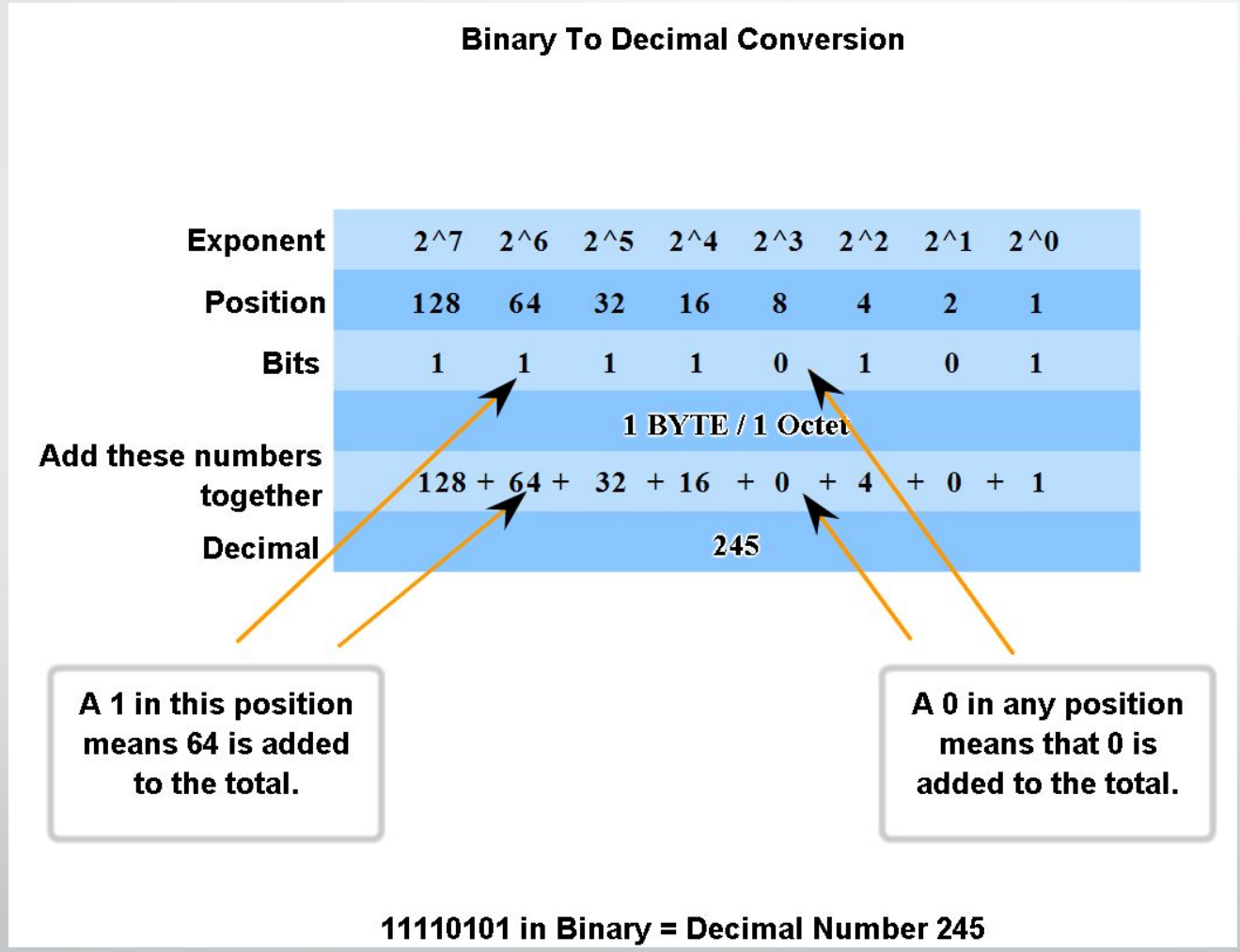


IP version 4 (IPv4) is the current form of addressing used on the Internet.

Anatomy of an IPv4 Address

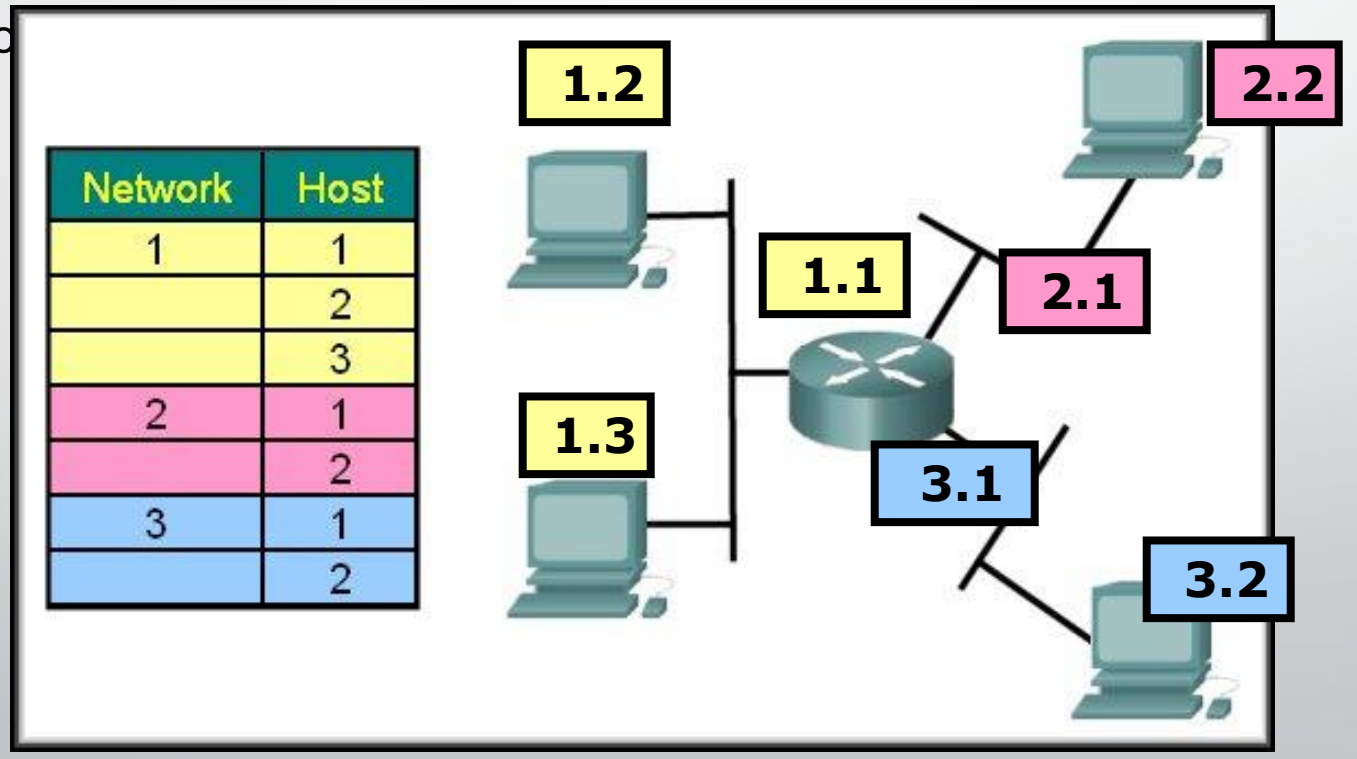


Binary to decimal and Vice Versa



Networks and Hosts

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



Network Portion

- Network Portion:
  - Some portion of the high-order bits
  - A network can be defined as a group of hosts that have identical bit patterns in the network address portion of their addresses

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

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

Network Portion

- Host Portion:
  - A variable number of least significant 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

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

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

Prefix Mask

- How do we or devices identify the network part or the host part?
- **Answer:** Using the **"Prefix Mask".**
- **192.168.10.2/24**
  - Means that the **first 24 bits** are the network portion.
  - The **last 8 bits** are the host portion.
- **Subnet M**
  - Prefix le 5.0

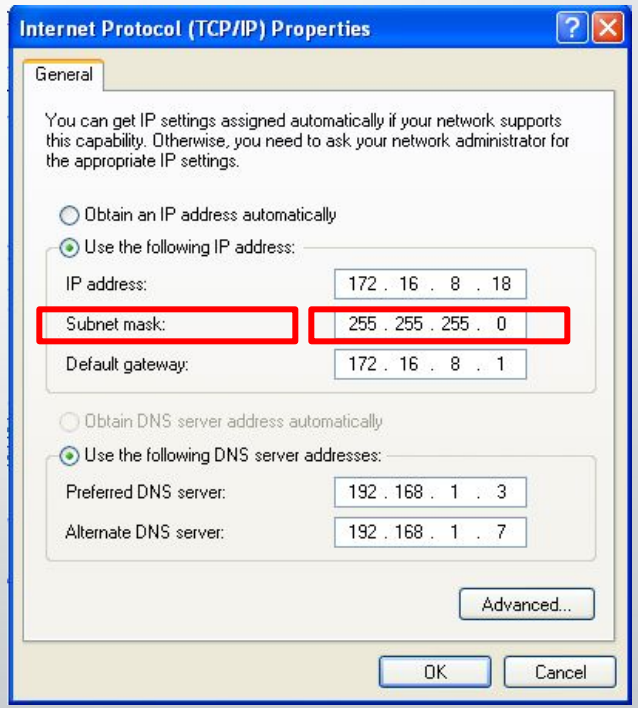
```
Z:\>ipconfig

Windows IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . . : 172.16.8.18
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 172.16.8.1

Z:\>
```



Subnet Mask

- The Prefix Mask and the Subnet Mask are different ways of representing the same information.
- Examples:
  - Prefix Mask of **/24** or a subnet mask of **255.255.255.0**
  - Prefix Mask of **/16** or a subnet mask of **255.255.0.0**
  - Prefix Mask of **/8** or a subnet mask of **255.0.0.0**
- Conversion:
  - Subnet mask has the **same format** as an IP address. Hence, it has **32 bits divided into 8 bits (octets)**
  - Prefix mask of **/24** means, the **first (MSB) 24 bits** of subnet mask would be 1
  - Binary: 11111111.11111111.11111111.00000000

    Decimal: **255 . 255 . 255 . 0**

Exercise

- What's the **subnet mask** of the following?
  - **IP Address:** 10.24.36.2 / 4
  - **IP Address:** 10.24.36.2 / 12
  - **IP Address:** 10.24.36.2 / 16
  - **IP Address:** 10.24.36.2 / 23
- What's the **prefix mask** of the following?
  - **IP Address:** 10.24.36.2; **Subnet Mask:** 255.255.224.0
  - **IP Address:** 10.24.36.2; **Subnet Mask:** 255.255.255.192
  - **IP Address:** 10.24.36.2; **Subnet Mask:** 255.255.255.252
  - **IP Address:** 10.24.36.2; **Subnet Mask:** 255.254.0.0
  - **IP Address:** 10.24.36.2; **Subnet Mask:** 255.255.240.0

ANDing the Binaries

- Inside data network devices, digital logic is applied for their interpretation of the addresses.
- AND is used in determining the network address.
  - 0 AND 0 = 0
  - 1 AND 0 = 0
  - 1 AND 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 Address	135.15.0.0	

But Why 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 then determines the best path for the frame.

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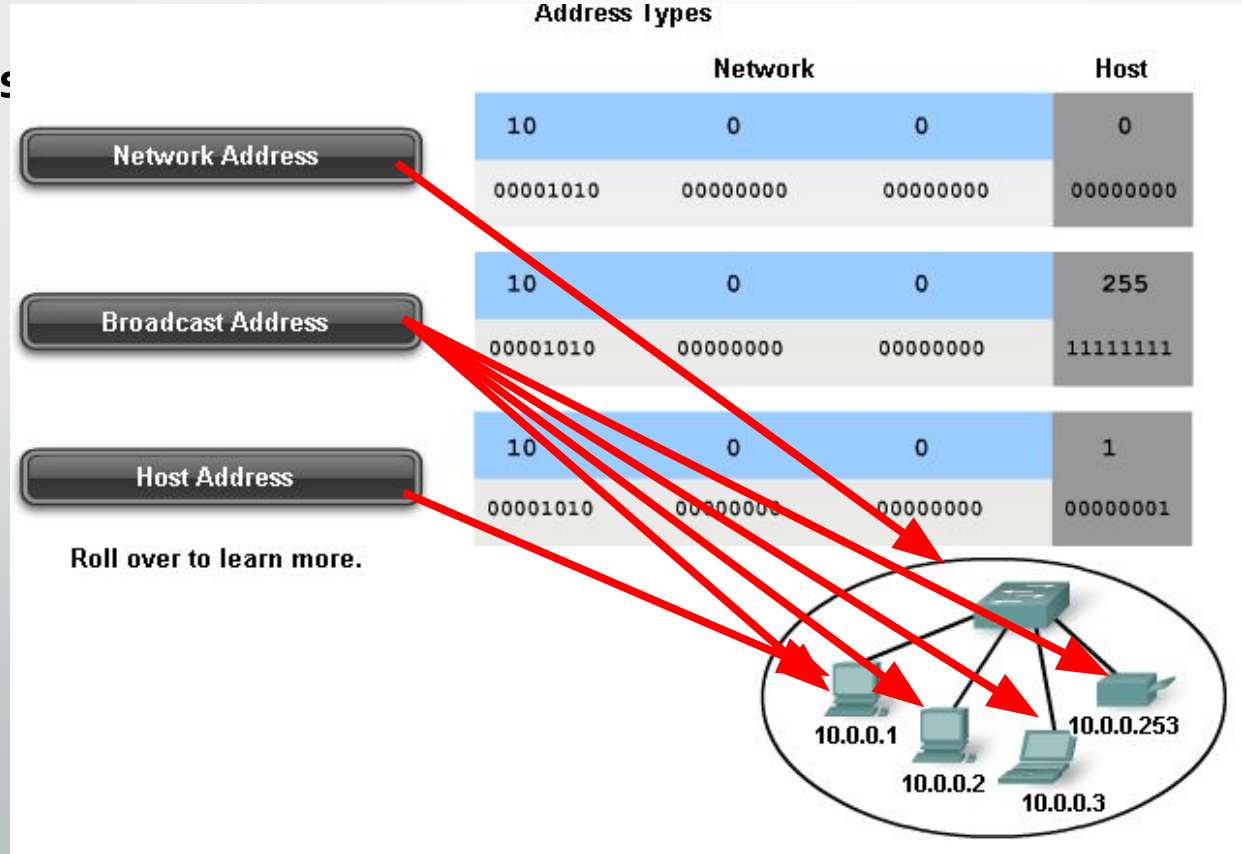
Types of Addresses

Types of address

- Every network has
  - **Network Address** – The first IP in the range
  - **Broadcast Address** – The last IP in the range
  - **Host Address**



The Addresses

- Network 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
  - Cannot be assigned to a device.
  - Each host bit in this address will be 1.
- Host Address
  - The unique address assigned to each device on the network.
  - For a network of 192.168.10.0/24
    - Addresses **192.168.10.1** through **192.168.10.254** are all host addresses

The Addresses at a Glance

- Say, you have a random IP address 192.168.10.193/24

Network Prefix

- The network prefix is not always /24.

Using Different Prefixes for the 172.16.4.0 Network

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

SAME NETWORK ADDRESS ALL PREFIXES

DIFFERENT BROADCAST ADDRESS EACH PREFIX

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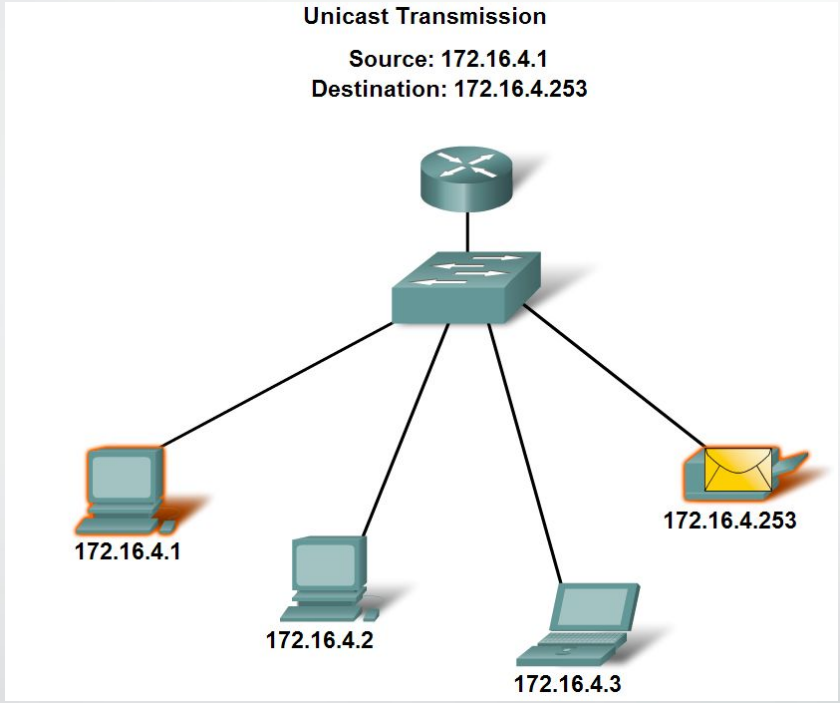
Special Addresses

Special Addresses

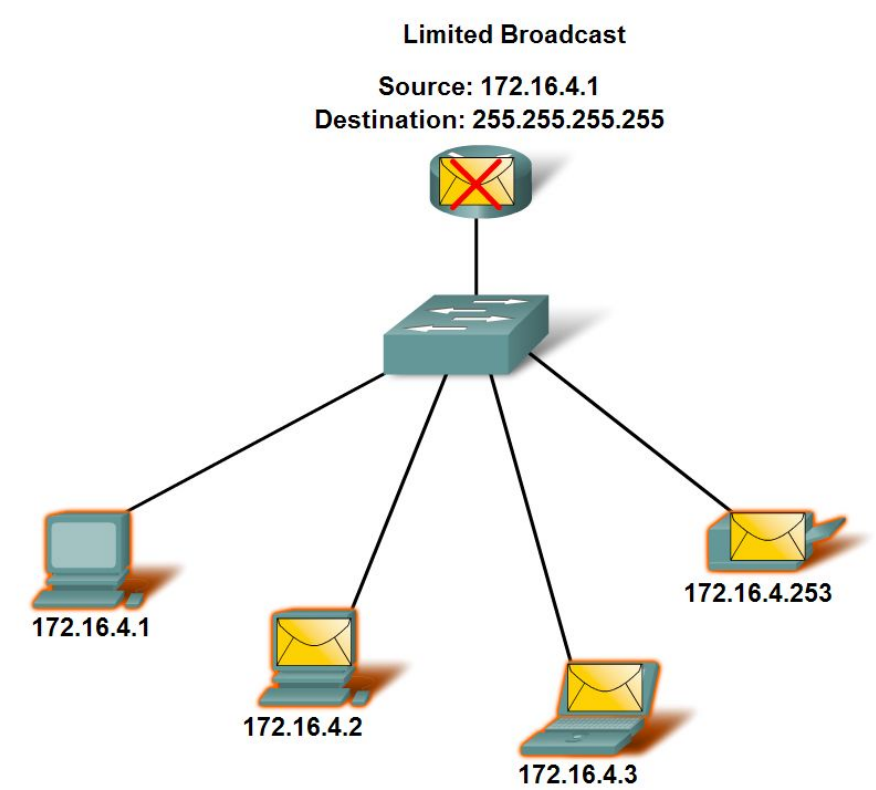
- **Unicast**
  - A message addressed to one host
- **Broadcast**
  - A message addressed to all hosts on a network.
  - Uses network's broadcast address or **255.255.255.255** locally
- **Multicast**
  - A message addressed to a group of hosts.
  - Uses an IP address starting with **224 - 239**

Unicast


Unicast Transmission
Source: 172.16.4.1
Destination: 172.16.4.253
172.16.4.1
172.16.4.2
172.16.4.3
172.16.4.253

Broadcast Address

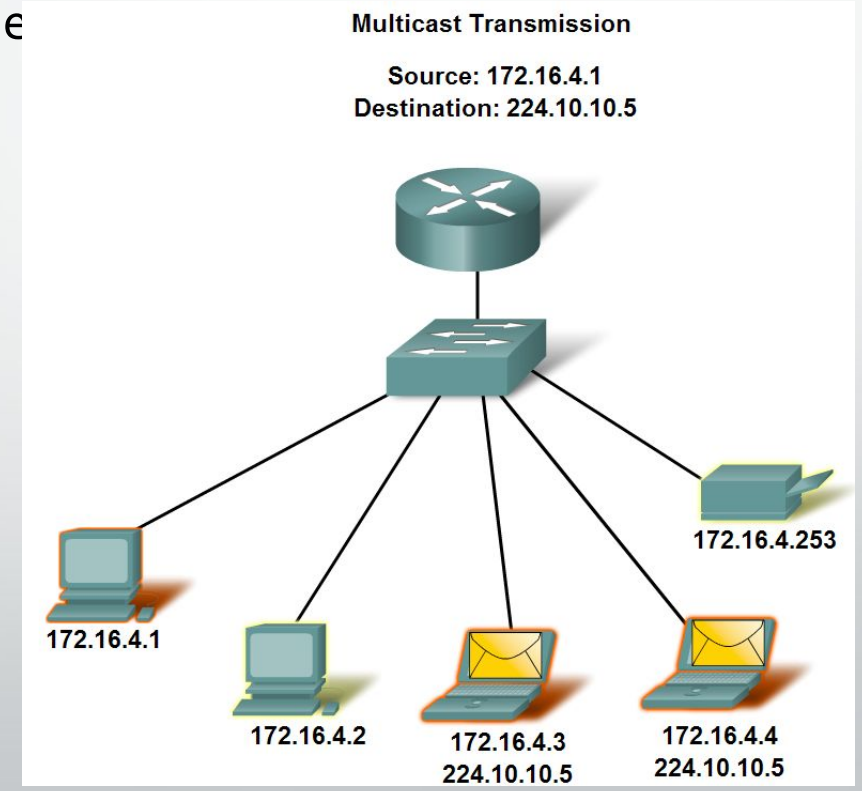
- Limited Broadcast



- Directed Broadcast
  - For a host outside of the network to communicate with the hosts within the **172.16.4.0 /24** network, the destination address of the packet would be **172.16.4.255**.

Multicast

- Examples of Multicast Application
  - Video and audio broadcasts
  - Routing information exchange
  - Distribution of software
  - News feeds



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Anatomy of IPv6

IPv6

- Initial motivation:
  - 32-bit address space soon to be completely allocated.
- Additional motivation:
  - Simpler header format helps speed processing/forwarding
  - header changes to facilitate QoS

Reasons for using IPv6

- Address Availability:
  - IPv4: 4 octets - 32 bits
    - 2^32 or 4,294,467,295 IP Addresses.
  - IPv6: 16 octets - 128 bits
    - 3.4 x 10^38 or

340,282,366,920,938,463,463,374,607,431,768,211,456

(340 undecillion) IP Addresses.

- *Every atom of every person on Earth could be assigned 7 unique addresses with some to spare (assuming 7×10^{27} atoms per human x 6.5 Billion).*

IPv6 Address

- 128 bits
- given below is a 128 bit IPv6 address represented in binary format and divided into eight 16-bits blocks

```
0010000000000001 0000000000000000 0011001000111000 1101111111100001
0000000001100011 0000000000000000 0000000000000000 1111111011111011
```

- Each block is then converted into Hexadecimal and separated by ':' symbol

```
2001:0000:3238:DFE1:0063:0000:0000:FEFB
```

- Called **string notation**

IPv6 Addressing

- IPv6 Representation – Rule 1:
  - The leading zeros in any 16-bit segment do not have to be written. If any 16-bit segment has fewer than four hexadecimal digits, it is assumed that the missing digits are leading zeros.

```
2031 : 0000 : 130F : 0000 : 0000 : 09C0 : 876A : 130B
2031 :    0 : 130F :    0 :    0 :  9C0 : 876A : 130B

8105 : 0000 : 0000 : 4B10 : 1000 : 0000 : 0000 : 0005
8105 :    0 :    0 : 4B10 : 1000 :    0 :    0 :    5

0000 : 0000 : 0000 : 0000 : 0000 : 0000 : 0000 : 0000
   0 :    0 :    0 :    0 :    0 :    0 :    0 :    0
```

IPv6 Addressing

- IPv6 Representation – Rule 2:
  - Any single, contiguous string of one or more 16-bit segments consisting of all zeroes can be represented once with a double colon.

1080:0:0:0:8:800:200C:417A	=
FF01:0:0:0:0:0:0:101	=
0:0:0:0:0:0:0:1	=
0:0:0:0:0:0:0:0	=

IPv6 Addressing

- IPv6 Representation – Rule 2:
  - *Any single, contiguous string of one or more 16-bit segments consisting of all zeroes can be represented once with a double colon.*

Example: **1843:f01::22::fa**

- Illegal because the length of the two all-zero strings is ambiguous.

1843:00f0:0000:0000:0022:0000:0000:00fa ←

or

1843:00f0:0000:0000:0000:0022:0000:00fa ←

or

1843:00f0:0000:0022:0000:0000:0000:00fa ←

Representing IPv6 addresses

- No more net masks
  - Represented by a "/prefixlen" appended to the end of an address where prefixlen indicates the number of bits in the address that make up the network address
    - Similar to classless address representation in IPv4
    - For example:

2001:db8:abcd:0012::0/64 specifies a subnet with a range of IP addresses from:

2001:db8:abcd:0012:0000:0000:0000:0000 to
2001:db8:abcd:0012:ffff:ffff:ffff:ffff.

Network part : 2001:db8:abcd:0012

Host part : ::0