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Network Layer: IP Addressing

Lecture 6 | CSE421 – Computer Networks

Department of Computer Science and Engineering
School of Data & Science

Objectives

- IPv4 Address
  - Structure
  - Subnet/Prefix Mask
- Types of IPv4 Address
- IPv6 Address
  - Structure

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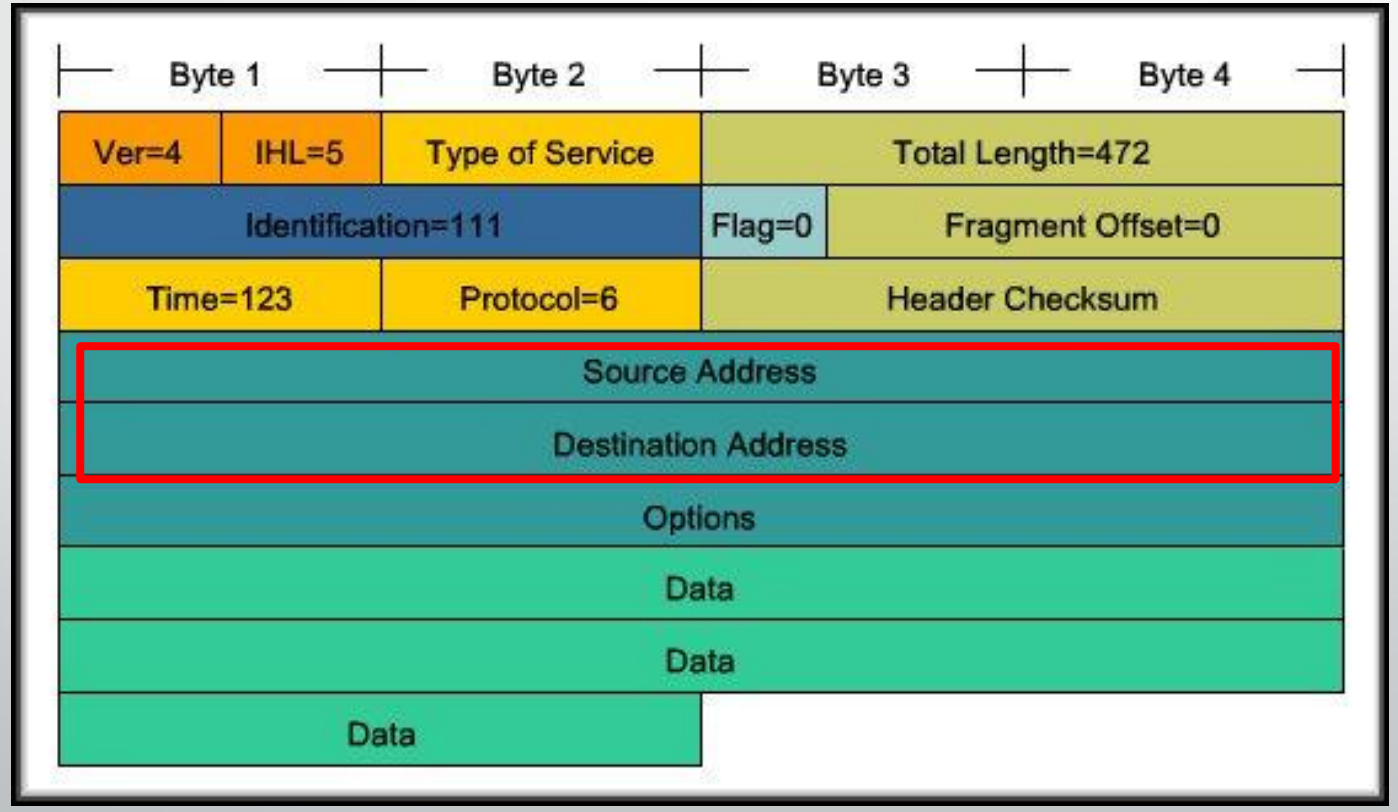
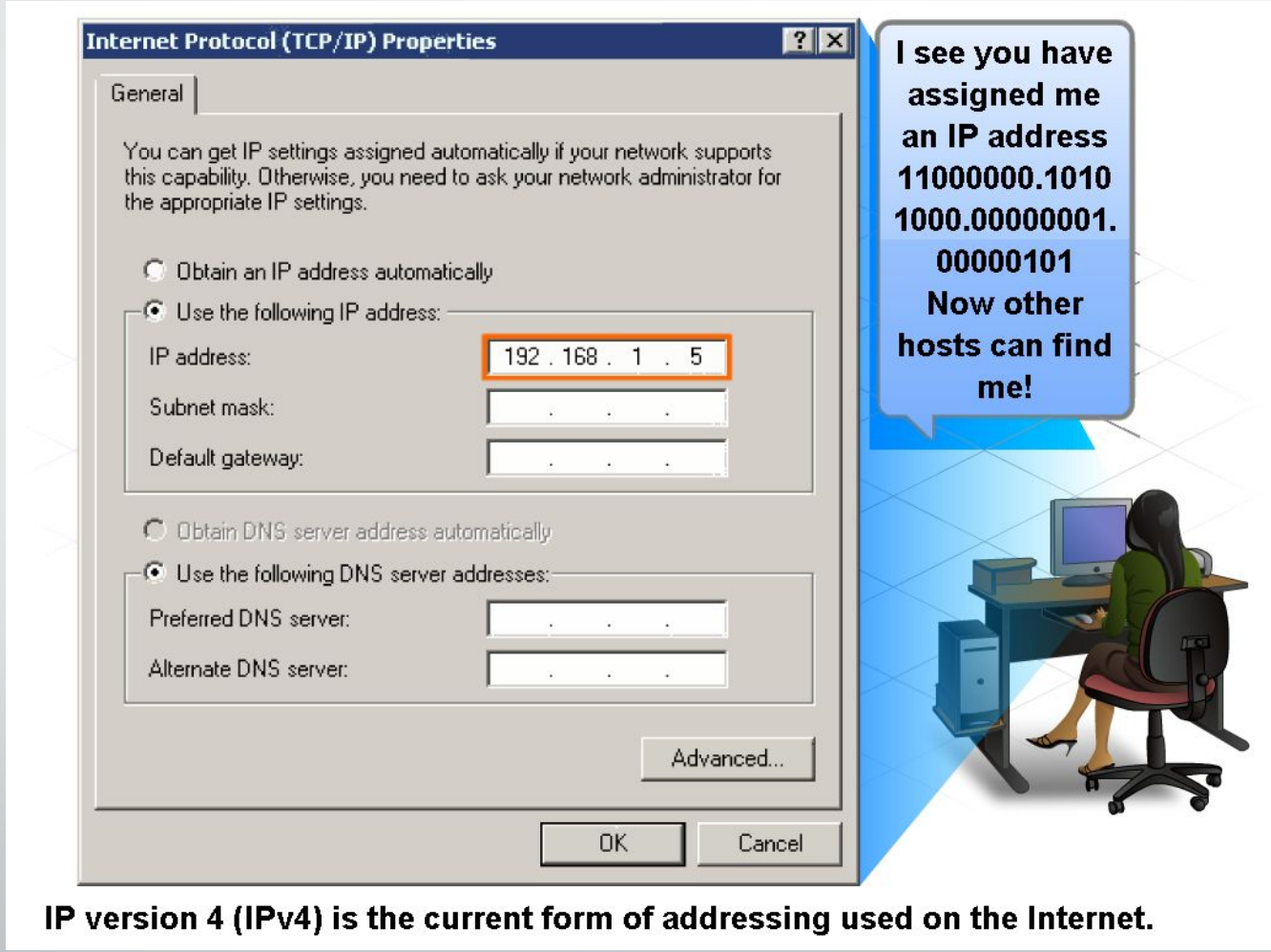
Anatomy of IPv4

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.

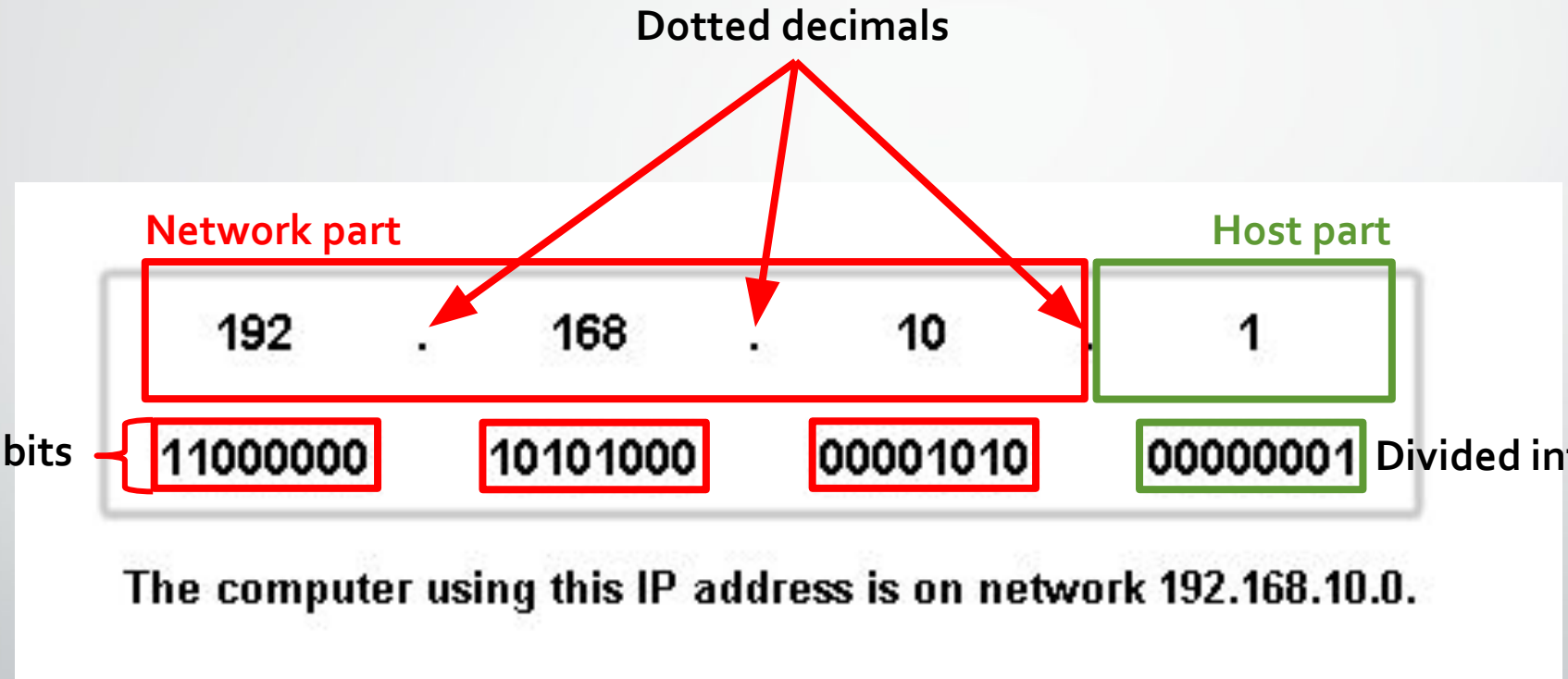


IPv4 Addressing Structure

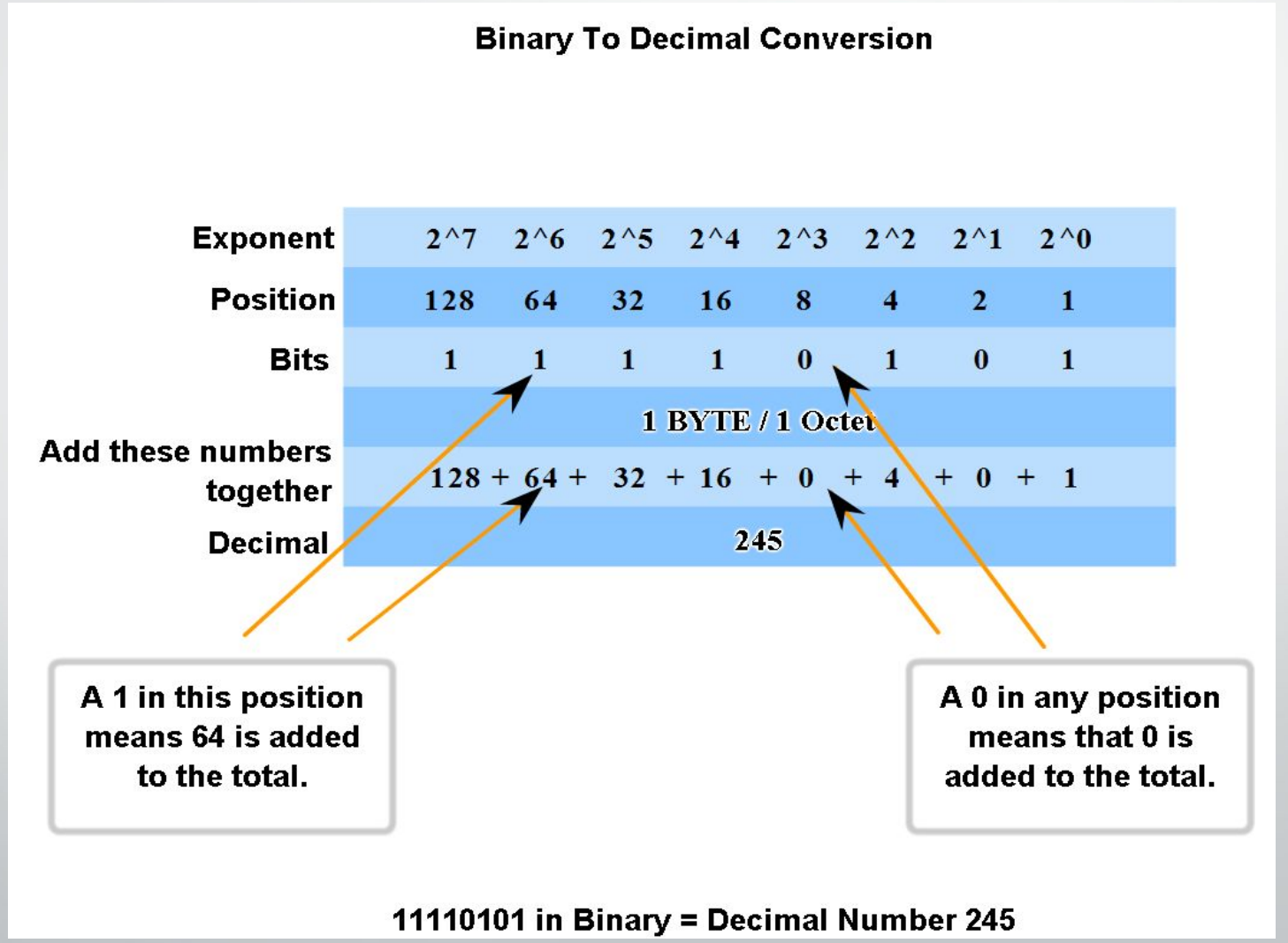


IP version 4 (IPv4) is the current form of addressing used on the Internet.

Anatomy of an IPv4 Address

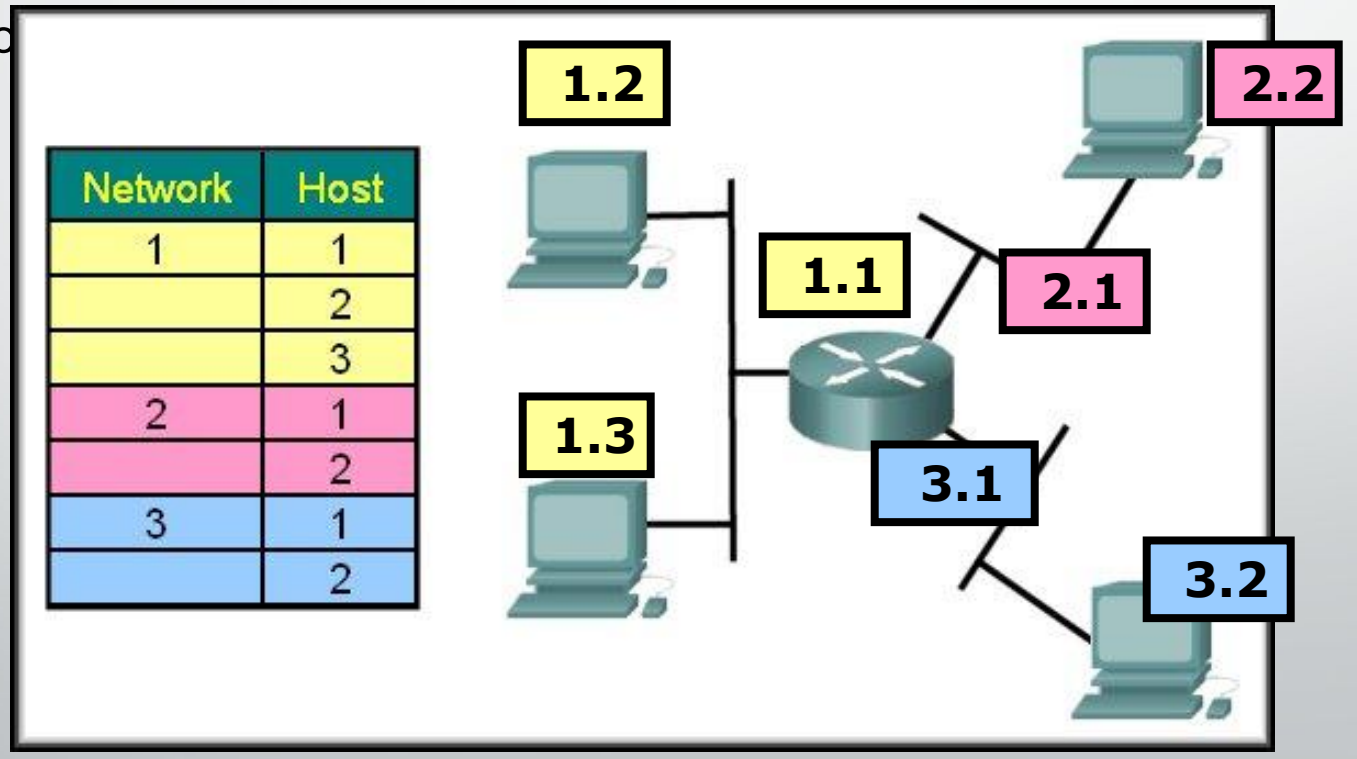


Binary to decimal and Vice Versa



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

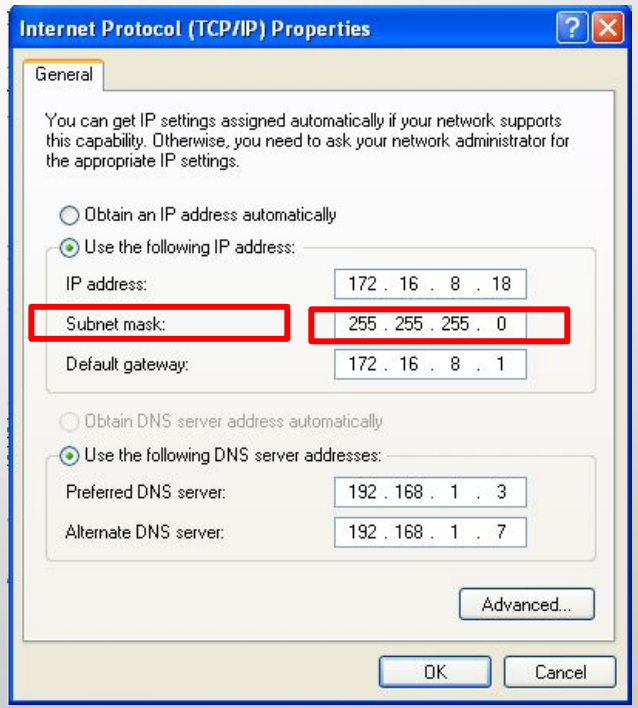
```
Z:\>ipconfig

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**.
- **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** and the rest will be **0**
  - Decimal: **255**.**255**.**255**.**0**
  - Binary: **11111111.11111111.11111111.**00000000
  - 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**

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

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?

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- **Routers** use the **ANDing** process to determine the route a packet will take.
- The network number of the **destination IPv4 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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IPv4 Addresses

Network Address

Broadcast Address

Host Address

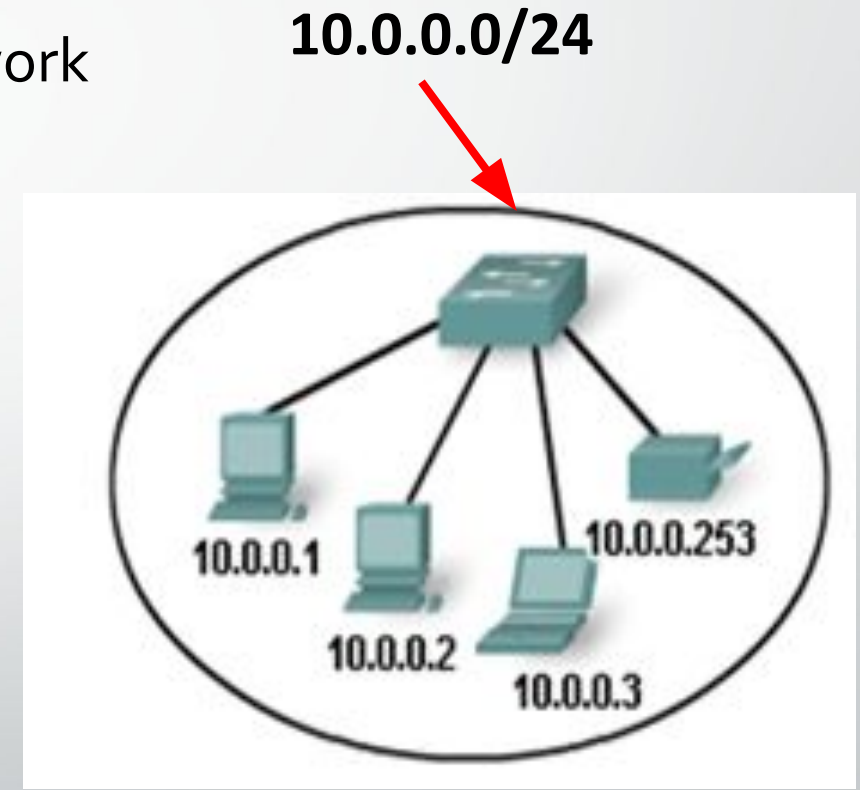
The Addresses

- **Network Address**
  - All hosts in the network will have the same network bits.
  - Cannot be assigned to a device.
  - All host bits in this address will be **zero**.

10.0.0.0/24

IP Address	10.	0.	0.	0
IP Address in Binary	00001010	00000000	00000000	00000000

Network Part | Host Part



The Addresses

Broadcast Address

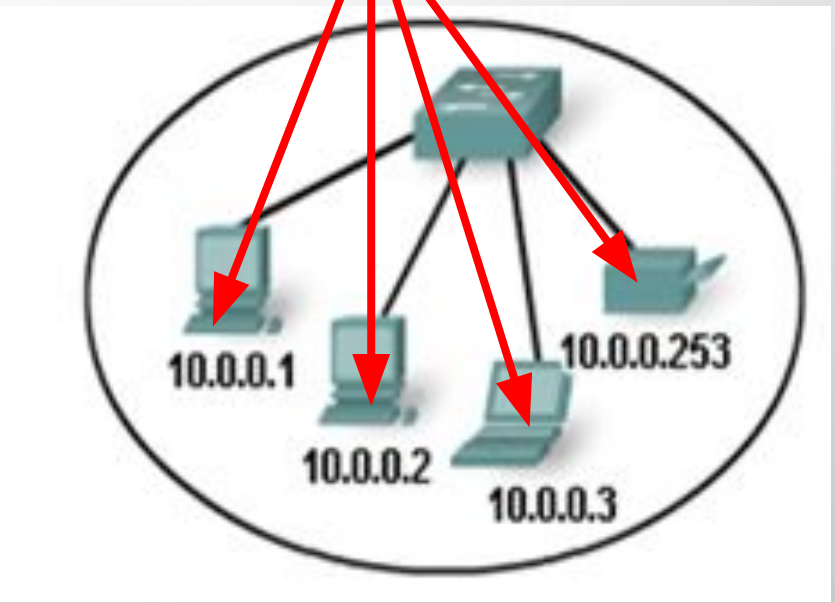
- Used to send message to all hosts in the network using one single address
- Cannot be assigned to a device.
- All host bits in this address will be **one**.

10.0.0.255/24

IP Address	10.	0.	0.	255
IP Address in Binary	00001010	00000000	00000000	11111111

Network Part | Host Part

Broadcast Address of 10.0.0.0/24 network is 10.0.0.255/24



The Addresses

Host Address

- The unique address assigned to each device on the network.
- For a network of 10.0.0.0/24
  - Addresses **10.0.0.1** through **10.0.0.254** are
  - All host bits in this address will **vary**.

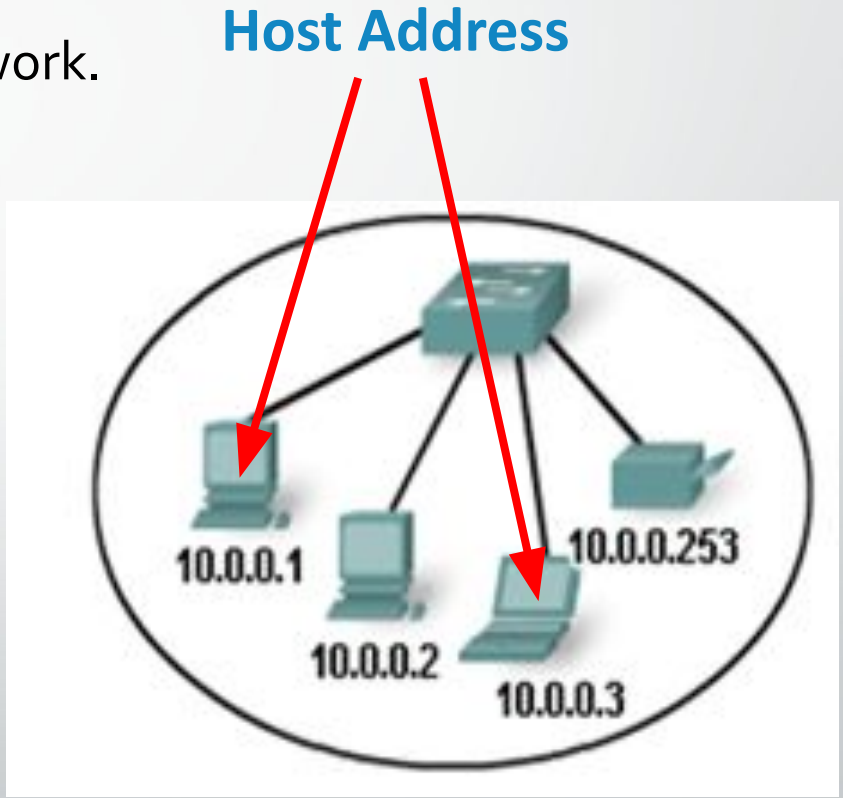
10.0.0.5/24

IP Address	10.	0.	0.	1
IP Address in Binary	00001010	00000000	00000000	00000001

Network Part

Host Part

IP Address	10.	0.	0.	3
IP Address in Binary	00001010	00000000	00000000	00000011



The Addresses

- Say, you have a random IP address **192.168.10.193/24 or given as 192.168.10.193 255.255.255.0**
- Say, you have a random IP address **200.32.16.192/26 or given as 200.32.16.192 255.255.255.192**

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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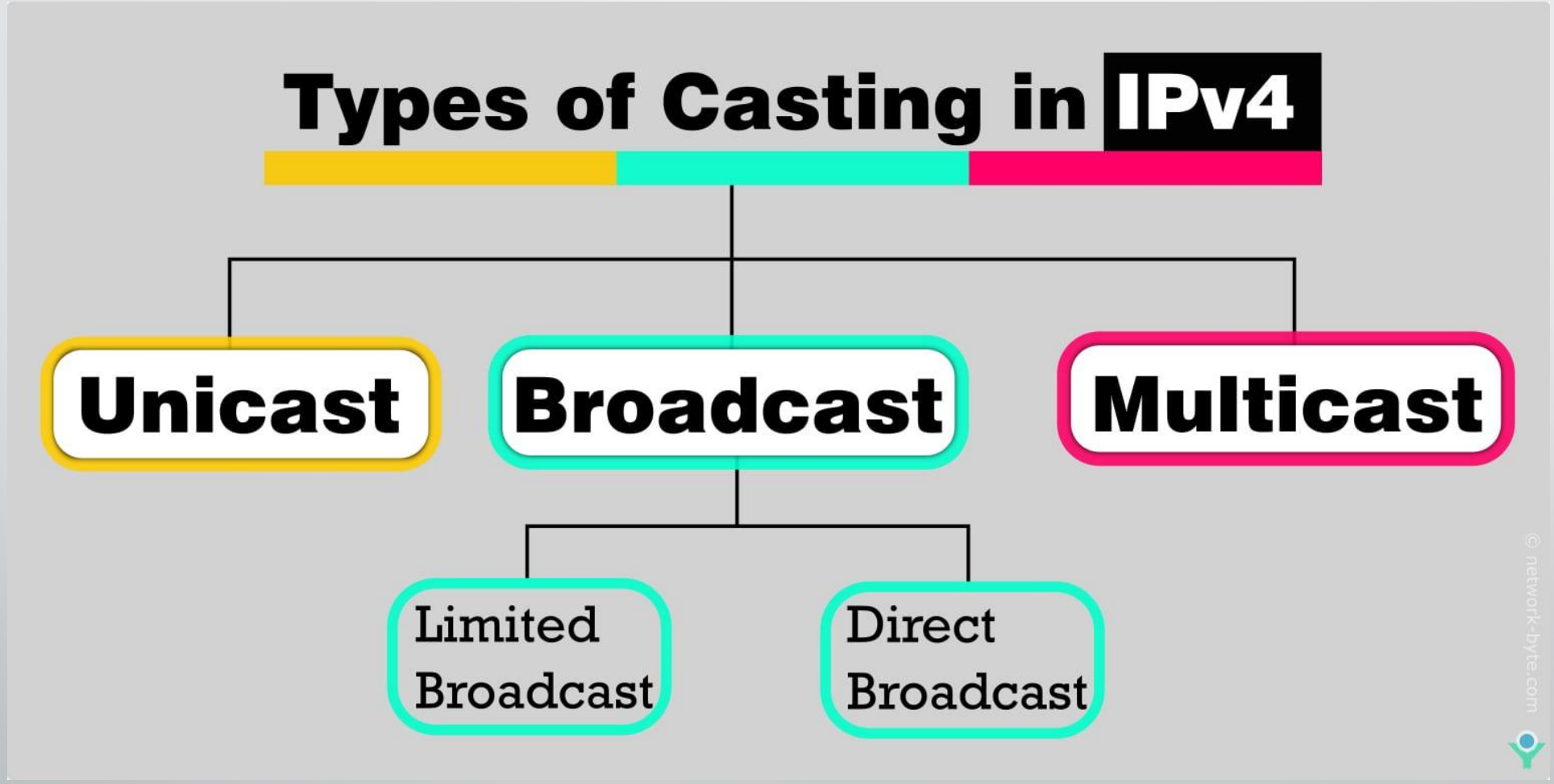
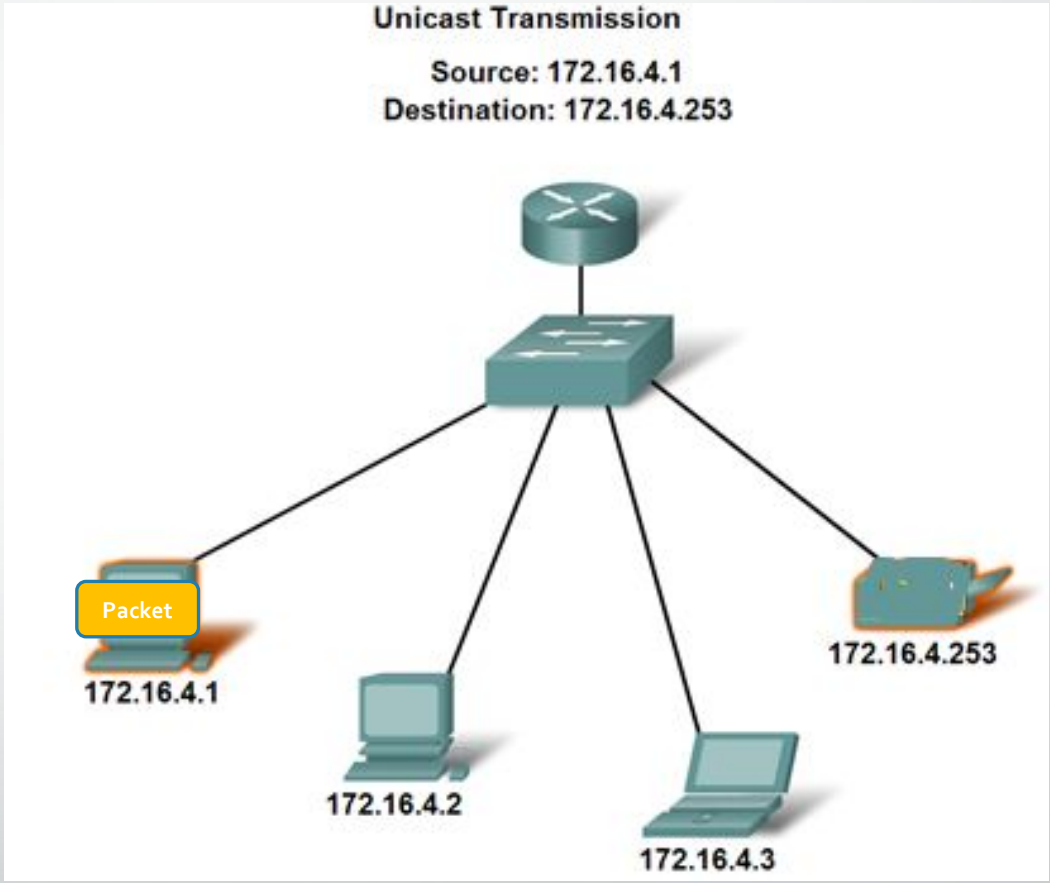
Types of IPv4 Addresses

Special Addresses



Unicast

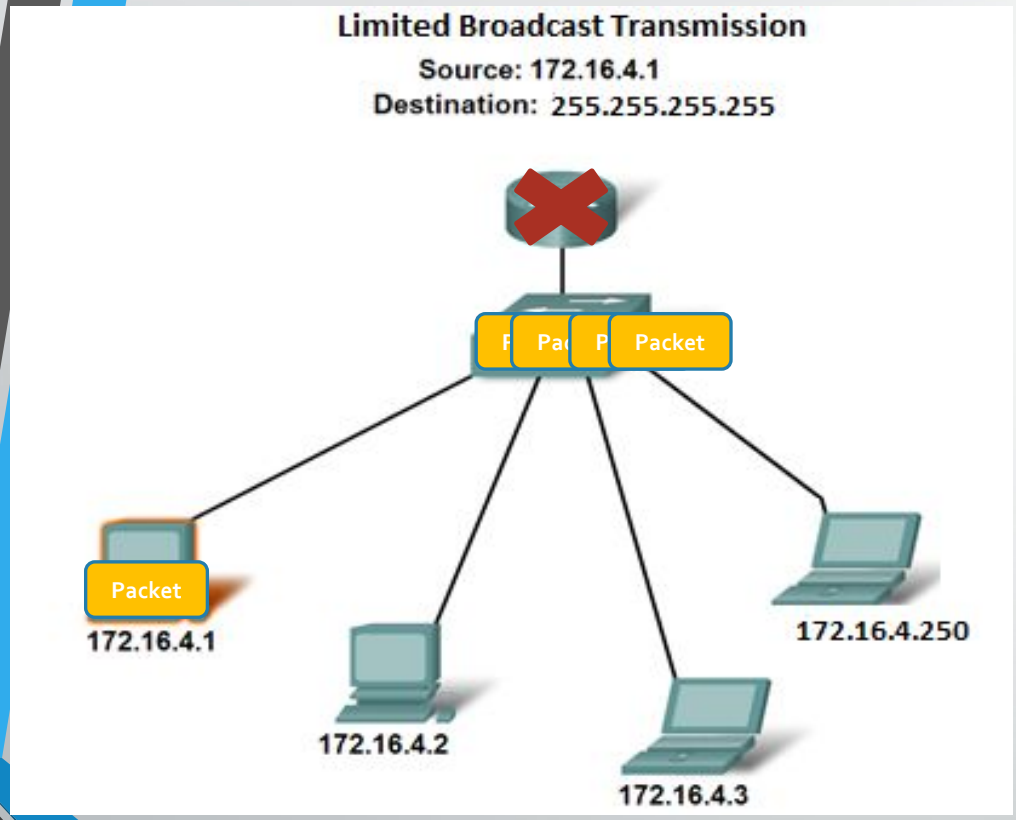
- **Unicast**
  - A message to one host.
  - **Individual IPv4 addresses**



172.16.4.253	172.16.4.1	Data

Dest IP Add	Source IP Add	Packet

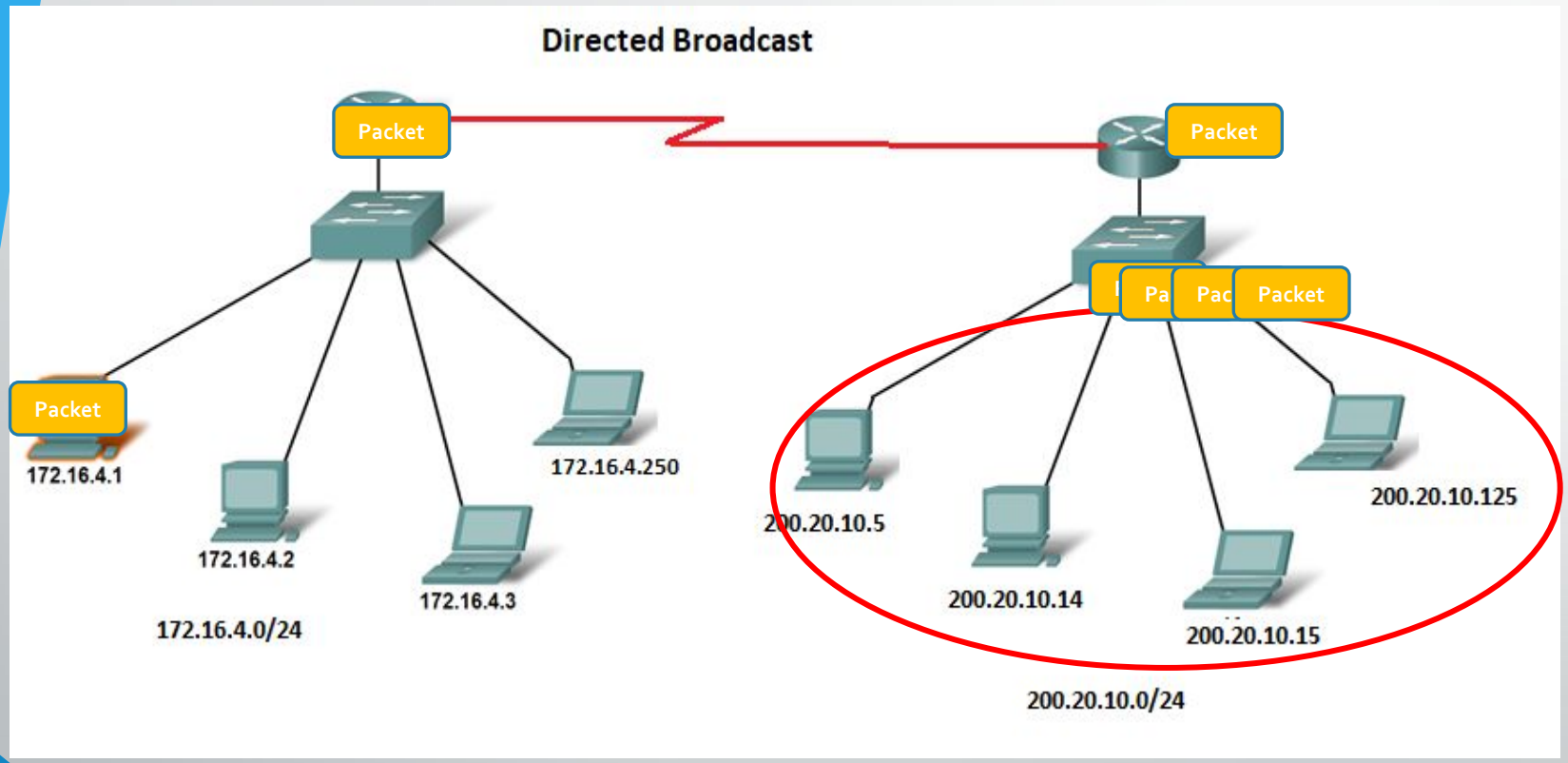
Broadcast



255.255.255.255	172.16.4.1	Data
Dest IP Add	Source IP Add	Packet

- **Limited Broadcast**
  - A message to all hosts on the same physical/local network or subnet.
  - 255.255.255.255
  - Never forwarded by routers!

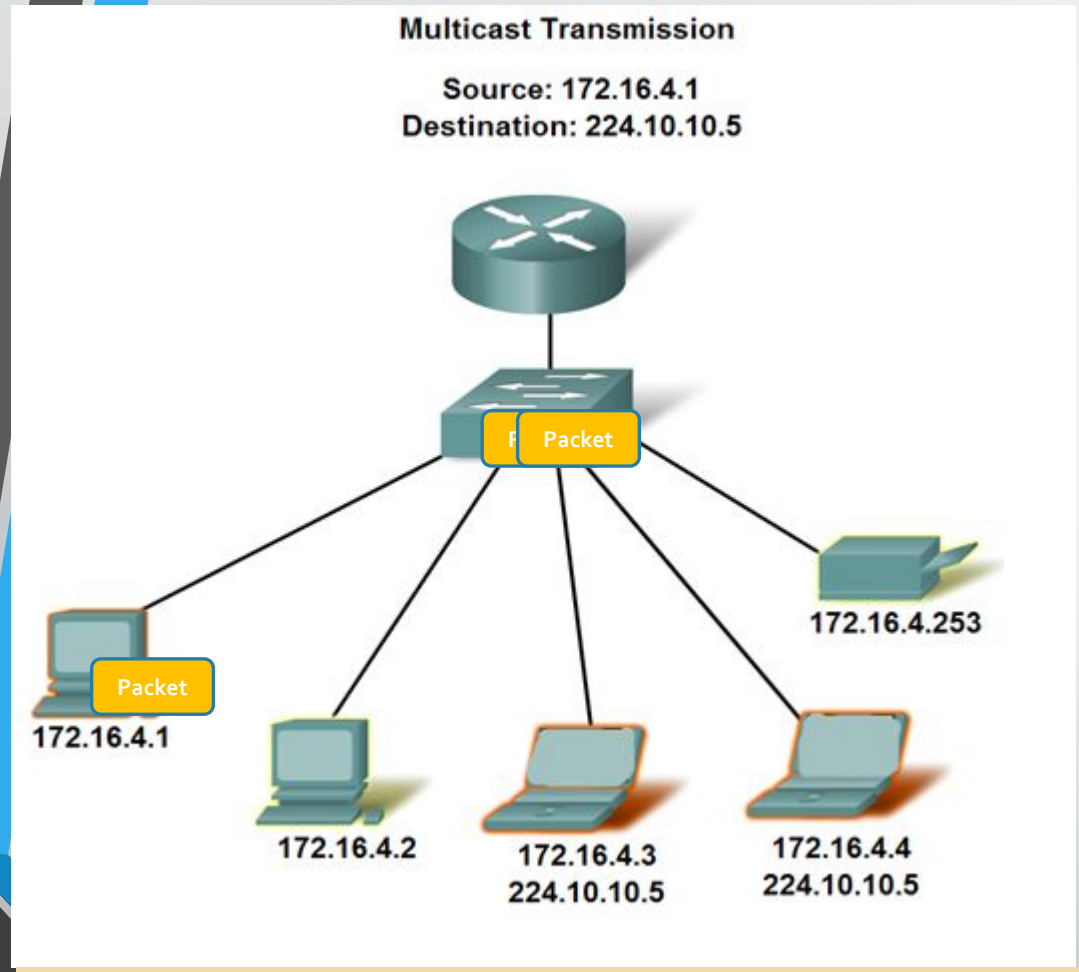
Broadcast



200.20.10.255	172.16.4.1	Data
Dest IP Add	Source IP Add	Packet

- **Directed Broadcast**
  - A message to all hosts on a different network or subnet.
  - **broadcast address of a network**
  - Example : 200.20.10.255

Multicast

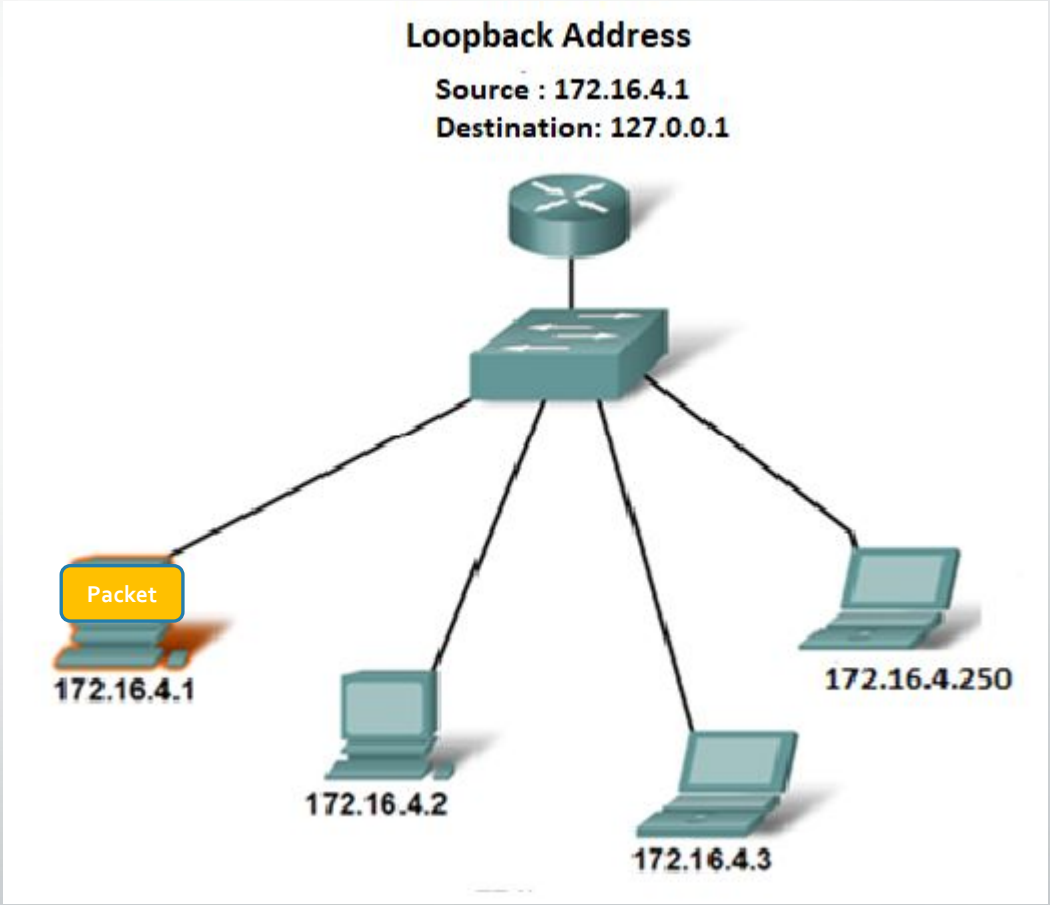


Dest IP Add	Source IP Add	Packet
224.10.10.5	172.16.4.1	Data

- **Multicast Addresses**
  - A message addressed to a group of hosts.
  - Uses an IP address starting within this range of **224 - 239**
- Examples of Multicast Application
  - Video and audio broadcasts
  - Distribution of software
  - News feeds

Loopback

- **Loopback Address**
  - A message addressed to loop back in the device itself.
  - **127.x.x.x of 127.0.0.0/8**
  - Not assigned to any device
  - Testing and Troubleshooting purpose



127.0.0.1	172.16.4.1	Data
Dest IP Add	Source IP Add	Packet

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Anatomy of IPv6 Address

Reasons for using IPv6

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

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

(340 undecillion) IP Addresses.

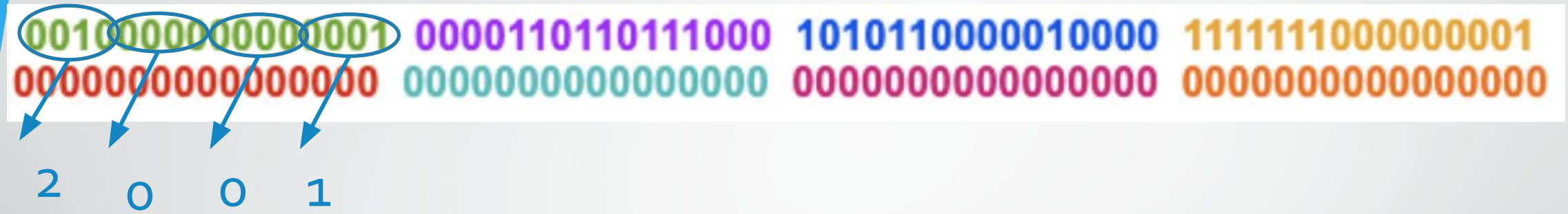
Every grain of sand on every beach on Earth could be assigned over a million unique IPv6 addresses, with plenty to spare (assuming approximately **7.5 X 10^18** grains of sand globally and **2^128** IPv6 addresses).

IPv6 Address

- 128 bits
- given below is a 128 bit IPv6 address represented in binary

- Each 4 bits is converted into a Hexadecimal digit
- Each block contains 4 Hexadecimal digits
- Each block is separated by ':' symbol

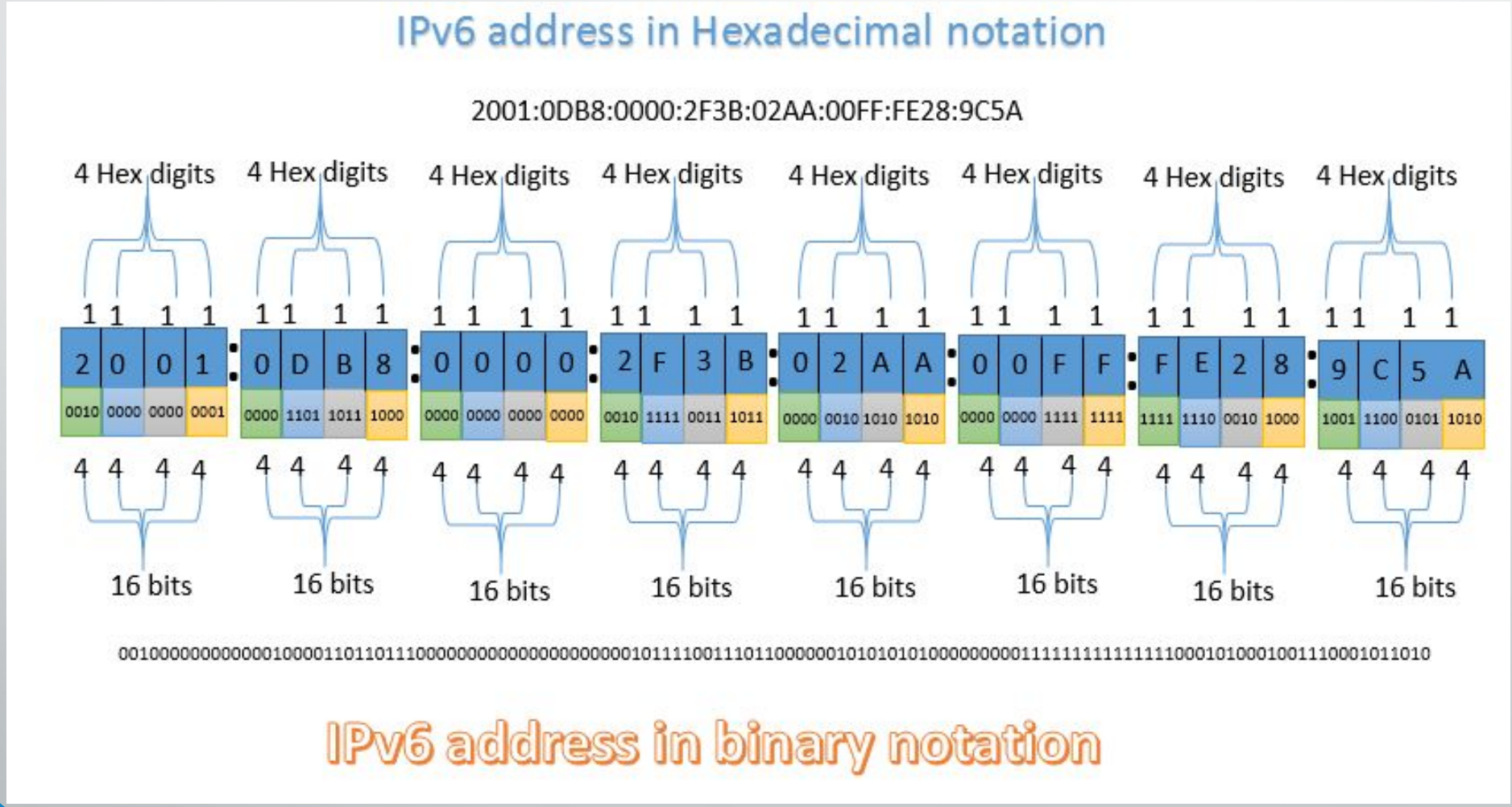
IPv6 Address



2001 : 0db8 : ac10 : fe01 : 0000 : 0000 : 0000 : 0000

- Called **string notation**

IPv6 Address



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::22::fa**

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

1843:0000:0000:0000:0022:0000:0000:00fa

or

1843:0000:0000:0022:0000:0000:0000:00fa

Representing IPv6 addresses

- IPv4 Address

- IPv6 Address
- No Subnet masks in dotted decimal format in IPv6

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The End