# IP ADDRESSING

Prepared by
Dr. Raheem Abdul Sahib
UOT/Computer Sc. Dept

# *IP Addresses:*
# *Classful Addressing*

- **Objectives**

***Understand IPv4 addresses and classes***

- ***Identify the class of an IP address***
- ***Find the network address given an IP address***
- ***Understand masks and how to use them***

# INTRODUCTION

## Introduction

- IP Address is Internet Protocol which is used to identified the HOST, NETWORK
- IP Address is 32 Bit Logical Address
- IP Address is divided in four octet which is separated by DOT (.)
- An octet is a set of 8 bits . Eg 192.128.56.43



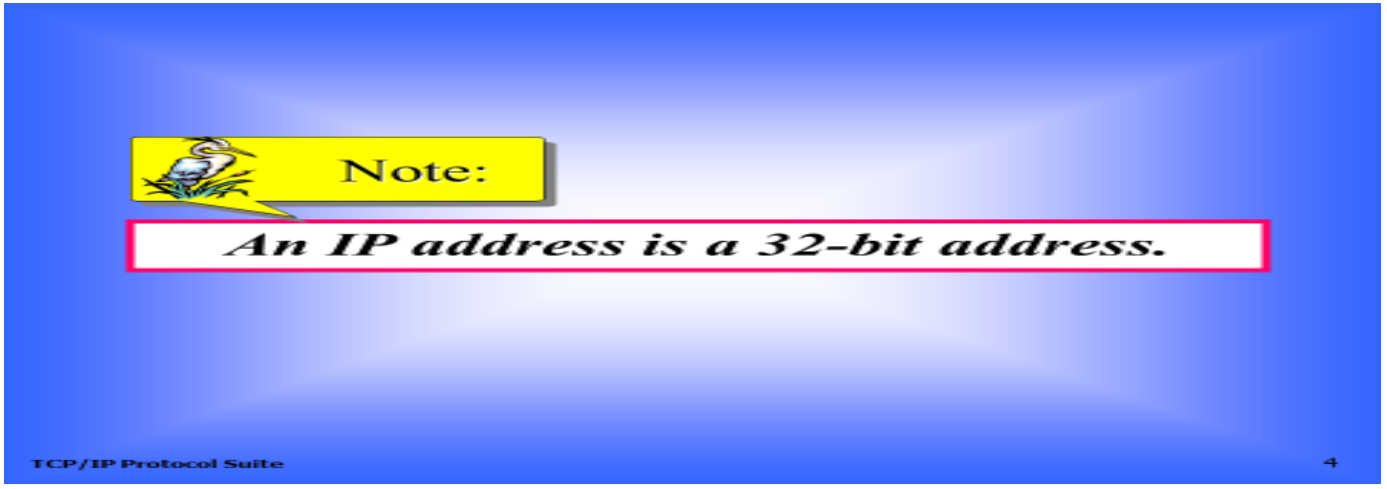
- **IP Addressing is Logical Addressing**
- **It works on Network Layer (Layer 3)**
- **Two Version of Addressing Scheme**
  - **IP version 4 – 32 bit addressing**
  - **IP version 6 – 128 bit addressing**

**IP address is a 32-bit binary number that is unique for each device**
**IP address is converted to a decimal format to make them readable for the humans**
**Within the network, the IP address is interpreted in a binary format consisting of 0 and 1**

# What is IP address?

- IP address - An Internet Protocol address (IP address) is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication. An IP address serves two main functions: host or network interface identification and location addressing.
- An IP address is written in "dotted decimal" notation, which is 4 sets of numbers separated by period each set representing 8-bit number ranging from (0-255). An example of IPv4 address is 216.3.128.12
- An IP address is a unique identifier for every machine using the internet. Known as your “internet protocol address,” this identifier is written as a string of numbers separated by periods.

# IP Address →32 bits , Unique




# Types OF IP Address

- IPv4 is a 32-Bit (4 bytes) IP Address.
- IPv6 is 128 Bit (16 Bytes) IP Address.

Addressing method.

- IPv4 is a numeric address, and its binary bits are separated by a dot (.)
- IPv6 is an alphanumeric address whose binary bits are separated by a colon (:)

## IPv4 and IPv6 Comparison

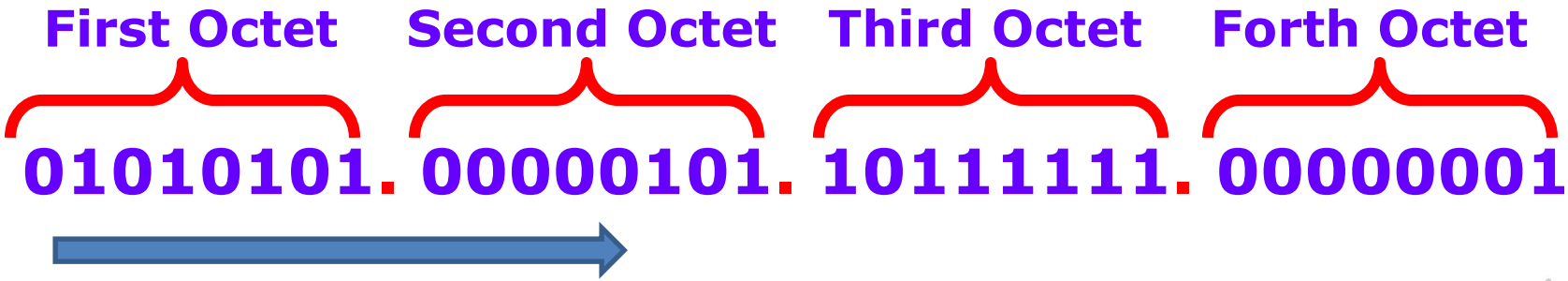
| IP version | IPv4 | IPv6 |
|---|---|---|
| Deployed | 1981 | 1999 |
| Address Size | 32-bit number | 128-bit number |
| Address Format | Dotted Decimal Notation: 192.0.2.76 | Hexadecimal Notation: 2001:0DB8:0234:AB00: 0123:4567:8901:ABCD |
| Number of Addresses | $2^{32}$ = 4,294,967,296 | $2^{128}$ = 340,282,366,920,938,463, 463,374,607,431,768,211,456 |
| Examples of Prefix Notation | 192.0.2.0/24<br>10/8<br>(a "/8" block = 1/256th of total IPv4 address space = $2^{24}$ = 16,777,216 addresses) | 2001:0DB8:0234::/48<br>2600:0000::/12 |

- **What is BIT ?**

  **Bit is a value that will represent 0's or 1's (i.e. Binary)**

**01010101000001011011111100000001**

- **32 bits are divided into 4 Octets known as Dotted Decimal Notation**



# IPv6 Address Format

- **128-bit address is divided along 16-bit boundaries, and each 16-bit block is converted to a 4-digit hexadecimal number and separated by colons (:) (Colon-Hex Notation)**

  **FEDC:BA98:7654:3210:FEDC:BA98:7654:3210**

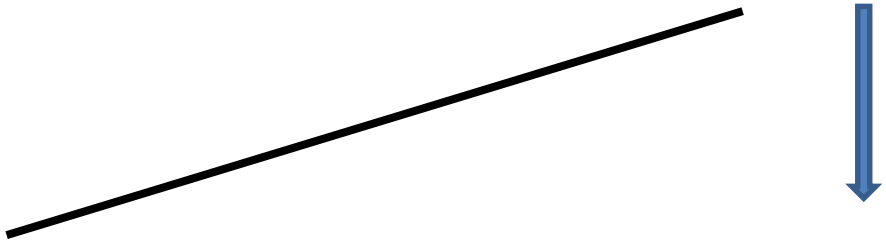
# How To Compute Byte Values -→IPv4

**Taking Example for First Octet :**

**Total 8 bits, Value will be 0's and 1's**

**i.e. $2^8$ = 256 combination**

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | = | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | = | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | = | 3 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | = | 4 |



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = | 255 |

**Total IP Address Range**

**0 . 0 . 0 . 0**

**to**

**255.255.255.255**

# TYPES OF CLASSES (ClassFull)

- **Total IP Addressing Scheme is divided into 5 Classes**

- **CLASS A**
- **CLASS B** } **LAN & WAN**
- **CLASS C**
- **CLASS D** } **Multicasting & Newsgroups**
- **CLASS E** } **Research & Development**

- **To identify the range of each class we will be using Priority Bit Concept**
- **Priority Bit is the left most bits in the First Octet**
- **CLASS A priority bit is 0**
- **CLASS B priority bit is 10**
- **CLASS C priority bit is 110**
- **CLASS D priority bit is 1110**
- **CLASS E priority bit is 1111**

**For Class A range reserved first bit in first octet,the value of that bit should not change.**

**0xxxxxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx**

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | = | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | = | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | = | 3 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | = | 4 |
| | | | | | | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = | 127 |

**Class A Range**

**0 . 0 . 0 . 0 to 127.255.255.255**

**Exception**

**0.X.X.X and 127.X.X.X network are reserved**

**For Class B range reserved first two bit in first octet,the value of that bit should not change.**

**10xxxxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx**

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = | 128 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | = | 129 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | = | 130 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | = | 131 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | = | 132 |
| 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | = | 191 |

**Class B Range**

**128. 0 . 0 . 0**

**to**

**191.255.255.255**

**For Class C range reserved first three bit in first octet,the value of that bit should not change.**

**110xxxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx**

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | = | 192 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | = | 193 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | = | 194 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | = | 195 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | = | 196 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | = | 223 |

**Class C Range**

**192. 0 . 0 . 0**

**to**

**223.255.255.255**

**For Class D range reserved first four bit in first octet,the value of that bit should not change.**

**1110xxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx**

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | = | 224 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | = | 225 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | = | 226 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | = | 227 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | = | 228 |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | = | 239 |

**Class D Range**

**224. 0 . 0 . 0**

**to**

**239.255.255.255**

**For Class E range reserved first four bit in first octet,the value of that bit should not change.**

**1111xxxx. xxxxxxxx. xxxxxxxx. xxxxxxxx**

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | = | 240 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | = | 241 |
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | = | 242 |
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | = | 243 |
| 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | = | 244 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = | 255 |

**Class E Range**

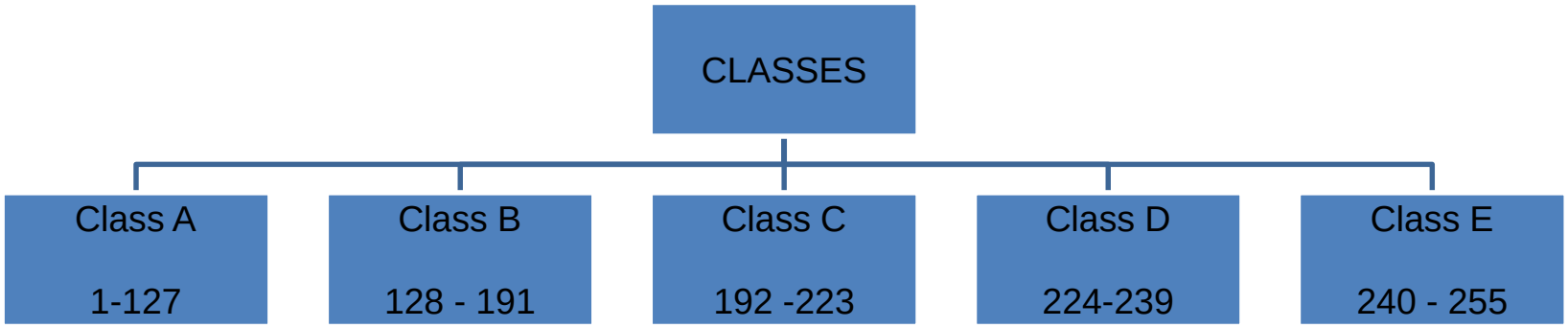
**240. 0 . 0 . 0**

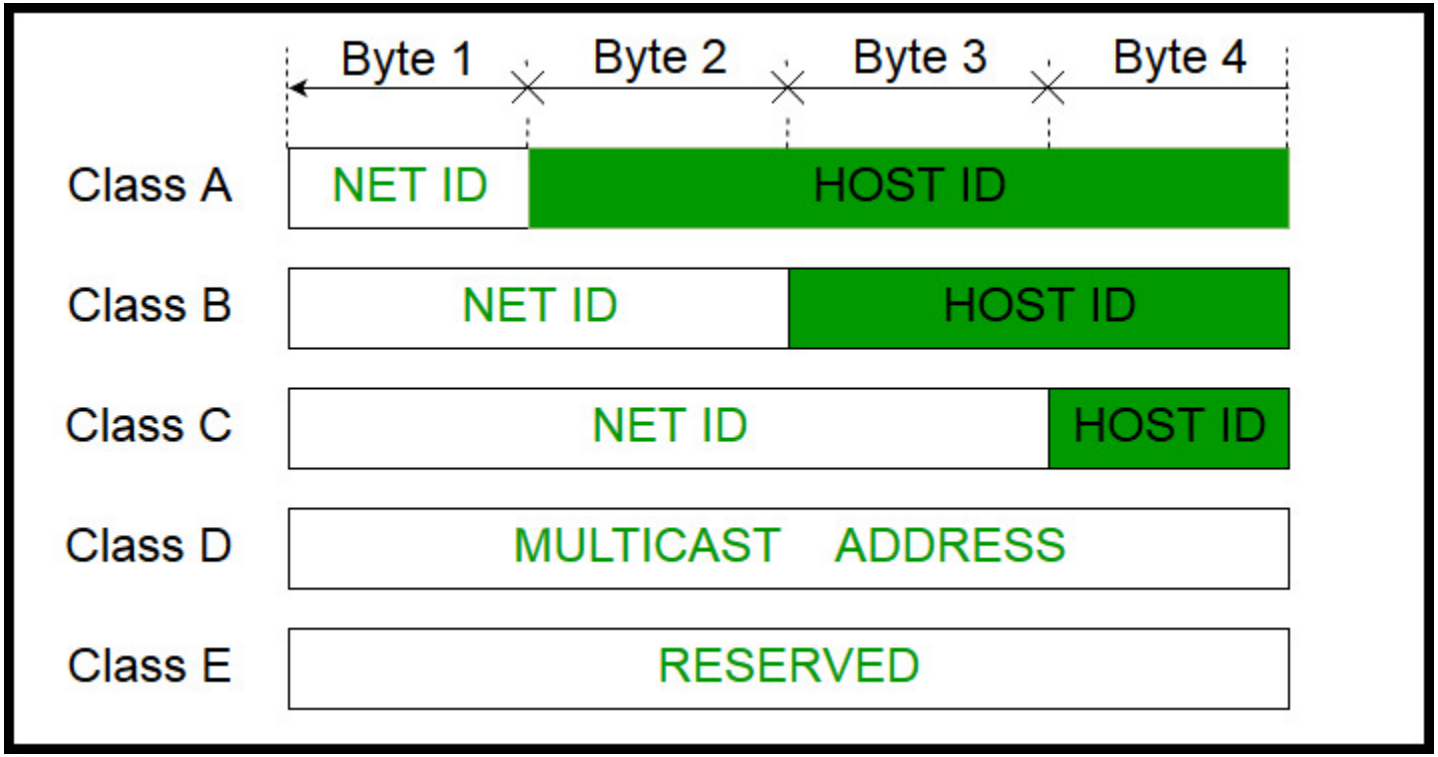
**to**

**255.255.255.255**

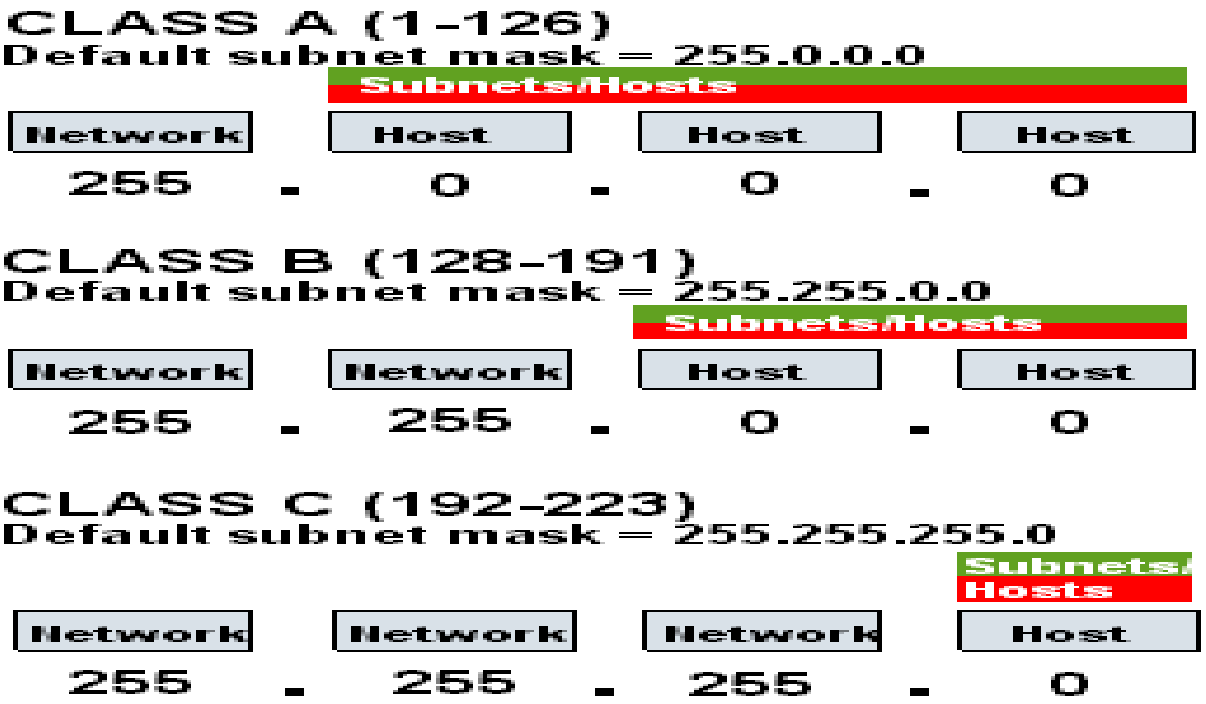
Classification of IP Addresses

# CLASS OF IP ADDRESS



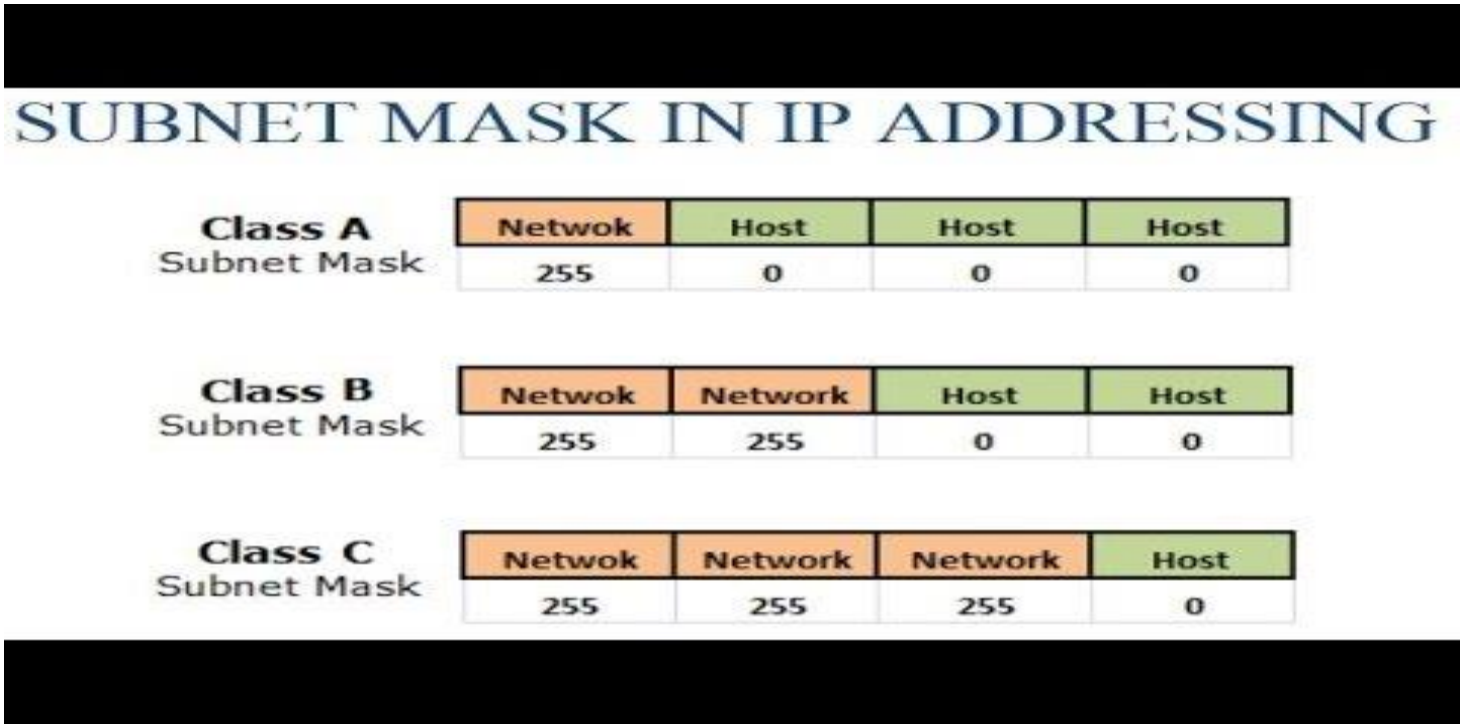

Byte 1
Byte 2
Byte 3
Byte 4
Class A
NET ID
HOST ID
Class B
NET ID
HOST ID
Class C
NET ID
HOST ID
Class D
MULTICAST ADDRESS
Class E
RESERVED

# Classes, Range, Default Subnet Mask



# Subnet Mask

- A subnet mask is another group of dotted decimal numbers, representing a binary number that distinguishes which part of the IP address re
- The default subnet mask for Class A IP address is 255.0. 0.0 which implies that Class A addressing can have 126 networks ($2^7$-2) and 16777214 hosts ($2^{24}$-2)



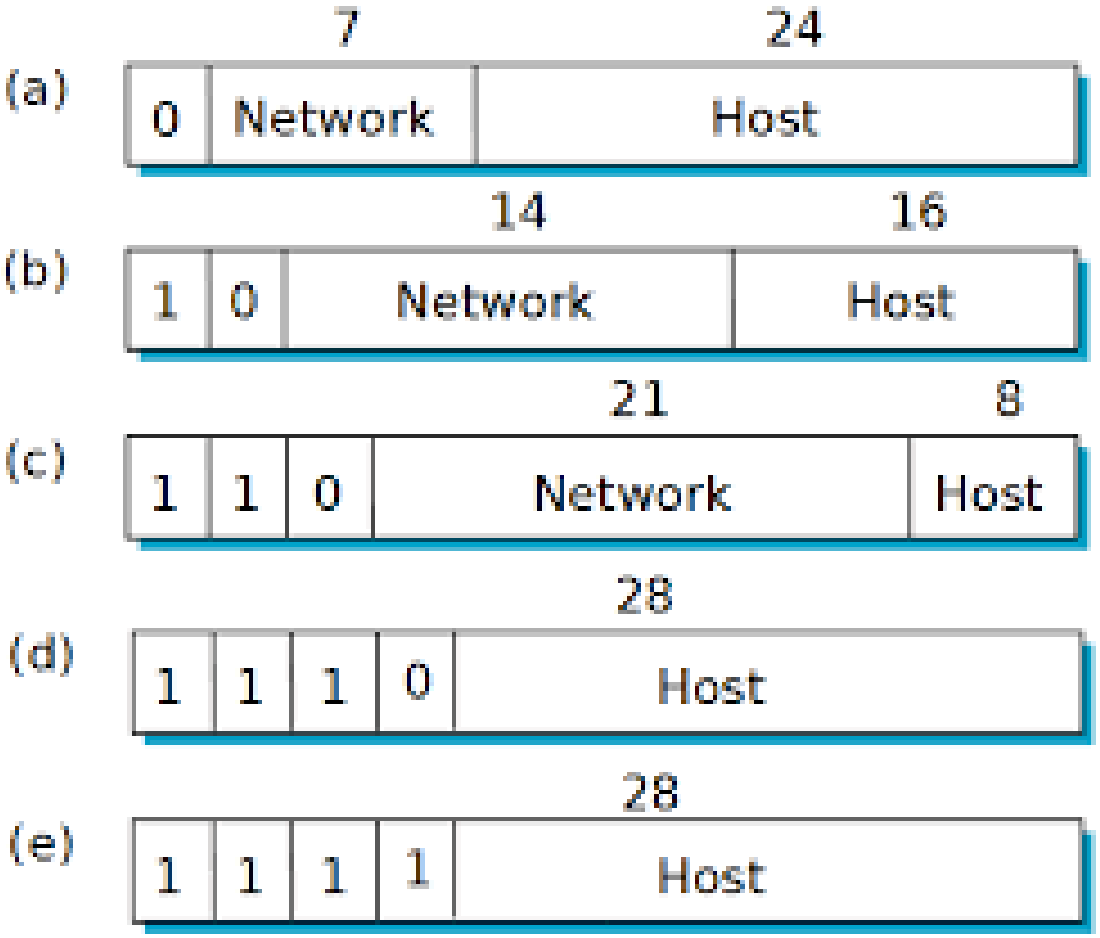
# Ranges and Default Subnet Mask

| Address Class | RANGE | Default Subnet Mask |
|---|---|---|
| A | 1.0.0.0 to 126.255.255.255 | 255.0.0.0 |
| B | 128.0.0.0 to 191.255.255.255 | 255.255.0.0 |
| C | 192.0.0.0 to 223.255.255.255 | 255.255.255.0 |
| D | 224.0.0.0 to 239.255.255.255 | Reserved for Multicasting |
| E | 240.0.0.0 to 254.255.255.255 | Experimental |

Note: Class A addresses 127.0.0.0 to 127.255.255.255 cannot be used and is reserved for loopback testing.

- **IP address is divided into Network & Host Portion**
- **CLASS A is written as** **N.H.H.H**
- **CLASS B is written as** **N.N.H.H**
- **CLASS C is written as** **N.N.N.H**

# How Determine Net_ID and Host_TD



# An example of a practical application

| Class | Leading bits | Size of *network number* bit field | Size of *rest* bit field | Number of networks | Addresses per network | Total addresses in class | Start address | End addres |
|---|---|---|---|---|---|---|---|---|
| Class A | 0 | 8 | 24 | 128 ($2^7$) | 16,777,216 ($2^{24}$) | 2,147,483,648 ($2^{31}$) | 0.0.0.0 | 127.255.25 |
| Class B | 10 | 16 | 16 | 16,384 ($2^{14}$) | 65,536 ($2^{16}$) | 1,073,741,824 ($2^{30}$) | 128.0.0.0 | 191.255.25 |
| Class C | 110 | 24 | 8 | 2,097,152 ($2^{21}$) | 256 ($2^8$) | 536,870,912 ($2^{29}$) | 192.0.0.0 | 223.255.25 |
| Class D (multicast) | 1110 | not defined | not defined | not defined | not defined | 268,435,456 ($2^{28}$) | 224.0.0.0 | 239.255.25 |
| Class E (reserved) | 1111 | not defined | not defined | not defined | not defined | 268,435,456 ($2^{28}$) | 240.0.0.0 | 255.255.25 |

# More details of Classes

| Address Class | 1st octet range (decimal) | 1st octet bits (green bits don't change) | Network (N) and Host (H) parts of address | Default subnet mask (decimal and binary) | Numbers of possible networks and hosts per network | Notes and host address range** |
|---|---|---|---|---|---|---|
| A | 1 - 127* | 00000000 - 01111111 | N.H.H.H | 255.0.0.0 11111111.00000000.00000000.00000000 | 128 nets (2^7) 16,777,214 hosts per net (2^24-2) | Commercial 1.0.0.1 - 126.255.255.254 |
| B | 128 - 191 | 10000000 - 10111111 | N.N.H.H | 255.255.0.0 11111111.11111111.00000000.00000000 | 16,384 nets (2^14) 65,534 hosts per net (2^16-2) | Commercial 128.0.0.1 - 191.255.255.254 |
| C | 192 - 223 | 11000000 - 11011111 | N.N.N.H | 255.255.255.0 11111111.11111111.11111111.00000000 | 2,097,152 nets (2^21) 254 hosts per net (2^8-2) | Commercial 192.0.0.1 - 223.255.255.254 |
| D | 224- 239 | 11100000 - 11101111 | Not for commerical use as a host | | | Multicast (reserved) 224.0.0.1 - 239.255.255.254 |
| E | 240 - 255 | 11110000 - 11111111 | Not for commerical use as a host | | | Experimental (reserved) 240.0.0.1 - 255.255.255.255 |

# Subnetting

## Lecture No. 8

*UOT / Computer Sci. Dept. (Iraq)*

*For*

*Branches: Security -3rd class and AI- 4th Class*

*Prepared by:*

*Asst. Prof.*

*Dr. Raheem Abdul Sahib Olga*

*110137@uotechnology.edu.iq*

*Reference*

*Data Communications and Networking, 5th Edition*

*by Behrouz A. Forouzan (Author),2018*

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*ISBN-10: 0073376221*

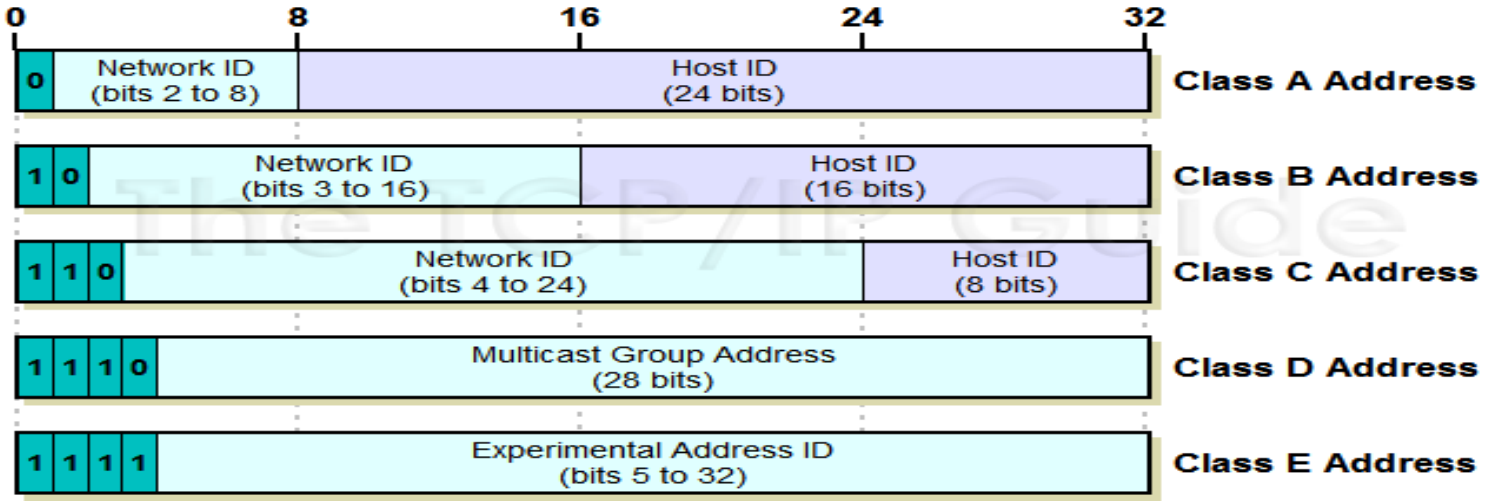
# *CONTENTS*

- **REVIEW**
- **SUBNETTING**
- **SUPERNETTING**
- **CLASSLESS ADDRSSING**

# Review the Previous LectureNo. 7

## IP Addressing , Class Full, Ranges

مراجعة المحاضرة السابقة رقم 7




| Address Class | RANGE | Default Subnet Mask |
|---|---|---|
| A | 1.0.0.0 to 126.255.255.255 | 255.0.0.0 |
| B | 128.0.0.0 to 191.255.255.255 | 255.255.0.0 |
| C | 192.0.0.0 to 223.255.255.255 | 255.255.255.0 |
| D | 224.0.0.0 to 239.255.255.255 | Reserved for Multicasting |
| E | 240.0.0.0 to 254.255.255.255 | Experimental |

Note: Class A addresses 127.0.0.0 to 127.255.255.255 cannot be used and is reserved for loopback testing.

# SUBNETTING
# عنونة الشبكات الفرعية

# What is Subnetting ?

**As a basic definition, Subnetting is dividing the network into smaller network groups and by doing this, using the IP Address Block more efficient. For Subnetting, Subnet Masks are used. Subnets masks are 32 bit addresses like IP Addresses. Subnet Masks are used with IP Addresses**

## What is IP Subnetting?

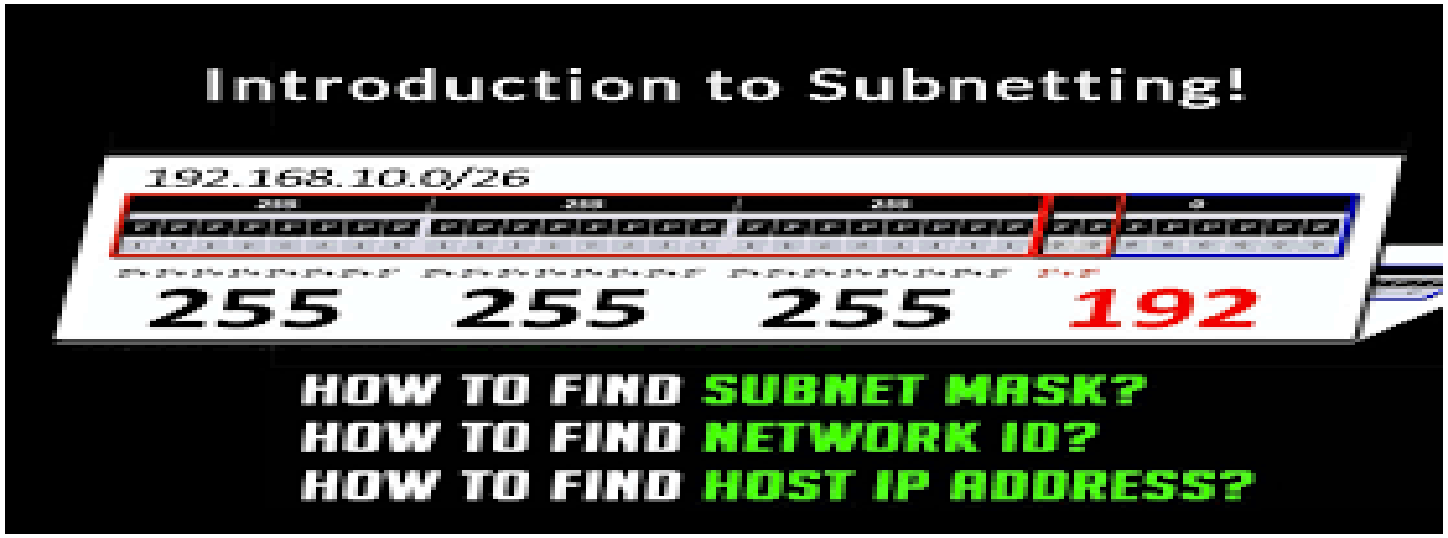
**IP Subnetting is a process of dividing a large IP network in smaller IP networks. In Subnetting we create multiple small manageable networks from a single large IP network.**

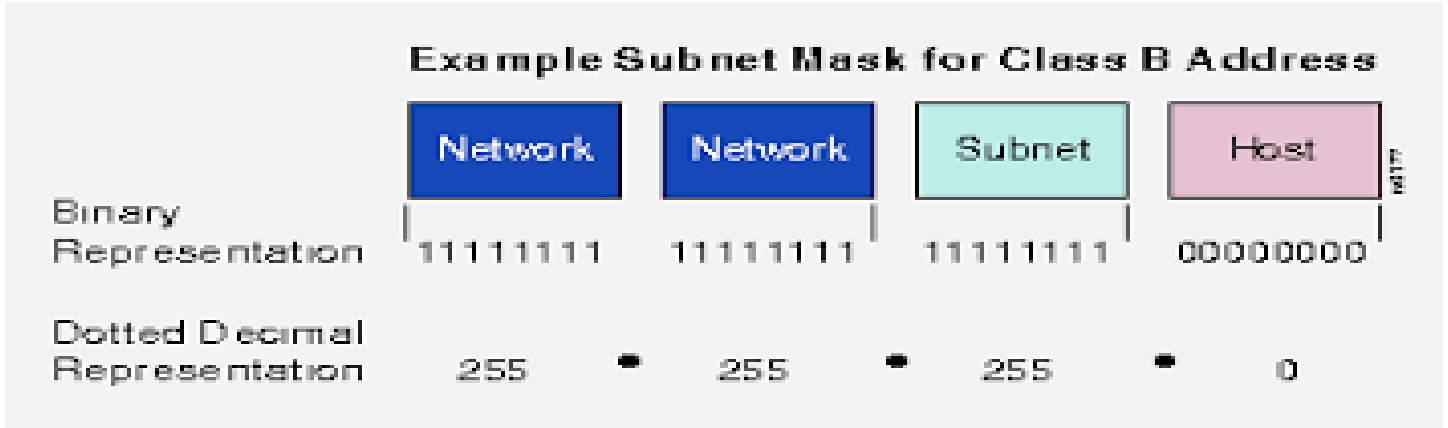
## Subnet

**A subnet is a single small network created from a large network. In Subnetting we break a single large network in multiple small networks. These networks are known as subnets.**

# Subnet mask ? Is it different from default mask? Yes

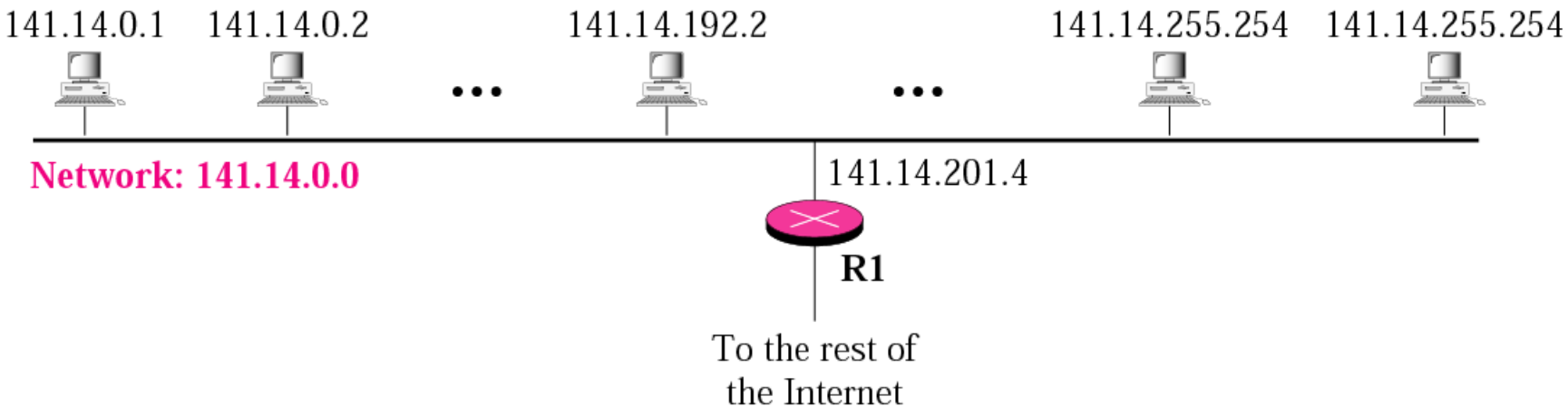
**Subnet mask is a mask used to determine what subnet an IP address belongs to. An IP address has two components, the network address and the host address.**



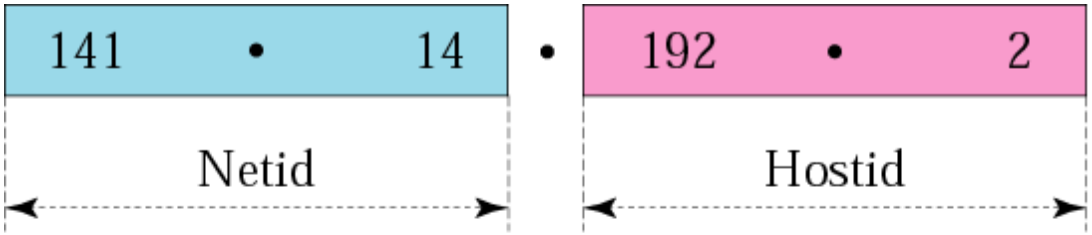



# *IP addresses are designed with two levels of hierarchy.*

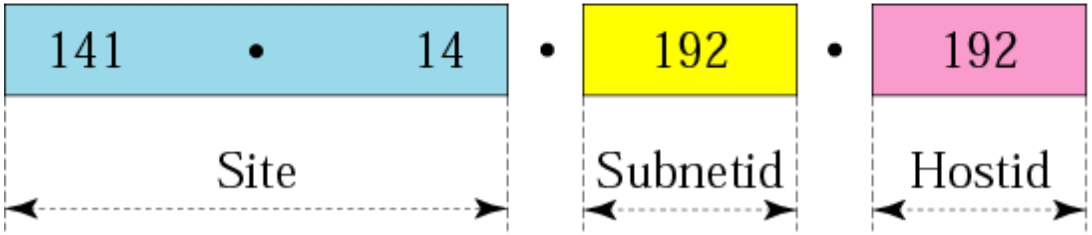
## A network with two levels of hierarchy (not subnetted)



# Addresses in a network with and without subnetting




a. Without subnetting




b. With subnetting

**IP addresses are designed with two level of hierarchy .**

- **Two levels of hierarchy is not enough**

**Solution: Subnetting**

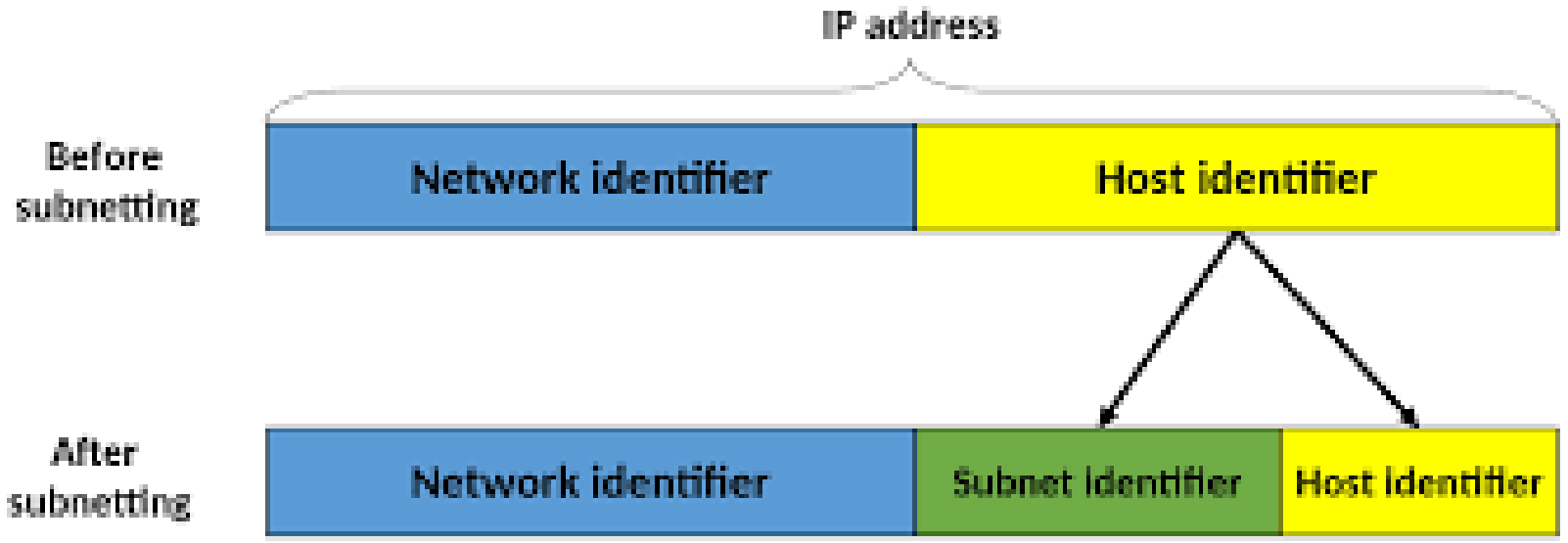
- ✓ **A network is divided into several smaller networks**
- ✓ **Each smaller network is called a subnetwork or a subnet**

# Three Levels of Hierarchy

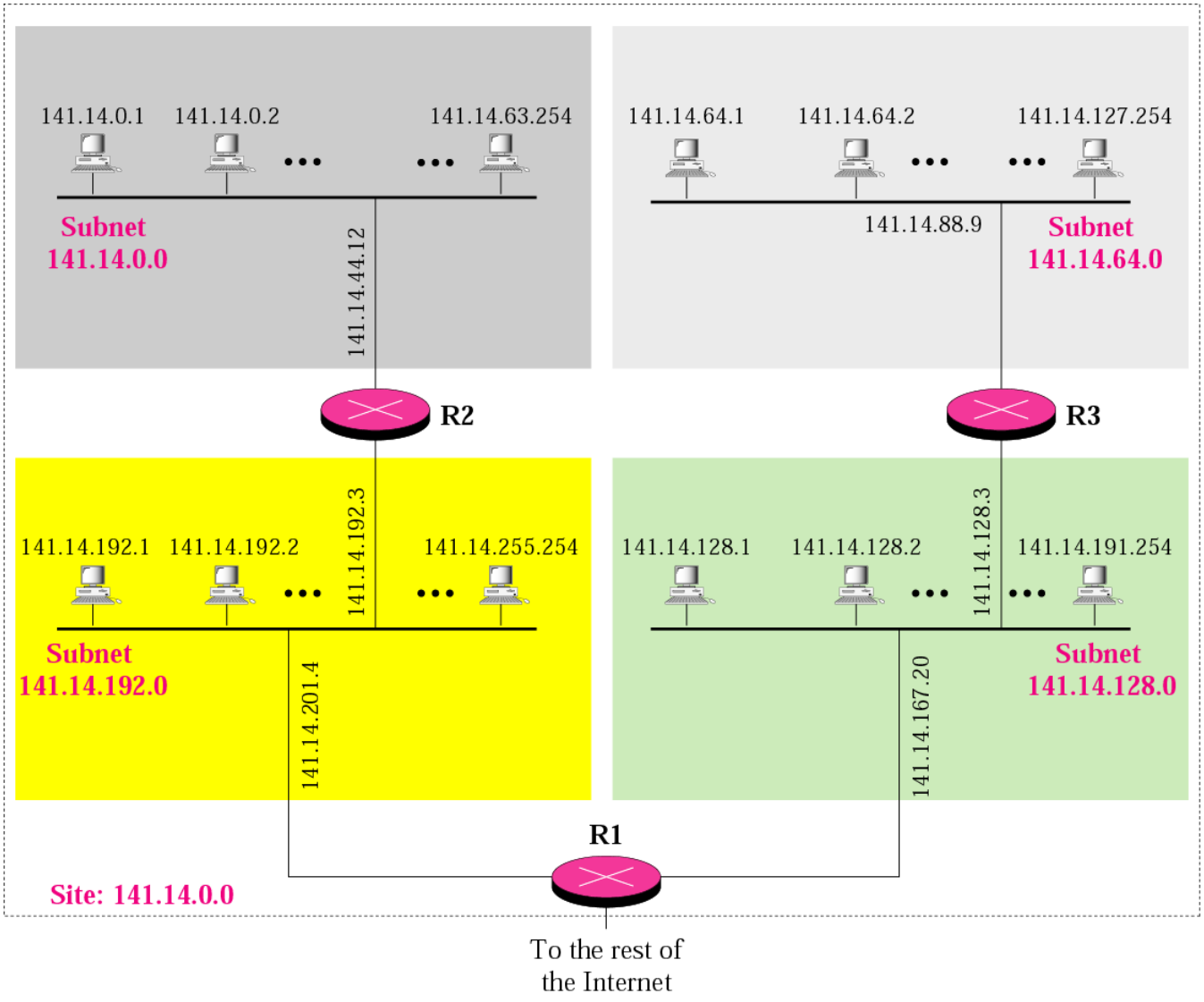
- **Three level**
  - **Site, subnet, and host**

- **The routing of an IP datagram now involves three step**
  - **Delivery to the site**
  - **Delivery to the subnetwork**
  - **Delivery to the host**

# Subnetting Levels

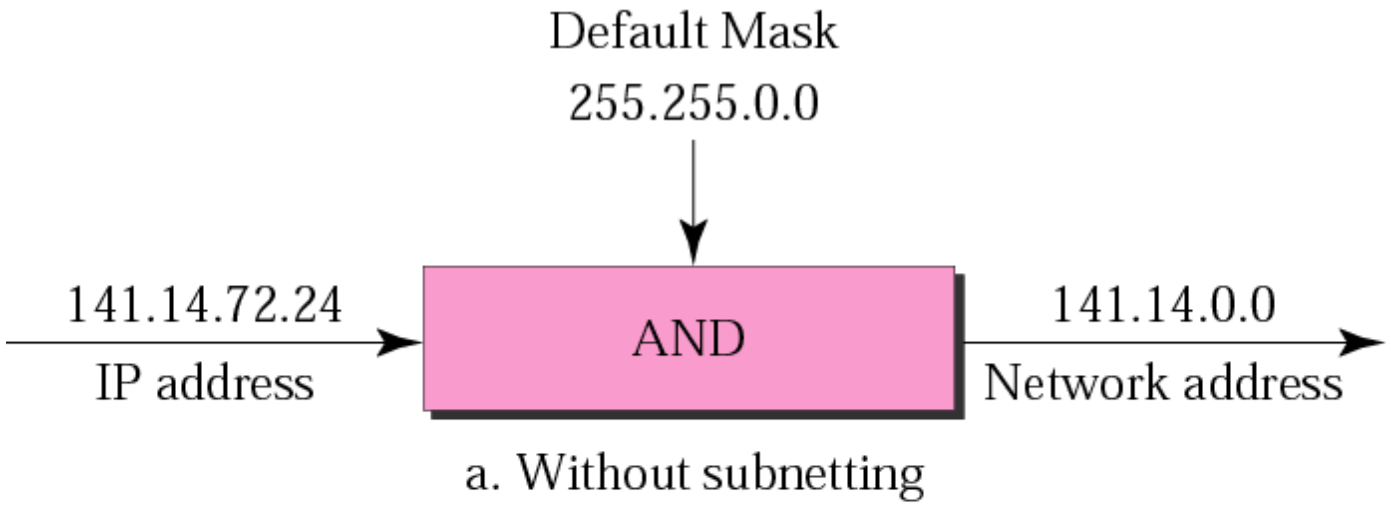


# A network with three levels of hierarchy (subnetted)

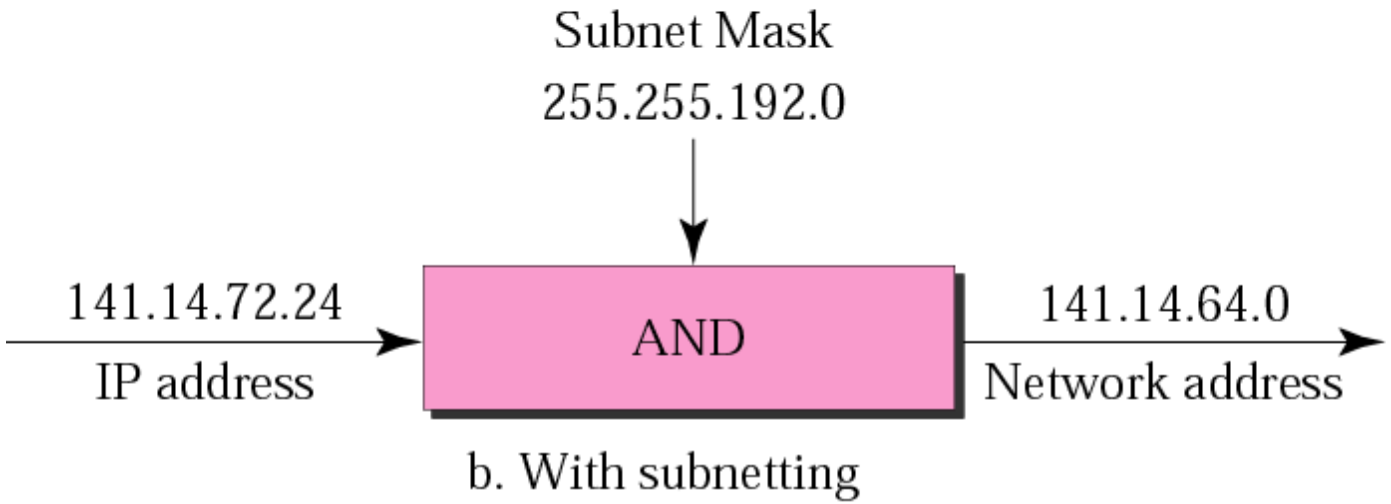


# Hierarchy concept in a telephone number

# Default mask and subnet mask




a. Without subnetting




b. With subnetting

# Finding the Subnet Address

- Given an IP address, we can find the *subnet address* in the same way as we found the *network address* .

- *Apply the mask to the address:*

- Two ways: straight or short-cut

.

# Straight Method

In the straight method, we use binary notation for both the address and the mask and then apply the AND operation to find the subnet address.

- **Use binary notation for both the address and the mask**
- **Then apply the AND operation to find the subnet address**

## *Example 1*

What is the subnetwork address if the destination address is 200.45.34.56 and the subnet mask is 255.255.240.0?

## *Solution*

11001000 00101101 00100010 00111000

11111111 11111111 1111**0000** **00000000**

11001000 00101101 0010**0000** **00000000**

By using AND operation between them
The subnetwork address is **200.45.32.0**.

## Short-Cut Method

** If the byte in the mask is 255, copy the byte in the address.

** If the byte in the mask is 0, replace the byte in the address with 0.

** If the byte in the mask is neither 255 nor 0, we write the mask and the address in binary and apply the AND operation.

- **If the byte in the mask is 255, copy the byte in the address**
- **If the byte in the mask is 0, replace the byte in the address with 0**
- **If the byte in the mask is neither 255 nor 0, we write the mask and the address in binary and apply the AND operation**

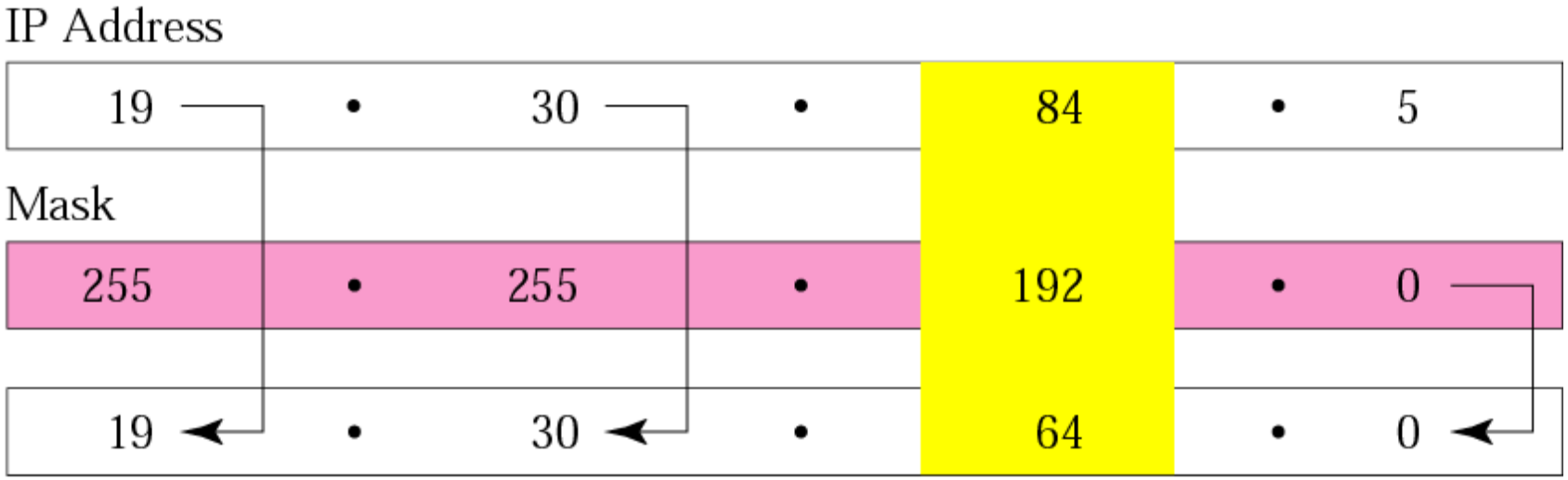
## *Example 2*

What is the subnetwork address if the destination address is 19.30.80.5 and the mask is 255.255.192.0?

## *Solution*

See Next Figure

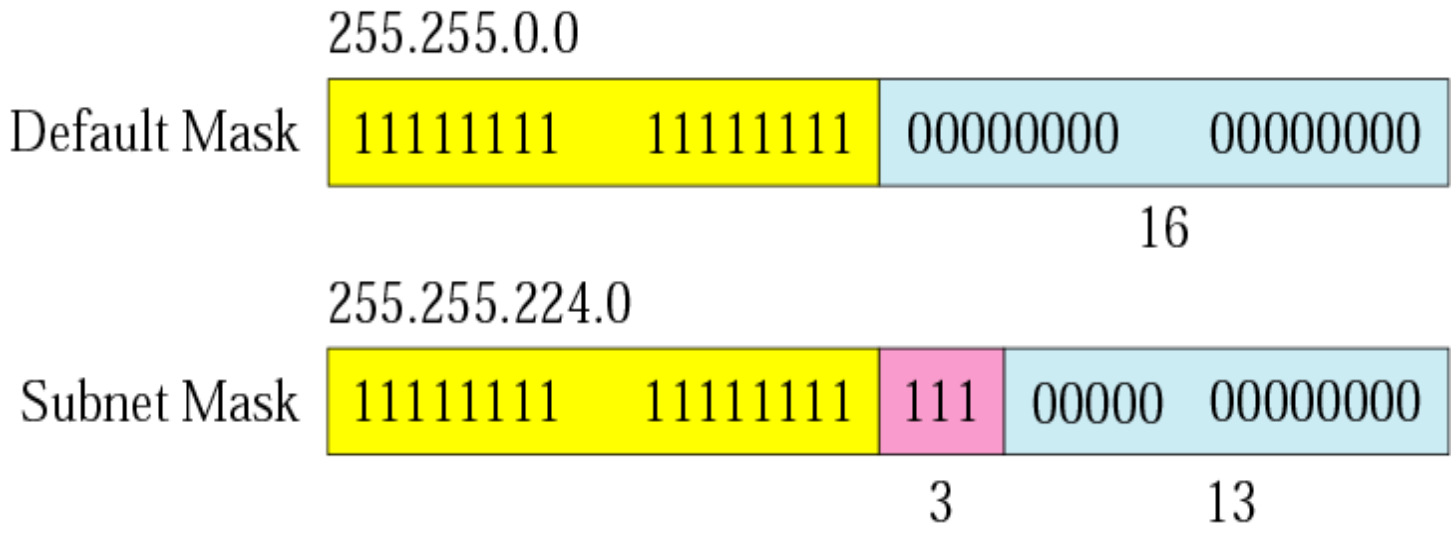
# Example 2 Cont.




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 84 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 192 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 64 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Figure 5-7

# Comparison of a default mask and a subnet mask



Note

***The number of subnets must be a power of 2.***

انتباه

1. كيف تحسب الرنج( Ranges) $2^h$
2. كيف تحسب البلوك ( Block) ( increment ) 256-X
3. كيف تحسب عدد عنوانين السبكات $2^n$
4. كيف تحسب عدد عنوانين المستخدمة الاجهزة داخل كل شبكة $2^h$ -2

h : هي عدد البتات المخصصة لجزء الهوست عادة تكون قيمتها اصفار

n:هي عدد البتات المستعارة من جزء عنوان الشبكة عادة تكون قيمتها واحدات

X: هي قيمة البتات المستعارة مثلا تم استعارة ثلاث بتات ..كم قمتها؟

224=32+64+128

اذا ماهي قيمة البلوك في هذه الحالة: 32=224-256

# Example

**An organization has purchased the Class C Address 195.5.20.0 and would to create networks of 50 hosts each.**

**IP: 195.5.20.0**
**Subnet Mask: 255.255.255.0**
---
**Hosts number = 50**
***First*: Convert the number of networks to binary.**
50 = 00110010

6 bits

***Second*: Reserve bits in subnet mask and find your increment.**

**Subnet Mask: 255.255.255.0 = 11111111.11111111.11111111.00000000**
**11111111.11111111.11111111.11000000**

2 bits

**No. of the networks = 2^number of 1's = 2^2 = 4] Networks**
**No. of the hosts= 2^number of 0's -2 [2^6 = 64 – (2) =62] Hosts number**

6 bits

**The increment value= 64**

| Bit Values in a Octet: | 128 | **64** | 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Lowest incrementing value

# Cont..

**Third: Use increment to find the network ranges**

| No | Subnet | First valid address | Last valid address | Broadcast Address |
|---|---|---|---|---|
| 1 | 195.5.20.0 | 195.5.20.1 | 195.5.20.62 | 195.5.20.63 |
| 2 | 195.5.20.64 | 195.5.20.65 | 195.5.20.126 | 195.5.20.127 |
| 3 | 195.5.20.128 | 195.5.20.129 | 195.5.20.190 | 195.5.20.191 |
| 4 | 195.5.20.192 | 195.5.20.193 | 195.5.20.254 | 195.5.20.255 |

## *Example 3*

A company is granted the site address 201.70.64.0 (class C). The company needs six subnets. Design the subnets.

## *Solution*

The number of 1s in the default mask is 24 (class C).

## *Solution (Continued)*

The company needs six subnets. This number 6 is not a power of 2. The next number that is a power of 2 is 8 ($2^3$). We need 3 more 1s in the subnet mask. The total number of 1s in the subnet mask is 27 (24 + 3).

The total number of 0s is 5 (32 – 27). The mask is

## *Solution (Continued)*

**11111111 11111111 11111111 111**00000

or

**255.255.255.224**

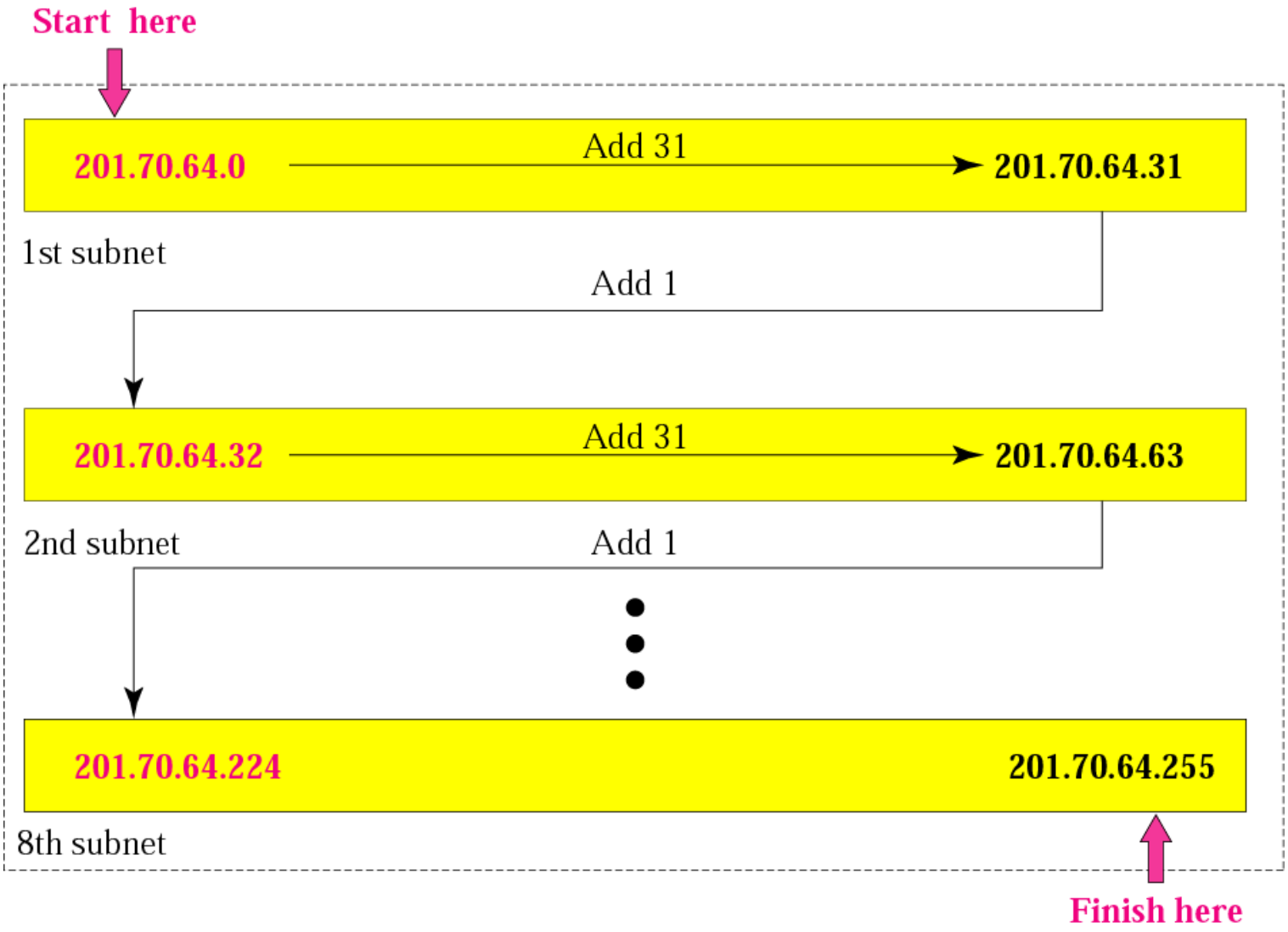
The number of subnets is 8.

The number of addresses in each subnet is $2^5$ (5 is the number of 0s) or 32.

See Next Figure

Figure 5-8

# Example 3



## *Example 4*

A company is granted the site address 181.56.0.0 (class B). The company needs 1000 subnets. Design the subnets.

## *Solution*

The number of 1s in the default mask is 16 (class B).

## *Solution (Continued)*

The company needs 1000 subnets. This number is not a power of 2. The next number that is a power of 2 is 1024 ($2^{10}$). We need 10 more 1s in the subnet mask.

The total number of 1s in the subnet mask is 26 (16 + 10).

The total number of 0s is 6 (32 – 26).

## *Solution (Continued)*

The mask is

11111111 11111111 11111111 11000000

or

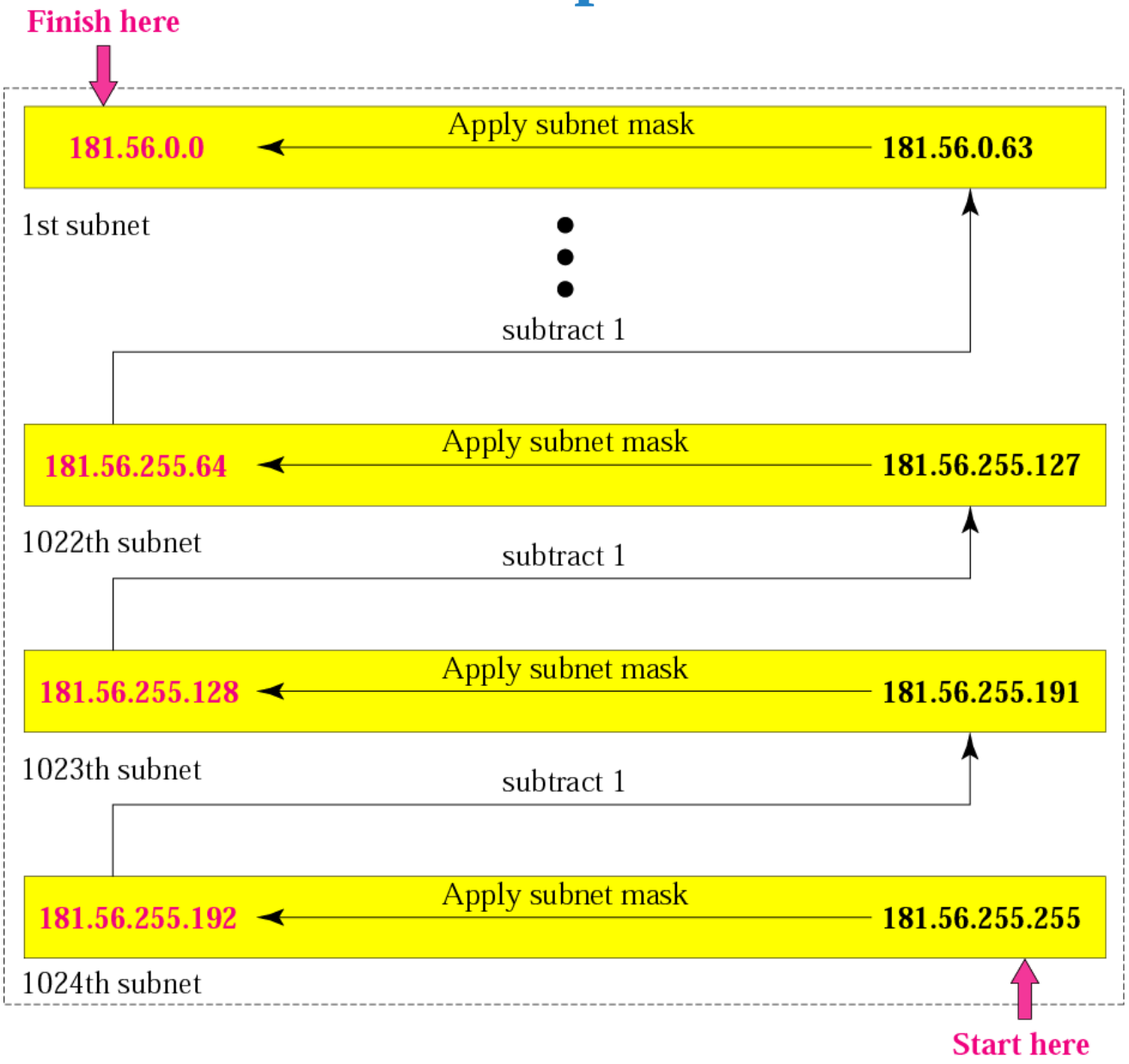
**255.255.255.192.**

The number of subnets is 1024.

The number of addresses in each subnet is $2^6$ (6 is the number of 0s) or 64.

See Figure 5.9

# Example 4


Finish here
181.56.0.0
Apply subnet mask
181.56.0.63
1st subnet
subtract 1
181.56.255.64
Apply subnet mask
181.56.255.127
1022th subnet
subtract 1
181.56.255.128
Apply subnet mask
181.56.255.191
1023th subnet
subtract 1
181.56.255.192
Apply subnet mask
181.56.255.255
1024th subnet
Start here