Computer Network(CSC 503)

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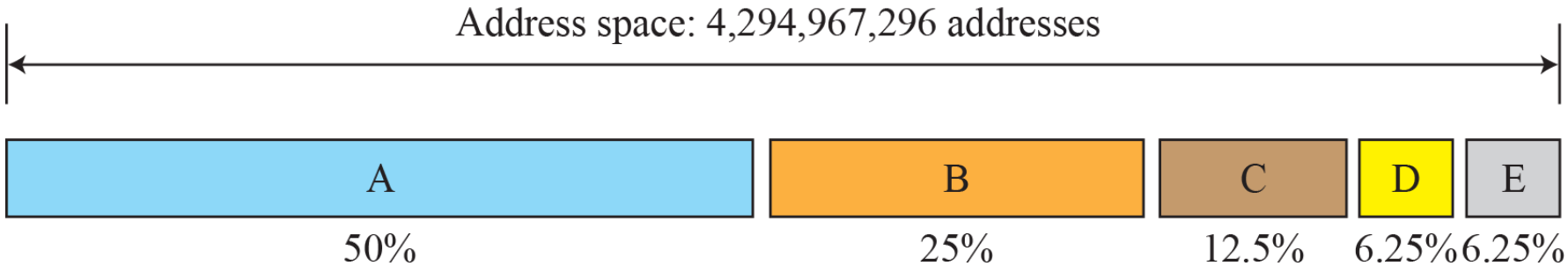
Lecture 23

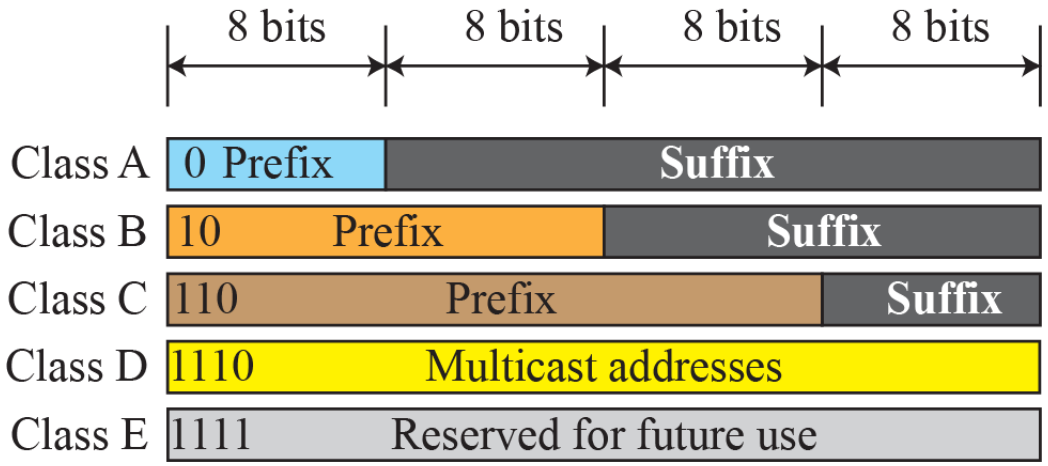
Classless Addressing or Classless Inter-Domain Routing (CIDR)

Classless Addressing

- To overcome the depletion of address space.

Occupation of the address space in classful addressing





Class	Prefixes	First byte
A	n = 8 bits	0 to 127
B	n = 16 bits	128 to 191
C	n = 24 bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Structure of IPv4 Address

- Consists of Net ID and Host ID.

Class	*Binary*	*Dotted-Decimal*	*CIDR*
A	**11111111** 00000000 00000000 00000000	**255**.0.0.0	/8
B	**11111111 11111111** 00000000 00000000	**255.255**.0.0	/16
C	**11111111 11111111 11111111** 00000000	**255.255.255**.0	/24

- Mask
  - 32-bit number of contiguous 1's followed by contiguous 0's.
  - To help to find the net ID and the host ID.
    - 1→network ID
    - 0 → Host ID

Classless Addressing

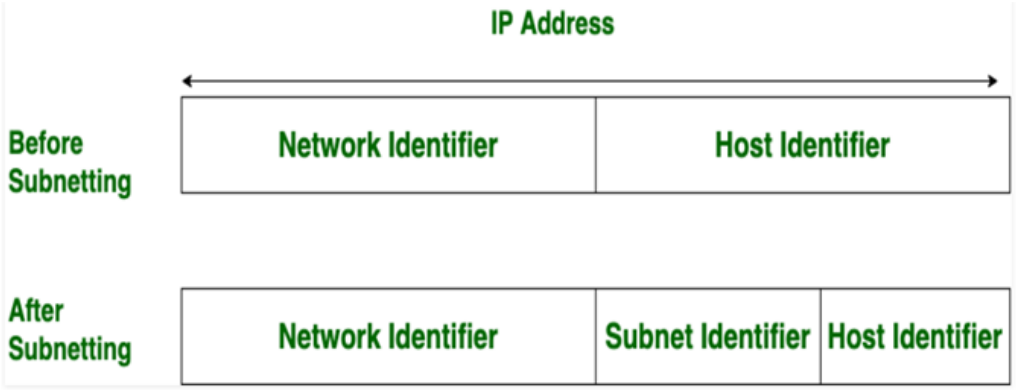
- **Classless Addressing** is an improved IP **Addressing** system, which makes the allocation of IP **Addresses** more efficient.
- It replaces the older classful **addressing** system based on classes. It is also known as **Classless** Inter Domain Routing (**CIDR**).
- **CIDR** improves the allocation of IP addresses. It replaces the old system of classful addresses containing strictly classes A, B, and C etc. This scheme also helped greatly extend the life of IPv4 as well as slow the growth of routing tables

To alleviate address depletion , two strategies were proposed

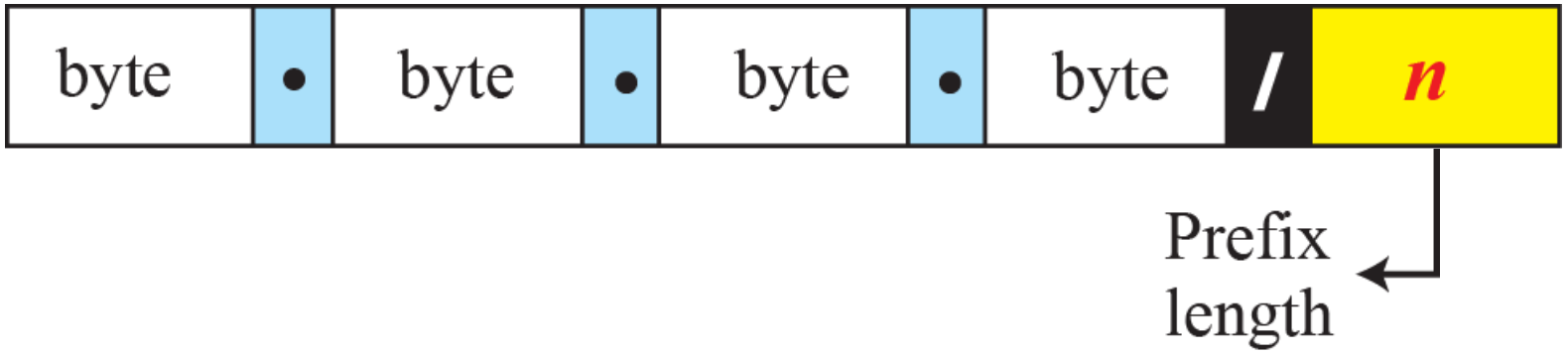
- **1. Subnetting :** Divide a large address block into smaller sub-groups and uses flexible net mask.
- **2. Supernetting :** Several networks are combined to create a supernetwork.

Subnetting

- A subnet mask is a 32 bits address used to distinguish between a network address and a host address in IP address.
- It can be used to find if an IP address is present on a **subnet** or not.
- Subnet mask is utilized for isolating the **network** id and host ids.
- It identifies which part of an IP address is the network address and the host address.
- IP subnetting is the practice of dividing a network into two or smaller networks.
- Subnetting helps you to maximize IP addressing efficiency.
- Two types of subnet masks are:
  - **i)Default Subnet Mask(Classful addressing)**
  - **ii)Custom Subnet Mask**



Slash notation (CIDR)



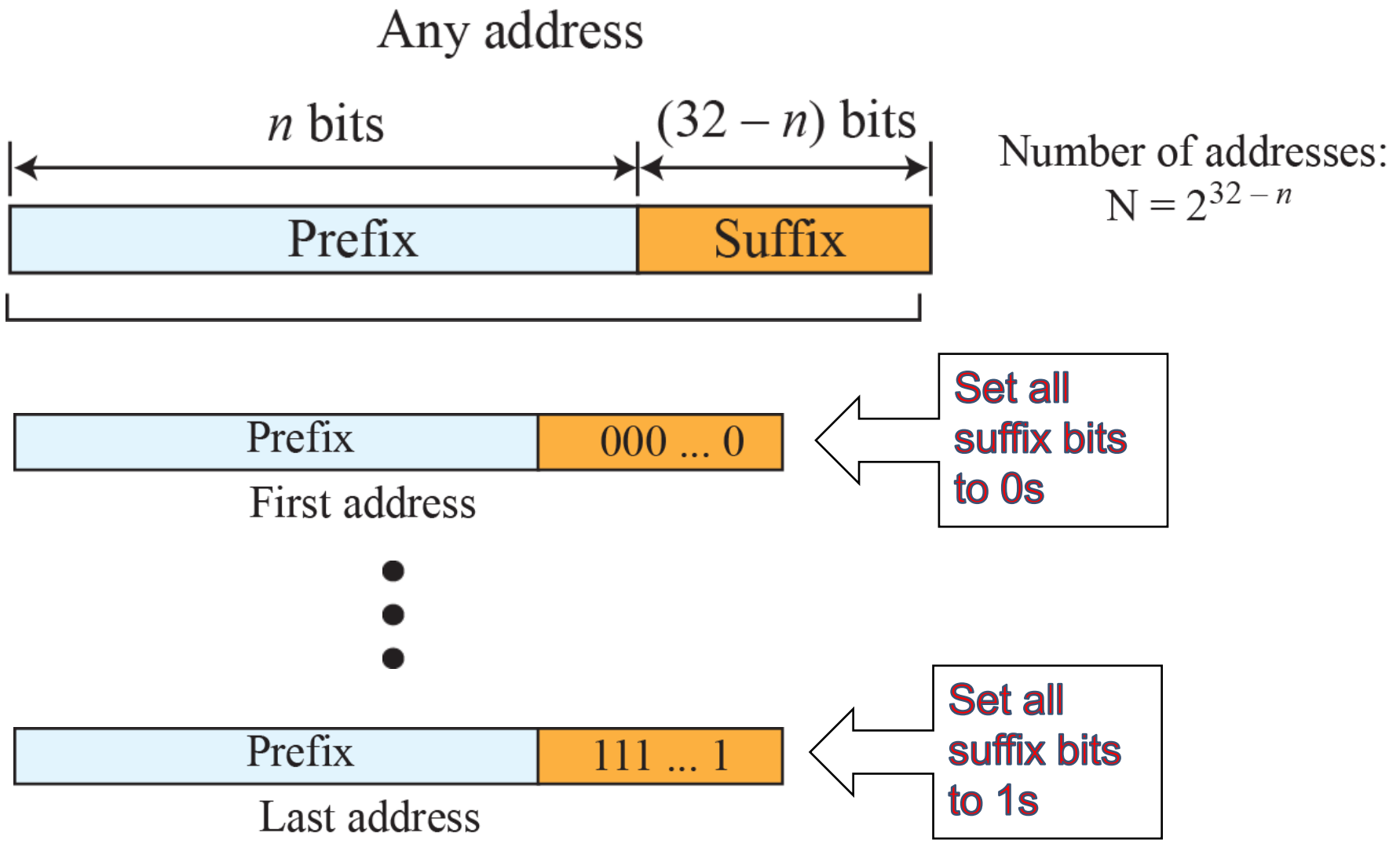
Examples:

12.24.76.8/**8**

23.14.67.92/**12**

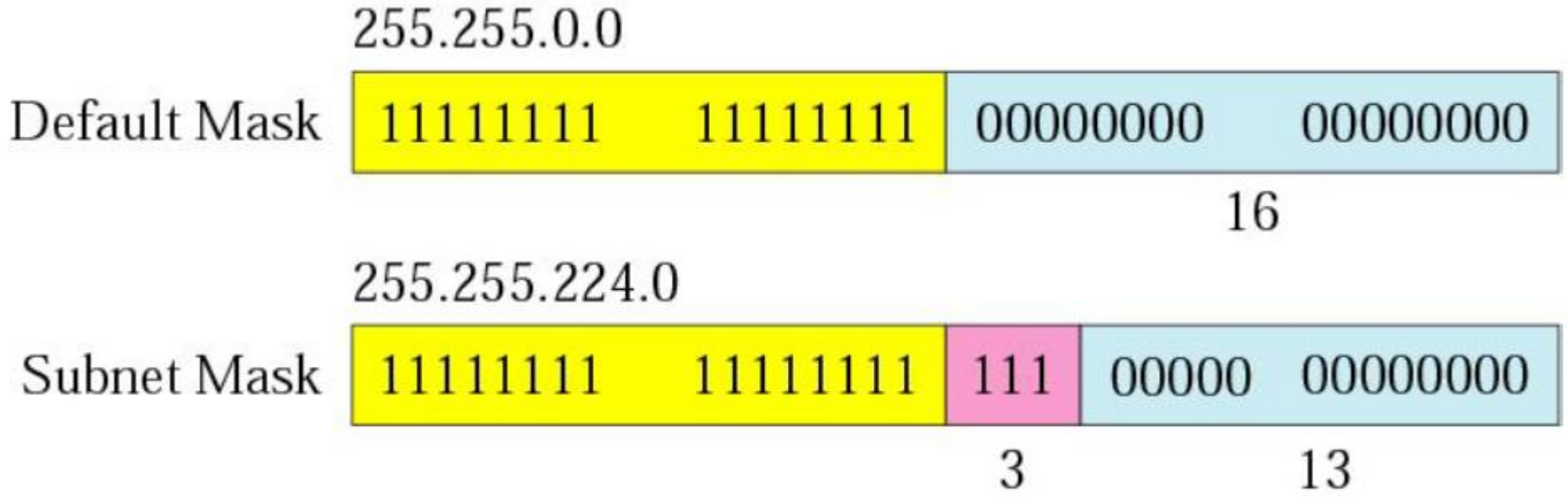
220.8.24.255/**25**

Information extraction in classless addressing



Comparison of a default mask and a subnet mask

- Borrowing bits from host address



The number of subnets must be a power of 2.

- Example: Class C network id: 199.24.65.0/28
- (If you use 4 bits for subnet identifier)
- 11111111 . 11111111 . 11111111 . **11110000**

Subnet Mask :255. 255.255 .240

(4 bits subnet ID,4 bits Host ID)

0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111

Example1: 199.24.65.17

Address: 199.24.65.00010001

Example2: 199.24.65.30

Address: 199.24.65.00011110

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

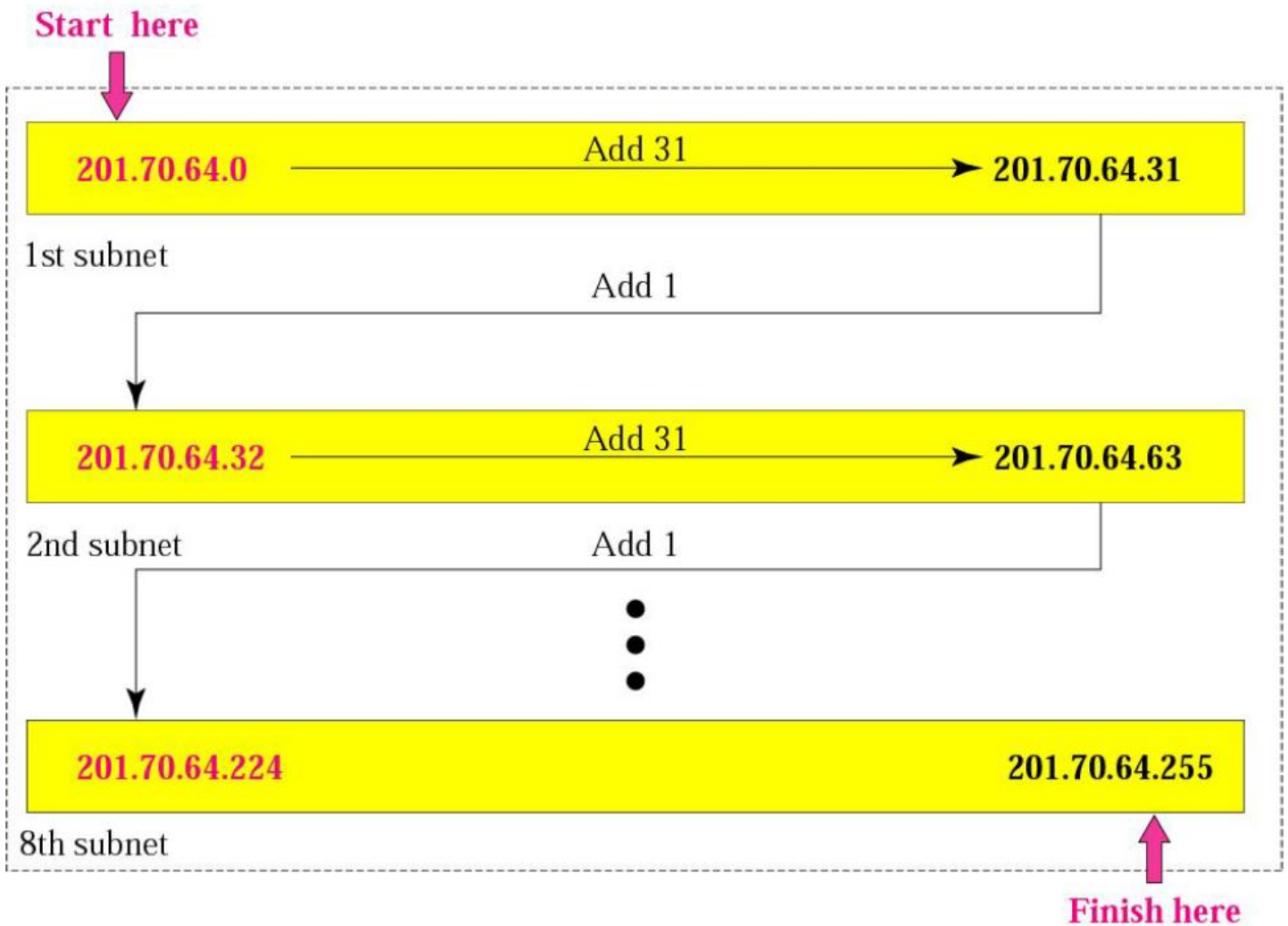
- The number of 1s in the default mask is 24 (class C). The company needs six subnets. This number 6 is not a power of 2. The next number that is a power of 2 is 8 (2^3). We need 3 more 1s in the subnet mask. The total number of 1s in the subnet mask is 27 (24 +3). The total number of 0s is 5 (32 – 27). The mask is :

11111111 11111111 11111111 11100000

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**.


Start here
201.70.64.0
Add 31
201.70.64.31
1st subnet
Add 1
201.70.64.32
Add 31
201.70.64.63
2nd subnet
Add 1
201.70.64.224
201.70.64.255
8th subnet
Finish here

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

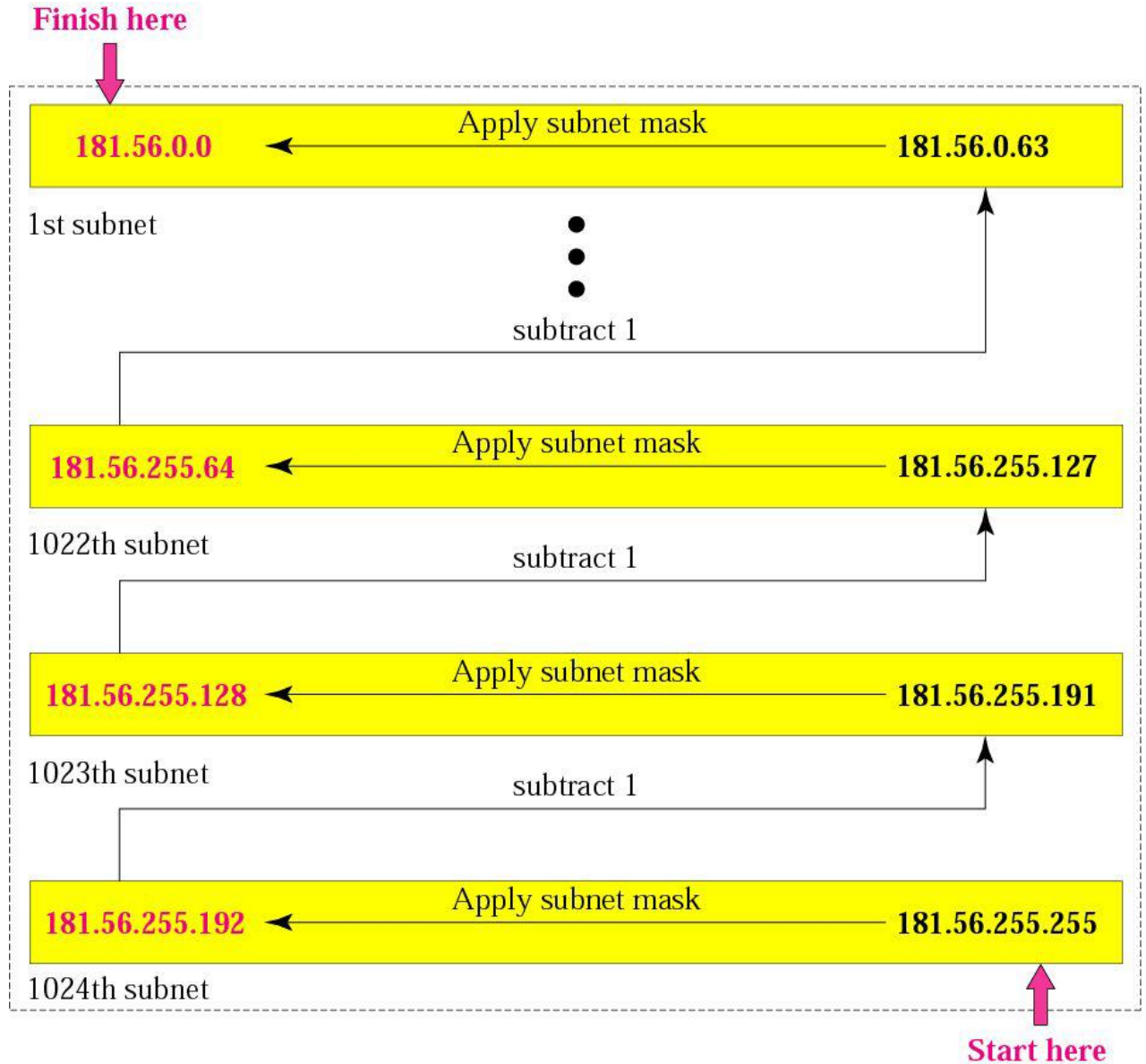
- The number of 1s in the default mask is 16 (class B).
- The company needs 1000 subnets. This number is not a power of 2. The next number that is a power of 2 is 1024 (2^10).
- We need 10 more 1s in the subnet mask.
- The total number of 1s in the subnet mask is 26 (16 + 10).
- The total number of 0s is 6 (32 − 26).
- 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.


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

In subnetting,
we need the first address of the subnet and the subnet mask to define the range of addresses.

Classless Addressing

- **Tips:**
  - In IPv4 addressing, a block of addresses can be defined as x.y.z.t /n, in which x.y.z.t defines one of the addresses and the /n defines the mask.
  - The **first address in the block** can be found by setting the rightmost 32 – n bits to 0s.
  - The **last address in the block** can be found by setting the **rightmost 32 – n bits to 1s**.
  - The **number of addresses in the block** can be found by using the formula $\mathbf{2^{32-n}}$.

- In IPv4 CIDR the size of the network prefix is also mentioned as part of the IP address and shows a variation based on the number of bits required
- IPv4 is :192.30.250.00/18

→ The "192.30.250.0" is the network address itself and the "18" indicates that the starting eighteen bits are the network portion of the address, leaving the ending fourteen bits for particular host addresses.

Example 1

A classless address is given as 167.199.170.82/27. We can find the three pieces of information as follows. The number of addresses in the network is $2^{32-n} = 2^5 = 32$ addresses. The first address can be found by keeping the first 27 bits and changing the rest of the bits to 0s.

Address: 167.199.170.82/**27**	10100111	11000111	10101010	01010010
First address: 167.199.170.64/**27**	10100111	11000111	10101010	01000000

The last address can be found by keeping the first 27 bits and changing the rest of the bits to 1s.

Address: 167.199.170.82/**27**	10100111	11000111	10101010	01010010
Last address: 167.199.170.95/**27**	10100111	11000111	10101010	01011111

Example 2

In classless addressing, an address cannot per se define the block the address belongs to. For example, the address 230.8.24.56 can belong to many blocks. Some of them are shown below with the value of the prefix associated with that block.

Prefix length:16	→	Block:	230.8.0.0	to	230.8.255.255
Prefix length:20	→	Block:	230.8.16.0	to	230.8.31.255
Prefix length:26	→	Block:	230.8.24.0	to	230.8.24.63
Prefix length:27	→	Block:	230.8.24.32	to	230.8.24.63
Prefix length:29	→	Block:	230.8.24.56	to	230.8.24.63
Prefix length:31	→	Block:	230.8.24.56	to	230.8.24.57

Example

A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block?

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32−28 =4 rightmost bits to 0, we get

11001101 00010000 00100101 00100000

or

205.16.37.32.

Example

Find the last address for the block in previous Example (205.16.37.39/28).

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

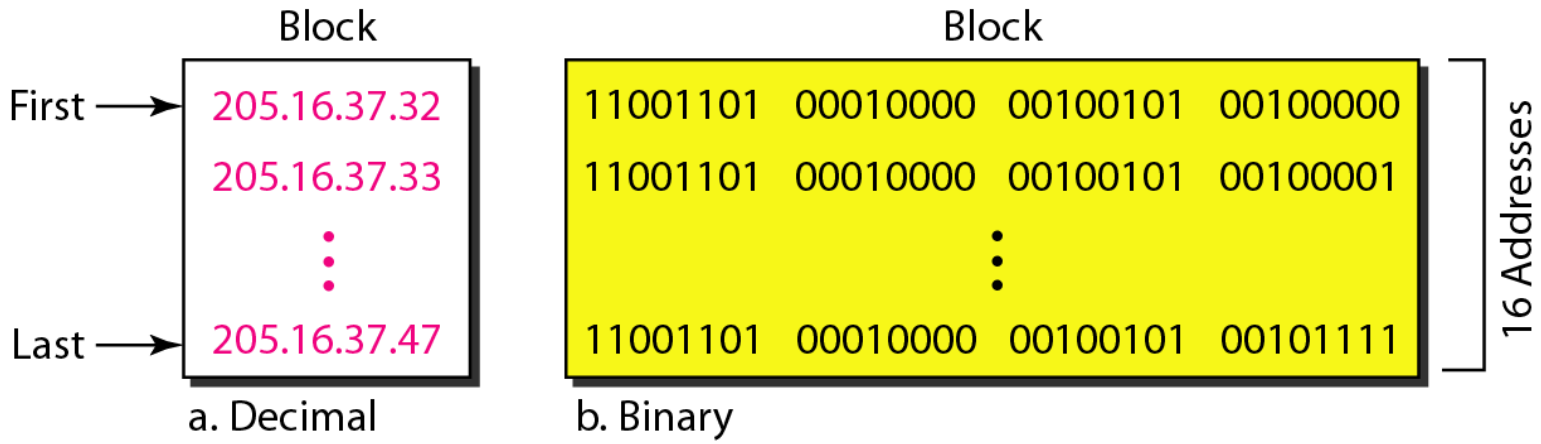
If we set 32 − 28 rightmost bits to 1, we get

*11001101 00010000 00100101 0010**1111***

or

205.16.37.47

Ans: Figure : *A block of 16 addresses granted to a small organization*



Example

Find the number of addresses in Example 205.16.37.39/28

Solution

The value of n is 28, which means that number of addresses is $2^{32-28} = \mathbf{2^4}$ ***or 16***.

Example

Another way to find the first address, the last address, and the number of addresses is to represent the mask as a 32-bit binary (or 8-digit hexadecimal) number. This is particularly useful when we are writing a program to find these pieces of information. In Example(205.16.37.39/28) the /28 can be represented as

11111111 11111111 11111111 11110000

(twenty-eight 1s and four 0s).

Find

a. The first address

b. The last address

c. The number of addresses.

Solution

a. The first address can be found by ANDing the given addresses with the mask. ANDing here is done bit by bit. The result of ANDing 2 bits is 1 if both bits are 1s; the result is 0 otherwise.

Address:	11001101	00010000	00100101	00100111
Mask:	**11111111**	**11111111**	**11111111**	**11110000**
First address:	11001101	00010000	00100101	00100000

b. The last address can be found by ORing the given addresses with the complement of the mask.

Oring here is done bit by bit. The result of ORing 2 bits is 0 if both bits are 0s; the result is 1 otherwise. The complement of a number is found by changing each 1 to 0 and each 0 to 1.

Address:	11001101	00010000	00100101	00100111
Mask complement:	**00000000**	**00000000**	**00000000**	**00001111**
Last address:	11001101	00010000	00100101	00101111

c. The number of addresses can be found by complementing the mask, interpreting it as a decimal number, and adding 1 to it.

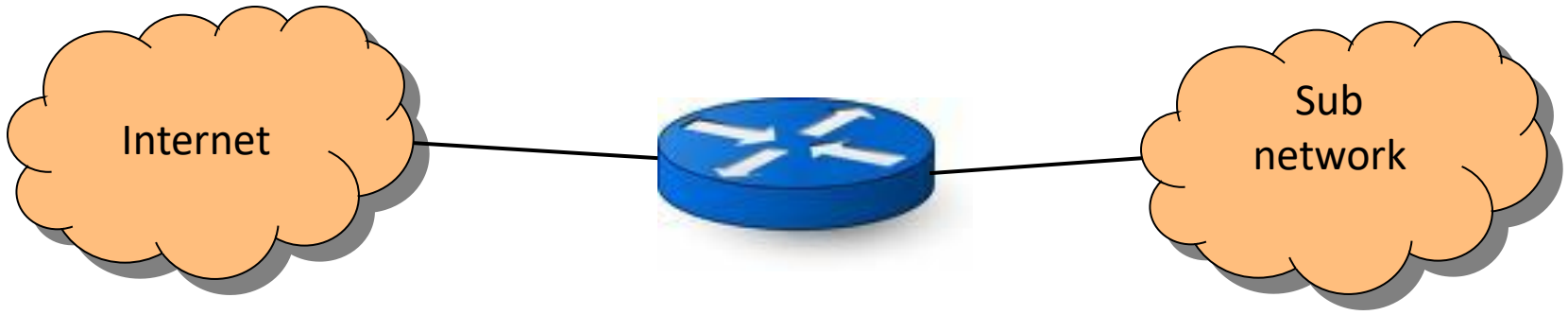
Mask complement:	**00000000 00000000 00000000 00001111**
Number of addresses:	15 + 1 = 16

Special Addresses

- **Network address**
  - The first address in a block is normally not assigned to any device; it is used as the **network address** that represents the organization to the rest of the world.
- **Broadcast address**
  - The last address in a block is used for **broadcasting** to all devices under the network.

Routing in IPv4

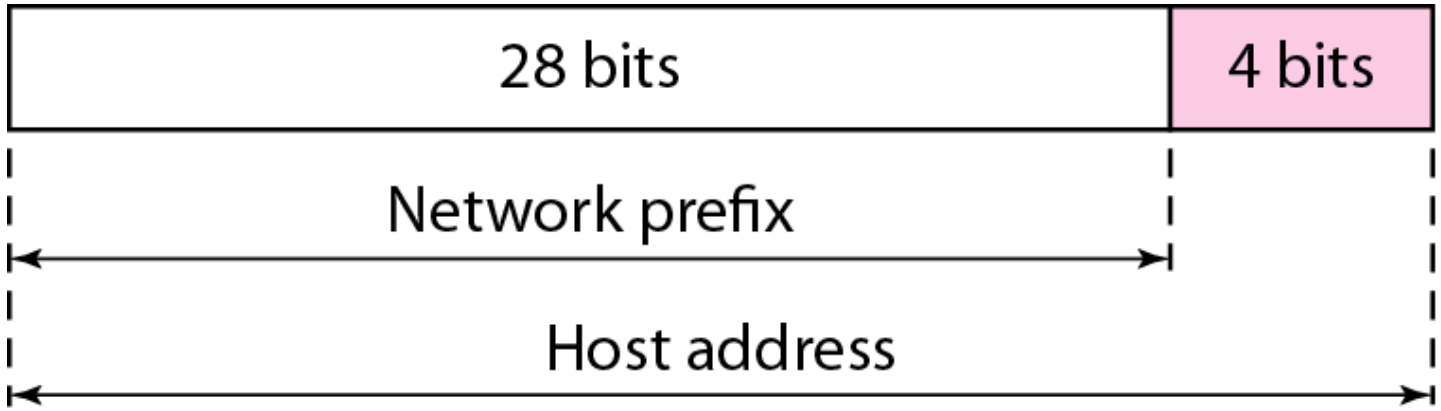
- A router has two addresses
  - An address through which the device inside of the router can be accessed.
  - Another address belongs to the granted block (sub-network).



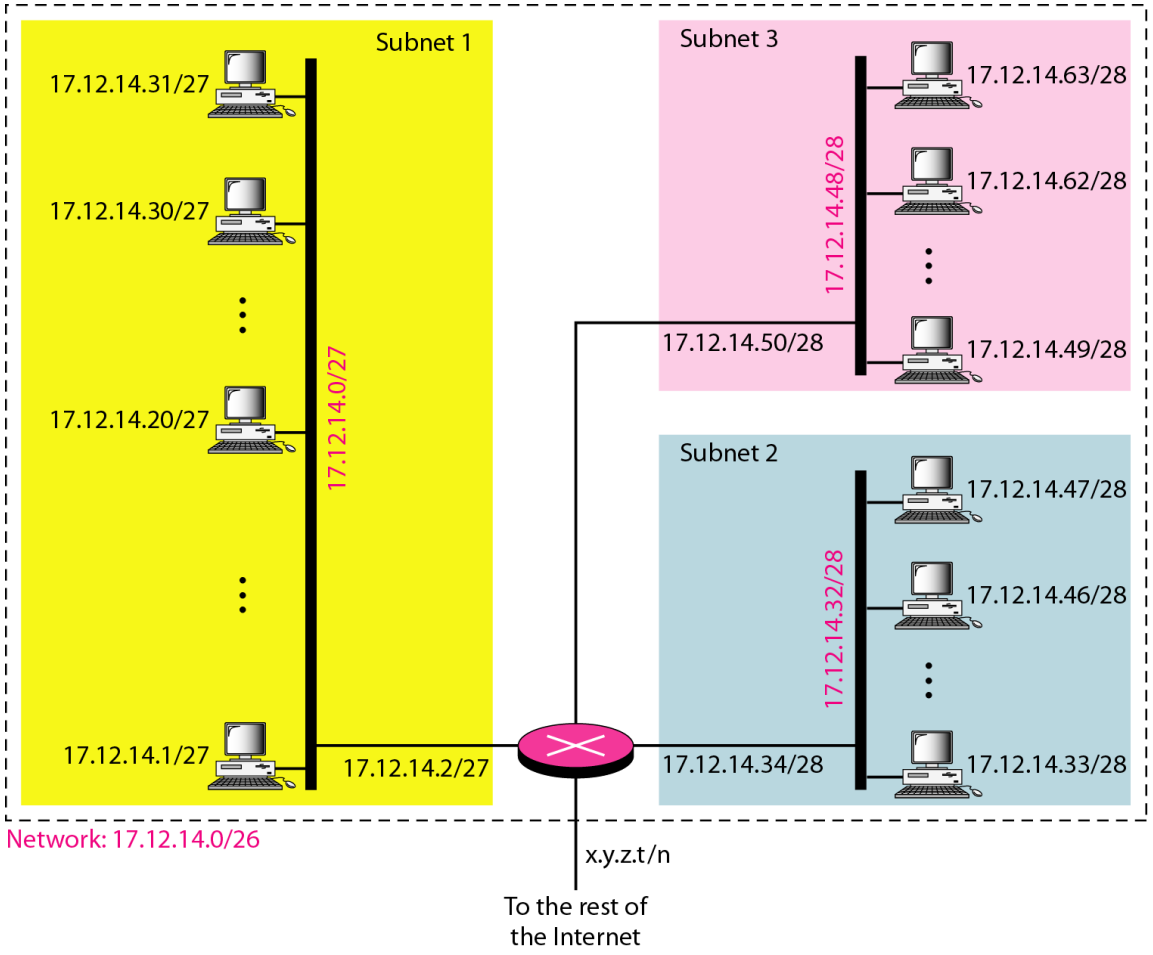
Hierarchy of IPv4 Addressing

- Each address in the block can be considered as a two-level hierarchical structure: the leftmost *n* bits (prefix) define the network; the rightmost 32 − *n* bits define the host.
- Why Hierarchy?

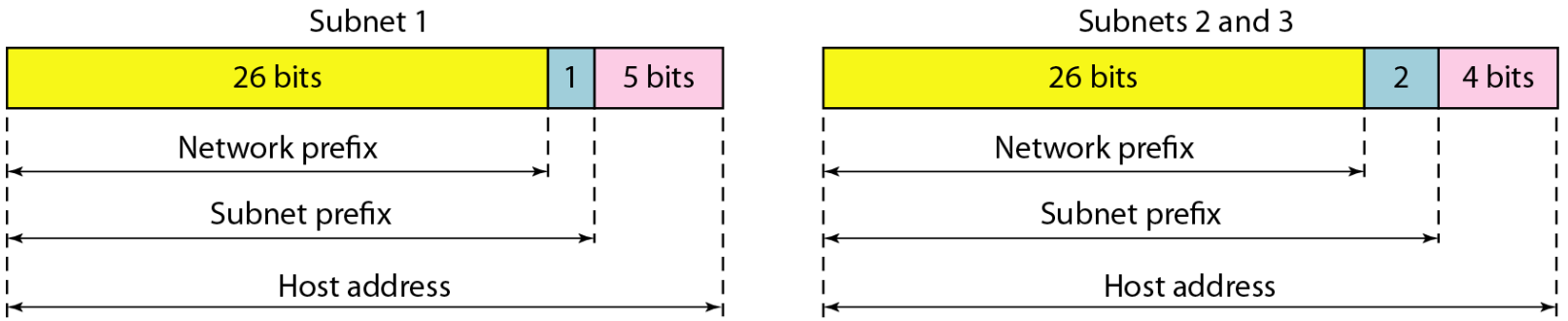
Two Level of Hierarchy



Three Level of Hierarchy



Three Level of Hierarchy



Example

An ISP is granted a block of addresses starting with 190.100.0.0/16 (65,536 addresses). The ISP needs to distribute these addresses to three groups of customers as follows:

a. The first group has 64 customers; each needs 256 addresses.

b. The second group has 128 customers; each needs 128 addresses.

c. The third group has 128 customers; each needs 64 addresses.

Design the subblocks and find out how many addresses are still available after these allocations.

Example (continued) 190.100.0.0/16 (65,536 addresses).

a. The first group has 64 customers; each needs 256 addresses.

Solution

Group 1

- *For this group, each customer needs 256 addresses. This means that* ***8 (log2 256)*** *bits are needed to define each host.*

- *The prefix length is then 32 − 8 = 24. The addresses are*

1st Customer:	*190.100.0.0/24*	*190.100.0.255/24*
2nd Customer:	*190.100.1.0/24*	*190.100.1.255/24*
. . .		
64th Customer:	*190.100.63.0/24*	*190.100.63.255/24*

Total = 64 × 256 = 16,384

Example (continued) 190.100.0.0/16 (65,536 addresses).

Group 2

For this group, each customer needs 128 addresses. This means that 7 (log2 128) bits are needed to define each host. The prefix length is then 32 − 7 = 25. The addresses are

1st Customer:	*190.100.64.0/25*	*190.100.64.127/25*
2nd Customer:	*190.100.64.128/25*	*190.100.64.255/25*
. . .		
128th Customer:	*190.100.127.128/25*	*190.100.127.255/25*

Total = 128 × 128 = 16,384

Example (continued) 190.100.0.0/16 (65,536 addresses).

Group 3

For this group, each customer needs 64 addresses. This means that 6 ($log_2 64$) bits are needed to each host. The prefix length is then 32 − 6 = 26. The addresses are

1st Customer:	*190.100.128.0/26*	*190.100.128.63/26*
2nd Customer:	*190.100.128.64/26*	*190.100.128.127/26*
. . .		
128th Customer:	*190.100.159.192/26*	*190.100.159.255/26*

Total = 128 × 64 = 8192

Number of granted addresses to the ISP: 65,536
Number of allocated addresses by the ISP: 40,960
Number of available addresses: 24,576