Lecture 3.2

Subnetting/Supernetting

IP addresses are designed with 2 levels of hierarchy: network-ID & host-ID

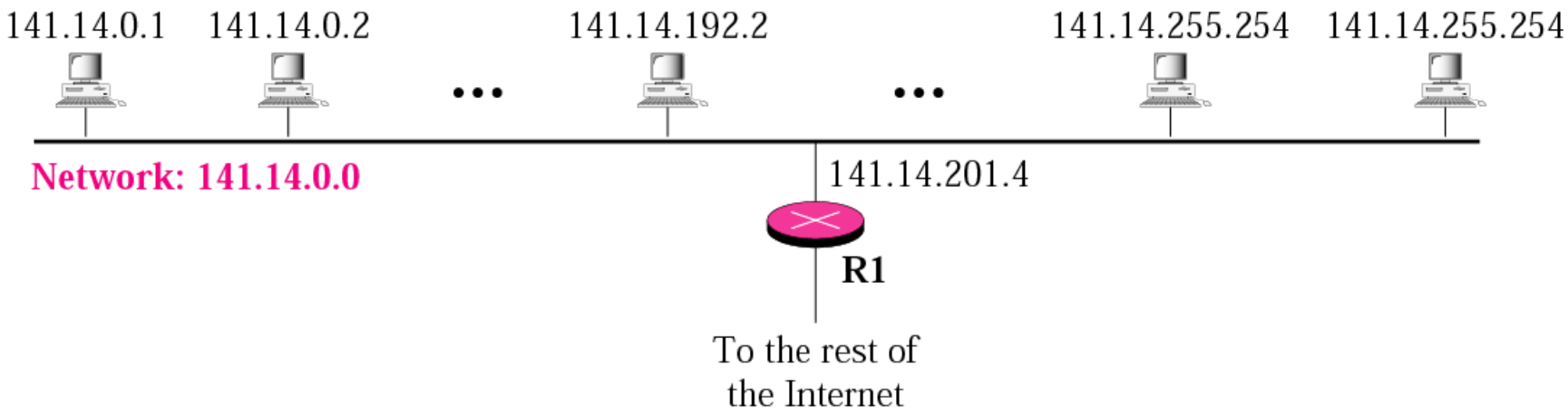
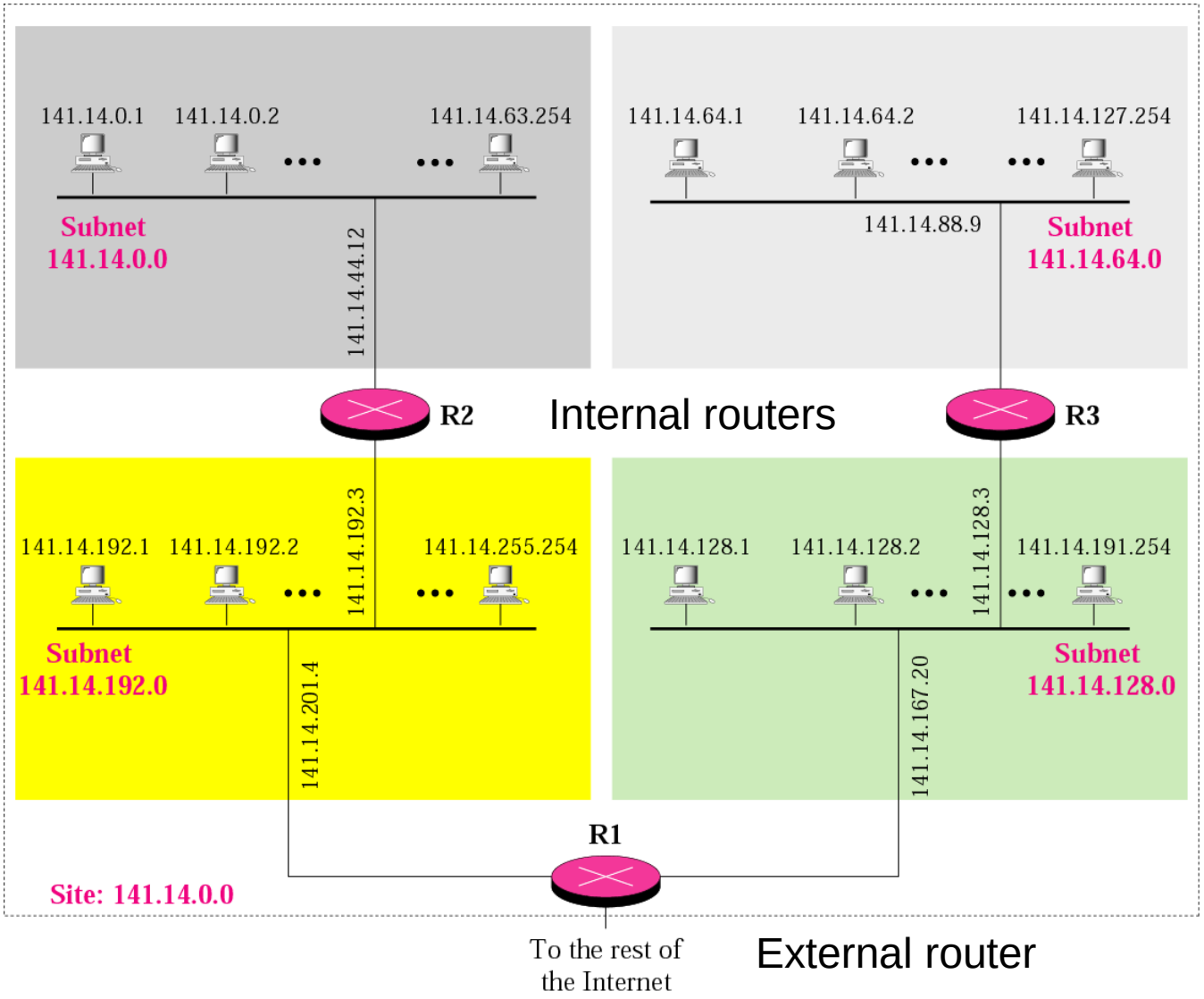


Fig: A network with two levels of hierarchy (not subnetted)

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*

A network with three levels of hierarchy (subnetted)



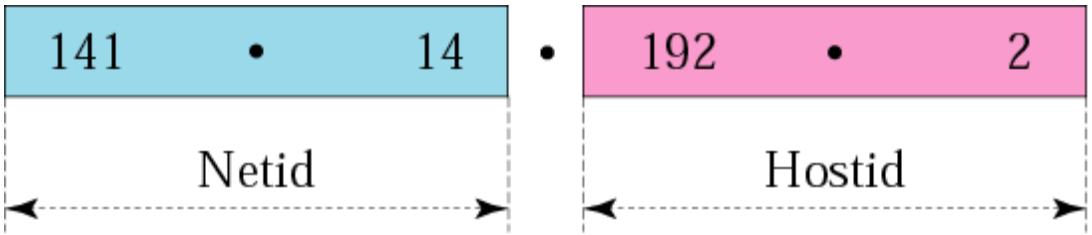
Subnetting (Cont.)

- The subnetworks still appear as a single network to the rest of the Internet
- For example, a packet destined for host 141.14.192.2 still reaches router R1
- However, R1 knows the network 141.14 is physically divided into subnetworks
  - It deliver the packet to subnetwork 141.14.192.0

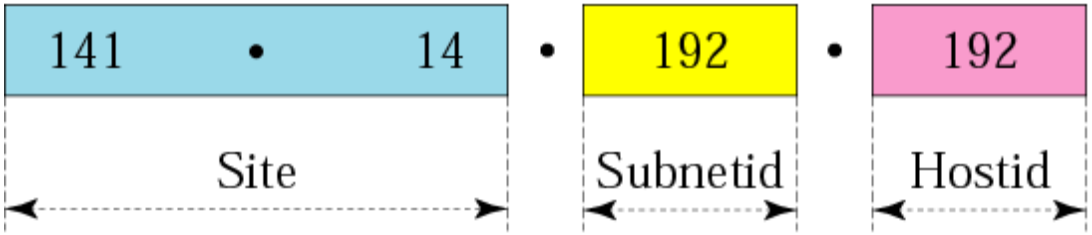
Three Levels of Hierarchy

- 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*

Addresses in a network
With and without subnetting



a. Without subnetting



b. With subnetting

Just like telephone system

Network Addresses/subnetting

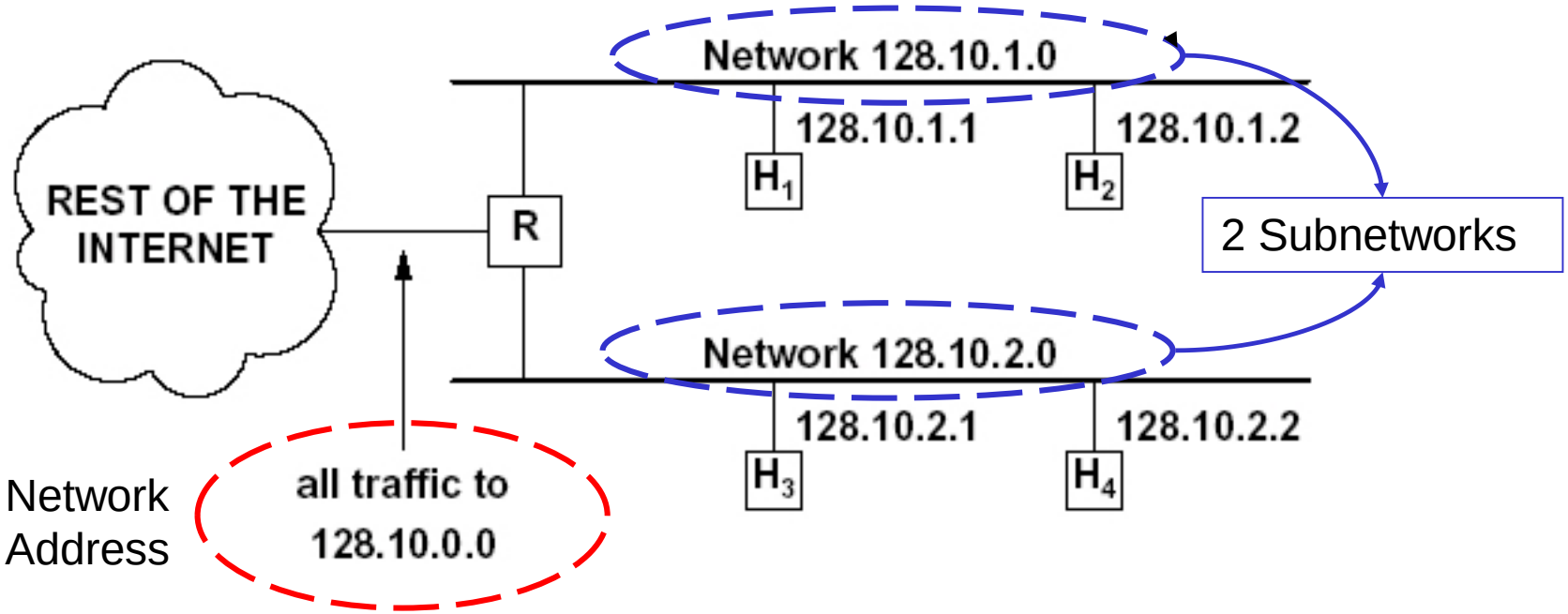


Figure 10.3 A site with two physical networks using subnet addressing to label them with a single class *B* network address. Router *R* accepts all traffic for net 128.10.0.0 and chooses a physical network based on the third octet of the address.

IP-Addressing/**Subnetting**

a) IP address designed with 2 levels of hierarchy: network-ID & host-ID.

b) However, often organisation needs to assemble the hosts into groups: the network needs to be divided into several sub-networks (subnets); hence requires 3 levels of hierarchy. (netid: subnetid : hostid)

c) Remember that, the outside world only knows the organisation by its network address. Inside the organisation each sub-network is recognised by its sub-network address.

d) In subnetting, a network is divided into several smaller groups that have its own subnet address depends on the hierarchy of subnetting but still appear as a single network to the rest of the Internet.

e) The question is how a router knows whether it is a network address or a subnet?

- *The key is using the **subnet mask**. (similar to def. mask).*

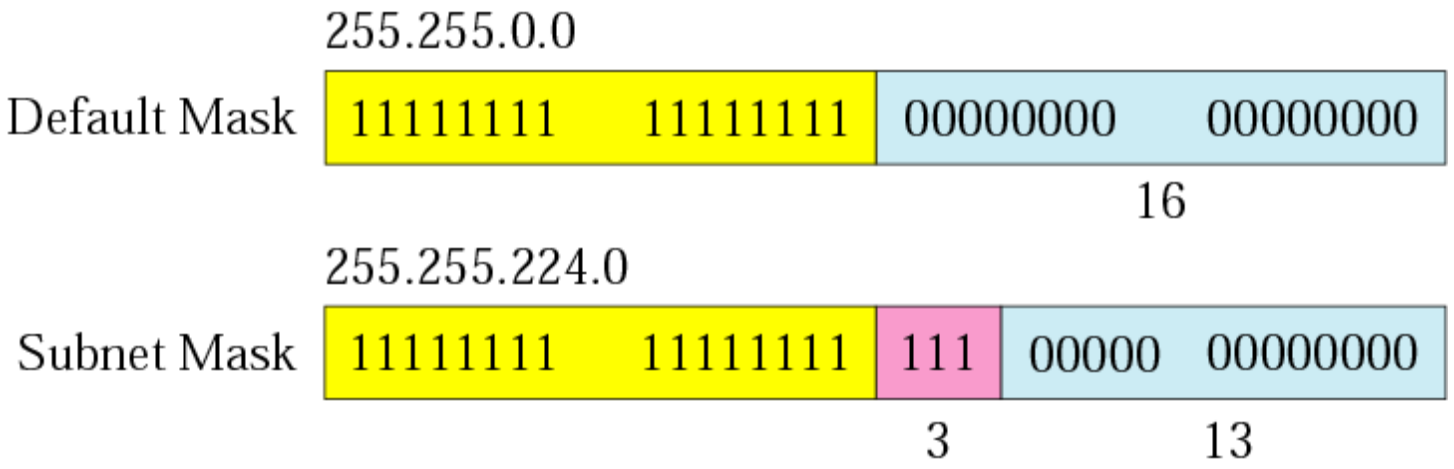
f) Only the network administrator knows about the network address and subnet address but router does not. External router has routing table based on network addresses; Internal router has routing table based on sub-network addresses.

Default Mask and Subnet Mask

- The number of *1s* in a default mask is perdetermined
  - 8, 16, or 24

- But, in a subnet mask, the number of 1s is more than the number of 1s in the corresponding default mask

Comparison of a default mask and a subnet mask



Note

The number of subnets must be a power of 2.

Number of Subnetworks

- Found by counting the number of extra bits that are added to the default mask in a subnet mask

- For example, in above figure
  - The number of extra 1s is 3
    - The length of subnetid = 3
  - The number of subnets is 2^3 = 8

Number of Addresses per Subnet

- Found by counting the number of *0s* in the subnet mask

- For example, in above figure
  - The number of 0s is 13
    - The length of hostid = 13
  - The number of addressed in each subnet is 2^13 = 8192

Designing Subnets

- How a network managers design subnets
  - Deciding the number of subnets
  - Finding the subnet mask
  - Find the range of address in each subnet
    - Start with the first subnet and its first address is the first address in the block
    - Add the number of addresses in each subnet minus one to get the last address
    - Add one to the last address in obtain step to obtain the first address in the next subnet

Example-1

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).

The company needs six subnets. Since 6 is not a power of 2, the next number that is a power of 2 is 8 (2^3). That means up to 8 subnets.

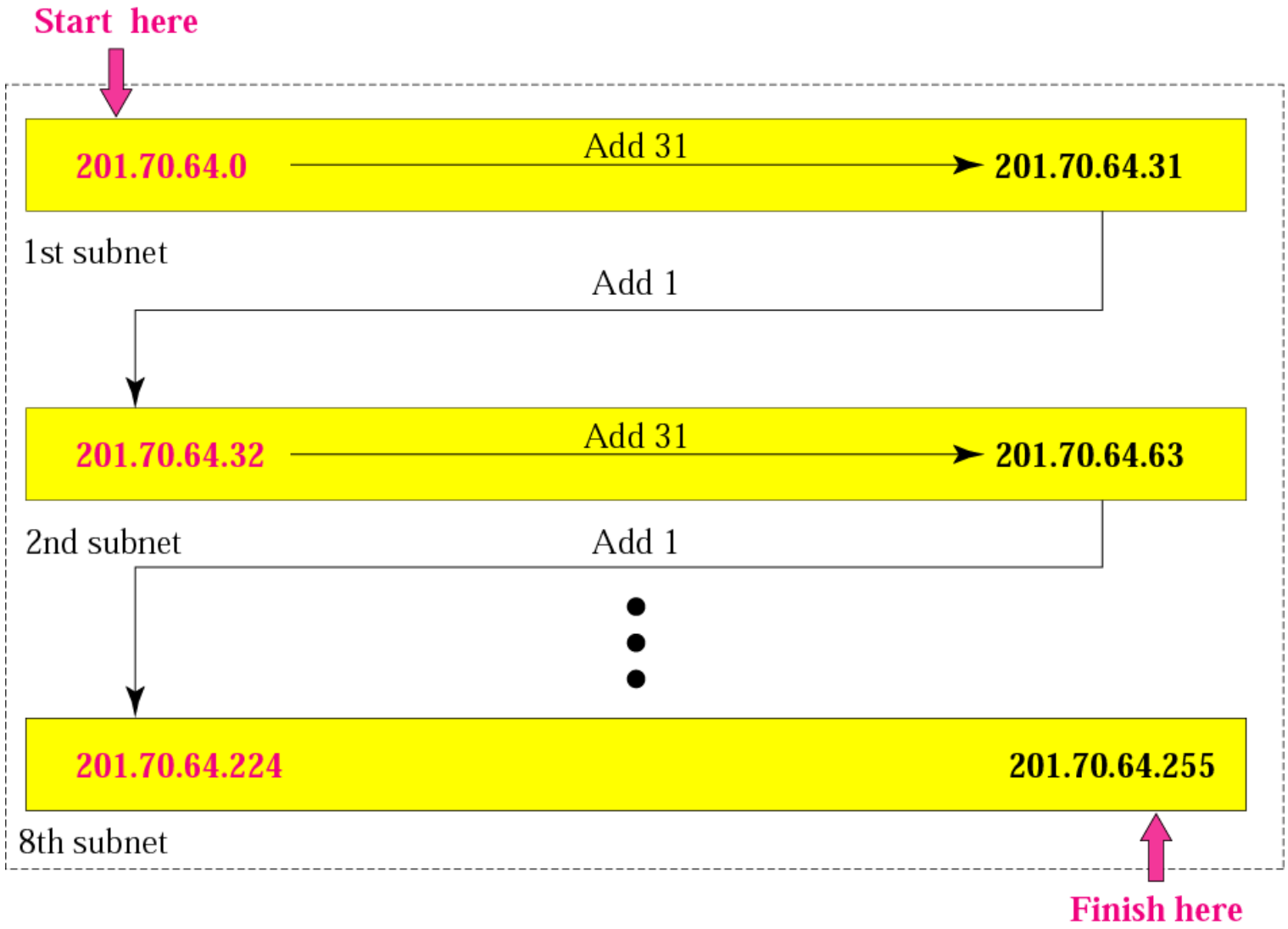
Hence, we need 3 more '1's in the subnet mask = 11111111.11111111.11111111.11100000 or 255.255.255.224

The total number of 1s in the subnet mask is 27 (24 + 3).

Since the total number of 0s is 5 (32 - 27).

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

Solution (Continued)



Example

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).
- The company needs 1000 subnets. Since it is not a power of 2, the next number 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 submask is

11111111 11111111 11111111 11000000

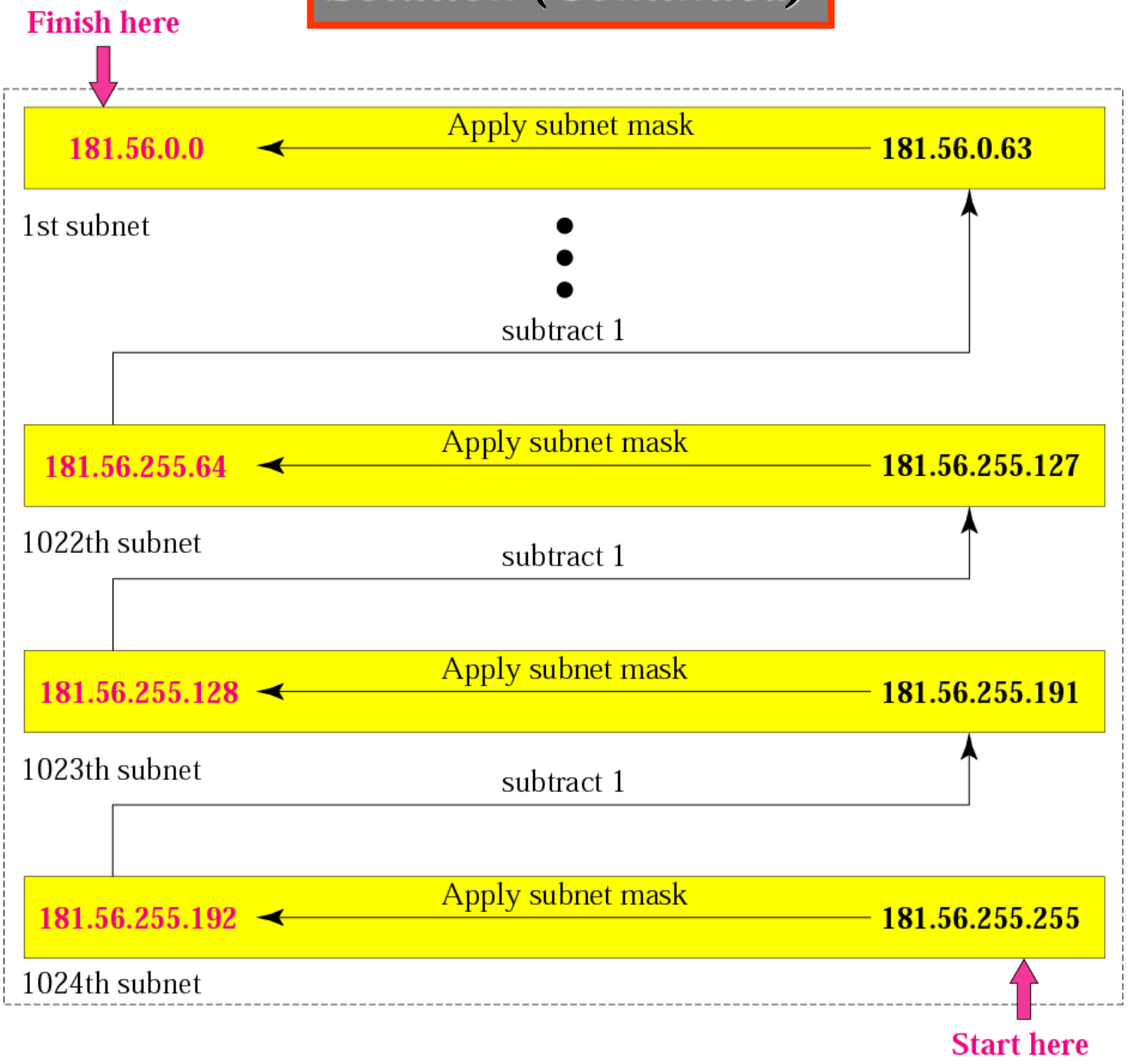
or

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.

Solution (Continued)



Supernetting

a) Although class A and B addresses are almost depleted, Class C addresses are still available.

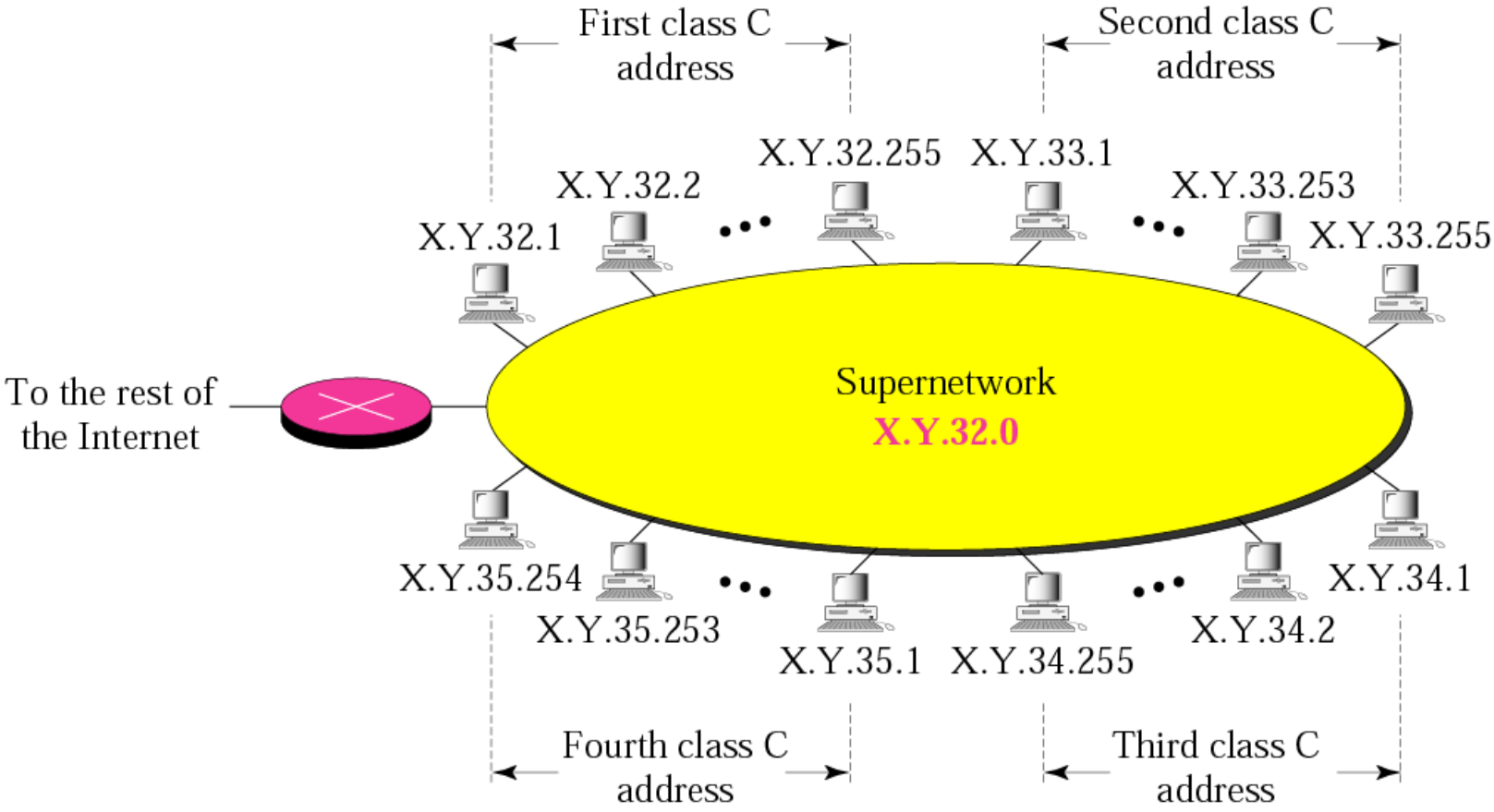
b) However, the size of a class C block with a maximum number of 256 addresses may not satisfy the needs of an organisation.

c) One solution is supernetting.

d) In supernetting, an organisation can combine several class C blocks to create a large range of addresses.

e) In order words, several networks are combined to create a supernetwork. This is done by applying a set of class C blocks instead of just one.

Example of a Supernetwork



Rules:

** The number of blocks must be a power of 2 i.e: (2, 4, 8, 16, . . .).

** The blocks must be contiguous in the address space (no gaps between the blocks).

** The third (3^{rd}) byte of the first (1^{st}) address in the superblock must be evenly divisible by the number of blocks. In other words, if the number of blocks is *N*, the third byte must be divisible by *N*.

Example-5

A company needs 600 addresses. Which of the following set of class C blocks can be used to form a supernet for this company?

a. 198.47.32.0 198.47.33.0 198.47.34.0

b. 198.47.32.0 198.47.42.0 198.47.52.0 198.47.62.0

c. 198.47.31.0 198.47.32.0 198.47.33.0 198.47.52.0

d. 198.47.32.0 198.47.33.0 198.47.34.0 198.47.35.0

Solution

a: No, there are only three blocks. (not to the power of 2)

b: No, the blocks are not contiguous.

c: No, 31 in the **first block** is not divisible by 4.

d: Yes, all three requirements are fulfilled.

Supernet Mask

- In original block of addresses, we know the range of addresses from the first address
  - Since the mask is perdefined (default mask)

- In subnetting or supernetting, the first address alone cannot derive the range of addresses
  - We need to know the *mask*, subnet mask or supernet mask, as well.

Vital notes: Supernetting

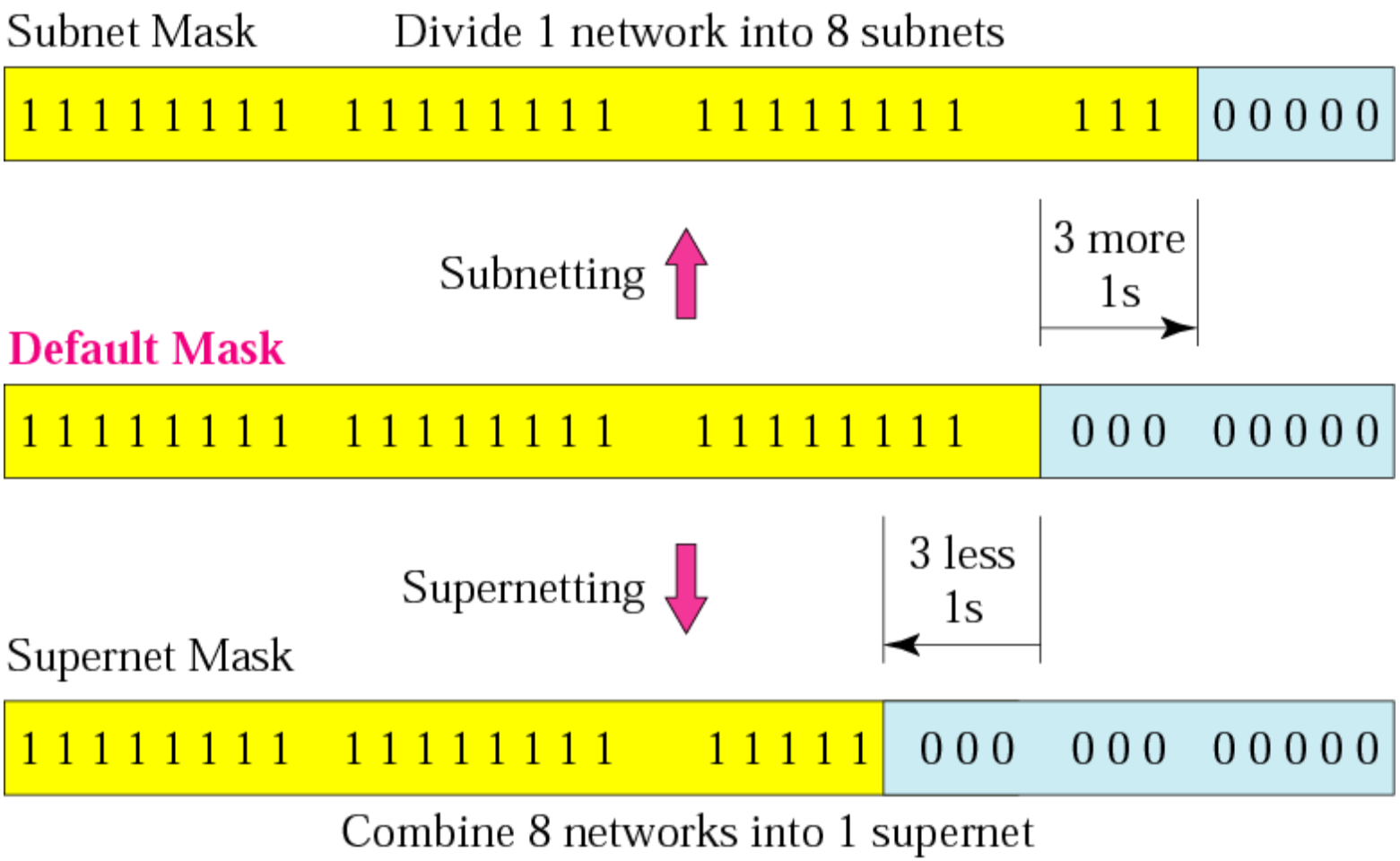
In subnetting, we need the first address of the subnet and the subnet mask to define the range of addresses.

In supernetting, we need the first address of the supernet and the supernet mask to define the range of addresses.

Supernet Mask (Cont.)

- A supernet mask is the reverse of a subnet mask
  - A subnet mask has more 1s than the default mask
  - A supernet mask has less 1s than the default mask

Comparison of subnet, default, and supernet masks



Example-6

We need to make a supernetwork out of 16 class C blocks. What is the supernet mask?

Solution

Class C mask is defaulted with 24 of '1' is

11111111 11111111 11111111 00000000

We need 16 blocks. For 16 blocks we need to change four 1s to 0s in the default mask. So the mask is

11111111 11111111 1111**0000** 00000000

or

255.255.240.0

Example-7

A supernet has a first address of 205.16.32.0 and a supernet mask of 255.255.248.0. A router receives 3 packets with the following destination addresses:

205.16.37.44

205.16.42.56

205.17.33.76

Q: Which packet belongs to the supernet?

Solution

We apply the supernet mask to find the beginning address.

205.16.37.44 AND 255.255.248.0 ➔ 205.16.32.0

205.16.42.56 AND 255.255.248.0 ➔ 205.16.40.0

205.17.33.76 AND 255.255.248.0 ➔ 205.17.32.0

Only the first address belongs to this supernet.

Example-8

A supernet has a first address of 205.16.32.0 and a supernet mask of 255.255.248.0. How many blocks are in this supernet and what is the range of addresses?

Solution

- The supernet has 21 1s.
- The default mask has 24 1s.
- Since the difference is 3
  - There are 8 blocks in this supernet.
- The blocks are 205.16.32.0 to 205.16.39.0.
  - The first address is 205.16.32.0.
  - The last address is 205.16.39.255.