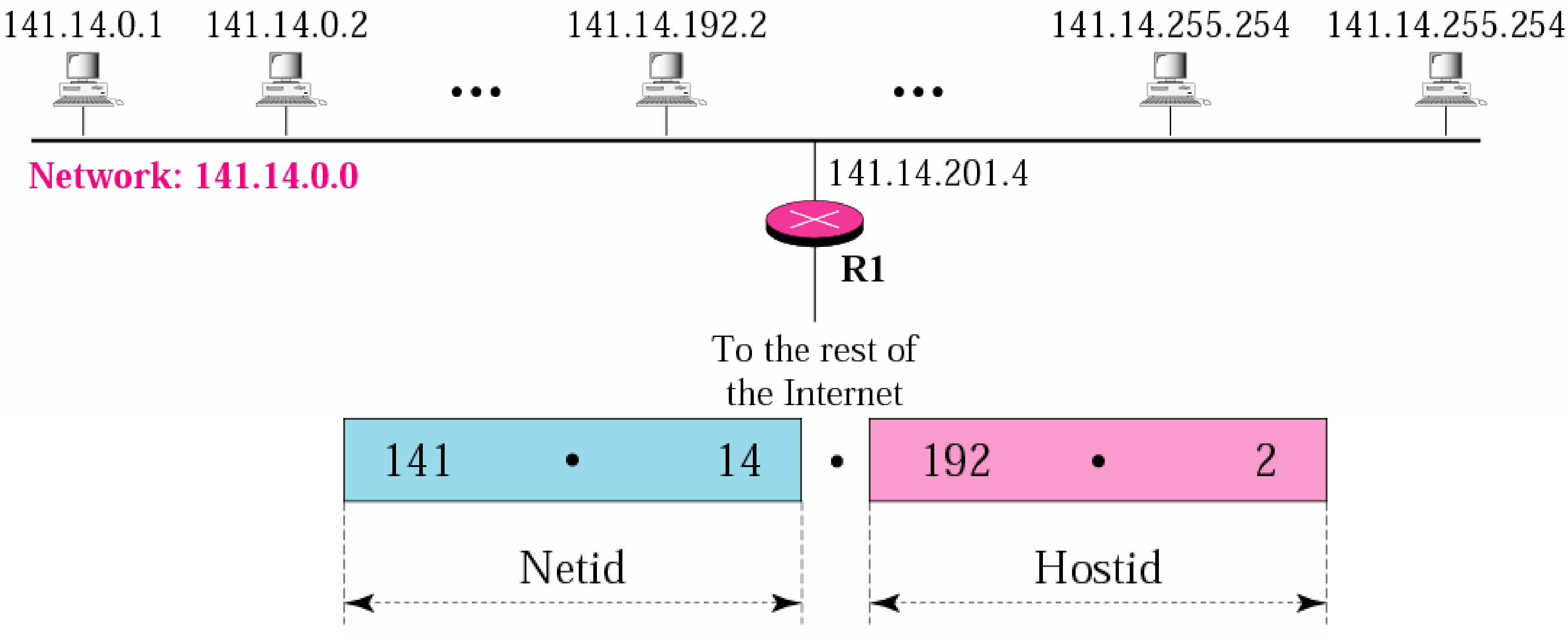
Chapter 5

Subnetting/Supernetting and Classless Addressing

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

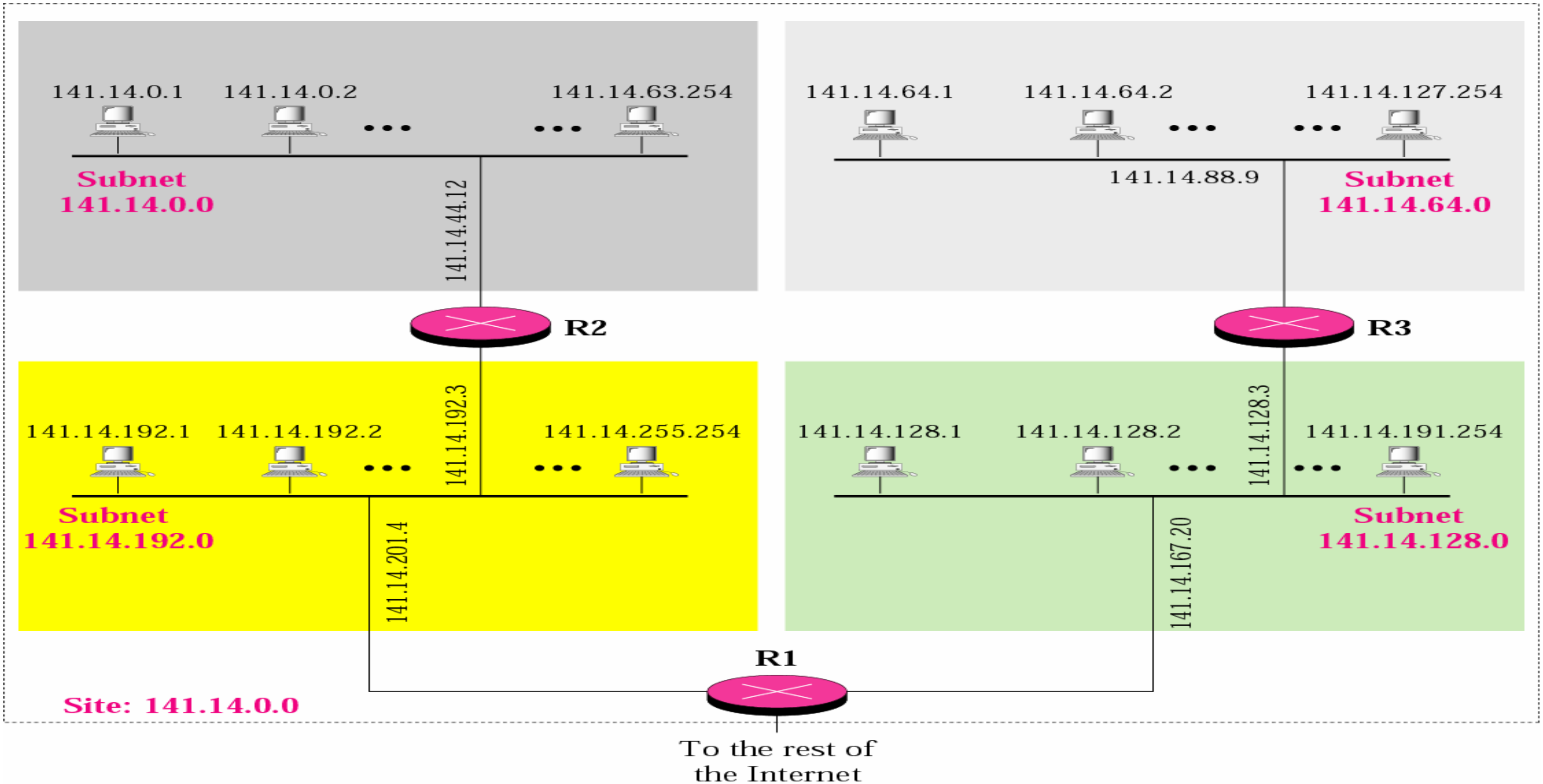
5.1 SUBNETTING

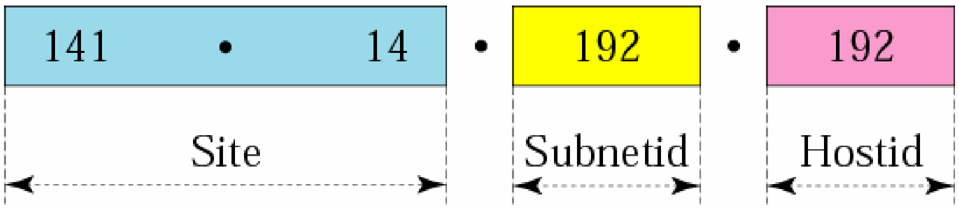
A network with two levels of hierarchy (not subnetted)



- All hosts in such a large network must be laid out as ONE physical network
- May not always be feasible (due to geographic constraints)

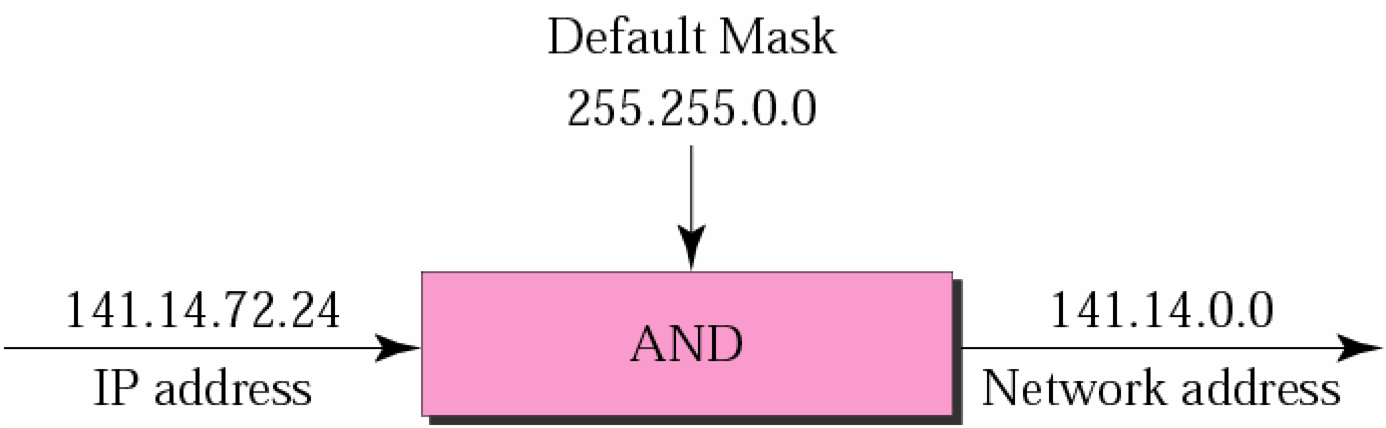
A network with three levels of hierarchy (subnetted)



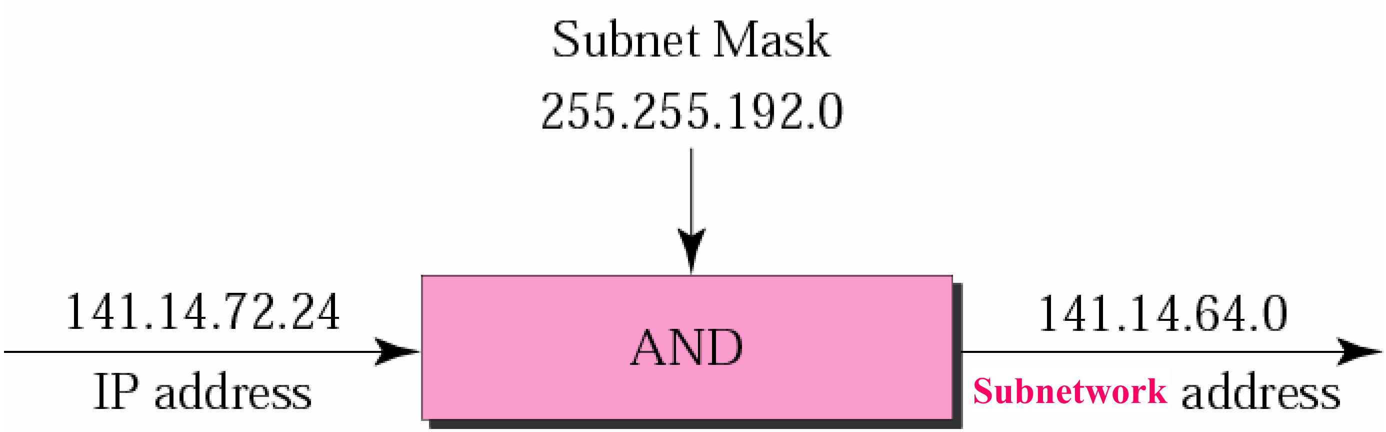


- 3-step delivery: site, subnet, host.

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 the same way we found the network address in the previous chapter. We apply the mask to the address. We can do this in 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.

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?

11001000 00101101 00100010 00111000

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

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

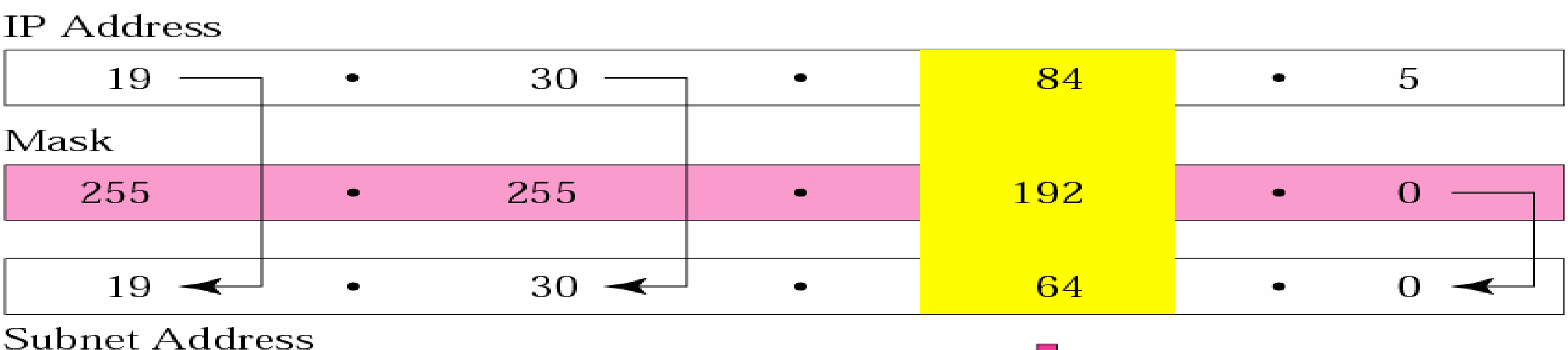
The subnetwork address is **200.45.32.0**.

Short-Cut Method

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

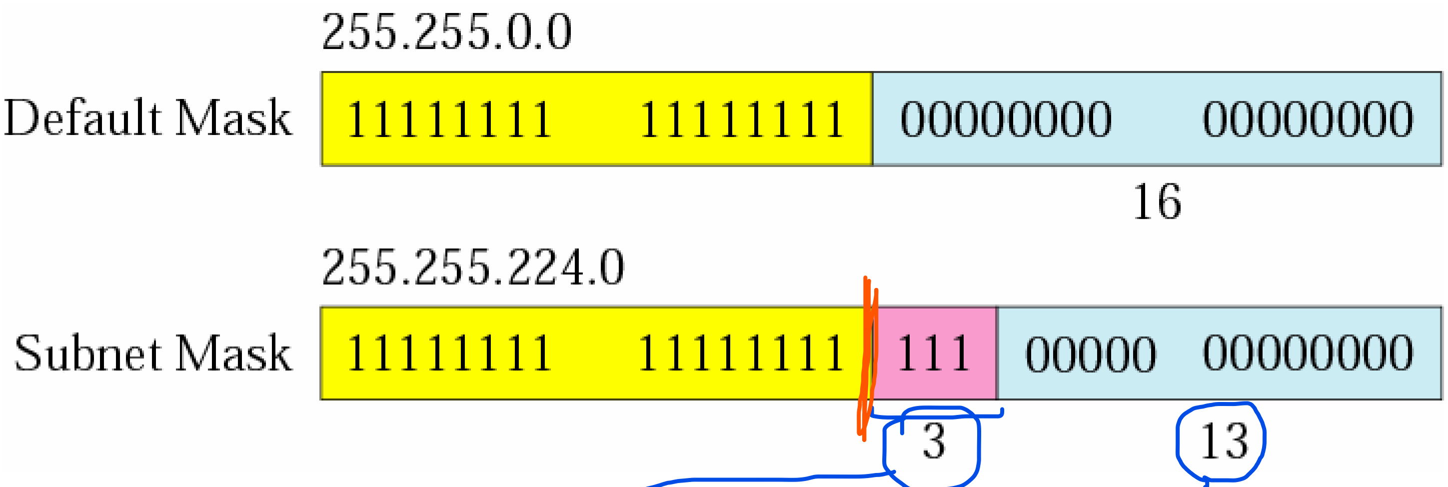
** If the byte in the mask is 0, replace the byte in the address with 0.

** 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.



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

Comparison of a default mask and a subnet mask



- #of Subnetworks = 2^3 (always a power of 2)
- #of Addresses/subnet = 2^{13} (always a power of 2)
- Special Addresses:
  - Hostid 0 : Subnetwork Address
  - HostId all 1's: Limited Broadcast inside subnetwork

Designing Subnets

- The number of subnets N must be a power of 2.

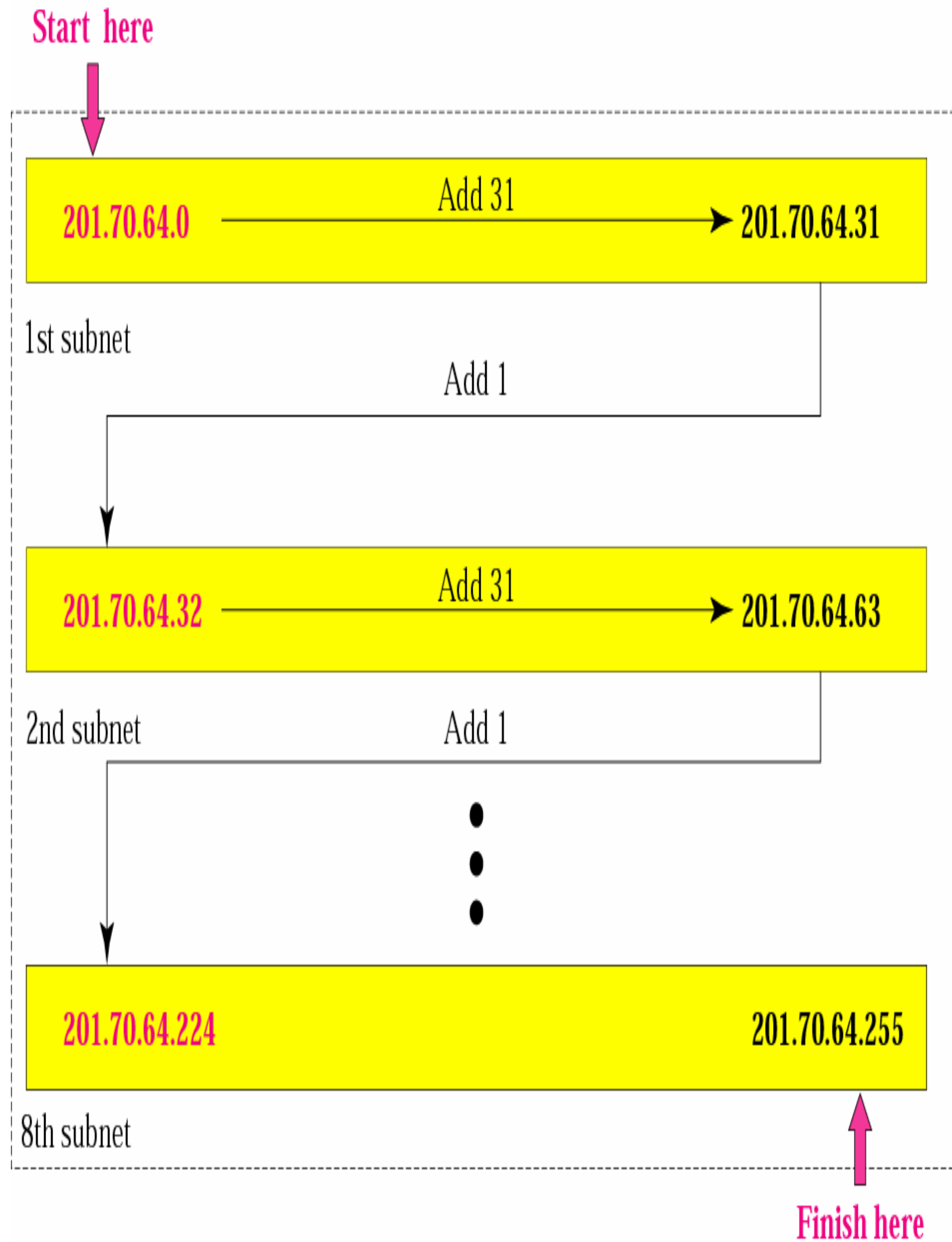
1. Find the Subnet Mask
   - 1-Bits: 1’s from default mask + Log_2 N
   - 0-Bits: The remaining bits (of the 32-bit IP address)
2. Number of Addresses in Each Subnet = $2^{\#\text{of 0-Bits}}$.
3. Range of Addresses in ach Subnet.

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).
- 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.

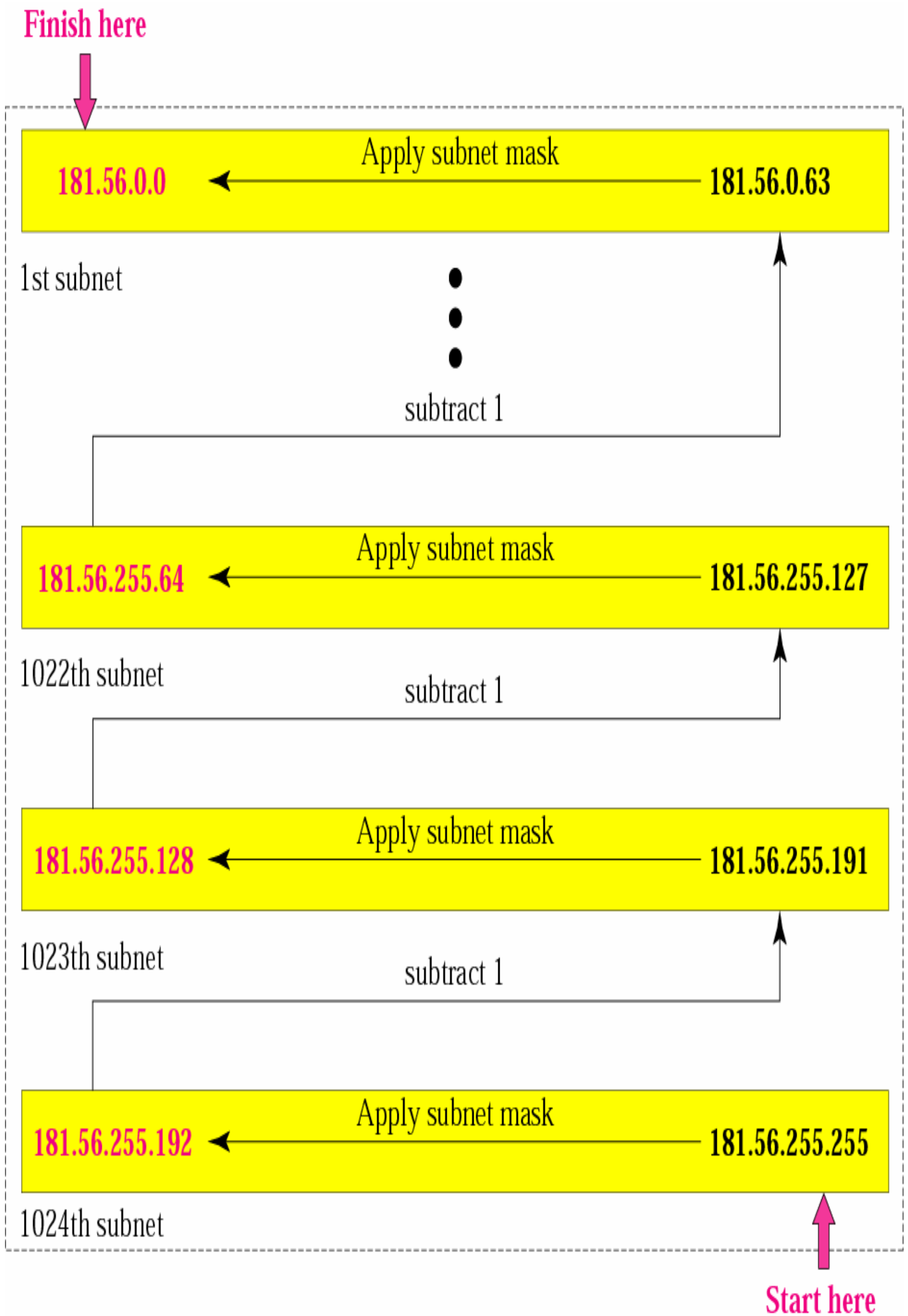


Example 4

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

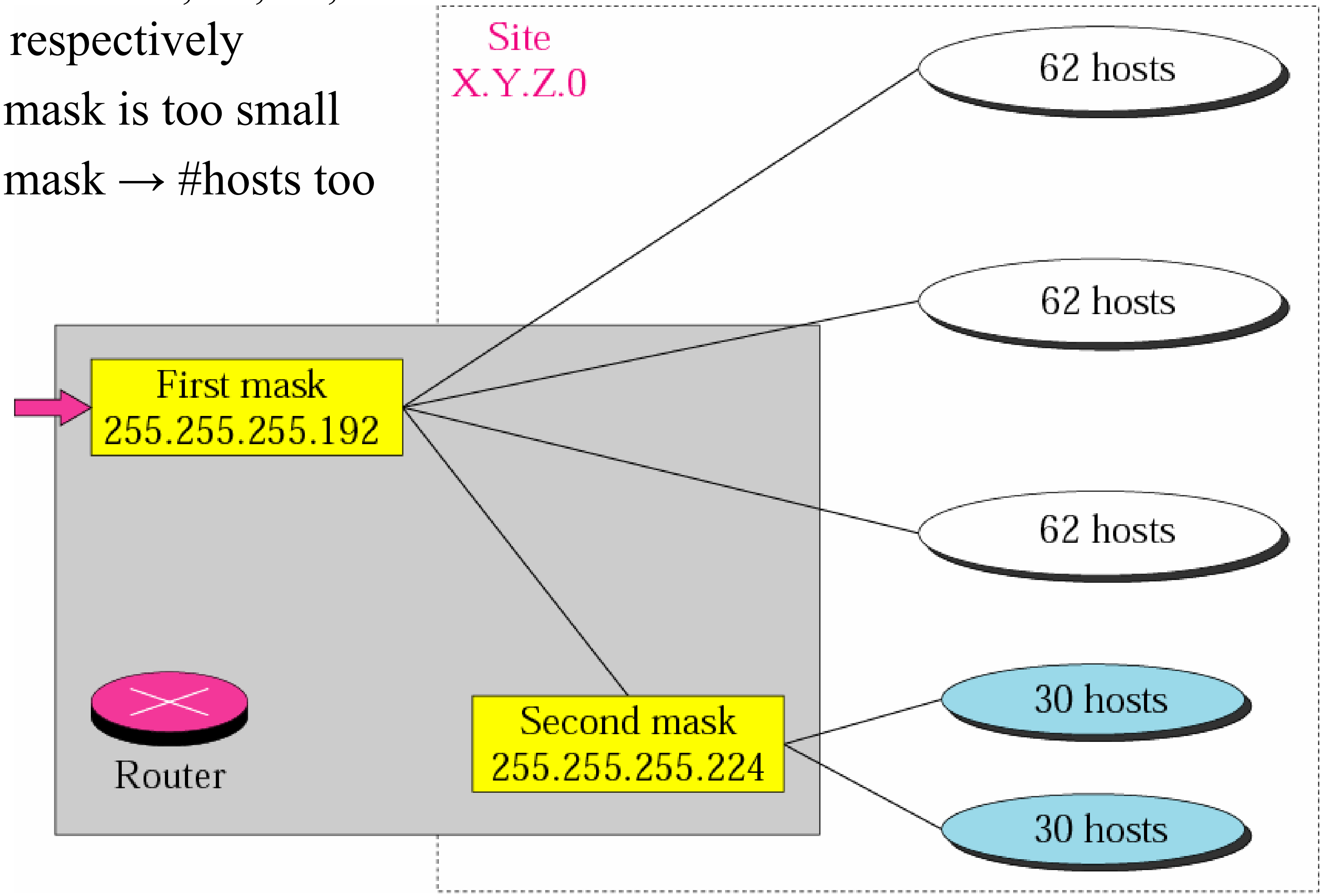
Solution

- The 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.



Variable-length subnetting

- Granted a Class C address
- Needs 5 subnets of 60, 60, 60, 30, 30 hosts, respectively
- 2-bit Subnet mask is too small
- 3-bit Subnet mask → #hosts too small



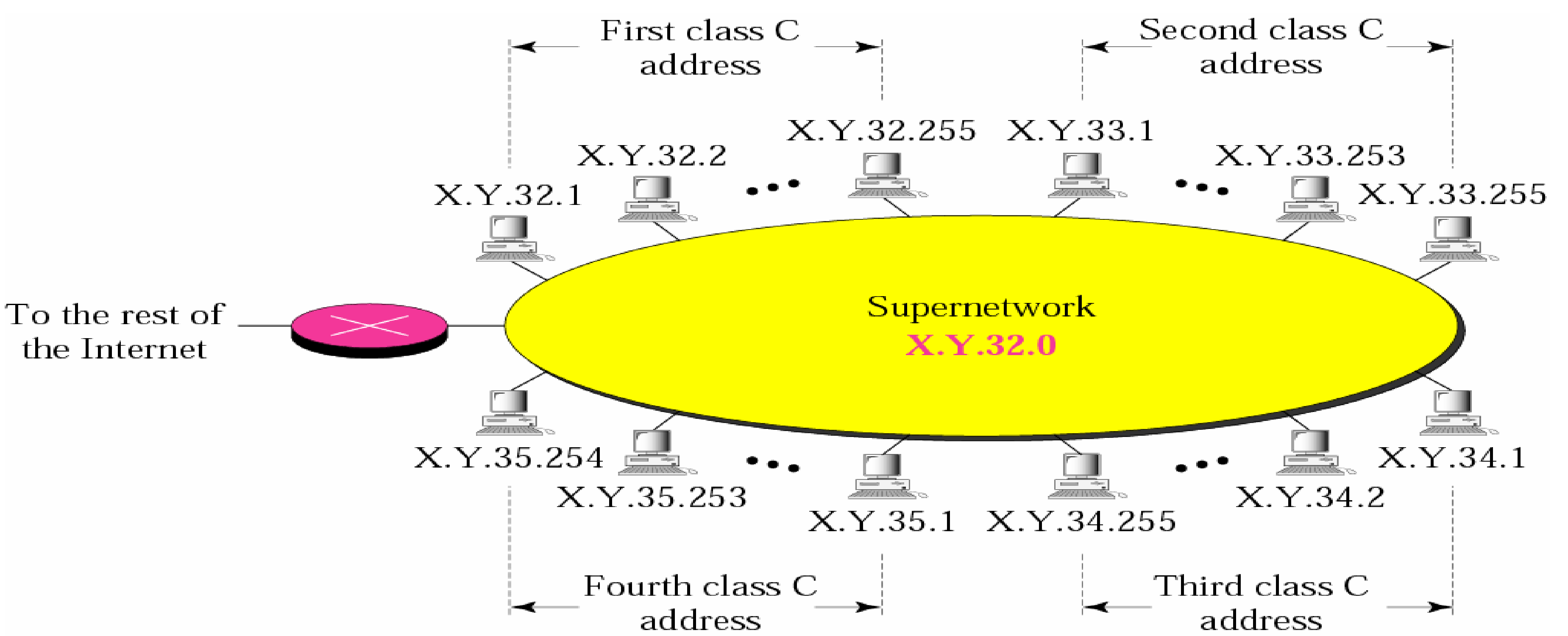
5.2

SUPERNETTING

A supernetwork

- Combine several Class C blocks to create a larger superblock

1. #of blocks *N* is a power of 2
2. Blocks are contiguous
3. Byte 3 of starting address is 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?

198.47.32.0 198.47.33.0 198.47.34.0

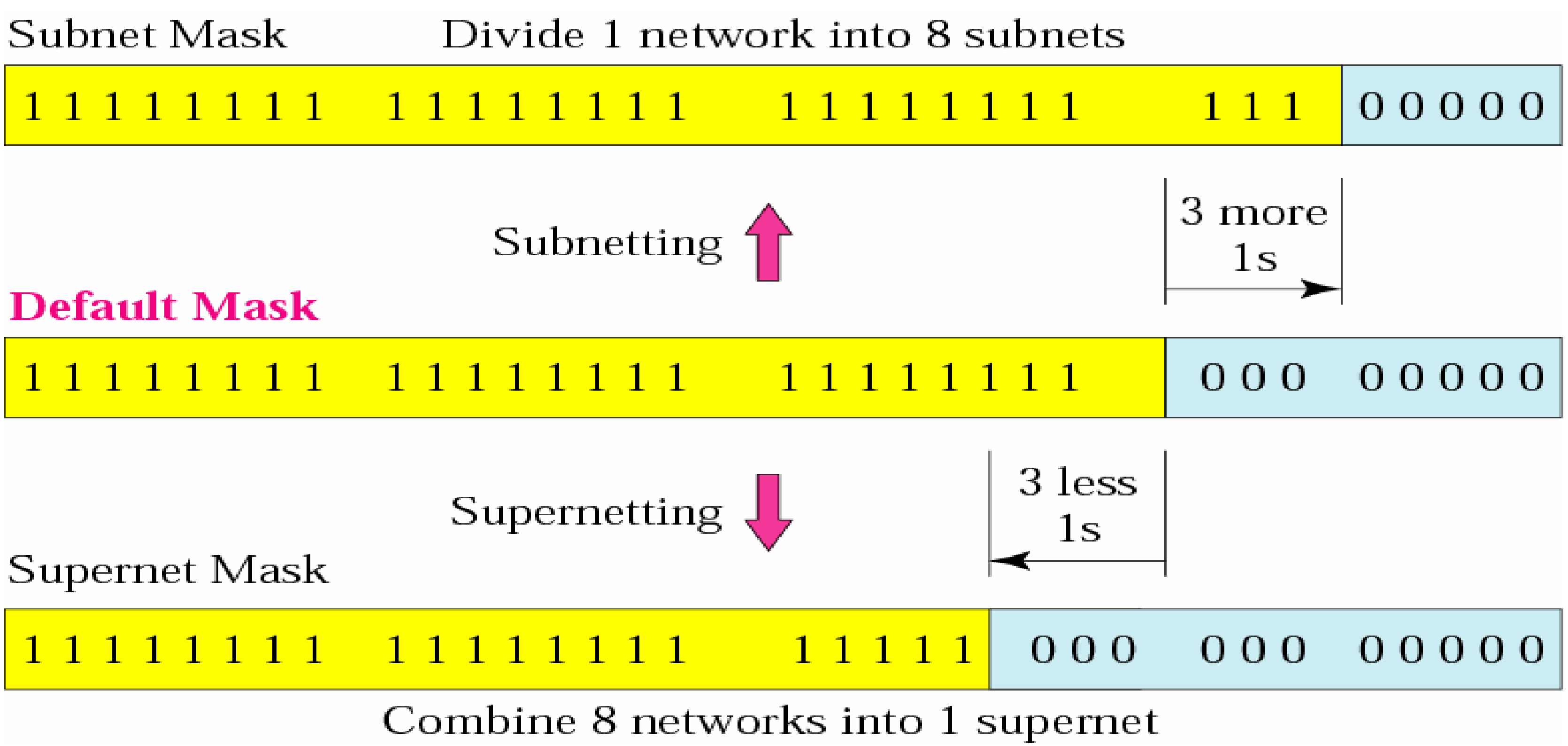
198.47.32.0 198.47.42.0 198.47.52.0 198.47.62.0

198.47.31.0 198.47.32.0 198.47.33.0 198.47.52.0

198.47.32.0 198.47.33.0 198.47.34.0 198.47.35.0

Comparison of subnet, default, and supernet masks

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



Example 6

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

Solution

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 three packets with the following destination addresses:

205.16.37.44
205.16.42.56
205.17.33.76

Which packet belongs to the supernet?

We apply the supernet mask to see if we can 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?

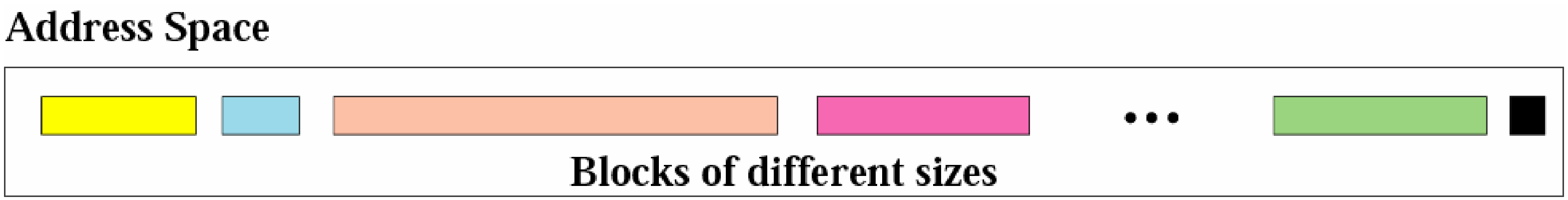
Solution

The supernet has 21 1s. The default mask has 24 1s. Since the difference is 3, there are 2^3 or 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.

5.3

CLASSLESS ADDRESSING

Variable-length blocks



Number of Addresses in a Block

There is only one condition on the number of addresses in a block; it must be a power of 2 (2, 4, 8, . . .). A household may be given a block of 2 addresses. A small business may be given 16 addresses. A large organization may be given 1024 addresses.

Beginning Address

The beginning address must be evenly divisible by the number of addresses. For example, if a block contains 4 addresses, the beginning address must be divisible by 4. If the block has less than 256 addresses, we need to check only the rightmost byte. If it has less than 65,536 addresses, we need to check only the two rightmost bytes, and so on.

Example 9

Which of the following can be the beginning address of a block that contains 16 addresses?

205.16.37.32
190.16.42.44
17.17.33.80
123.45.24.52

Solution

The address 205.16.37.32 is eligible because 32 is divisible by 16. The address 17.17.33.80 is eligible because 80 is divisible by 16.

Example 10

Which of the following can be the beginning address of a block that contains 1024 addresses?

205.16.37.32
190.16.42.0
17.17.32.0
123.45.24.52

Solution

To be divisible by 1024, the rightmost byte of an address should be 0 and the second rightmost byte must be divisible by 4. Only the address 17.17.32.0 meets this condition.

Slash notation

A.B.C.D/*n*

Attach the #of 1s in the mask (a.k.a. prefix length) to a classless address.

Slash notation is also called
CIDR
notation.

Example 11

A small organization is given a block with the beginning address and the prefix length **205.16.37.24/29** (in slash notation). What is the range of the block?

Solution

The beginning address is 205.16.37.24. To find the last address we keep the first 29 bits and change the last 3 bits to 1s.

Beginning:**11001111 00010000 00100101 00011**000

Ending :**11001111 00010000 00100101 00011**111

There are only 8 addresses in this block.

Example 13

What is the network address if one of the addresses is 167.199.170.82/27?

Solution

The prefix length is 27, which means that we must keep the first 27 bits as is and change the remaining bits (5) to 0s. The 5 bits affect only the last byte. The last byte is 01010010. Changing the last 5 bits to 0s, we get 01000000 or 64. The network address is 167.199.170.64/27.

Subnetting a Classless Address

Example 14

An organization is granted the block 130.34.12.64/26. The

Solution

The suffix length is 6. This means the total number of addresses in the block is 64 (2^6). If we create four subnets, each subnet will have 16 addresses.

Solution (Continued)

Let us first find the subnet prefix (subnet mask). We need four subnets, which means we need to add two more 1s to the site prefix. The subnet prefix is then /28.

Subnet 1:

130.34.12.64/28 → 130.34.12.79/28.

Subnet 2 :

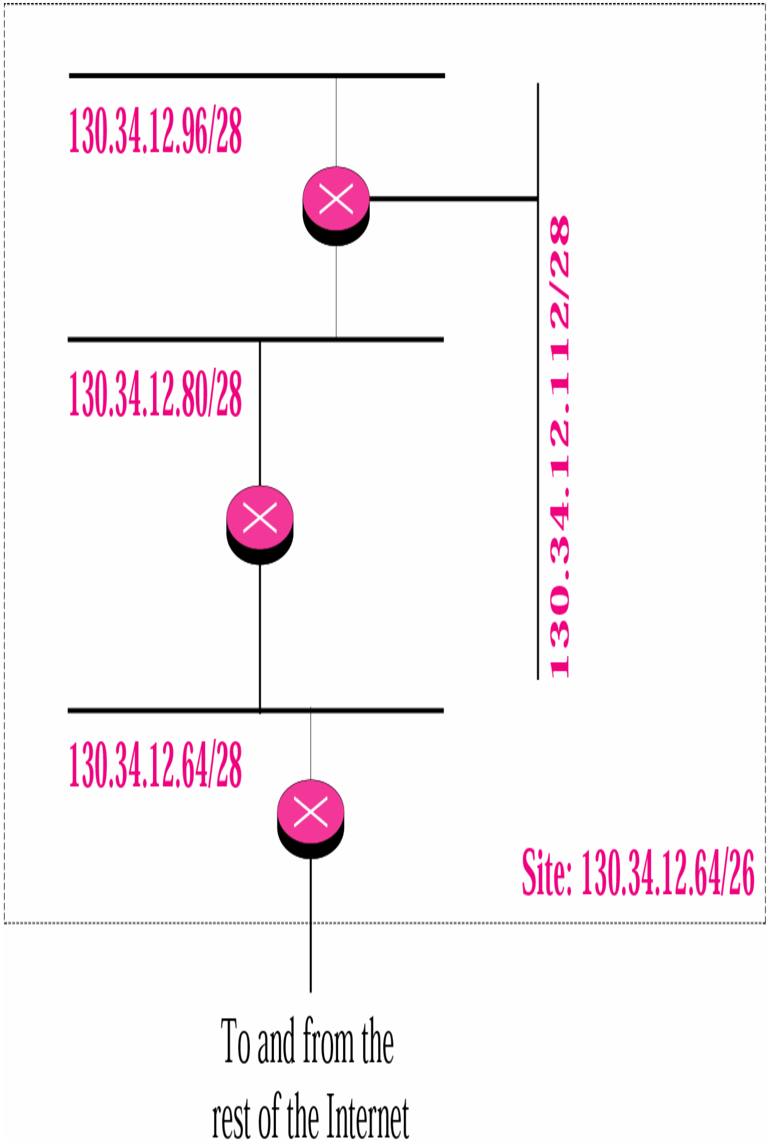
130.34.12.80/28 → 130.34.12.95/28.

Subnet 3:

130.34.12.96/28 → 130.34.12.111/28.

Subnet 4:

130.34.12.112/28 → 130.34.12.127/28.



Example 15

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

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

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

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

Design the subblocks and give the slash notation for each subblock. Find out how many addresses are still available after these allocations.

Solution

Group 1

For this group, each customer needs 256 addresses. This means the suffix length is 8 ($2^8 = 256$). The prefix length is then $32 - 8 = 24$.

01: 190.100.0.0/24 ➔ 190.100.0.255/24

02: 190.100.1.0/24 ➔ 190.100.1.255/24

…………………………………..

64: 190.100.63.0/24 ➔ 190.100.63.255/24

Total = $64 \times 256 = 16{,}384$

Solution (Continued)

Group 2

For this group, each customer needs 128 addresses. This means the suffix length is 7 ($2^7 = 128$). The prefix length is then $32 - 7 = 25$. The addresses are:

001: 190.100.64.0/25 ➔ 190.100.64.127/25

002: 190.100.64.128/25 ➔ 190.100.64.255/25

003: 190.100.127.128/25 ➔ 190.100.127.255/25

Total = $128 \times 128 = 16,384$

Solution (Continued)

Group 3

For this group, each customer needs 64 addresses. This means the suffix length is 6 ($2^6 = 64$). The prefix length is then $32 - 6 = 26$.

001:190.100.128.0/26 ➔ 190.100.128.63/26

002:190.100.128.64/26 ➔ 190.100.128.127/26

…………………………

128:190.100.159.192/26 ➔ 190.100.159.255/26

Total = 128 × 64 = 8,192

Number of granted addresses : 65,536

Number of allocated addresses: 40,960

Number of available addresses: 24,576