

*Subnetting  
and  
Classless Addressing*

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**CONTENTS**

- SUBNETTING
- CLASSLESS ADDRESSING

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**5.1**

**SUBNETTING**

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Note

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

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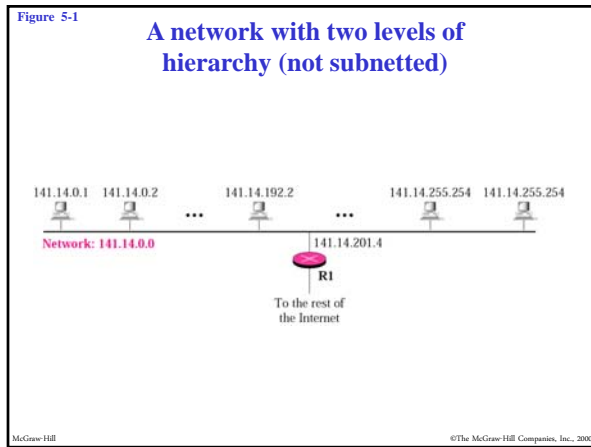
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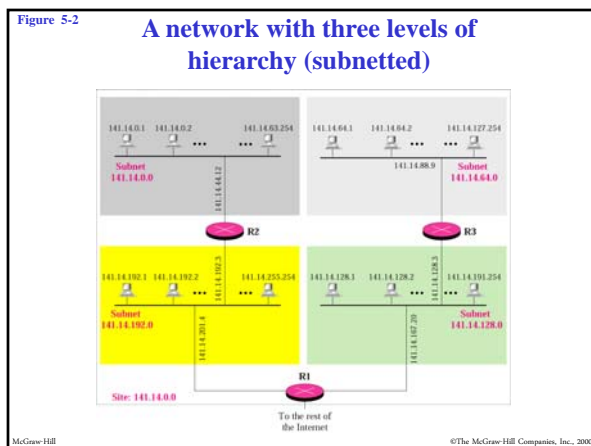
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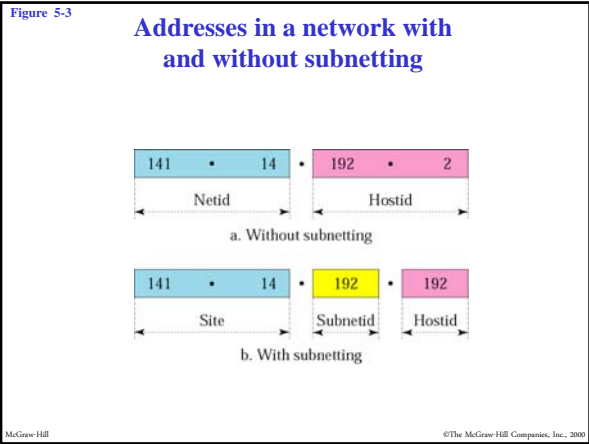
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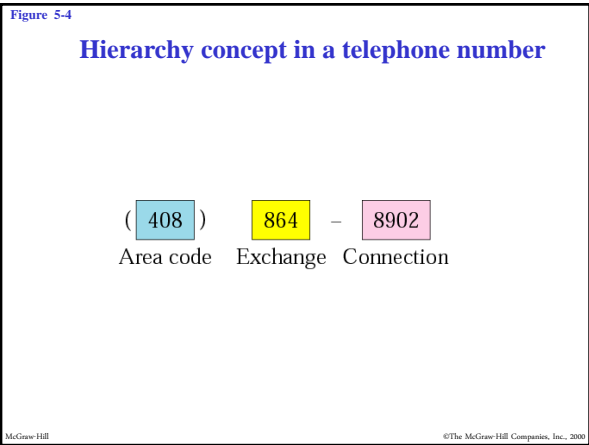
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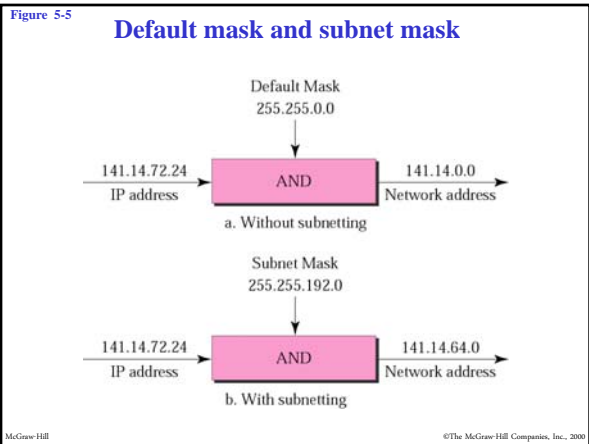
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**Finding the Subnet Address**

Given an IP address, we can find the subnet address by applying the mask to the address. We can do this in two ways: straight or short-cut.

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**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.

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**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?

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**Solution**

11001000 00101101 00100010 00111000  
11111111 11111111 11110000 00000000  
11001000 00101101 00100000 00000000

The subnetwork address is **200.45.32.0**.

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**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.

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**Example 2**

What is the subnetwork address if the destination address is 19.30.84.5 and the mask is 255.255.192.0?

**Solution**

See Figure 5.6

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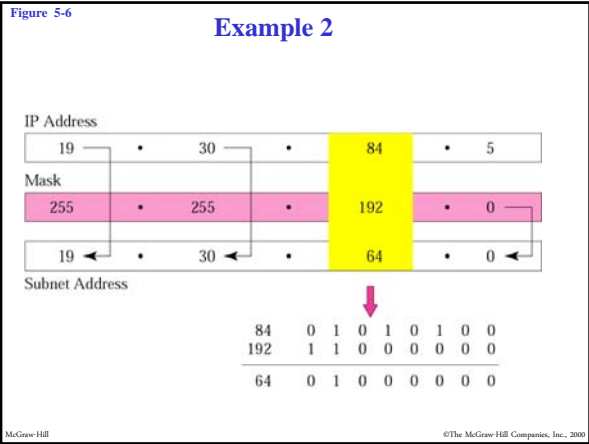
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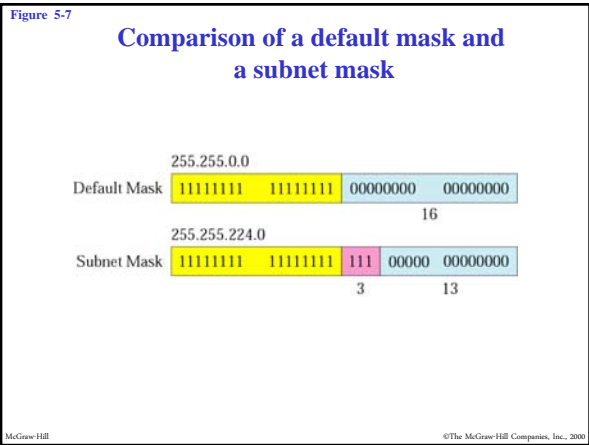
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Note

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

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**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).

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**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

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**Solution (Continued)**

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.

See Figure 5.8

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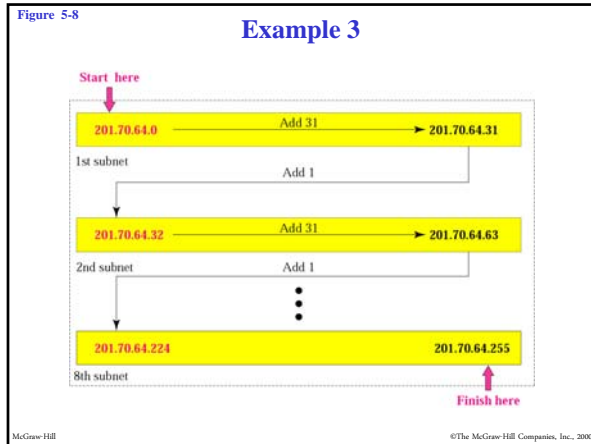
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### Example 4

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).

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**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 ( $32 - 26$ ).

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**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

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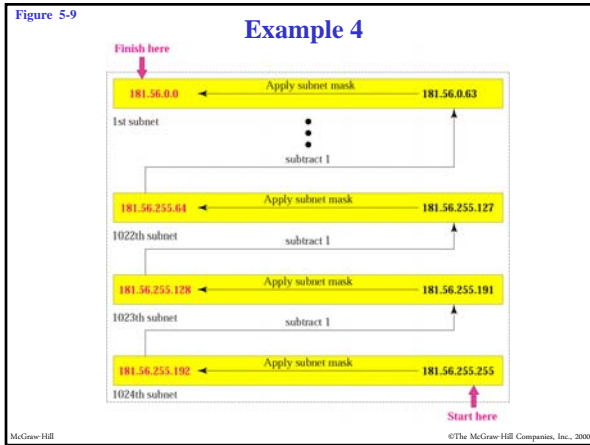
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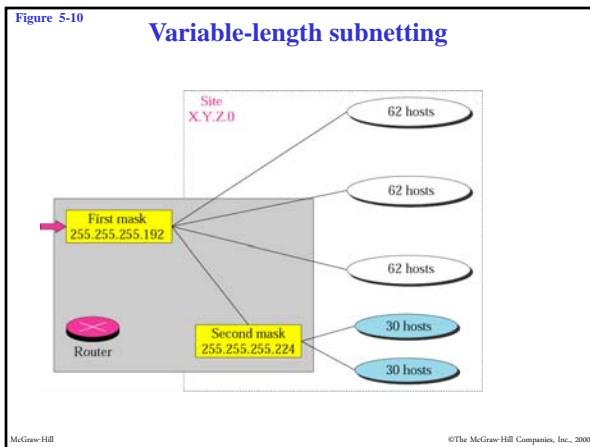
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5.3

## CLASSLESS ADDRESSING

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Figure 5-13

### Variable-length blocks

Address Space

Blocks of different sizes

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### 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.

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***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.

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***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.

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***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.

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Figure 5-14

**Slash notation**

**A.B.C.D/n**

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**Note**

*Slash notation is also called  
**CIDR**  
notation.*

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**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 00011000**  
Ending : **11001111 00010000 00100101 00011111**

There are only 8 addresses in this block.

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**Example 12**

We can find the range of addresses in Example 11 by another method. We can argue that the length of the suffix is  $32 - 29 = 3$ . So there are  $2^3 = 8$  addresses in this block. If the first address is 205.16.37.24, the last address is 205.16.37.31 ( $24 + 7 = 31$ ).

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**Note**

**A block in classes A, B, and C can easily be represented in slash notation as *A.B.C.D/n* where *n* is either 8 (class A), 16 (class B), or 24 (class C).**

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**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.

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**Example 14**

An organization is granted the block 130.34.12.64/26. The organization needs to have four subnets. What are the subnet addresses and the range of addresses for each subnet?

**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.

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**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 to 130.34.12.79/28.

Subnet 2 : 130.34.12.80/28 to 130.34.12.95/28.

Subnet 3: 130.34.12.96/28 to 130.34.12.111/28.

Subnet 4: 130.34.12.112/28 to 130.34.12.127/28.

**See Figure 5.15**

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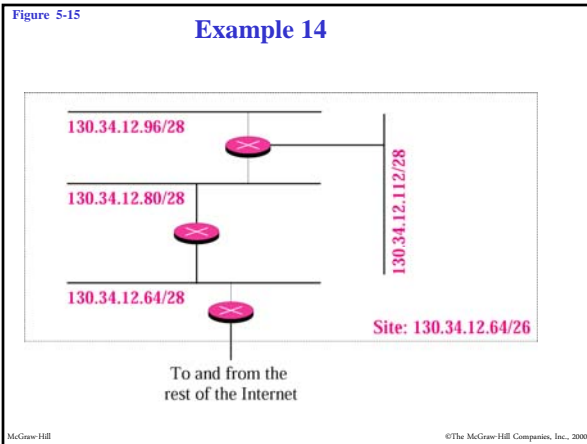
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**Example 15**

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.

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**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 =  $64 \times 256 = 16,384$

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

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**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 =  $128 \times 64 = 8,192$**

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**Solution (Continued)**

Number of granted addresses: 65,536

Number of allocated addresses: 40,960

Number of available addresses: 24,576

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