CSE3151

COMPUTER NETWORKS

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NETWORK LAYER

Medium Access Sublayer: Pure and slotted ALOHA, Persistent and Non persistent CSMA, CSMA with collision detection and collision free protocols, IEEE standard 802.3 and Ethernet.

Data Link Layer: Types of errors, framing, error detection & correction methods; Flow control, Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, HDLC.

Network Layer: Internet address, classful address, subnetting, static vs. dynamic routing, shortest path algorithm, flooding, distance vector routing, link state routing, ARP, RARP, IP, ICMP.

Transport Layer: UDP, TCP, Connection management, Addressing, Establishing and Releasing Connection, Congestion control algorithm, Flow control and Buffering, Multiplexing.

Presentation Layer: Data Compression techniques, Frequency Dependent Coding, Context Dependent Encoding.

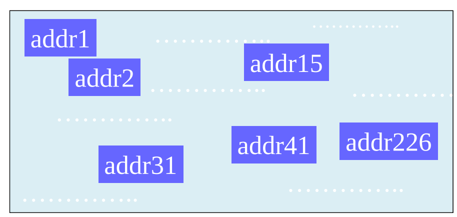
What is an IP Address?

An IP address is a
32-bit
address.

Note

***The IP addresses
are
unique.***

Address Space



Address space rule

**The address space in a protocol
That uses N-bits to define an
Address is:**

2^N

IPv4 address space

The address space of IPv4 is

2^{32}

or

4,294,967,296.

Binary Notation

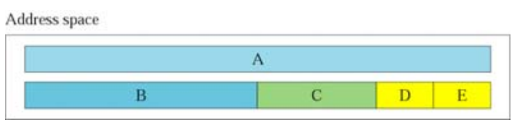
11000000 10101000 00000000 00000001

192 . 168 . 0 . 1

CLASSFUL ADDRESSING

Figure 4-2

Occupation of the address space



In classful addressing the address space is divided into 5 classes:

***A*, *B*, *C*, *D*, and *E*.**

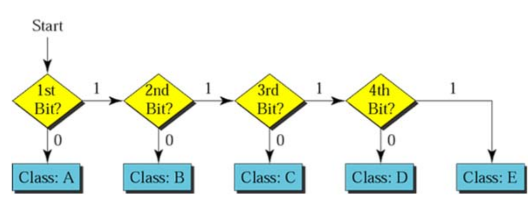
Figure 4-3

Finding the class in binary notation

	First byte	Second byte	Third byte	Fourth byte
Class A	0			
Class B	10			
Class C	110			
Class D	1110			
Class E	1111			

Figure 4-4

Finding the address class



Example 5

Show that Class ***A*** *has*
2^{31} = 2,147,483,648 addresses

Example 6

Find the class of the following IP addresses
00000001 00001011 00001011 11101111
11000001 00001011 00001011 11101111

Solution

•**0**0000001 00001011 00001011 11101111
1st is 0, hence it is Class A
•11000001 00001011 00001011 11101111
1st and 2nd bits are 1, and 3rd bit is 0 hence, Class C

Figure 4-5

Finding the class in decimal notation

	First byte	Second byte	Third byte	Fourth byte
Class A	**0 to 127**			
Class B	**128 to 191**			
Class C	**192 to 223**			
Class D	**224 to 239**			
Class E	**240 to 255**			

Example 7

Find the class of the following addresses
158.223.1.108
227.13.14.88

Solution

•158.223.1.108
1st byte = 158 (128<158<191) class B
•227.13.14.88
1st byte = 227 (224<227<239) class D

IP ADDRESS WITH APPENDING **PORT NUMBER**

- 158.128.1.108:25
- the for octet before colon is the IP address
- The number of colon (25) is the port number
- **16**-bit integer, so **65535**.

Netid and hostid

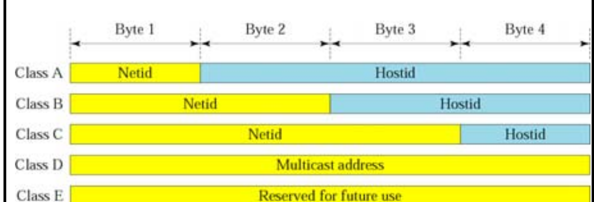
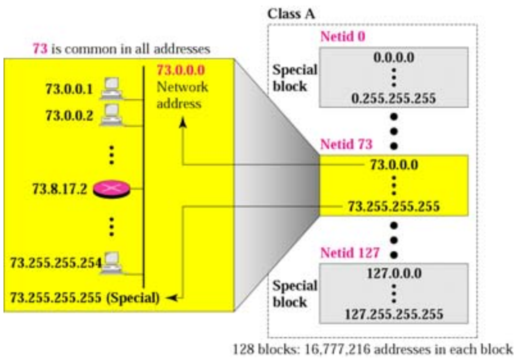


Figure 4-7

Blocks in class A

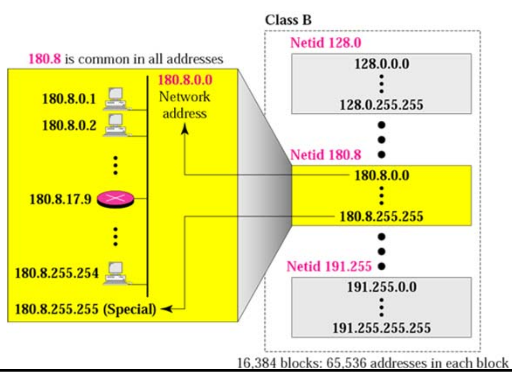


Note

Millions of class A addresses are wasted.

Figure 4-8

Blocks in class B

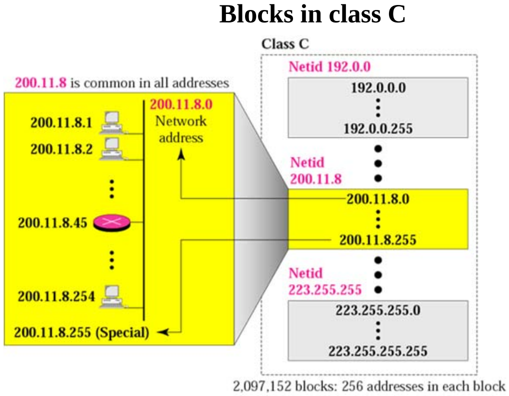


Note

Many class B addresses are wasted.

Figure 4-9

Blocks in class C



Note

The number of addresses in a class C block is smaller than the needs of most organizations.

Note

Class D addresses are used for multicasting; there is only one block in this class.

Note

Class E addresses are reserved for special purposes; most of the block is wasted.

Network Addresses

The network address is the first address.

The network address defines the network to the rest of the Internet.

Given the network address, we can find the class of the address, the block, and the range of the addresses in the block

Note

In classful addressing, the network address (the first address in the block) is the one that is assigned to the organization.

Mask

- A mask is a 32-bit binary number.
- The mask is ANDeD with IP address to get
  - The bloc address (Network address)
  - Mask And IP address = Block Address

Figure 4-10

Masking concept

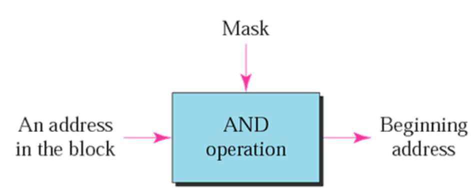
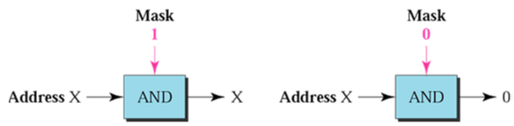


Figure 4-11

AND operation



Note

The network address is the beginning address of each block. It can be found by applying the default mask to any of the addresses in the block (including itself). It retains the netid of the block and sets the hostid to zero.

Default Mask

- Class A default mask is 255.0.0.0
- Class B default mask is 255.255.0.0
- Class C Default mask 255.255.255.0

Subnetting and Classless Addressing

SUBNETTING

Note

- Subnetting is done by borrowing bits from the host part and add them the network part

Figure 5-3

Addresses in a network with and without subnetting

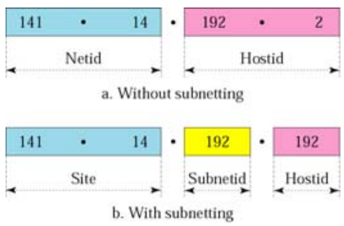
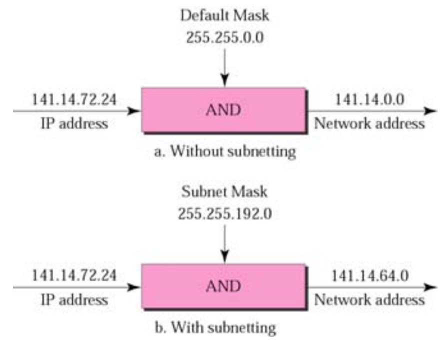


Figure 5-5

Default mask and subnet mask



Finding the Subnet Address

Given an IP address, we can find the subnet address the same way we found the network address. 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 9

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

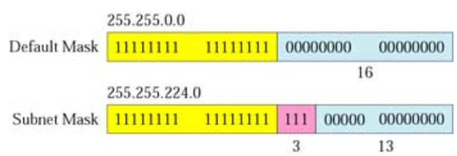
11111111 11111111 1111**0000** **00000000**

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

The subnetwork address is **200.45.32.0**.

Figure 5-7

Comparison of a default mask and a subnet mask



Note

The number of subnets must be a power of 2.

Example 11

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)

<u>11111111 11111111 11111111 111</u>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 slide

Figure 5-8

Example 3

Example 12

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. Th
number is not a power of 2. The next numbe
that is a power of 2 is 1024 (2^{10}). We need 1
more 1s in the subnet mask.

The total number of 1s in the subnet mask i
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 next slide

Figure 5-9

Example 4

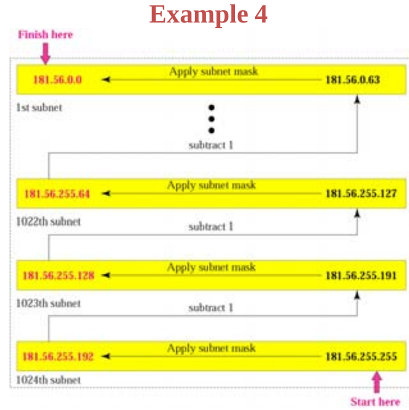
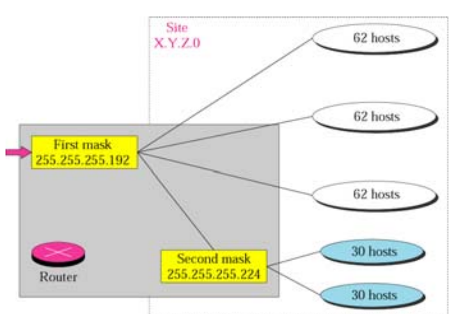


Figure 5-10

Variable-length subnetting

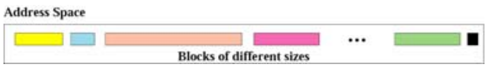


5.3

CLASSLESS ADDRESSING

Figure 5-13

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 16

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.

Figure 5-14

Slash notation

A.B.C.D/*n*

Note

Slash notation is also called CIDR notation.

Example 17

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.

Example 17 cont'd

We can find the range of addresses in Example 17 by another method. We can argue that the length of the suffix is 32 – 29 or 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).

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).

Example 18

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.

Example 19

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.

Solution (Continued)

Let us first find the subnet prefix (subnet mask). We need fou 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.

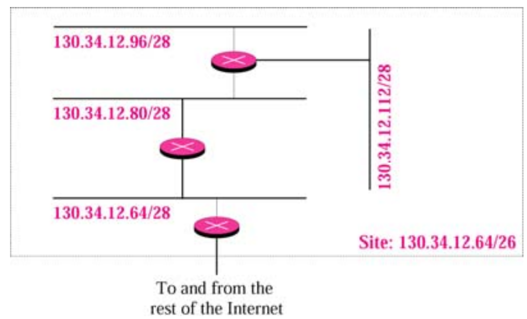
Subnet 3: 130.34.12.96/28 to 130.34.12.111/28.

Subnet 4: 130.34.12.112/28 to 130.34.12.127/28.

See Figure 5.15

Figure 5-15

Example 19 cont'd



Example 20

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 t 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 × 256 = 16,384

Solution (Continued)

Group 2

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

………………..

128: 190.100.127.128/25 → 190.100.127.255/25

Total = 128 × 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

Solution (Continued)

Number of granted addresses: 65,536

Number of allocated addresses: 40,960

Number of available addresses: 24,576