IP Addressing

Logical addressing (IP Addressing):

- Usually, computers communicate through the Internet. The packet(data) transmitted by the sender computer may pass through several LANs or WANs before reaching the destination computer. For this level of communication, we need a global addressing scheme what we call logical addressing. An IP address is used globally to refer to the logical address in the network layer.
- Types: 1. IPv4 Addressing

  2. IPv6 Addressing

IPv4 Addressing:

- An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a device (for example, a computer or a router) to the Internet.
- They are unique so that each address defines only one connection to the Internet. Two devices on the Internet can never have the same IPV4 address at the same time.

Address Space:

- IPv4 has a certain address space. An address space is the total number of addresses used by the protocol. If a protocol uses N bits to define an address, the address space is 2^N .
- IPv4 uses 32-bit address format, which means that the address space is 2^{32} or 4,294,967,296

IPv4 Address Notations:

1) Binary Notation

- In binary notation, the IPv4 address is displayed as 32 bits. Each octet is often referred to as a byte. So it is common to hear an IPv4 address referred to a 4-byte address. The following is an example of an IPv4 address in binary notation: 01110111 10010101 00000001 00000011

2**) Dotted-Decimal Notation**

- IPV4 addresses are usually written in decimal form with a decimal point (dot) separating the bytes since it's more compatible. The following is an example: 119.149.1.3 (above one and this one is same just different notation)
- N.B: Each number in dotted-decimal notation is a value ranging from 0 to 255.

3) Hexadecimal Notation

- Each 4 binary bits will be converted to its hexadecimal equivalent
- Example: 0X77950103 or 77950103_{16}

Classful Addressing:

Five Classes

- Class A
- Class B
- Class C
- Class D
- Class E

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**			

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

Find the class of the address:

11000001 10000011 00011011 11111111

Solution

The first 2 bits are 1; the third bit is 0.
This is a class C address.

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			

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

Find the class of the address:

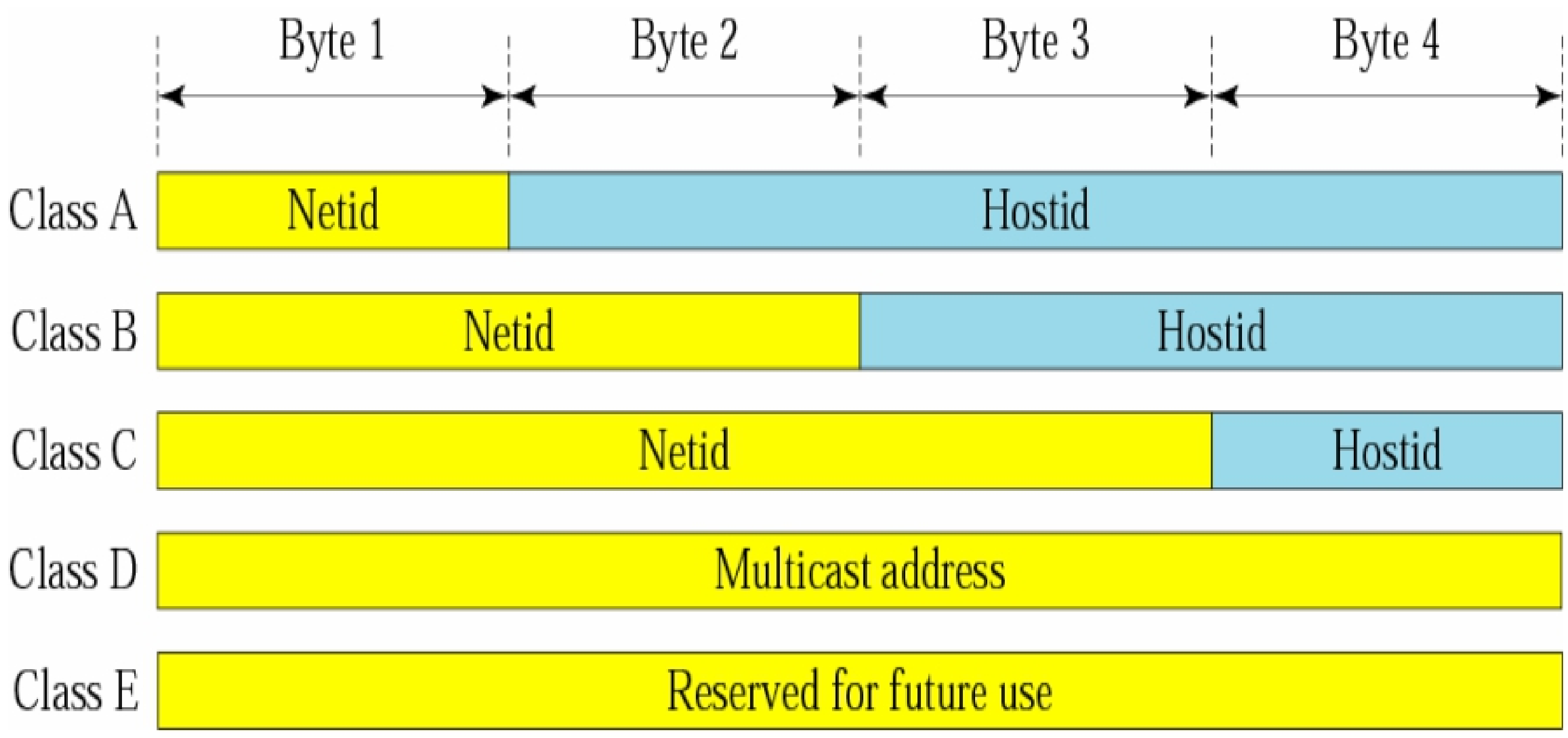
227.12.14.87

Solution

The first byte is 227 (between 224 and 239); the class is D.

Netid: The part of an IP address that identifies the network.
Hostid: The part of an IP address that identifies a host in a network.

Netid and Hostid



Network Addresses

The network address is the first address.

The network address defines the network to the rest of the Internet. Routers route a packet based on the network address.

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

Example

Given the network address 17.0.0.0, find the class, the block, and the range of the addresses.

Solution

The class is A because the first byte is between 0 and 127. The block has a netid of 17. The addresses range from 17.0.0.0 to 17.255.255.255.

Example

Given the network address 220.34.76.0, find the class, the block, and the range of the addresses.

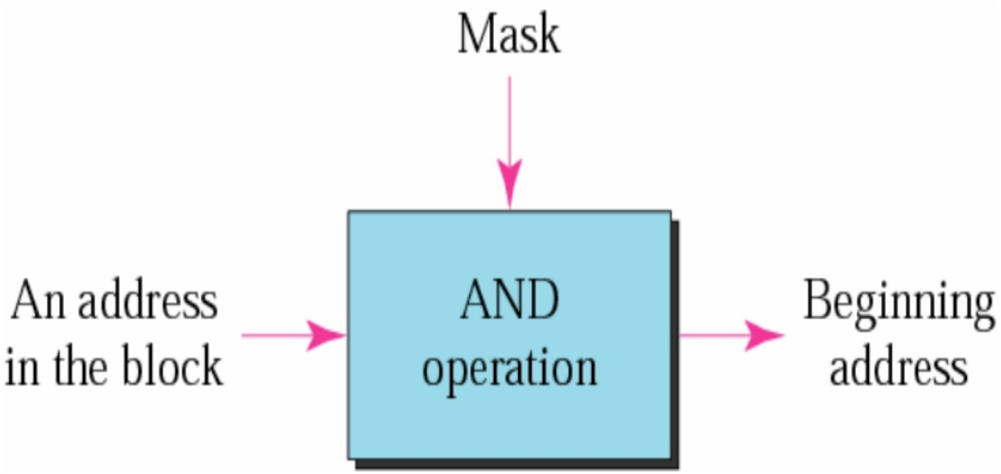
Solution

The class is C because the first byte is between 192 and 223. The block has a netid of 220.34.76. The addresses range from 220.34.76.0 to 220.34.76.255.

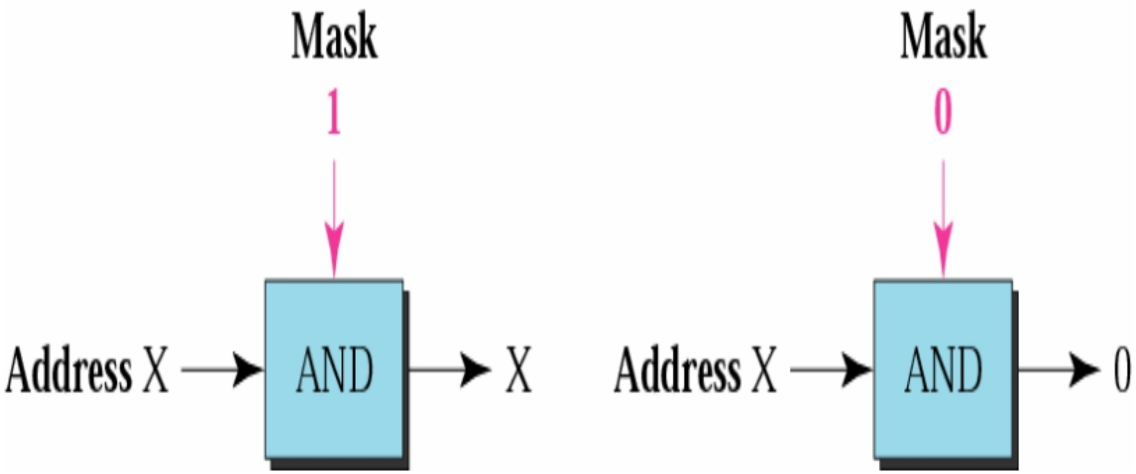
Mask

A mask is a 32-bit binary number that gives the first address in the block (the network address) when bitwise ANDed with an address in the block.

Masking concept



AND operation



Default Masks

- Class A
  - Mask in binary: **11111111** 00000000 00000000 00000000
  - Mask in dotted-decimal: **255.**0.0.0
- Class B
  - Mask in binary: **11111111 11111111** 00000000 00000000
  - Mask in dotted-decimal: **255.255.**0.0
- Class C
  - Mask in binary: **11111111 11111111 11111111** 00000000
  - Mask in dotted-decimal: **255.255.255.**0

Example

Given the address 23.56.7.91 and the default class A mask, find the beginning address (network address).

Solution

The default mask is 255.0.0.0, which means that only the first byte is preserved and the other 3 bytes are set to 0s.
The network address is 23.0.0.0.

Example

Given the address 201.180.56.5 and the class C default mask, find the beginning address (network address).

Solution

The default mask is 255.255.255.0, which means that the first 3 bytes are preserved and the last byte is set to 0. The network address is 201.180.56.0.

Disadvantage of Classful Addressing:

- Class A with a mask of 255.0.0.0 can support 16, 777, 214 addresses
- Class B with a mask of 255.255.0.0 can support 65, 534 addresses
- Class C with a mask of 255.255.255.0 can support 254 addresses

But what if someone requires 2000 addresses ?

- One way to address this situation would be to provide the person with class B network. But that would result in a waste of so many addresses. **not preferable**
- Another possible way is to provide multiple class C networks, but that too can cause a problem as there would be too many networks to handle. **not preferable**

To resolve problems like the one mentioned above **CIDR was introduced**.

Classless Inter-Domain Routing (CIDR):

- CIDR or Class Inter-Domain Routing was introduced in 1993 to replace classfull addressing. It allows the user to use VLSM or Variable Length Subnet Masks.

CIDR notation:

- In CIDR subnet masks are denoted by /X. For example a subnet of 255.255.255.0 would be denoted by /24. To work a subnet mask in CIDR, we have to first convert each octet into its respective binary value. For example, if the subnet is of 255.255.255.0. then :
  - First Octet: 255 has 8 binary 1's when converted to binary
  - Second Octet: 255 has 8 binary 1's when converted to binary
  - Third Octet: 255 has 8 binary 1's when converted to binary
  - Fourth Octet: 0 has 0 binary 1's when converted to binary

  Therefore, in total there are 24 binary 1's, so the subnet mask is /24.

- With CIDR, we can create Variable Length Subnet Masks, leading to less wastage of IP addresses. It is not necessary that the divider between the network and the host portions is at an octet boundary. For example, in CIDR a subnet mask like 255.224.0.0 or 11111111.11100000.00000000.00000000 can exist.
- Here the suffix will be **/11**

Example

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

Solution

- The prefix length is 27
  - We must keep the first 27 bits as it 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.

Special Addresses:

This-host Address The only address in the block **0.0.0.0/32** is called the *this-host* address. It is used whenever a host needs to send an IP datagram but it does not know its own address to use as the source address. We will see an example of this case in the next section.

Limited-broadcast Address. The only address in the block **255.255.255.255/32** is called the *limited-broadcast* address. It is used whenever a router or a host needs to send a datagram to all devices in a network. The routers in the network, however, block the packet having this address as the destination; the packet cannot travel outside the network.

Loopback Address. The block **127.0.0.0/8** is called the *loopback* address. A packet with one of the addresses in this block as the destination address never leaves the host; it will remain in the host. Any address in the block is used to test a piece of software in the machine. For example, we can write a client and a server program in which one of the addresses in the block is used as the server address. We can test the programs using the same host to see if they work before running them on different computers.

Private addresses Four blocks are assigned as private addresses: 10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16, and 169.254.0.0/16. We will see the applications of these address when we discuss NAT later in the chapter.

Multicast addresses The block 224.0.0.0/4 is reserved for multicast addresses. We discuss these addresses later in the chapter.