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CAP256: Computer Networks

Lecture 21-23
IP addresses

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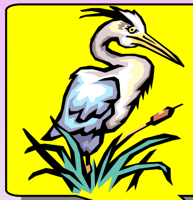
IP Addresses: Classful Addressing

Objectives

- *Understand IPv4 addresses*
- *Class full addresses*
- *Subnet mask and its purpose*
- *Class less inter domain routing.*
- *Sub netting and Super netting.*
- *Understand NAT*



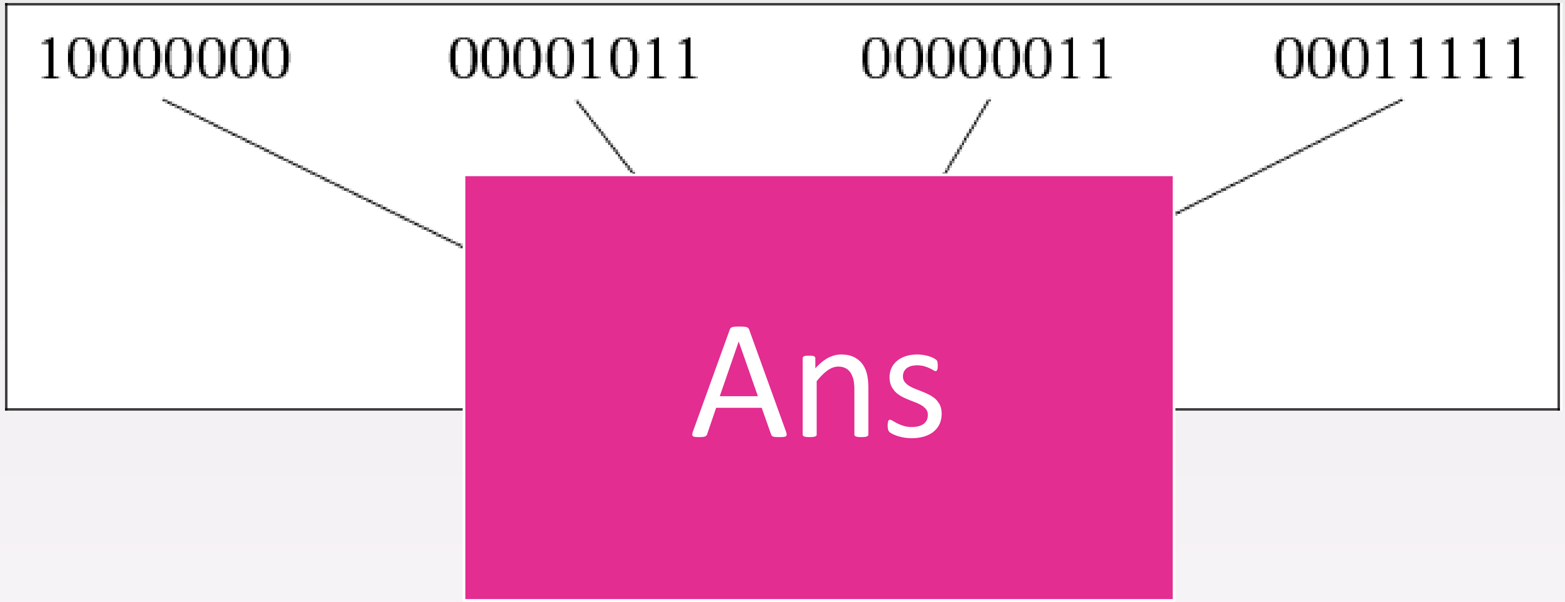
Note:

An IP address is a 32-bit address.

The IP addresses are unique.

The address space of IPv4 is 2^{32} or 4,294,967,296.

Dotted-decimal notation



Example 1

Change the following IP addresses from binary notation to dotted-decimal notation.

a. 10000001 00001011 00001011 11101111
b. 11000001 10000011 00011011 11111111
c. 11100111 11011011 10001011 01101111
d. 11111001 10011011 11111011 00001111

Answer

Example 2

Change the following IP addresses from dotted-decimal notation to binary notation.

a. *111.56.45.78*
b. *221.34.7.82*
c. *241.8.56.12*
d. *75.45.34.78*

Solution

Answer

Example 3

Find the error, if any, in the following IP addresses:

a. ***111.56.045.78***

b. ***221.34.7.8.20***

c. ***75.45.301.14***

d. ***11100010.23.14.67***

Solution

Answers

Example 4

Change the following IP addresses from binary notation to hexadecimal notation.

a. ***10000001 00001011 00001011 11101111***

b. ***11000001 10000011 00011011 11111111***

Solution

Ans

CLASSFUL ADDRESSING

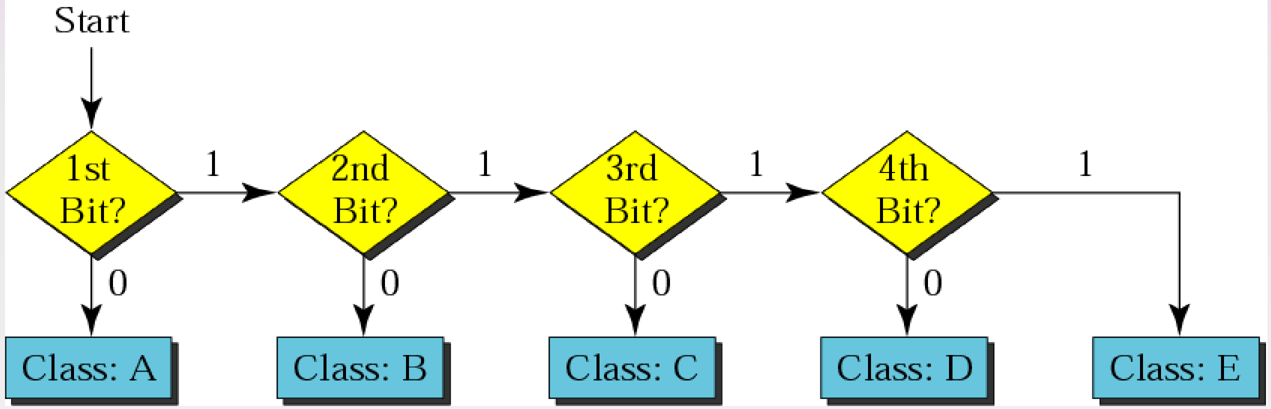
- *IP addresses, when started , used the concept of classes.*
- *This architecture is called classful addressing.*
- *In the mid-1990s, a new architecture, called classless addressing, was introduced and will eventually supersede the original architecture.*
- *However, part of the Internet is still using classful addressing, but the migration is very fast.*

Finding the class in binary notation

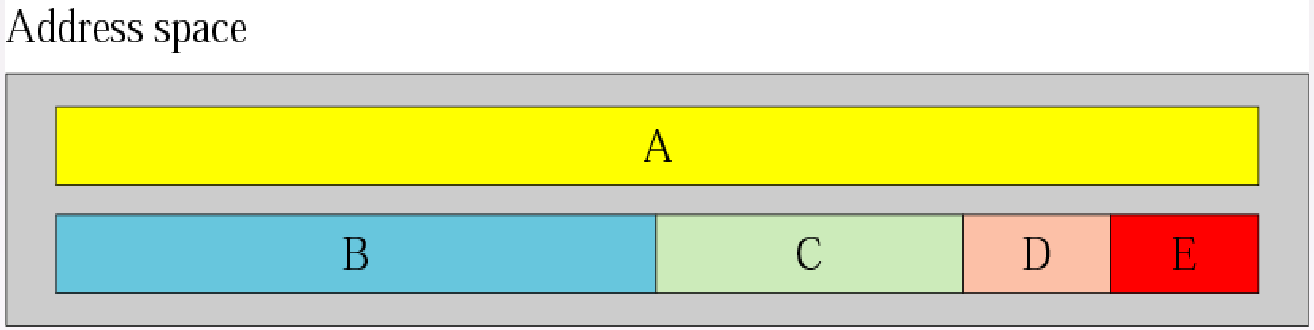
	First byte	Second byte	Third byte	Fourth byte
Class A	0			
Class B	10			
Class C	110			
Class D	1110			
Class E	1111			

	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			

CLASSFUL ADDRESSING



Class	*Number of Addresses*	*Percentage*
A	$2^{31} = 2,147,483,648$	50%
B	$2^{30} = 1,073,741,824$	25%
C	$2^{29} = 536,870,912$	12.5%
D	$2^{28} = 268,435,456$	6.25%
E	$2^{28} = 268,435,456$	6.25%



Example 6

Find the class of each address:

a. **00000001 00001011 00001011 11101111**
b. **11000001 10000011 00011011 11111111**
c. **10100111 11011011 10001011 01101111**
d. **11110011 10011011 11111011 00001111**

Answers

Example 7

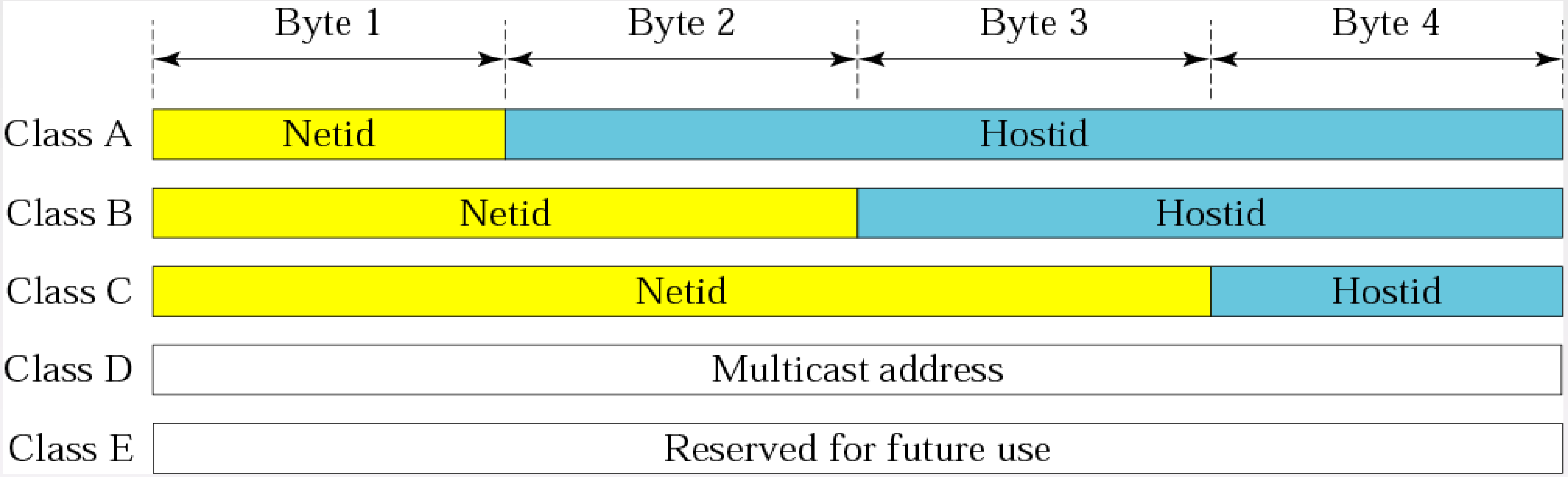
Find the class of each address:

a. ***227.12.14.87*** b. ***193.14.56.22*** c. ***14.23.120.8***

d. ***252.5.15.111*** e. ***134.11.78.56***

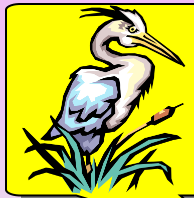
Answers

Netid and hostid



Note:

Class	*Mask in binary*	*Mask in dotted-decimal*
A	**11111111** 00000000 00000000 00000000	**255.**0.0.0
B	**11111111 11111111** 00000000 00000000	**255.255.**0.0
C	**11111111 111111111 11111111** 00000000	**255.255.255.**0



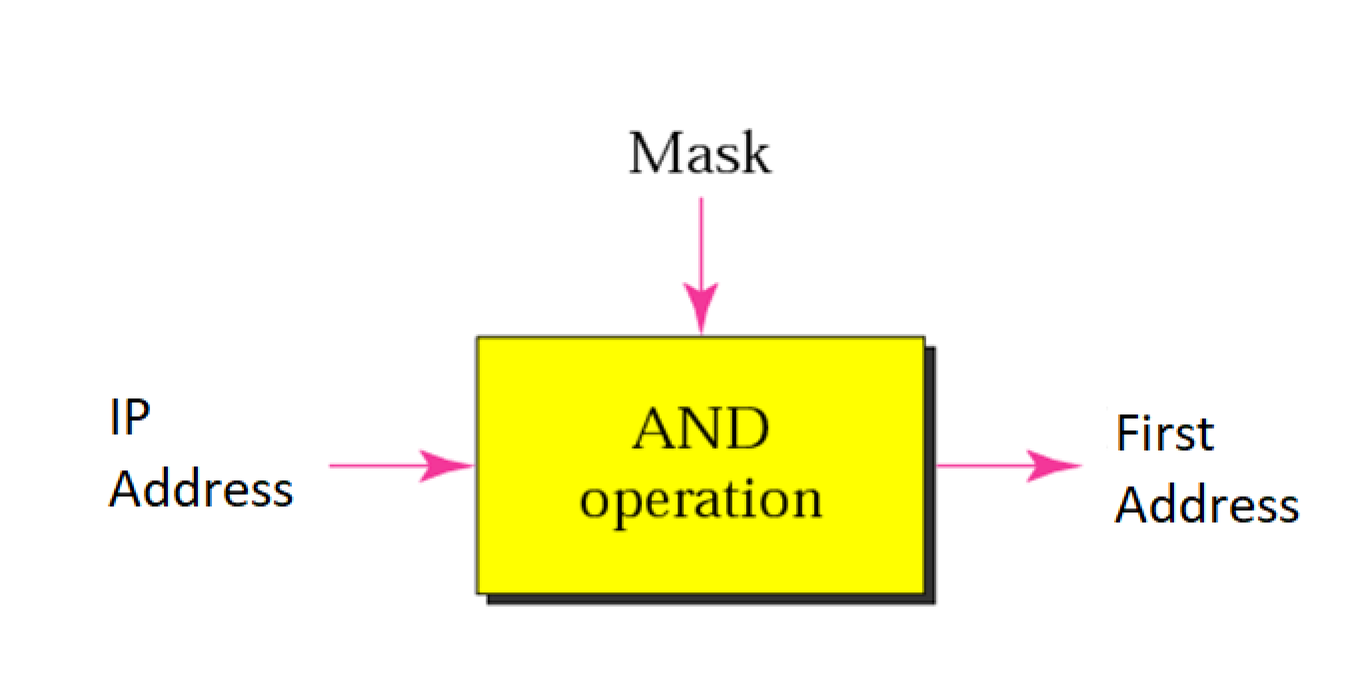
Note:

In classful addressing,

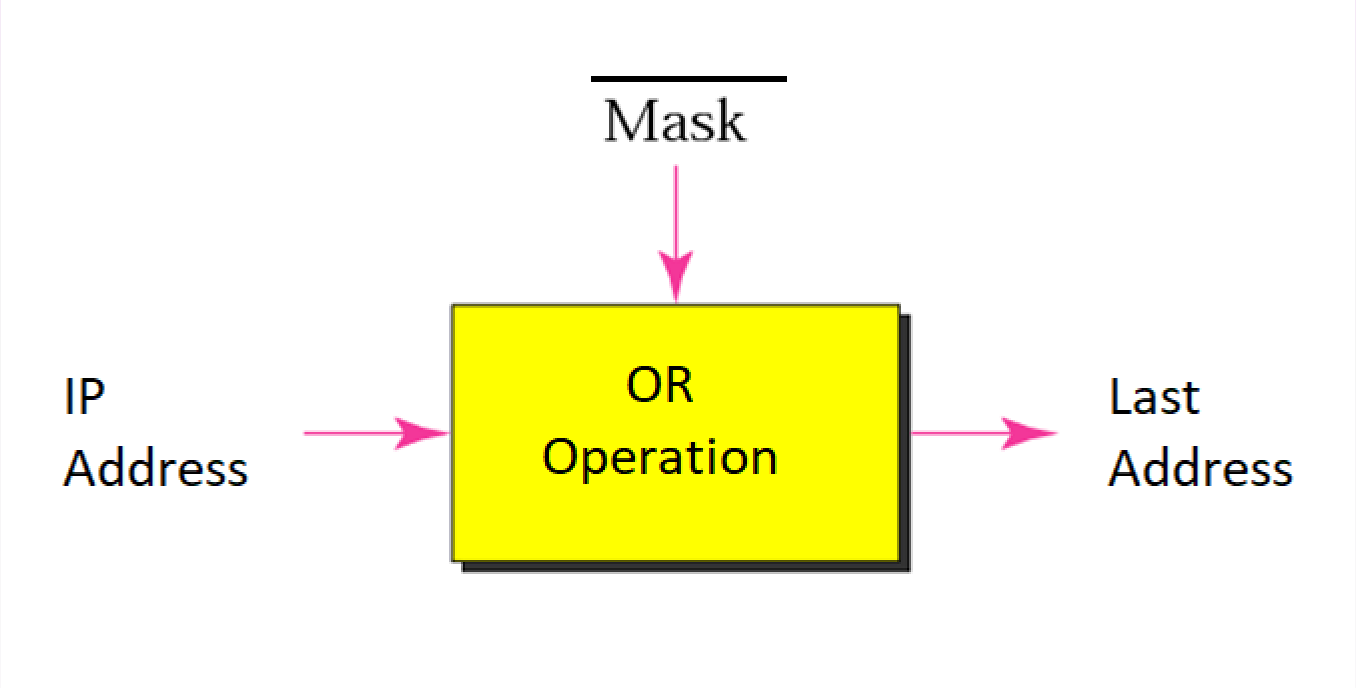
the network address (the first address in the block) is the one that is assigned to the organization.

The broadcast address (the last address in the block) .

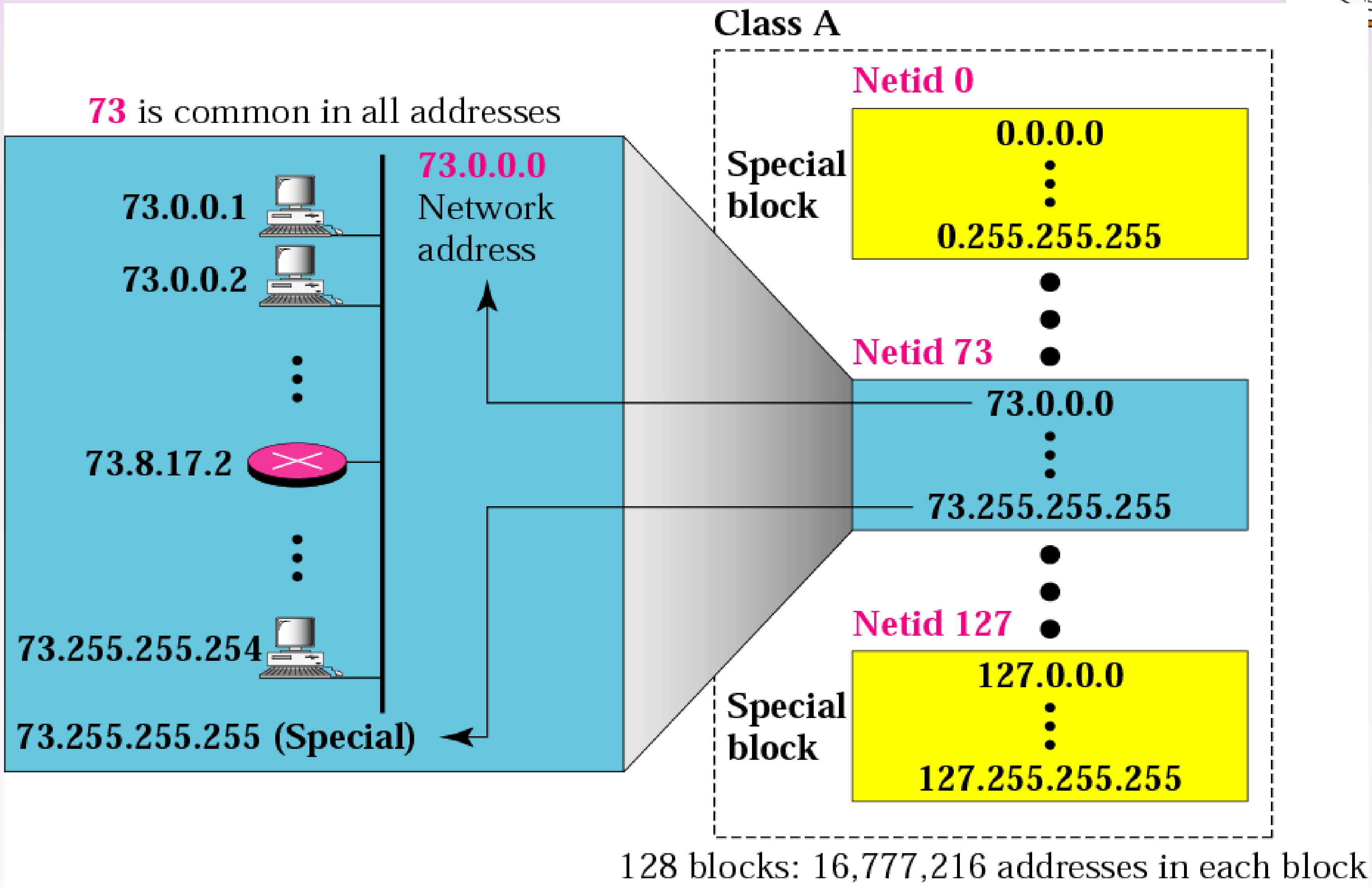
Calculating First or Network address



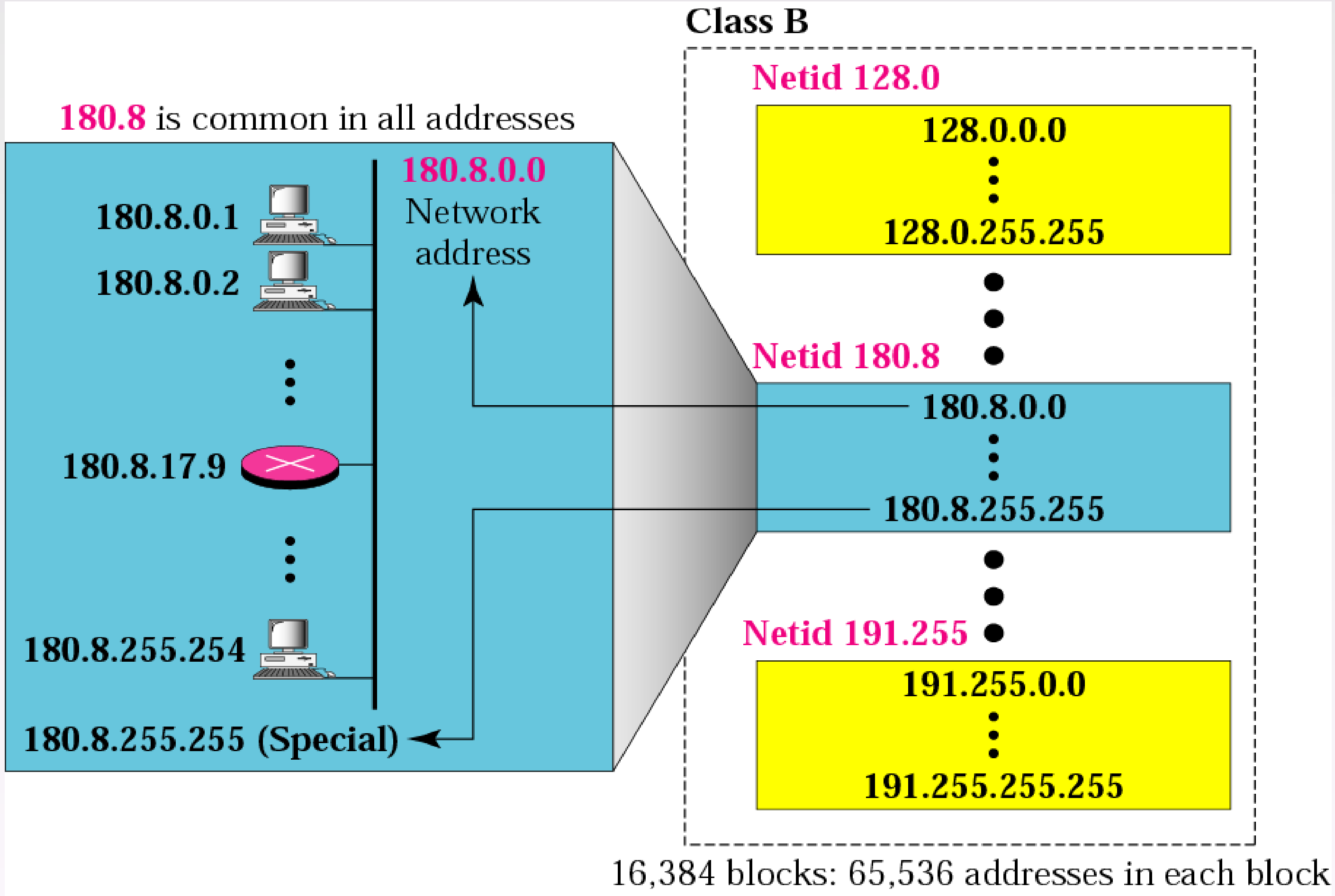
Calculating Last or Broadcast address



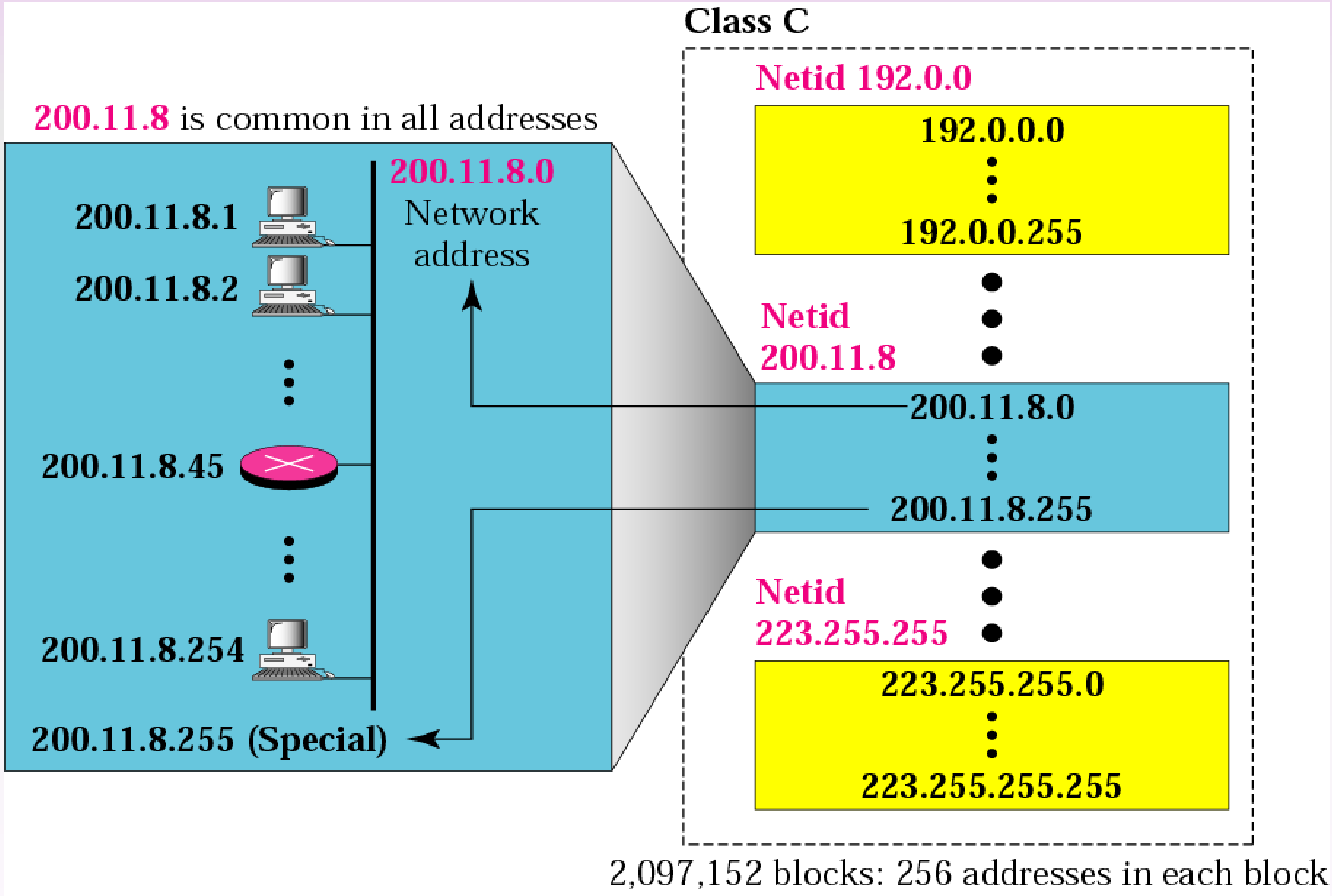
Blocks in class A



Blocks in class B



Blocks in class C



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 17.0.0.0

Broadcast address is 17.255.255.255

The addresses range from 17.0.0.0 to 17.255.255.255.

Example

Given the network address 132.21.0.0, find the class, the block, and the range of the addresses.

Solution

The class is B because the first byte is between 128 and 191. The block has a netid of 132.21.0.0

Broadcast address is 132.21.255.255

The addresses range from 132.21.0.0 to 132.21.255.255.

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 220.34.76.0

Broadcast address is 220.34.76.255

The addresses range from 220.34.76.0 to 220.34.76.255.

Example

Given the address 23.56.7.91, 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

The broadcast address is 23.255.255.255

Example

Given the address 132.6.17.85, find the beginning address (network address).

Solution

The default mask is 255.255.0.0, which means that the first 2 bytes are preserved and the other 2 bytes are set to 0s.

The network address is 132.6.0.0.

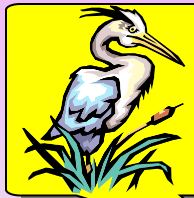
The broadcast addressis 132.6.255.255

Example

Given the address 201.180.56.5, find the beginning address (network address).

Solution

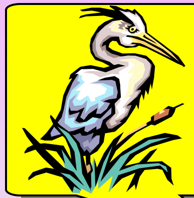
The default mask is 255.255.255.0, which means that the first 3 bytes are preserved and the last byte is set to 0. The network address is 201.180.56.0.



Note:

1st flaw in this design

- ***A block in class A address is too large for almost any organization.***
- ***This means most of the addresses in class A were wasted and were not used***



Note:

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2nd flaw in this design

- ***A block in class B is also very large, probably too large for many of the organizations that received a class B block***

Note:

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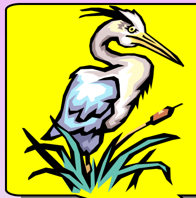
3rd flaw in this design

- ***A block in class C is probably too small for many organizations***



Note:

4th flaw in this design

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

5th flaw in this design

- ***Class E addresses are reserved for future purposes; most of the block is wasted.***

Solution

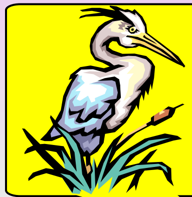
Subnetting and Supernetting

CIDR   Classless Interdomain Routing

NAT Network Address Translation

IP Version 6

SUBNETTING AND SUPERNETTING



Note:

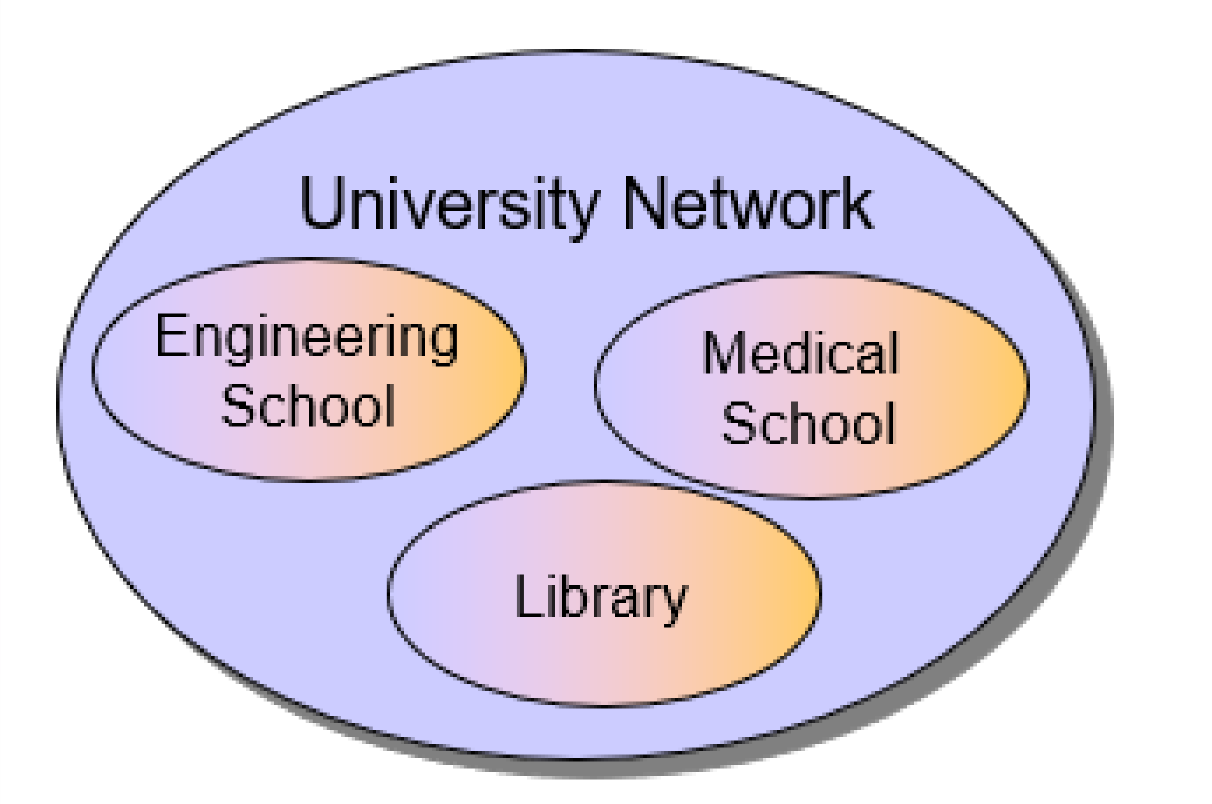
Subnetting means dividing a network in multiple small networks.

We use subnetting mainly to save the wastage of IP addresses.

In classful addressing, There are two types of subnetting,

- ***FLSM (Fixed Length Subnet Mask)***
- ***VLSM (Variable Length Subnet Mask).***

SUBNETTING Example FLSM



SUBNETTING Example FLSM

Let’s, consider an IP address 198.168.10.0

Divide this IP address into 4 subnetwork parts.
After dividing find out the range of IP addresses blocks.

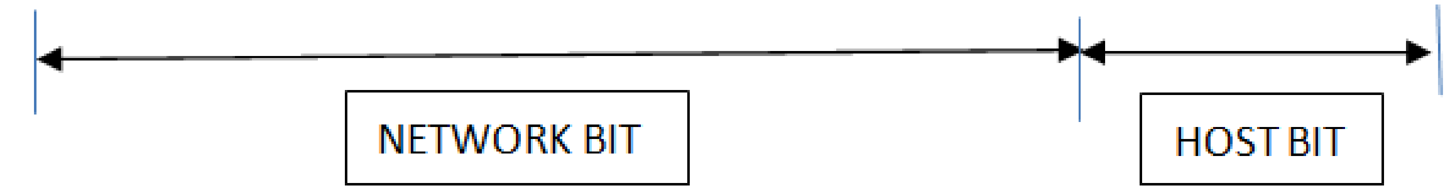
SUBNETTING Example FLSM

Step 1: Calculate the required subnet bit.

We are given a Class C IP address

default subnet mask for Class C is 255.255.255.0

11111111.11111111.11111111.00000000



SUBNETTING Example FLSM

Step 1: Calculate the required subnet bit.

Required subnetworks = 4

Here, we need to configure 4 subnets for this we need to borrow 2 bits and making the MSB of host bit of subnet mask to 1 and the value we will get

Step 2 Converted Subnet mask

11111111 . 11111111 . 11111111 . 11000000

255.255.255.192

i.e.

$2^1 = 2$

$2^2 = 4$

$2^3 = 8$

$2^4 = 16$

SUBNETTING Example FLSM

Step 3: We will find the range in this step.

Formula

Range: (Maximum Subnet Mask – Converted Subnet Mask)
Maximum Subnet Mask is always **255.255.255.255** for every case.

```
  255.255.255.255
- 255.255.255.192
=   0.  0.  0. 63
```

SUBNETTING Example FLSM

Step 4: Now we will divide the whole network with the help of the range.

First Network Block: 198.168.10.0 – 198.168.10.63
For this block Network ID will be **198.168.10.0**
and Broadcast address will be **198.168.10.63**

Second Network Block:198.168.10.64 – 198.168.10.127
For this block Network ID will be **198.168.10.64**
and Broadcast address will be **198.168.10.127**

SUBNETTING Example FLSM

Step 4: Now we will divide the whole network with the help of the range.

Third Network Block: 198.168.10.128 – 198.168.10.191

For this block Network ID will be **198.168.10.128**

and Broadcast address will be **198.168.10.191**

Fourth Network Block:198.168.10.192 – 198.168.10.255

For this block Network ID will be **198.168.10.192** and Broadcast address will be **198.168.10.255**

SUBNETTING Example VLSM

Difference between FLSM and VLSM

VLSM divide Network into multiple networks according to its need.

Let’s take the same IP address 198.168.10.0

configure the network in such a way that given network able to provide

A network with 20 IP addresses
and a network with 50 IP addresses.

SUBNETTING Example VLSM

Step 1

Arrange requirement in descending order.

I. A network with 50 IP addresses
II. A network with 20 IP addresses.

Calculate host bit for first network.

It is given 50 IP addresses is required but 1 IP is required for Network address and another is for Broadcast address.

So total requirement is 50+2=52 IP addresses.

SUBNETTING Example VLSM

Calculate host bit for first network.

52 IP addresses.

From here we can get that 6
Host bit is required,
Host bit = 6

$$\left.\begin{array}{l} 2^1 \geq 52 \\ 2^2 \geq 52 \\ 2^3 \geq 52 \\ 2^4 \geq 52 \\ 2^5 \geq 52 \end{array}\right\} \text{these are not possible}$$

$2^6 \geq 52 \quad => 64 \geq 52$

SUBNETTING Example VLSM

Step 2: Find out Network bit with the help of the given formula

Network bit= (32 – Host bit)

In this case Network bit = 32 – 6 =26

Step 3: Calculate updated subnet mask

Now we have the updated subnet mask:

11111111.11111111.11111111.11000000

255.255.255.192

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SUBNETTING Example VLSM

Step 3: Range = Maximum Subnet Mask – Updated Subnet Mask
Then we will get the final Range

```
  255.255.255.255
- 255.255.255.192
=   0.  0.  0. 63
```

Network Block for the 50 IP addresses is

198.168.10.0

to

198.168.10.63

SUBNETTING Example VLSM

Again, for 20 IP addresses we have to follow same 3 steps.

Total IP required = 20+2=22

Step 1:

$$\left.\begin{array}{l} 2^1 \geq 22 \\ 2^2 \geq 22 \\ 2^3 \geq 22 \\ 2^4 \geq 22 \end{array}\right\} \text{these are not possible}$$

$$2^5 \geq 22 \quad \Rightarrow \quad 32 \geq 22$$

Required Host Bit = 5

SUBNETTING Example VLSM

Step 2: Required Network Bits = 32 – 5= 27
Updated mask

11111111 . 11111111 . 11111111 . 11100000
255 . 255 . 255 . 224

SUBNETTING Example VLSM

Step 3

Range = Maximum Subnet Mask – Updated Subnet Mask

	255 . 255 . 255 . 255
-	255 . 255 . 255 . 224
Range	0 . 0 . 0 . 31

Network Block for 22 IP addresses is

from 198.168.10.64

to 198.168.10.95

SUPERNETTING or Aggregation

In supernetting, an organization can combine several class C blocks to create a larger range of addresses. In other words, several networks are combined to create a super network or a supernet.

An organization can apply for a set of class C blocks instead of just one Class B or A.

SUPERNETTING or Aggregation

For example, an organization that needs 1000 addresses can be granted four contiguous class C blocks. The organization can then use these addresses to create one supernetwork.

Supernetting decreases the number of Is in the mask.

For example, if an organization is given four class C addresses, the mask changes from /24 to /22.

Classless addressing eliminated the need for subnetting and supernetting.

SUPERNETTING or Aggregation

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For example, if an organization is given four class C addresses, the mask changes from /24 to /22.

Classless addressing eliminated the need for subnetting and supernetting.

SUPERNETTING or Aggregation

Conditions :

1. Networks should be contagious
2. Should be of same size and of 2^n.
3. First network should be divisible total size of the networks.

Example   Four class C networks as below:

200.1.0.0
200.1.1.0
200.1.2.0
200.1.3.0

Size of networks
4 Networks X 2^8
$= 2^2 \times 2^8 = 2^{10}$

First address: 200.1.0.0

11001000.00000001.00000000.00000000

SUPERNETTING or Aggregation

Examples Check Rule1 contagious :

List 1	List 2	List 3	List 4	List 5
192.168.0.0/24	192.168.1.0/24	192.168.0.0/24	192.168.0.0/24	10.4.0.0/16
192.168.1.0/24	192.168.2.0/24	192.168.1.0/24	192.168.1.0/24	10.5.0.0/16
		192.168.2.0/24	192.168.2.0/24	10.6.0.0/16
			192.168.4.0/24	10.7.0.0/16

Check contagious by adding 1 to IPs

The networks in List 1 are contiguous. ***Qualifies for next round***.
The networks in List 2 are contiguous. ***Qualifies for next round***.
The networks in List 3 are contiguous. ***Qualifies for next round***.
The networks in List 4 are not contiguous. ***Does not qualify for next round***.
The networks in List 5 are contiguous. ***Qualifies for next round***.

SUPERNETTING or Aggregation

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Examples Rule #2: Number of networks order of 2:

List 1	List 2	List 3	List 5
192.168.0.0/24	192.168.1.0/24	192.168.0.0/24	10.4.0.0/16
192.168.1.0/24	192.168.2.0/24	192.168.1.0/24	10.5.0.0/16
		192.168.2.0/24	10.6.0.0/16
			10.7.0.0/16

Check Number of networks order of 2:

There are 2 networks to be aggregated in List 1 which is an order of 2. Qualifies for next round.
There are 2 networks to be aggregated in List 2 which is an order of 2. Qualifies for next round.
There are 3 networks to be aggregated in List 3 which is not an order of 2. Does not qualify for next round.
There are 4 networks to be aggregated in List 5 which is an order of 2. Qualifies for next round.

SUPERNETTING or Aggregation

Examples Rule #3: Value of non-common octet in first IP block is zero or a multiple of the number of networks to be aggregated

List 1	List 2	List 5
192.168.0.0/24	192.168.1.0/24	10.4.0.0/16
192.168.1.0/24	192.168.2.0/24	10.5.0.0/16
		10.6.0.0/16
		10.7.0.0/16

Rule #3: Value of non-common octet in first IP block is zero or a multiple of the number of networks to be aggregated:

1. The first non-common octet in List 1 is the 3rd octet i.e. 0 vs. 1. The first (lowest) IP address block is 192.168.0.0/24. The decimal value of the 3rd octet in this address block is 0. Qualifies to be aggregated.

2. The first non-common octet in List 2 is the 3rd octet i.e. 1 vs. 2. The first (lowest) IP address block is 192.168.1.0/24. The decimal value of the 3rd octet in this address block is 1. This value is not zero or a multiple of the number of networks to aggregated (2). Does not qualify to be aggregated.

3. The first non-common octet in List 5 is the 2nd octet i.e. 4 vs. 5 vs. 6 vs. 7. The first (lowest) IP address block is 10.4.0.0/16. The decimal value of the 2nd octet in this address block is 4. This value is a multiple of the number of networks to aggregated (4). Qualifies to be aggregated.

How-To: Supernetting

How-To: Supernetting

Example, 192.168.0.0/24 and 192.168.1.0/24

These two networks are the same all the way to the 23rd block .
The 24th block is where the difference is.
Therefore, the subnet mask of the new supernet will be 1 all the way to the 23rd block and then 0 from tl

192	168	0	0
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0

192	168	1	0
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 0 0 1	0 0 0 0 0 0 0 0

255	255	254	0
1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 0	0 0 0 0 0 0 0 0

Finally, the supernet will be the first IP block is 192.168.0.0 with the new subnet mask

192.168.0.0 255.255.254.0 or 192.168.0.0/23.

How-To: Supernetting

How-To: Supernetting

Example:

10.4.0.0/16, 10.5.0.0/16, 10.6.0.0/16, 10.7.0.0/16.

These networks are the same up to the 14th bit. Therefore, the supernet is 10.4.0.0 255.252.0.0 or 10.4.0.0/14:

10	4	0	0
0 0 0 0 1 0 1 0	0 0 0 0 0 1 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
10	**5**	**0**	**0**
0 0 0 0 1 0 1 0	0 0 0 0 0 1 0 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
10	**6**	**0**	**0**
0 0 0 0 1 0 1 0	0 0 0 0 0 1 1 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
10	**7**	**0**	**0**
0 0 0 0 1 0 1 0	0 0 0 0 0 1 1 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
255	**252**	**0**	**0**
1 1 1 1 1 1 1 1	1 1 1 1 1 1 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0

Note:

The idea of subnetting and supernetting of classful addresses is almost obsolete.

CIDR - Classless Interdomain Routing

In 1993, the size of the routing tables started to outgrow the capacity of routers
Consequence: The Class-based assignment of IP addresses had to be abandoned

Goals:
Restructure IP address assignments to increase efficiency
Hierarchical routing aggregation to minimize route table entries

CIDR
Classless Interdomain routing, abandons the notion of classes:

Key Concept: The length of the network id (prefix) in the IP addresses is kept arbitrary

Consequence: Routers advertise the IP address and the length of the prefix

CIDR - Example

CIDR notation of a network address:

192.0.2.0/18

"18" says that the first 18 bits are the network part of the address and 14 bits are available for specific host addresses.

The network part is called the prefix

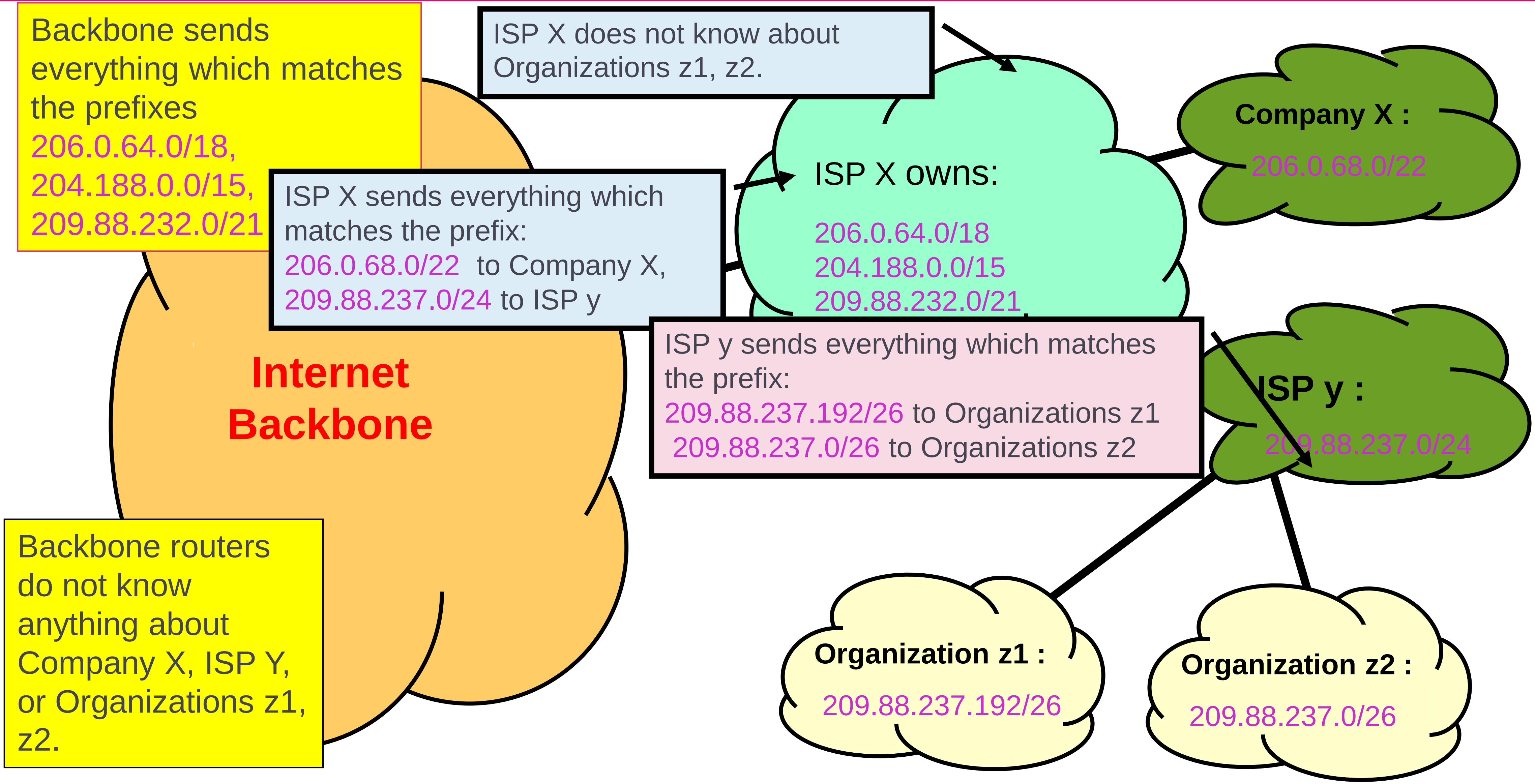
Assume that a site requires a network address with 1000 addresses
With CIDR, the network is assigned a continuous block of 1024 addresses with a 22-bit long prefix

CIDR and Routing Information

CIDR - Example

CIDR Block Prefix	# of Host Addresses
/27	32 hosts
/26	64 hosts
/25	128 hosts
/24	256 hosts
/23	512 hosts
/22	1,024 hosts
/21	2,048 hosts
/20	4,096 hosts
/19	8,192 hosts
/18	16,384 hosts
/17	32,768 hosts
/16	65,536 hosts
/15	131,072 hosts
/14	262,144 hosts
/13	524,288 hosts

CIDR - Routing Information



CIDR - Example

A router receives a packet with the destination address

131.24.67.32/20

Show how the router finds the network address of the packet.

Step 1 : First find Default mask , for / 20 so

Default mask DM

11111111.11111111.11110000.00000000

255.255.240.0

CIDR - Example

Step 2: Bitwise AND operation between IP and Default Mask, to find network address

Destination Address	131.	24.	67.	32
Default mask	255.	255.	240.	0

Destination Address	10000011.	00011000.	01000011.	00100000
Default mask	11111111.	11111111.	11110000.	00000000
Bitwise AND operation	10000011.	00011000.	01000000.	00000000
Network Address	131.	24.	64.	0

CIDR - Example

Step 3: Bitwise OR operation between IP and compliment of Default Mask, to find Direct Broadcast address

Destination Address	131.	24.	67.	32
Default mask	255.	255.	240.	0
Destination Address	10000011.	00011000.	01000011.	00100000
Compliment of Default mask	00000000.	00000000.	00001111.	11111111
Bitwise OR operation	10000011.	00011000.	01001111.	00000000
Network Address	131.	24.	79.	0

Limited Broadcast address is 255.255.255.255

NAT : Network Address Translation

- A short term solution to the problem of the depletion of IP addresses
  - Long term solution is IP v6
  - CIDR (Classless InterDomain Routing) is a possible short term solution
  - NAT is another

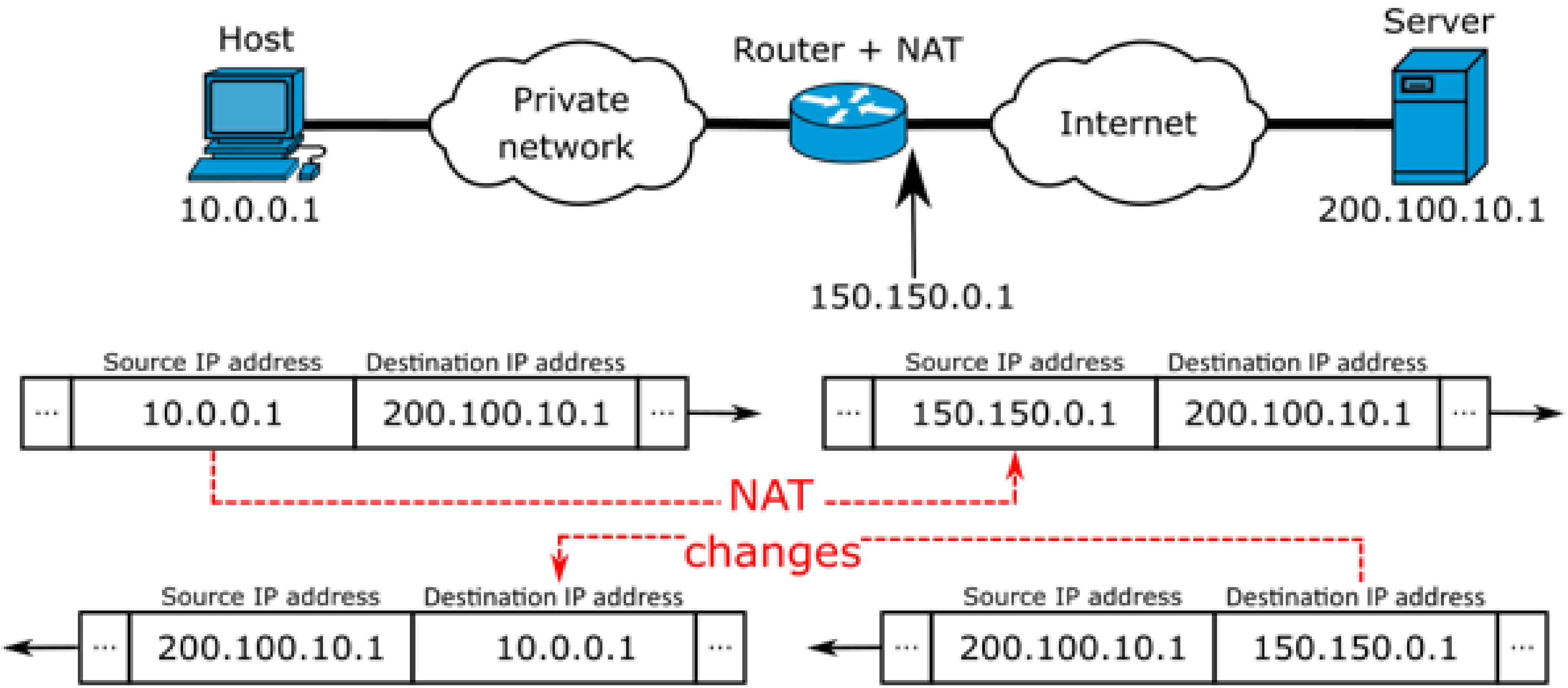
Private Addresses

Class A → 10.0.0.0 – 10.255.255.255,

Class B → 172.16.0.0 – 172.31.255.255,

Class C → 192.168.0.0 – 192.168.255.255

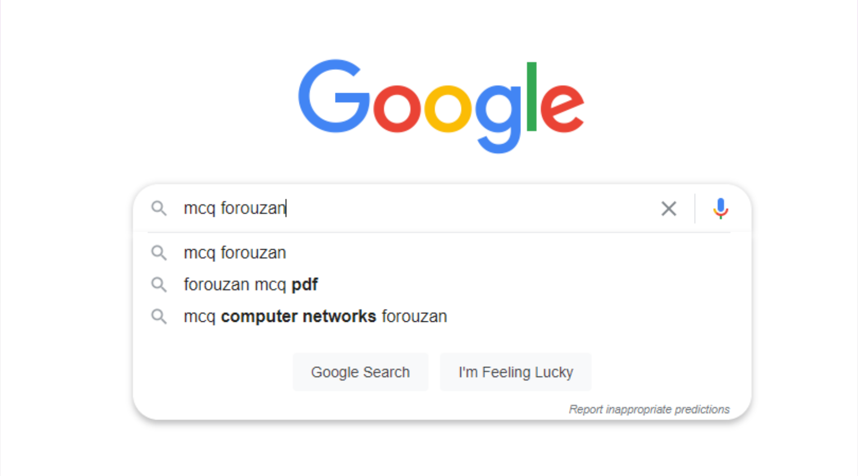
NAT : Network Address Translation

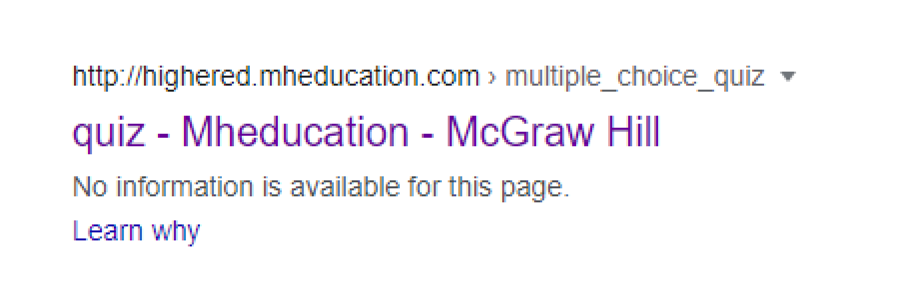


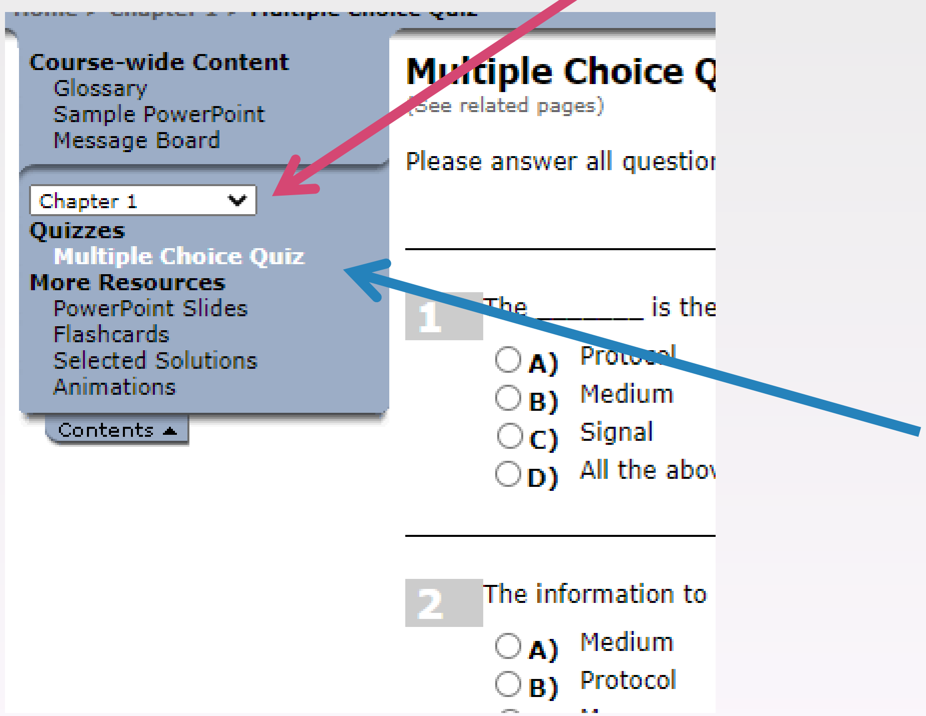
Key	Private IP Address	Public IP Address
Scope	Private IP address scope is local to present network.	Public IP address scope is global.
Communication	Private IP Address is used to communicate within the network.	Public IP Address is used to communicate outside the network.
Provider	Local Network Operator creates private IP addresses using network operating system.	ISP, Internet Service Provider controls the public IP address.
Cost	Private IP Addresses are free of cost.	Public IP Address comes with a cost.

Range	Private IP Address range:
	`10.0.0.0 – 10.255.255.255,`
	`172.16.0.0 – 172.31.255.255,`
	`192.168.0.0 – 192.168.255.255`
		Except private IP Addresses, rest IP addresses are public.

Links for mcq







Link for books mcq

http://highered.mheducation.com/sites/0072967757/student_view0/chapter1/multiple_choice_quiz.html

From the above link chose the chapter number and click on Multiple Choice Quiz.

See you in next class