IP ADDRESSES
CLASSFUL ADDRESSING
SUBNETTING
CLASSLESS ADDRESSING
SUPERNETTING
NAT

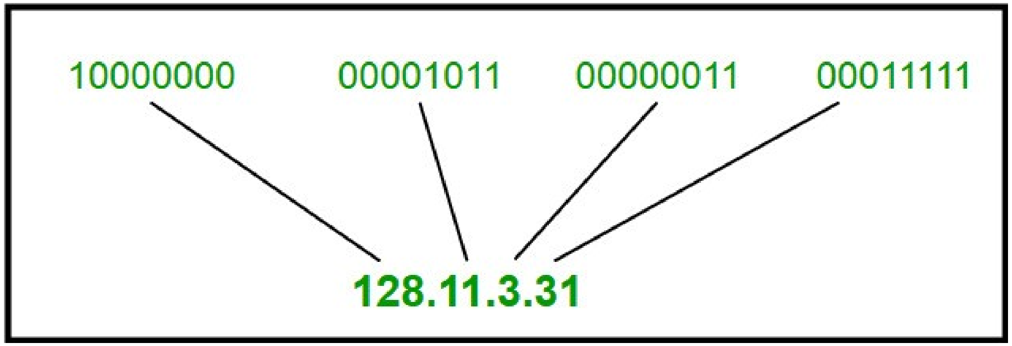
IP Addresses in depth

- Identify each individual machine on the internet
- 32 bits, with 8 bit groupings
  - E.x: 192.168.0.1
  - Each number between the dots can be between 0 and 255

Dotted Decimal Notation

The address space of IPv4 is

2^{32} or 4,294,967,296.



Hexadecimal Notation

0111 0101 1001 0101 0001 1101 1110 1010

75 95 1D EA

0x75951DEA

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

10000001 00001011 00001011 11101111

Find the error, if any, in the following IPv4 addresses:

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67

Convert from dotted decimal – binary and hexadecimal:

114.34.2.8

238.34.2.1

Convert from binary to dotted decimal

11000001 10000011 00011011 11111111

10100111 11011011 10001011 01101111

Netmasks

- IPv4 addresses consist of
  - **Network Part**: identifies the category of the network that's assigned.
  - **Host Part**: uniquely identifies the machine on your network.

  For each host on the network, the network part is the same, however, the host half must vary.
- Determined by the address and the class of the address
- Example (Class C):
  - IP Address: 192.168.3.16

What is the network address?

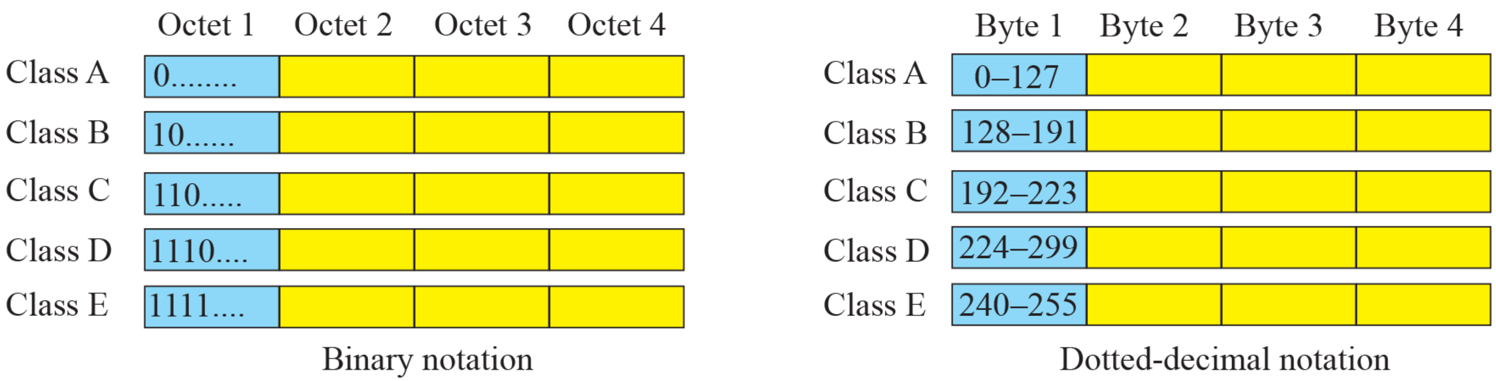
1. **IP:** 192.168.1.130
   Mask: 255.255.255.0
2. **IP:** 10.20.30.40
   Mask: 255.255.255.0
3. **IP:** 172.16.5.25
   Mask: 255.255. 255.0
4. **IP:** 172.16.5.25
   Mask: 255.255.0.0
5. **IP:** 10.20.30.40
   Mask: 255.0.0.0

RELATIONSHIP BETWEEN IP ADDRESS AND SUBNET MASK

- To find the network address, perform a bitwise AND between the IP address and the subnet mask.
- Each bit of the IP is compared with the subnet mask:
  - 1 AND 1 = 1
  - 1 AND 0 = 0
  - 0 AND 1 = 0
  - 0 AND 0 = 0

Classful Addressing

Class A	The network ID is 8 bits long. The host ID is 24 bits long. IP addresses ranges from 0.0.0.0 – 127.255.255.255. The default subnet mask for Class A is 255.x.x.x.
Class B	The network ID is 16 bits long. The host ID is 16 bits long. IP addresses ranges from 128.0.0.0 – 191.255.255.255. The default subnet mask for class B is 255.255.x.x.
Class C	The network ID is 24 bits long. The host ID is 8 bits long. IP addresses range from 192.0.0.0 – 223.255.255.255. The default subnet mask for class C is 255.255.255.x
Class D	Reserved for multi-casting. IP addresses range from 224.0.0.0 – 239.255.255.255. Class D does not possess any subnet mask
Class E	Reserved for experimental and research purposes. IP addresses range from 240.0.0.0 – 255.255.255.255 This class doesn't have any subnet mask.

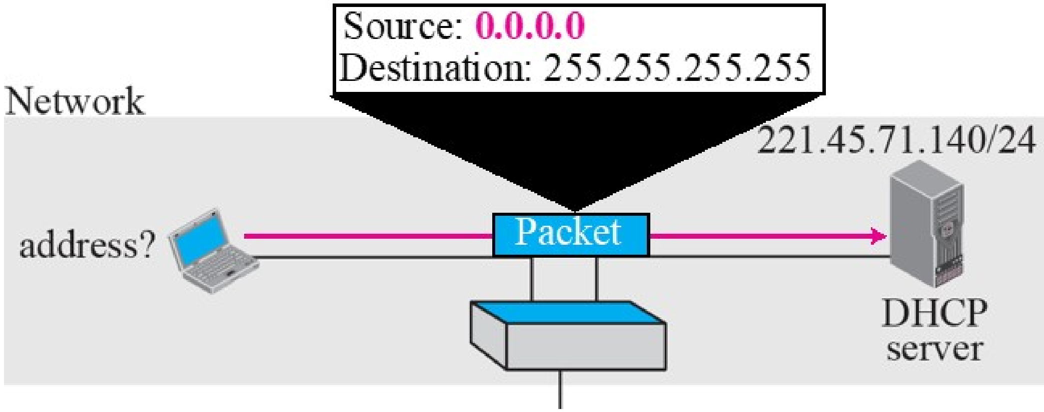


Five Different Classes of IPv4 Addresses

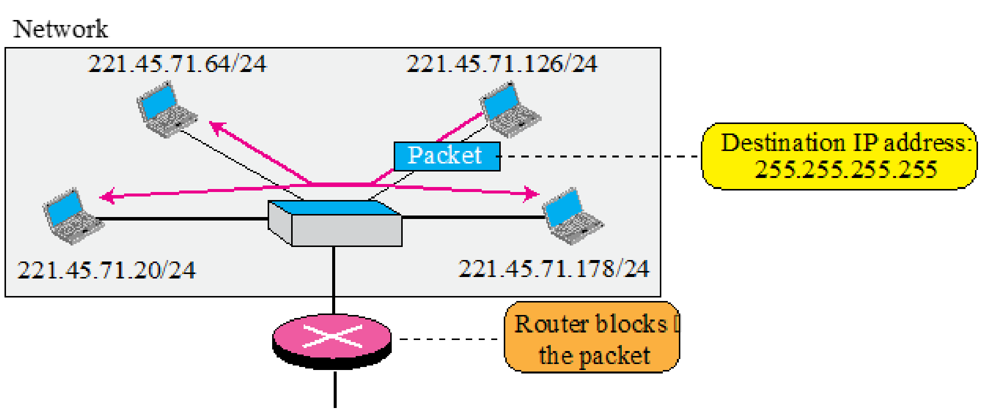
Class	First Octet decimal (range)	First Octet binary (range)	IP range	Subnet Mask	Hosts per Network ID	# of networks
Class A	0 – 127	0XXXXXXX	0.0.0.0-127.255.255.255	255.0.0.0	$2^{24}-2$	2^{7}
Class B	128 – 191	10XXXXXX	128.0.0.0-191.255.255.255	255.255.0.0	$2^{16}-2$	2^{14}
Class C	192 – 223	110XXXXX	192.0.0.0-223.255.255.255	255.255.255.0	$2^{8}-2$	2^{21}
Class D (Multicast)	224 – 239	1110XXXX	224.0.0.0-239.255.255.255			
Class E (Experimental)	240 – 255	1111XXXX	240.0.0.0-255.255.255.255			

Special Addresses

All-Zeros Address block To find its own address

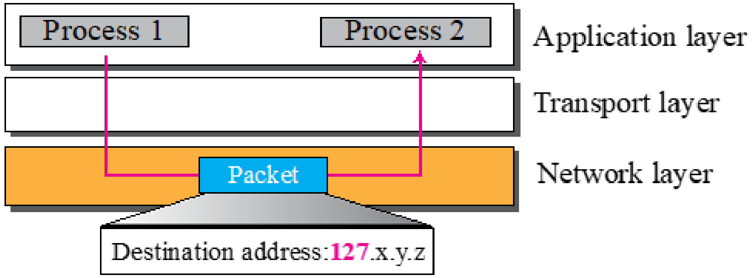


All-Ones Address: Limited Broadcast Address



Special Addresses

Loopback Addresses



ping 127.0.0.0

Used only as a destination address in an IPv4 packet

Private Addresses

Addresses for private networks

Block	*Number of addresses*	*Block*	*Number of addresses*
10.0.0.0/8	16,777,216	192.168.0.0/16	65,536
172.16.0.0/12	1,047,584	169.254.0.0/16	65,536

Assigned for private use, not recognized globally.

Multicast Addresses

The block 224.0.0.0/4 is reserved for multicast communication.

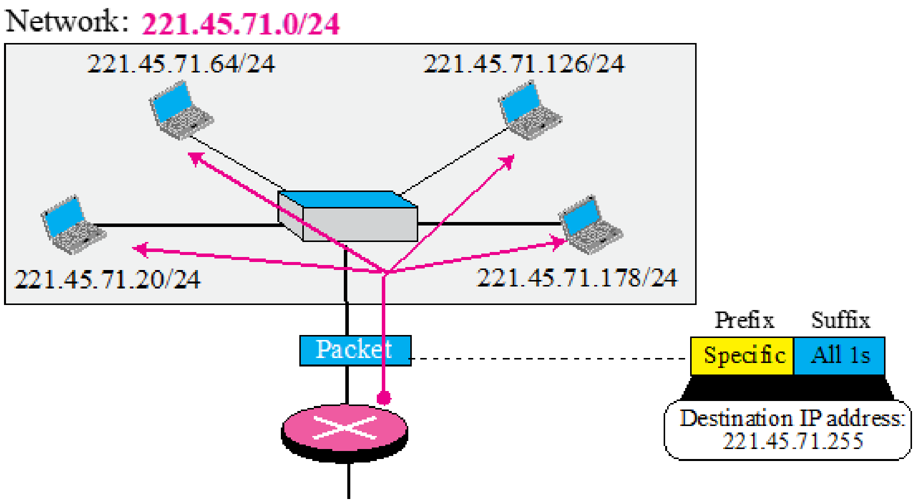
Special Addresses in each block

Network Address

The first address (with the suffix set all to 0s) in a block defines the network address. It actually defines the network itself and not any host in the network..

Direct Broadcast Address

The last address in a block or subblock (with the suffix set all to 1s) can be used as a direct broadcast address. Only used as a destination address in an IPv4 packet.



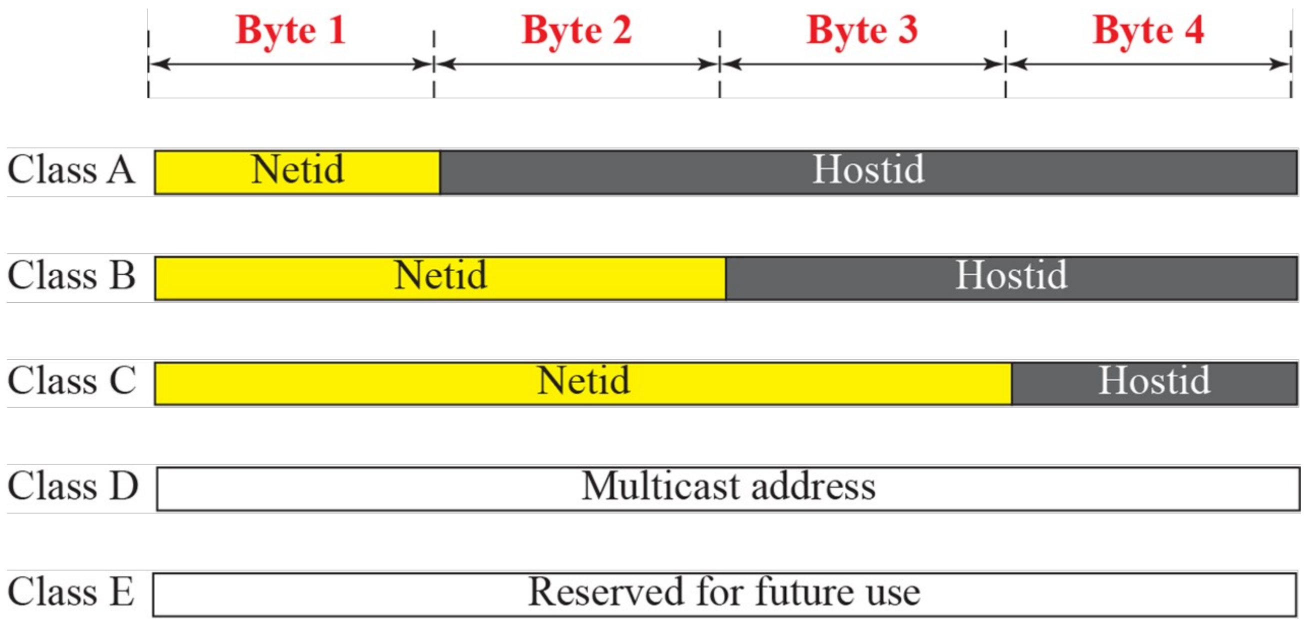
Find the class of each address:

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

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

- In classful addressing, an IP address in classes A, B, and C is divided into netid and hostid.

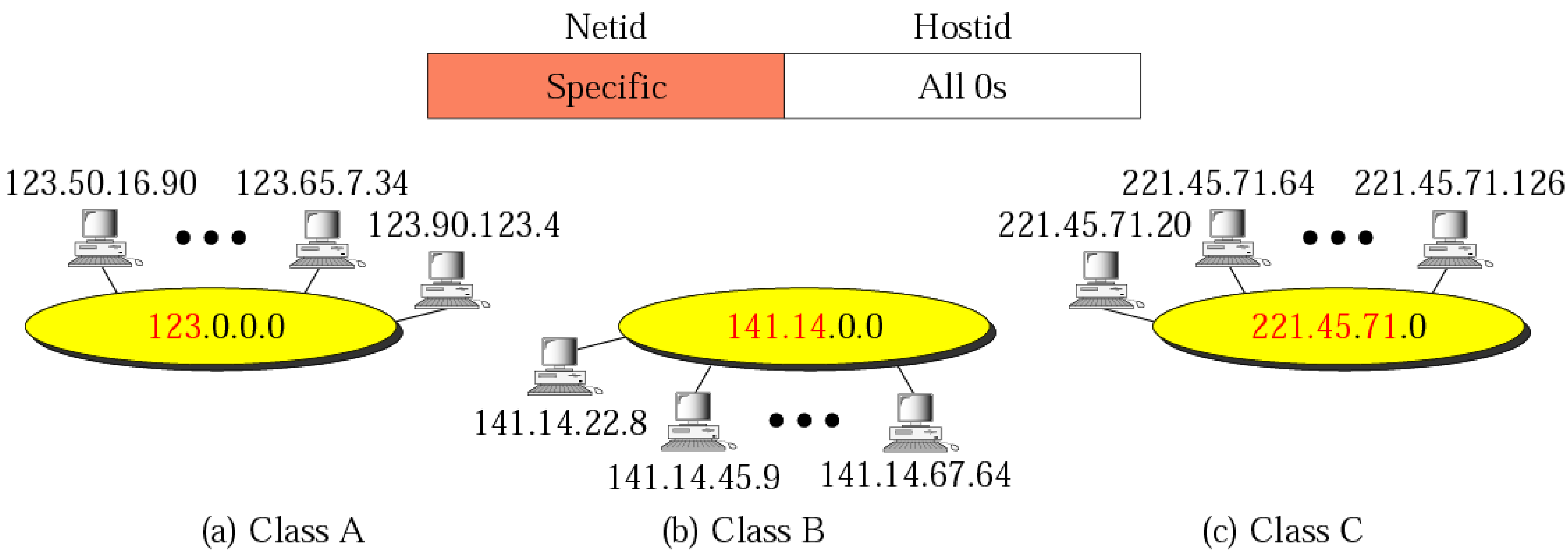


How can we prove that we have 2,147,483,648 addresses in class A?

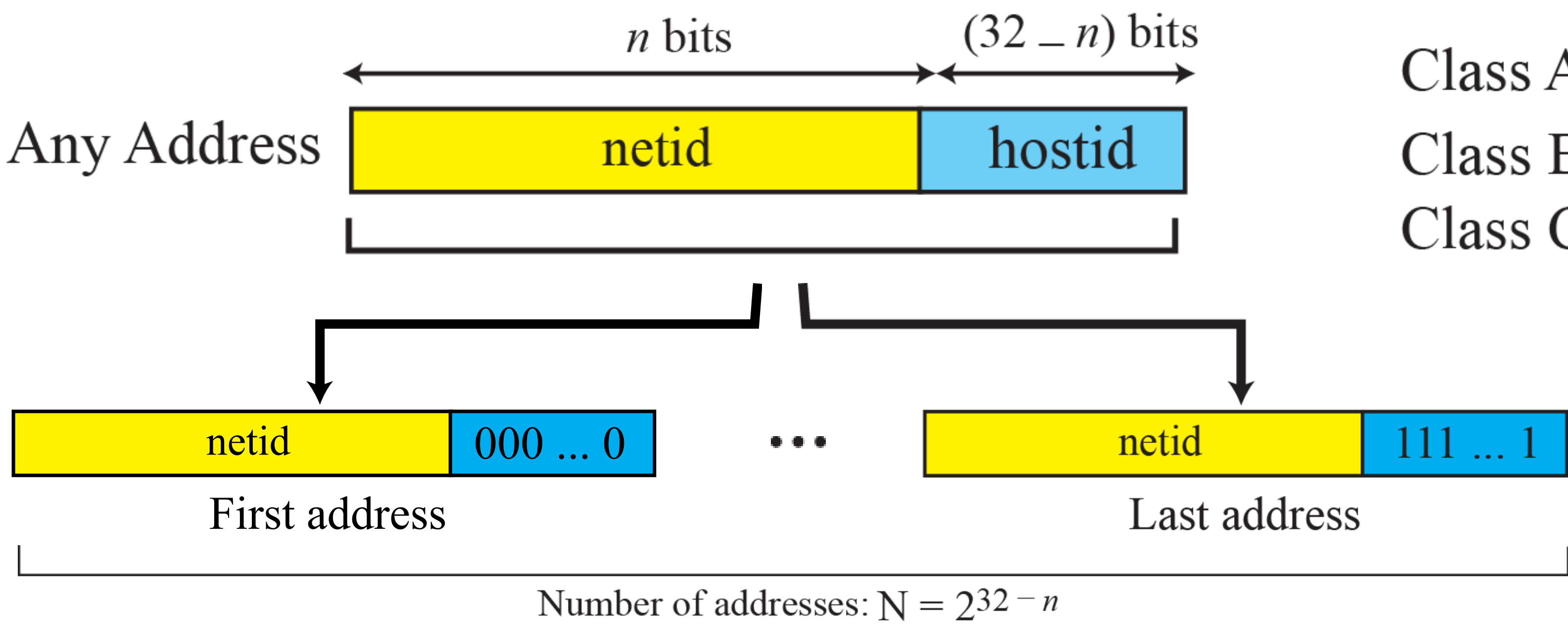
How can we prove this same fact using dotted-decimal notation?

Network Addresses

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


Netid
Hostid
Specific
All 0s
123.50.16.90
123.65.7.34
123.90.123.4
123.0.0.0
141.14.0.0
141.14.22.8
141.14.45.9
141.14.67.64
221.45.71.64
221.45.71.126
221.45.71.20
221.45.71.0
(a) Class A
(b) Class B
(c) Class C

Extracting Information in a Block



Class A: $n = 8$

Class B: $n = 16$

Class C: $n = 24$

1. The number of addresses in the block, N, can be found using $N = 2^{32-n}$.
2. To find the first address(Network address), we keep the n leftmost bits and set the $(32 - n)$ rightmost bits all to 0s.
3. To find the last address(broadcast address), we keep the n leftmost bits and set the $(32 - n)$ rightmost bits all to 1s.

The Host address are between the network and broadcast address

An organization is assigned the IP address **172.16.0.0**.

- Identify the class of this IP address.
- What is the default subnet mask for this class?
- Write the network address.
- Write the broadcast address for this network.
- How many valid host addresses are available in this network?

- Given IP address 132.6.17.85 and default class B mask, find the beginning address (network address).

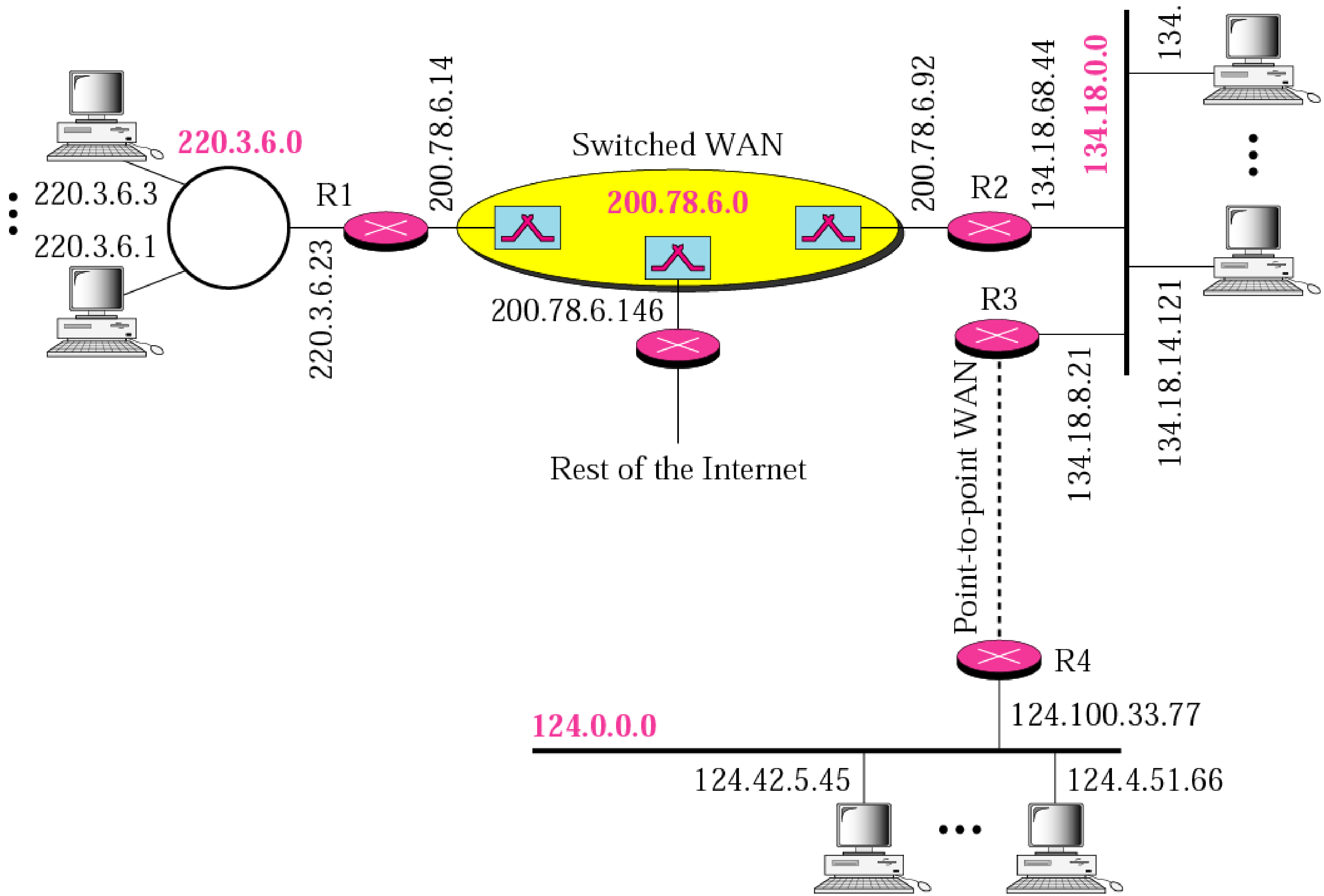
- An address in a block is given as 73.22.17.25. Find the number of addresses in the block, the Network address, the direct broadcast address and limited broadcast address. Also find the range of the IP addresses that can be assigned to the hosts in the network.

- An address in a block is given as 180.8.17.9. Find the number of addresses in the block, the first address, and the last address.

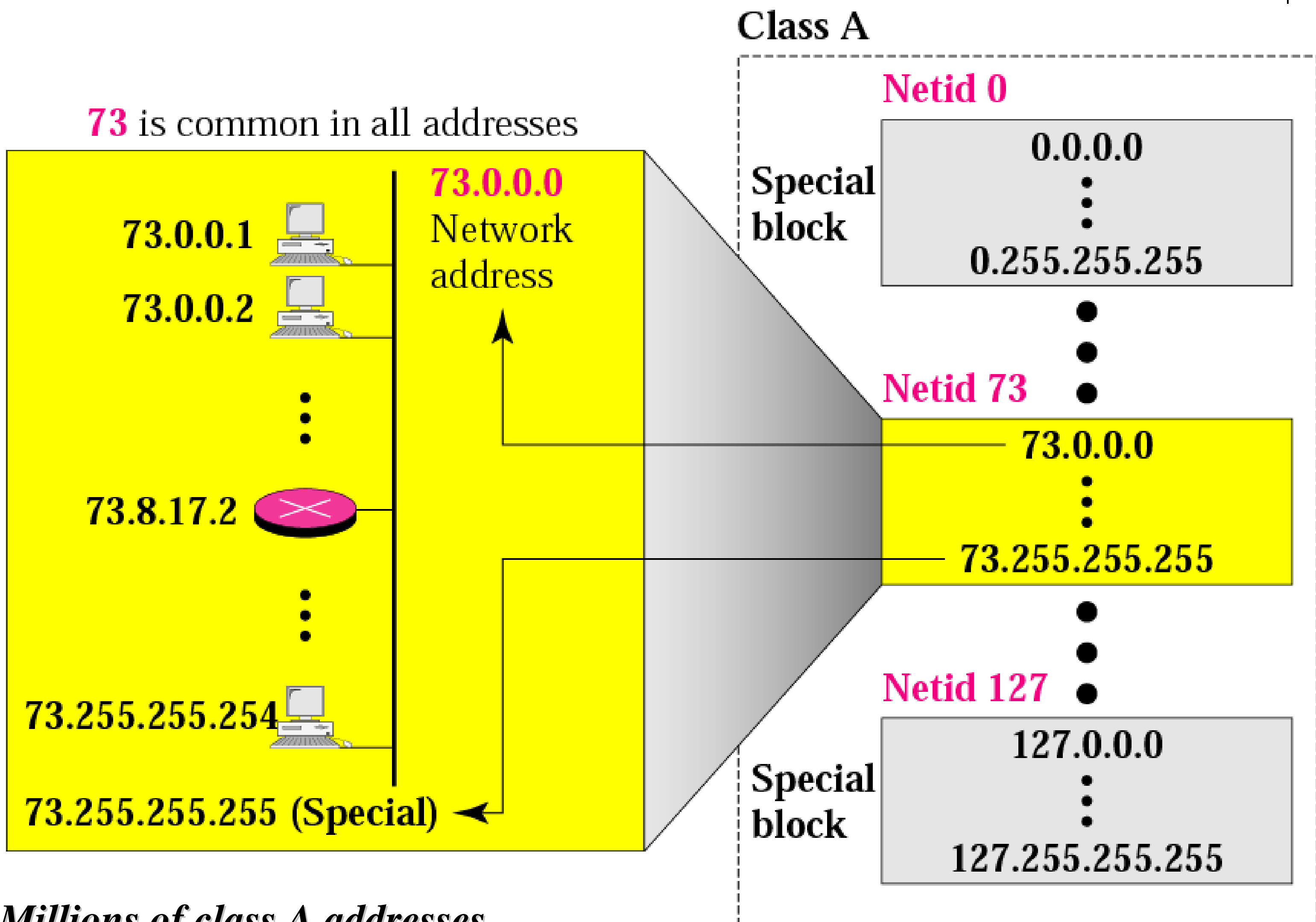
- An address in a block is given as 200.11.8.45. Find the number of addresses in the block, the first address, and the last address.

Figure 4-19

Sample internet



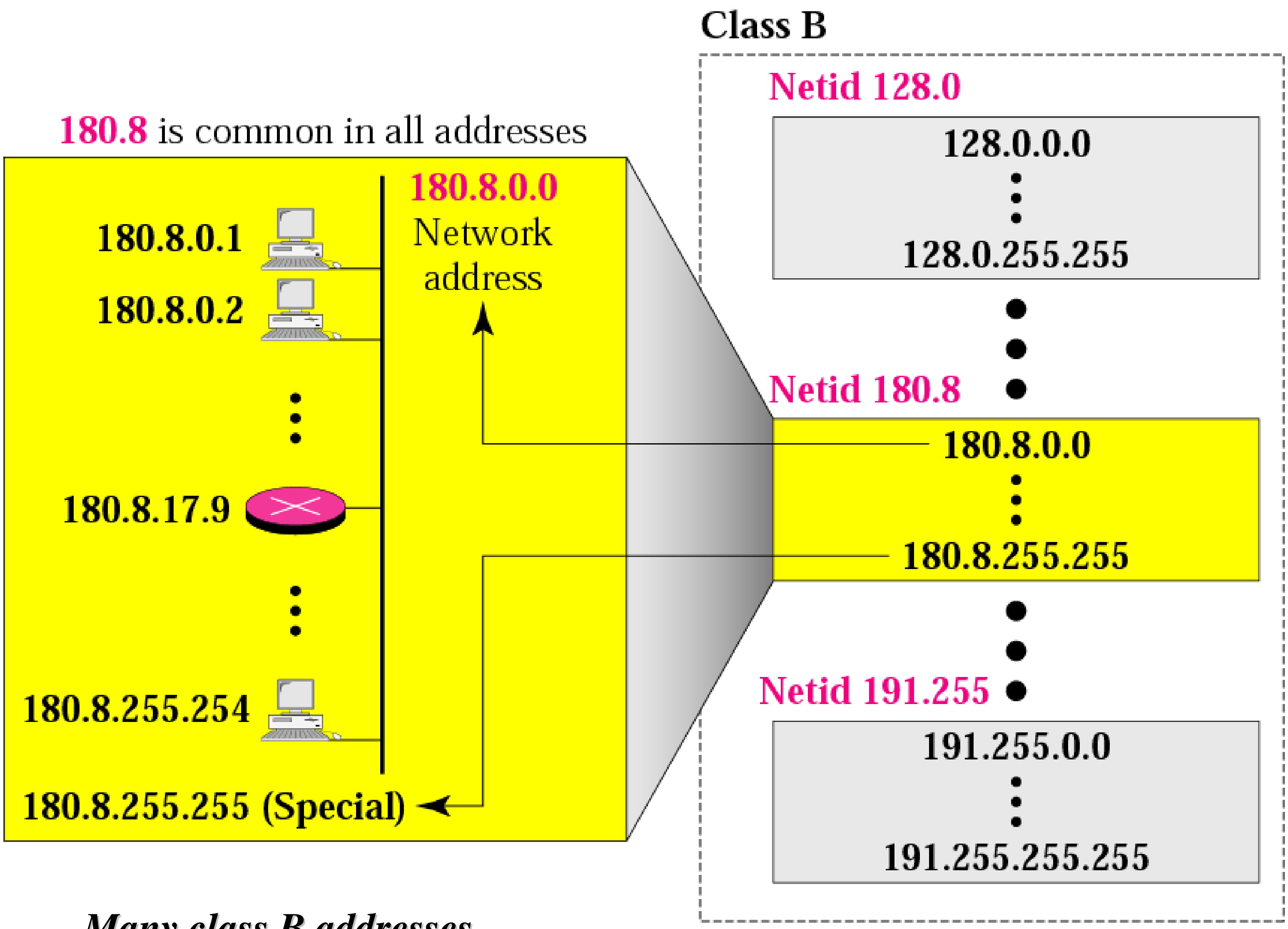
Blocks in class A



Millions of class A addresses are wasted.

128 blocks: 16,777,216 addresses in each block

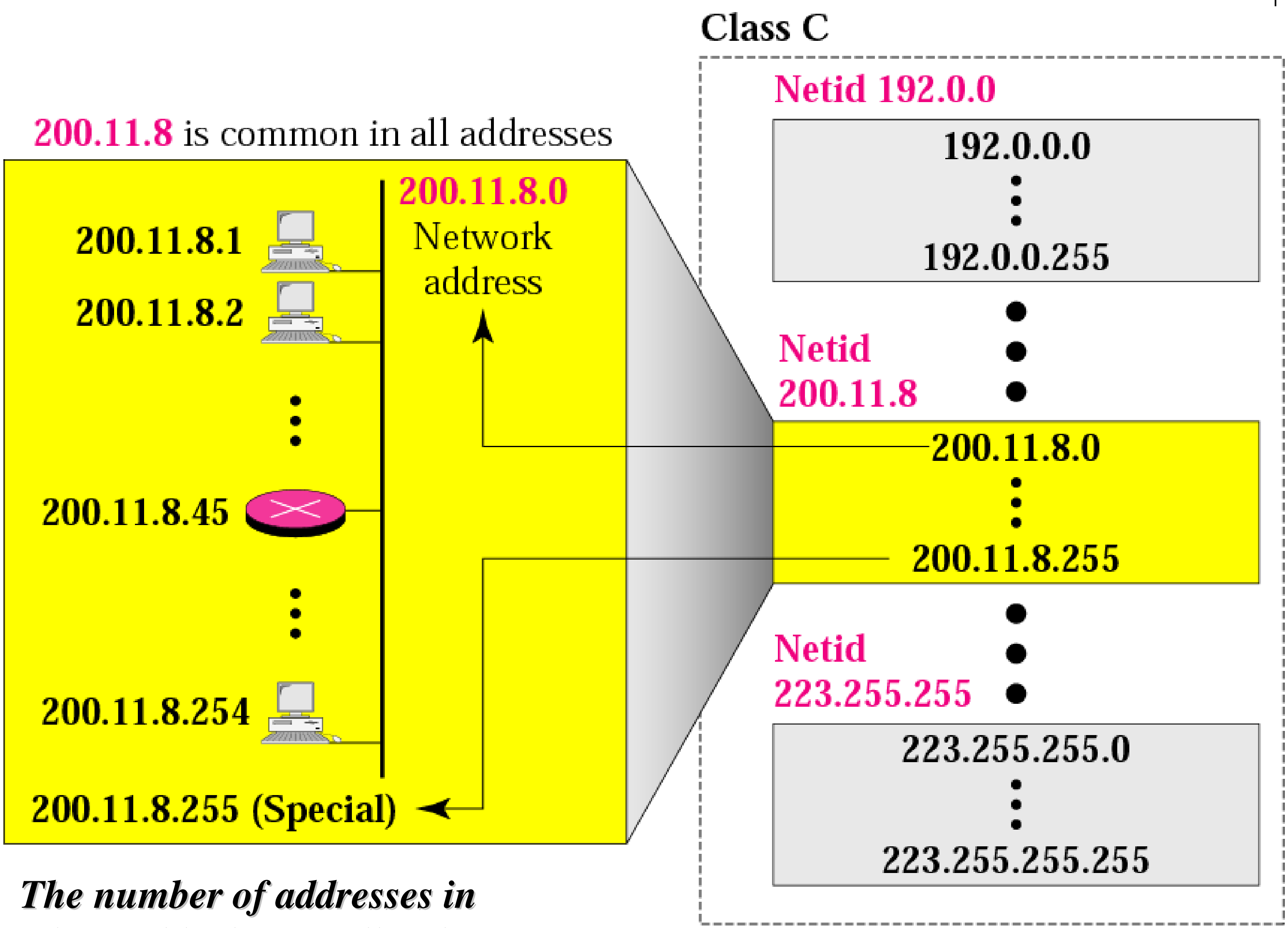
Blocks in class B



Many class B addresses are wasted.

16,384 blocks: 65,536 addresses in each block

Blocks in class C



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

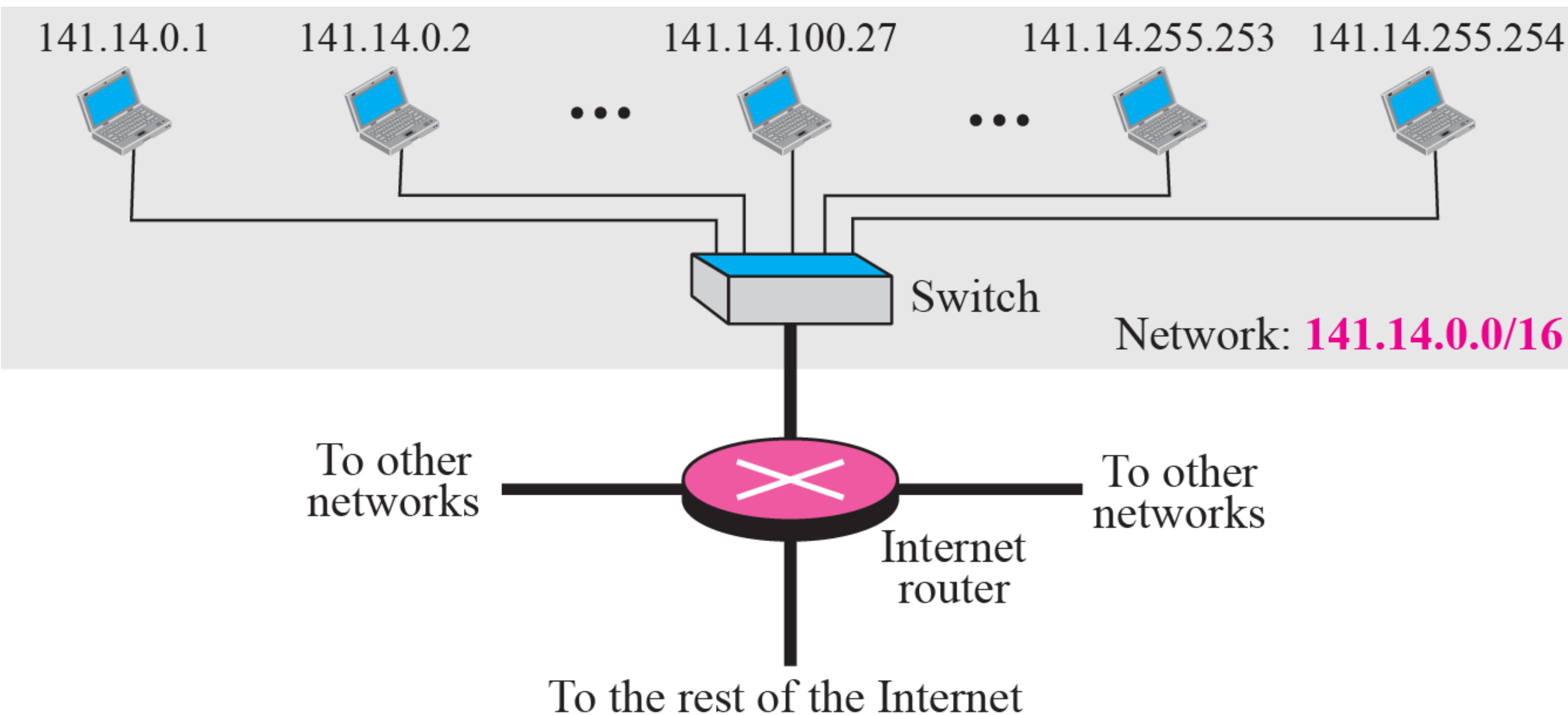
2,097,152 blocks: 256 addresses in each block

Subnetting

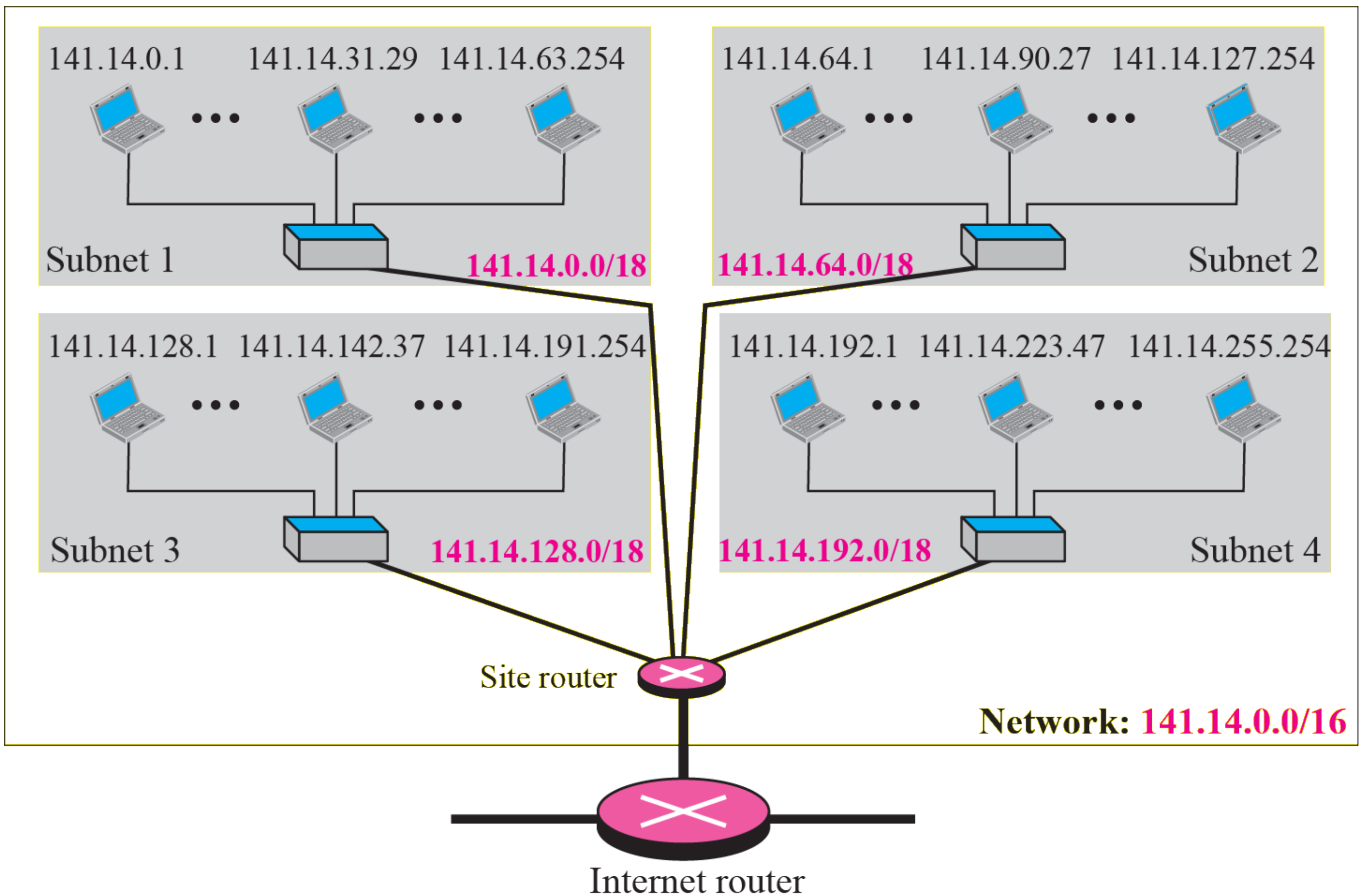
- Subnetting is a method used in IP networking to break down a large network into smaller, more manageable parts, known as subnets. This is done by altering the subnet mask of an IP address.

- IP addresses use the classful addressing where classes have a **fixed number of blocks** and each block has a **fixed number of hosts**.

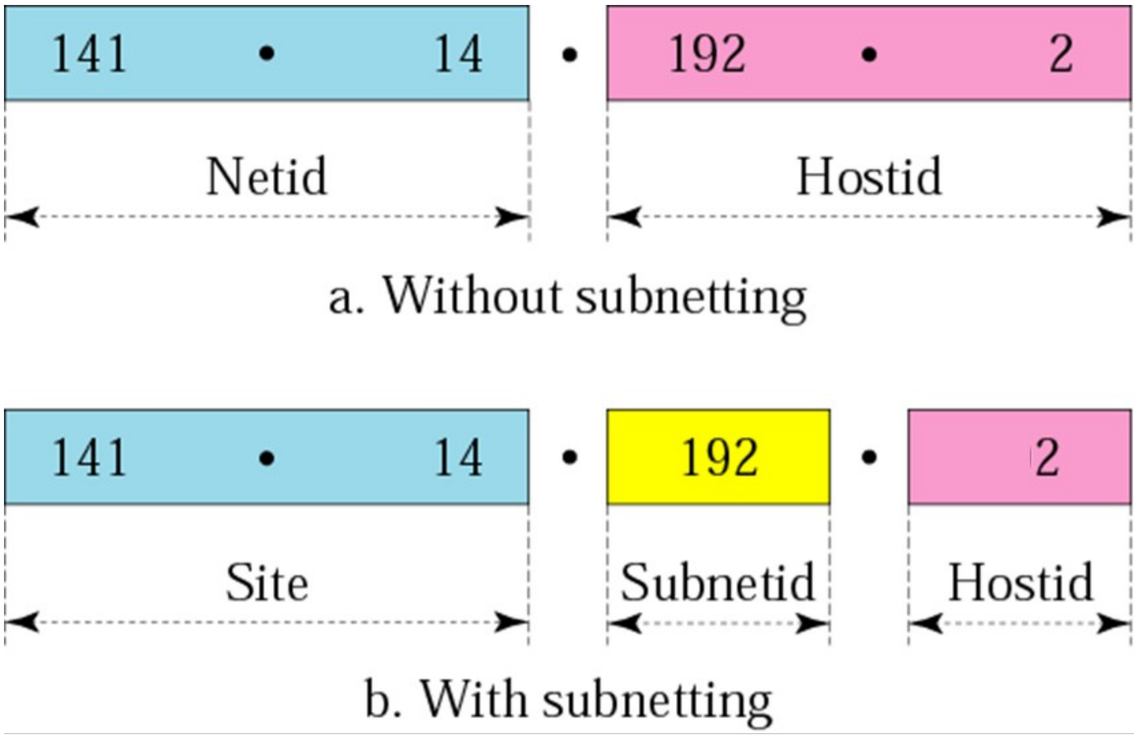
- A network using class B addresses, just one network with almost 2^{16} hosts (before subnetting)

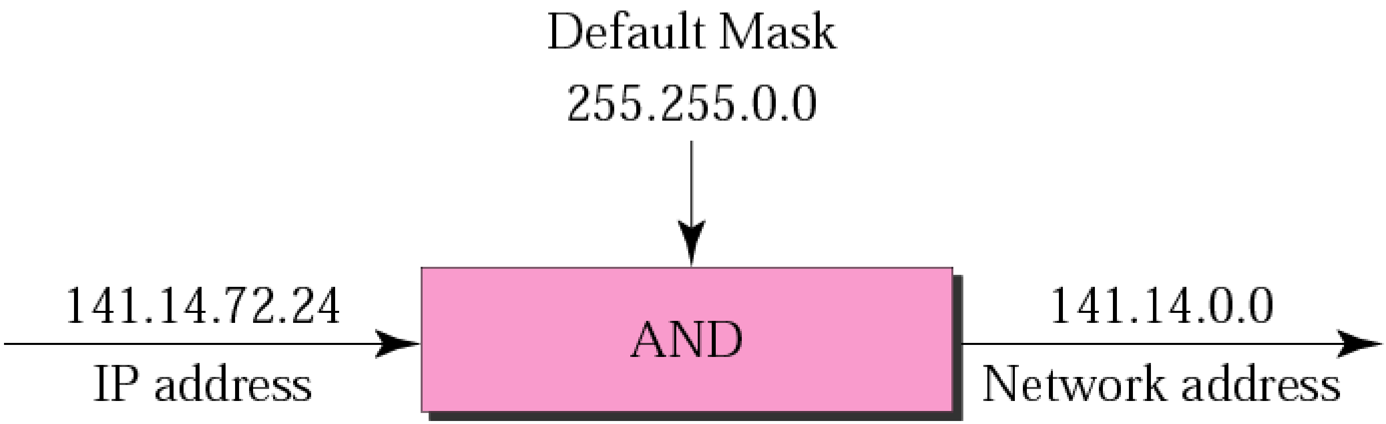


- The Internet sees only one network; internally the network is made of four subnetworks. Each subnetwork can now have almost 2^{14} hosts

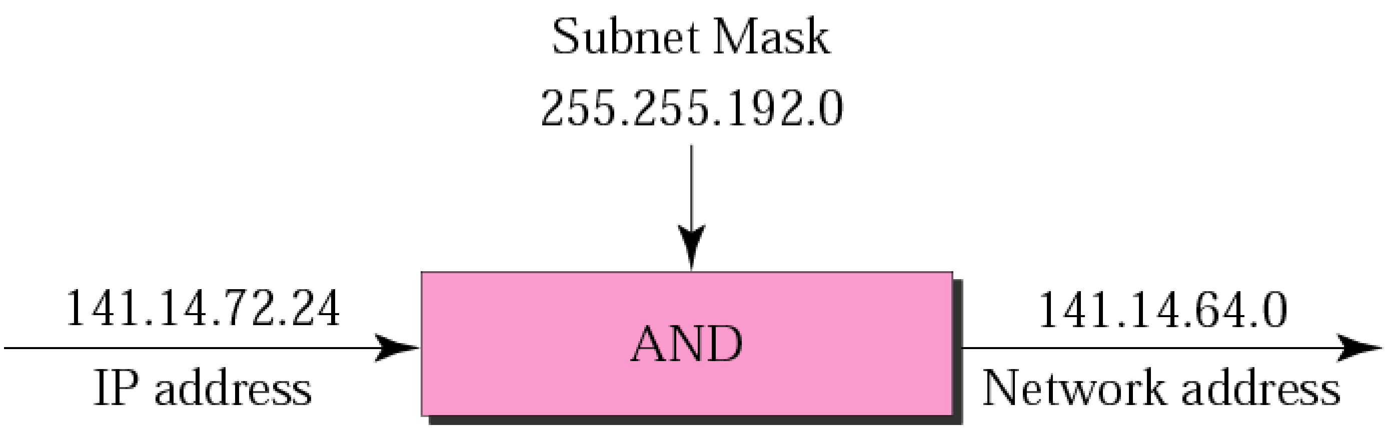


Addresses in a network with and without subnetting





a. Without subnetting



b. With subnetting

- *Slash notation is also called CIDR notation.*

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).

In a subnetted network, to get n, count the number of bits in the network id.

Instead of classifying the IP address based on classes, routers retrieve the network and host address as specified by the CIDR suffix

- Given the IP address and Subnet Mask, What is the First address(Subnet address) and last address(broadcast address) and host address range?
- IP 25.34.12.56 with SM 255.255.0.0
- IP 131.134.112.66 with SM 255.255.224.0
- IP 202.44.82.16 with SM 255.255.255.192
- 25.34.12.56/16
- 182.44.82.16/26

What is the subnetwork address if the destination address is 200.45.34.56 and the subnet mask is 255.255.240.0?

What is the subnetwork address if the destination address is 19.30.80.5 and the mask is 255.255.192.0?

Questions:

- What is the maximum number of IP addresses that can be assigned to hosts on a local subnet that uses the 255.255.255.224 subnet mask?

DESIGNING SUBNETS

- Once address block is granted, we assume
  - N – total number of addresses
  - n – prefix length
  - N_{sub} – address assigned to each subnetwork
  - s – total number of subnetworks
- Steps to follow for the proper operation of subnets

The number of addresses in each subnetwork should be a power of 2.

The prefix length for each subnetwork should be found as n

The starting address in each subnetwork should be divisible by the number of addresses in that subnetwork. This can be achieved if we first assign addresses to larger networks.

In subnetting, we need the first address of the subnet and the subnet mask to define the range of addresses.

Class A Subnets

To make more subnet in Class A, bits from Host part are borrowed and the subnet mask is changed accordingly.

For example, if one MSB (Most Significant Bit) is borrowed from host bits of second octet and added to Network address, it creates two Subnets ($2^1=2$) with ($2^{23}-2$) 8388606 Hosts per Subnet.

The Subnet mask is changed accordingly to reflect subnetting.

Network Bits	Subnet Mask	Bits Borrowed	Subnets	Hosts/Subnet
8	255.0.0.0	0	1	16777214
9	255.128.0.0	1	2	8388606
10	255.192.0.0	2	4	4194302
11	255.224.0.0	3	8	2097150
12	255.240.0.0	4	16	1048574
13	255.248.0.0	5	32	524286
14	255.252.0.0	6	64	262142
15	255.254.0.0	7	128	131070
16	255.255.0.0	8	256	65534
17	255.255.128.0	9	512	32766
18	255.255.192.0	10	1024	16382
19	255.255.224.0	11	2048	8190
20	255.255.240.0	12	4096	4094
21	255.255.248.0	13	8192	2046
22	255.255.252.0	14	16384	1022
23	255.255.254.0	15	32768	510
24	255.255.255.0	16	65536	254
25	255.255.255.128	17	131072	126
26	255.255.255.192	18	262144	62
27	255.255.255.224	19	524288	30
28	255.255.255.240	20	1048576	14
29	255.255.255.248	21	2097152	6
30	255.255.255.252	22	4194304	2

Class B Subnets

Network Bits	Subnet Mask	Bits Borrowed	Subnets	Hosts/Subnet
16	255.255.0.0	0	0	65534
17	255.255.128.0	1	2	32766
18	255.255.192.0	2	4	16382
19	255.255.224.0	3	8	8190
20	255.255.240.0	4	16	4094
21	255.255.248.0	5	32	2046
22	255.255.252.0	6	64	1022
23	255.255.254.0	7	128	510
24	255.255.255.0	8	256	254
25	255.255.255.128	9	512	126
26	255.255.255.192	10	1024	62
27	255.255.255.224	11	2048	30
28	255.255.255.240	12	4096	14
29	255.255.255.248	13	8192	6
30	255.255.255.252	14	16384	2

Class C Subnets

Network Bits	Subnet Mask	Bits Borrowed	Subnets	Hosts/Subnet
24	255.255.255.0	0	1	254
25	255.255.255.128	1	2	126
26	255.255.255.192	2	4	62
27	255.255.255.224	3	8	30
28	255.255.255.240	4	16	14
29	255.255.255.248	5	32	6
30	255.255.255.252	6	64	2

- You need to subnet a network that has 5 subnets, each with at least 16 hosts. Which class and subnet mask would you use?

- A company is granted the site address 201.70.64.0 (class C). The company needs six subnets. Design the subnets.

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

Number of needed subnets **126**
Number of needed usable hosts **131,070**
Network Address **118.0.0.0**

Address class ________

Default subnet mask ____

Custom subnet mask ____

Total number of subnets ________________________

Total number of host addresses ________________________

Number of usable addresses ________________________

Number of bits borrowed ________________________

Number of needed subnets **6**
Number of needed usable hosts **30**
Network Address **210.100.56.0**

Address class ________

Default subnet mask ______________________________

Custom subnet mask ______________________________

Total number of subnets _______________________

Total number of host addresses _______________________

Number of usable addresses _______________________

Number of bits borrowed _______________________

Number of needed subnets **5**
Network Address **218.35.50.0**

Address class ________

Default subnet mask ____________________________

Custom subnet mask ____________________________

Total number of subnets ________________________

Total number of host addresses ________________________

Number of usable addresses ________________________

Number of bits borrowed ________________________

Number of needed usable hosts **50**

Network Address **172.59.0.0**

Address class ________

Default subnet mask ______________________________

Custom subnet mask ______________________________

Total number of subnets ______________________

Total number of host addresses ______________________

Number of usable addresses ______________________

Number of bits borrowed ______________________

Number of needed subnets **2000**
Number of needed usable hosts **15**
Network Address **178.100.0.0**

Address class ___________

Default subnet mask __________________________________

Custom subnet mask __________________________________

Total number of subnets _____________________

Total number of host addresses _____________________

Number of usable addresses _____________________

Number of bits borrowed _____________________

Number of needed subnets **10**
Network Address **192.70.10.0**

Address class ___________

Default subnet mask ______________________________

Custom subnet mask ______________________________

Total number of subnets ____________________

Total number of host addresses ____________________

Number of usable addresses ____________________

Number of bits borrowed ____________________

What is the 9th subnet range? ______________________________________

What is the subnet number for the 4th subnet? _________________________

What is the subnet broadcast address for the 12th subnet? _________________________

What are the assignable addresses for the 10th subnet? ______________________________________

- From a Class B network of 190.201.0.0. how many subnets can you have if you have atleast 4000 host.

- Find the Network Address, broadcast address, and host range for 141.14.0.0/16

- Find the network mask, prefix length and suffix length from the address

12.23.24.78/8

130.11.232.156/16

167.199.170.82/27

- One of the addresses in a block is 167.199.170.82/27. Find the number of addresses in the network, the first address, and the last address.

- One of the addresses in a block is 17.63.110.114/24. Find the number of addresses, the first address, and the last address in the block.

- One of the addresses in a block is 110.23.120.14/20. Find the default mask for the class, address space, number of subnets available, custom mask, network address, direct broadcast address, limited broadcast address, the first address, and the last address in the block, .

cls A 8

20

→ 2^{12} (subnets)

- The first address in a range of addresses is 14.11.45.96. If the number of addresses in the range is 32, what is the last address?

- The beginning address is chosen as 18.14.12.0.An ISP has requested a block of 1000 addresses. How are the blocks granted?

- An organization is granted the block 130.34.12.64/26. The organization needs four subnetworks, each with an equal number of hosts. Design the subnetworks and find the information (subnet mask, first address, last address, etc.) about each network.

- The first address in a range of addresses is 14.11.45.96. If the number of addresses in the range is 32, what is the last address?

Find the number of addresses in a range if the first address is 146.102.29.0 and the last address is 146.102.32.25

146.102.32.255 - 146.102.29.0

0.0.3.255 in base 256

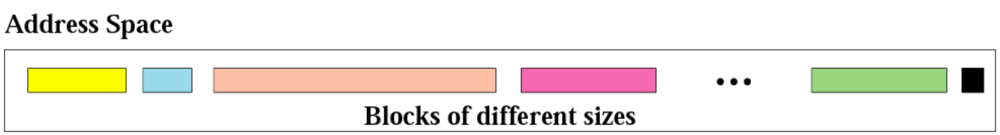
$$\text{Number of addresses} = (0 \times 256^3 + 0 \times 256^2 + 3 \times 256^1 + 255 \times 256^0) + 1 = 1024$$

- If the first address in a range is 122.12.7.0 and there are 2048 addresses in the range, what is the last address?

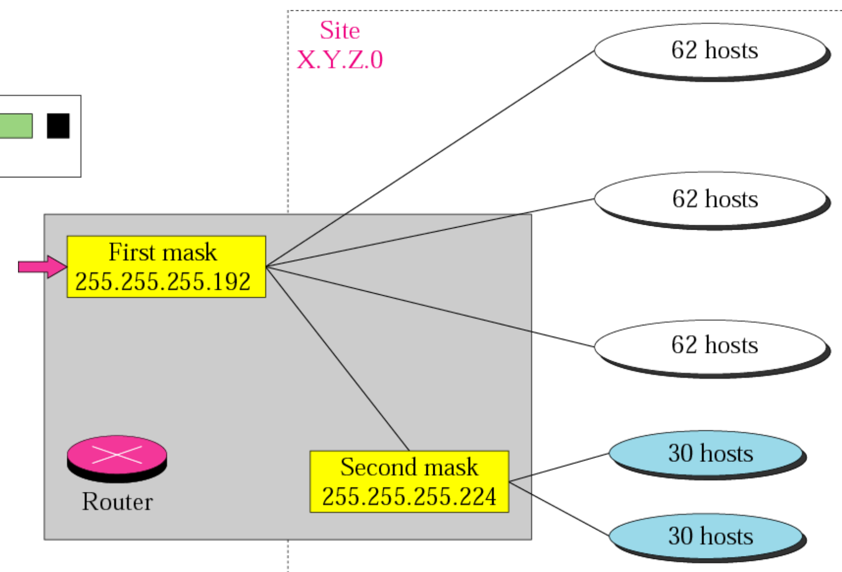
- A router receives a packet with the destination address 201.24.67.32. Show how the router finds the network address of the packet.

WHY?

- Address Depletion issue!
- In classless addressing, **variable-length blocks** are used that belong to no classes.
- a block of 1 address, 2 addresses, 4 addresses, 128 addresses, and so on.

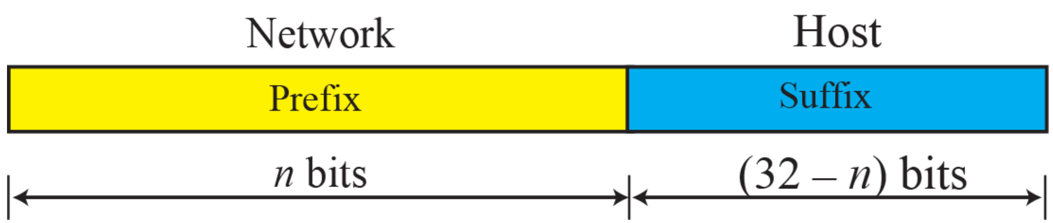


- Used variable length Subnet Masks



In classless addressing, the *prefix* defines the **network** and the *suffix* defines the **host**.

All addresses in the block have the same prefix; each with a different suffix.



- Classless addressing – n depends on the size of the block; 0, 1, 2, 3…32
- n refers to as prefix length
- 32 – n refers to as suffix length

A *small n* means a **larger block**; a *large n* means a **small block**

The address 230.8.24.56 can belong to many blocks some of them are shown below with the value of the prefix associated with that block:

Prefix length:16	→	Block:	230.8.0.0	to	230.8.255.255
Prefix length:20	→	Block:	230.8.16.0	to	230.8.31.255
Prefix length:26	→	Block:	230.8.24.0	to	230.8.24.63
Prefix length:27	→	Block:	230.8.24.32	to	230.8.24.63
Prefix length:29	→	Block:	230.8.24.56	to	230.8.24.63
Prefix length:31	→	Block:	230.8.24.56	to	230.8.24.57

So, In classless addressing, the prefix length cannot be found if we are given only an address in the block. The given address can belong to a block with any prefix length.

- 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

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

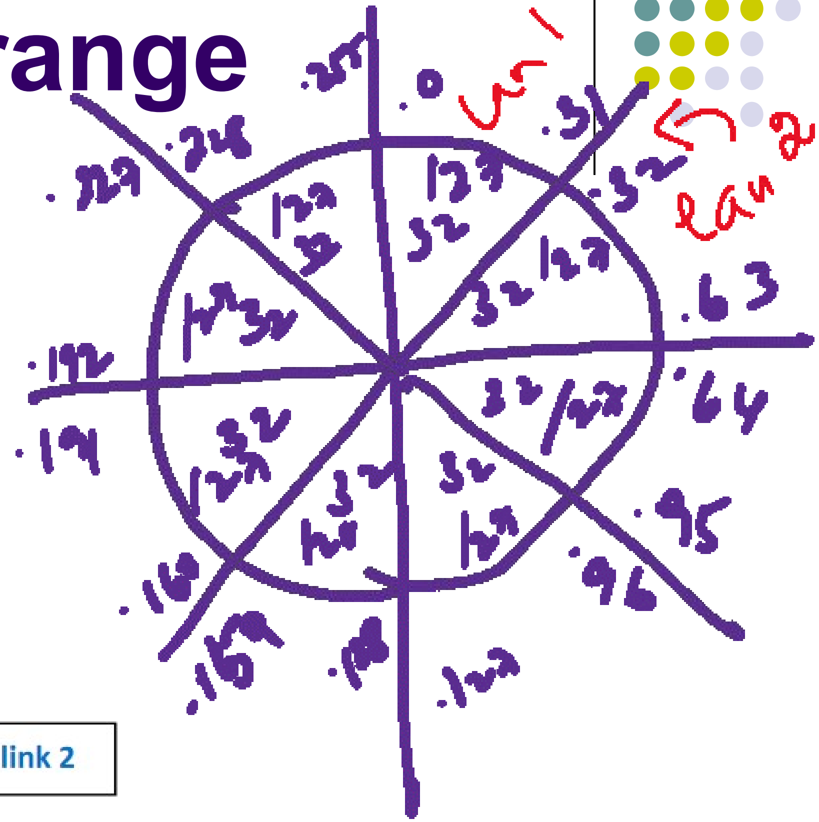
205.16.37.32
190.16.42.0
17.17.32.0
123.45.24.52

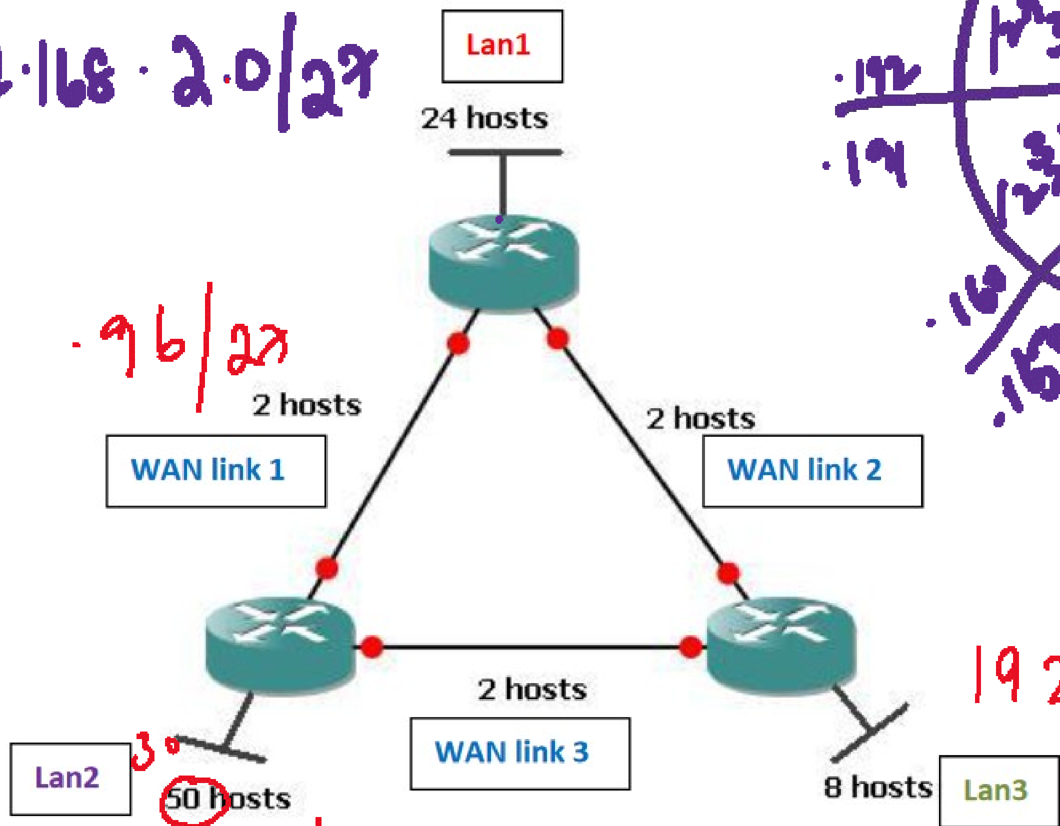
- A small organization is given a block with the beginning address and the prefix length 205.16.37.24/29 (in slash notation). What is the range of the block?

Assign IP address range

Available subnet - 192.168.2.0/24

192.168.2.0/27





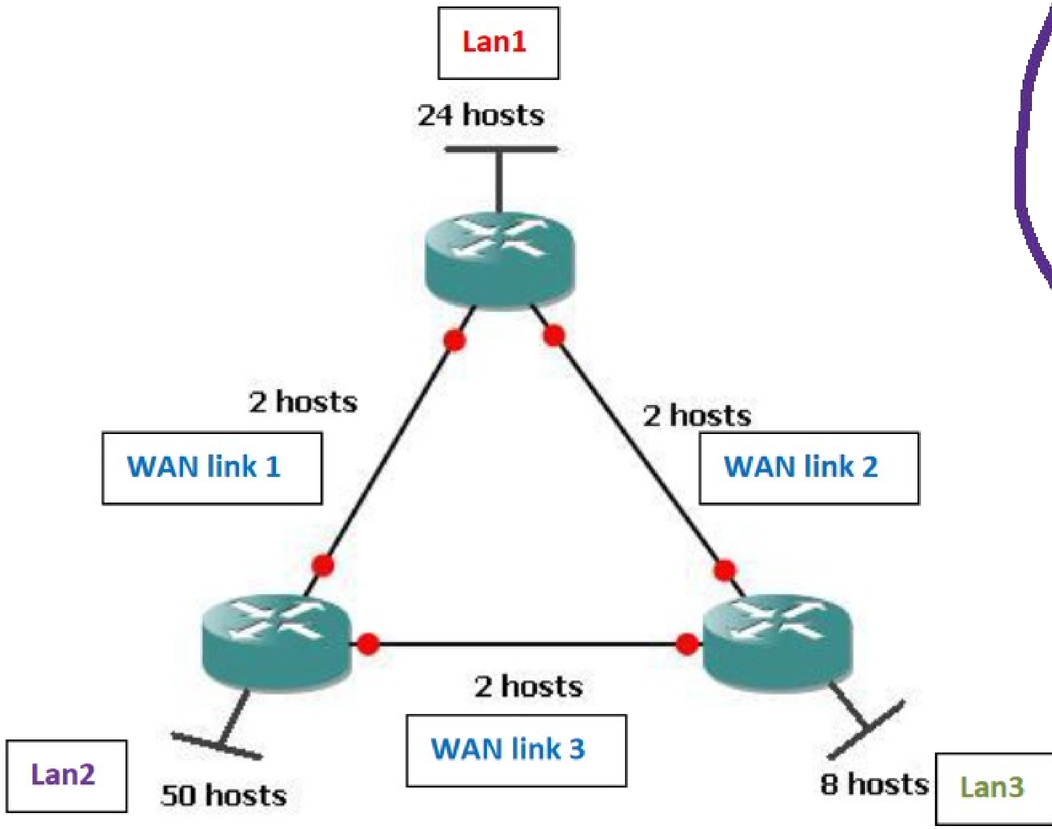
.96/27

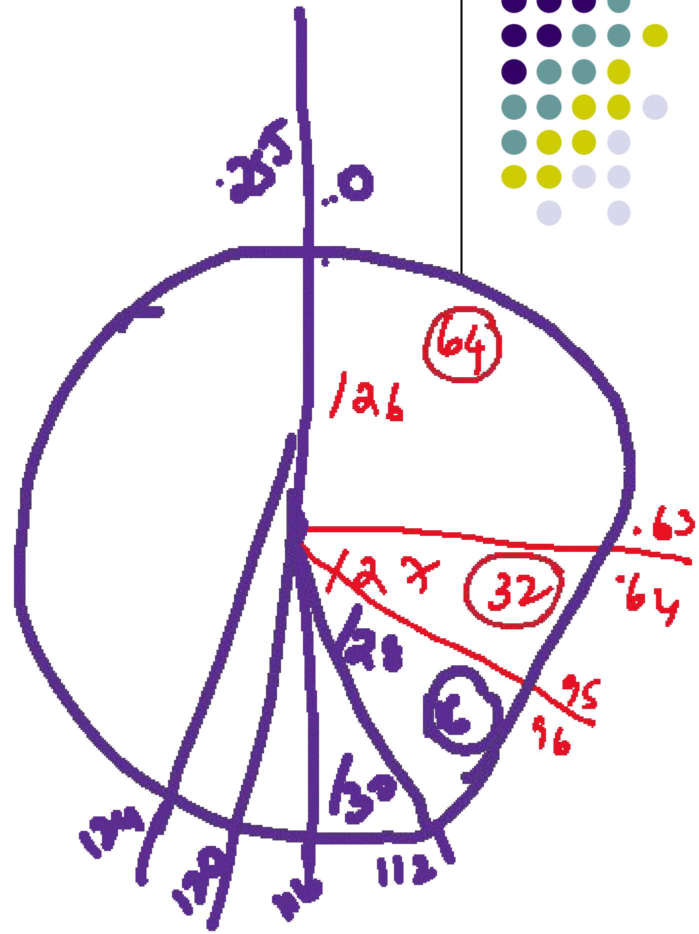
192.168.2.64/27

192.168.2.32/27

- Lan 2 → 192.168.2.0/26
- Lan 1 → 192.168.2.64/27
- Lan 3 → 192.168.2.96/28
- WAN 1 .112/30
- Wan2 .116/30
- Wan3 .120/30

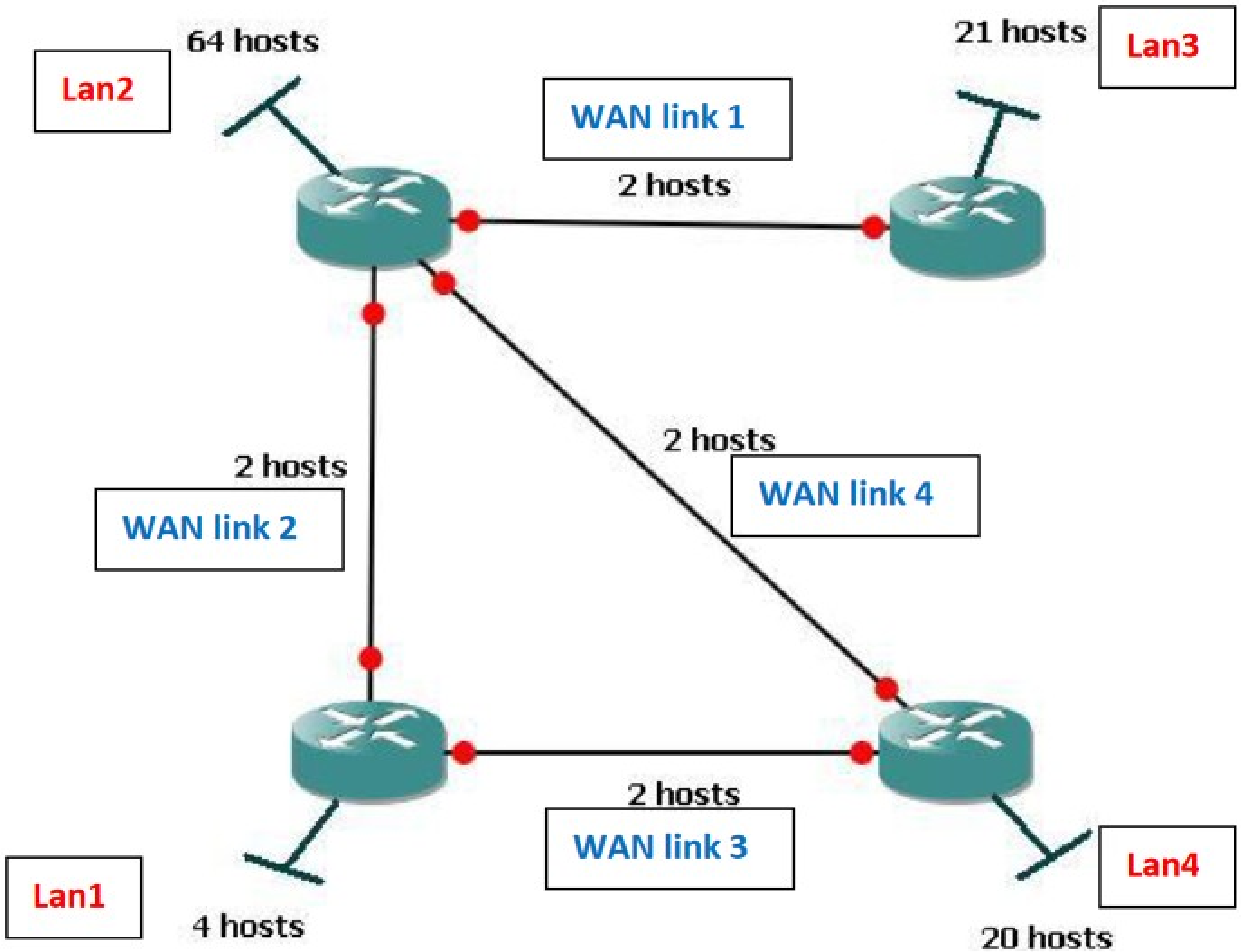
Available subnet - 192.168.2.0/24





Bits Borrowed (Sb)	1	2	3	4	5	6	
New Mask	/25 255.255.255.128	/26	/27	/28	/29	/30	
Host bits	7	6	5	4	3	2	
Block/ Address Space $2^{(h)}$	128	64	32	16	8	4	
Subnets $2^{(sb)}$	2	4	8	16	32	64	
Hosts per subnet	126	62	30	14	6	2	

Available subnet 10.23.22.0/24



- An organization is granted a block of addresses with the beginning address 208.8.5.0/24. The organization needs to have 4 subblocks of addresses to use in its four subnets: one subblock of 17 addresses, one subblock of 33 addresses, one subblock of 30 addresses and one subblock of 90 addresses. Draw a network topology, give IP assignments to each subblocks. Also, write subnet mask, first address and last address of each subblock.

- An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 sub blocks of addresses to use in its three subnets as shown below:
  - ✓ One subblock of 120 addresses.
  - ✓ One subblock of 60 addresses.
  - ✓ One subblock of 10 addresses.

- An organization is granted a block of addresses with the beginning address 15.15.15.0/24. The organization needs to have 3 subblocks of addresses to use in its three subnets: one subblock of 12 addresses, one subblock of 62 addresses, and one subblock of 120 addresses. Draw a network topology and Give IP assignments to each subblocks.

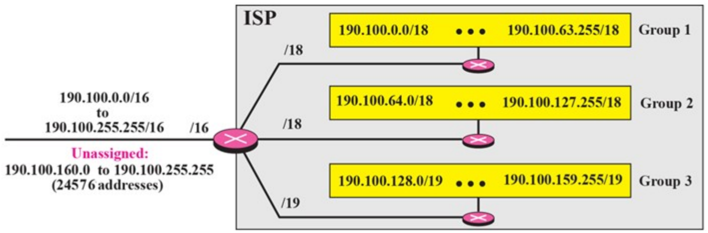
- An ISP is granted a block of addresses starting with 190.100.0.0/16. The ISP needs to distribute these addresses to three groups of customers as follows:

- 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.

First Step: The total number of addresses allocated to each group and the prefix length for each subblock can calculated as

Group 1: $64 \times 256 = 16{,}384$	$n_1 = 16 + \log_2 (65536/16384) = 18$
Group 2: $128 \times 128 = 16{,}384$	$n_2 = 16 + \log_2 (65536/16384) = 18$
Group 3: $128 \times 64 = 8192$	$n_3 = 16 + \log_2 (65536/8192) = 19$



Second Step:

Group: $n = 18$

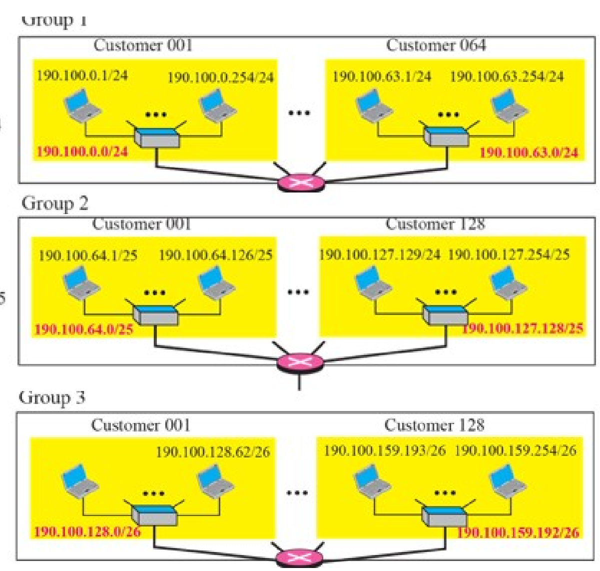
Subnet: $n = 18 + \log_2 (16384/256) = 24$

Group: $n = 18$

Subnet: $n = 18 + \log_2 (16384/128) = 25$

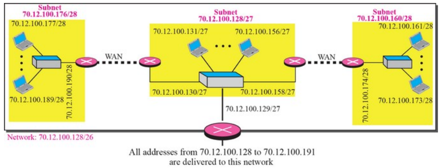
Group: $n = 19$

Subnet: $n = 19 + \log_2 (8192/64) = 26$



The prefix length changes for the networks in each group depending on the number of addresses used in each network.

- Assume a company has three offices: Central, East, and West. The Central office is connected to the East and West offices via private, point-to-point WAN lines. The company is granted a block of 64 addresses with the beginning address 70.12.100.128/26. The management has decided to allocate 32 addresses for the Central office and divides the rest of the addresses between the two other offices. Give the network ranges used in each of the offices.

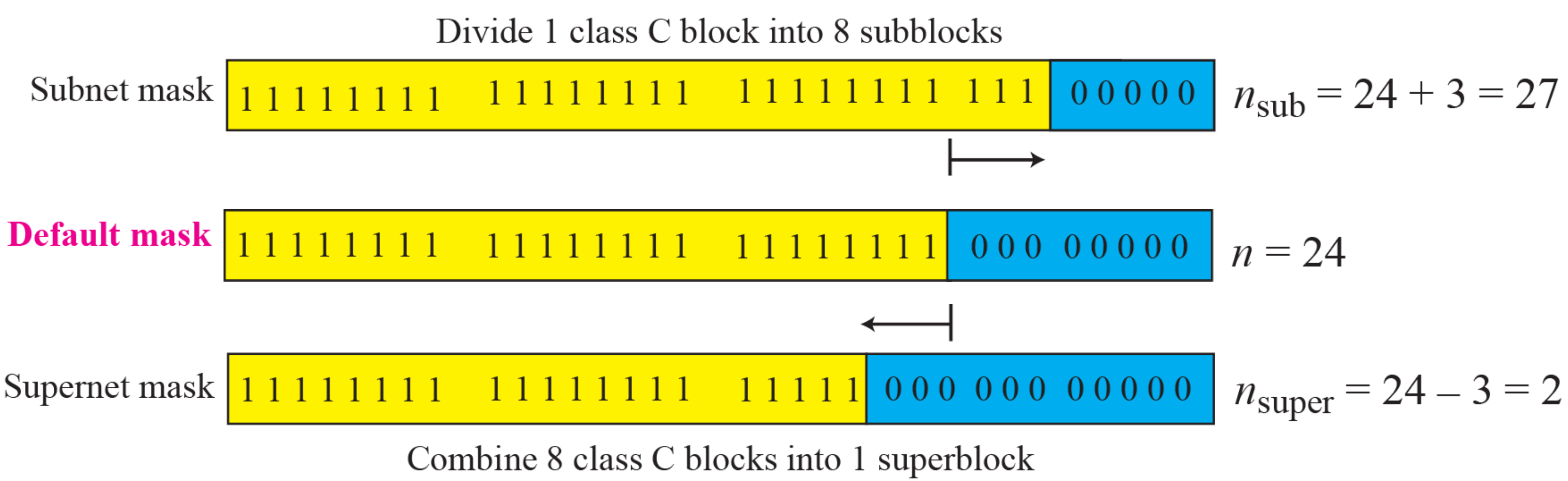


Supernetting

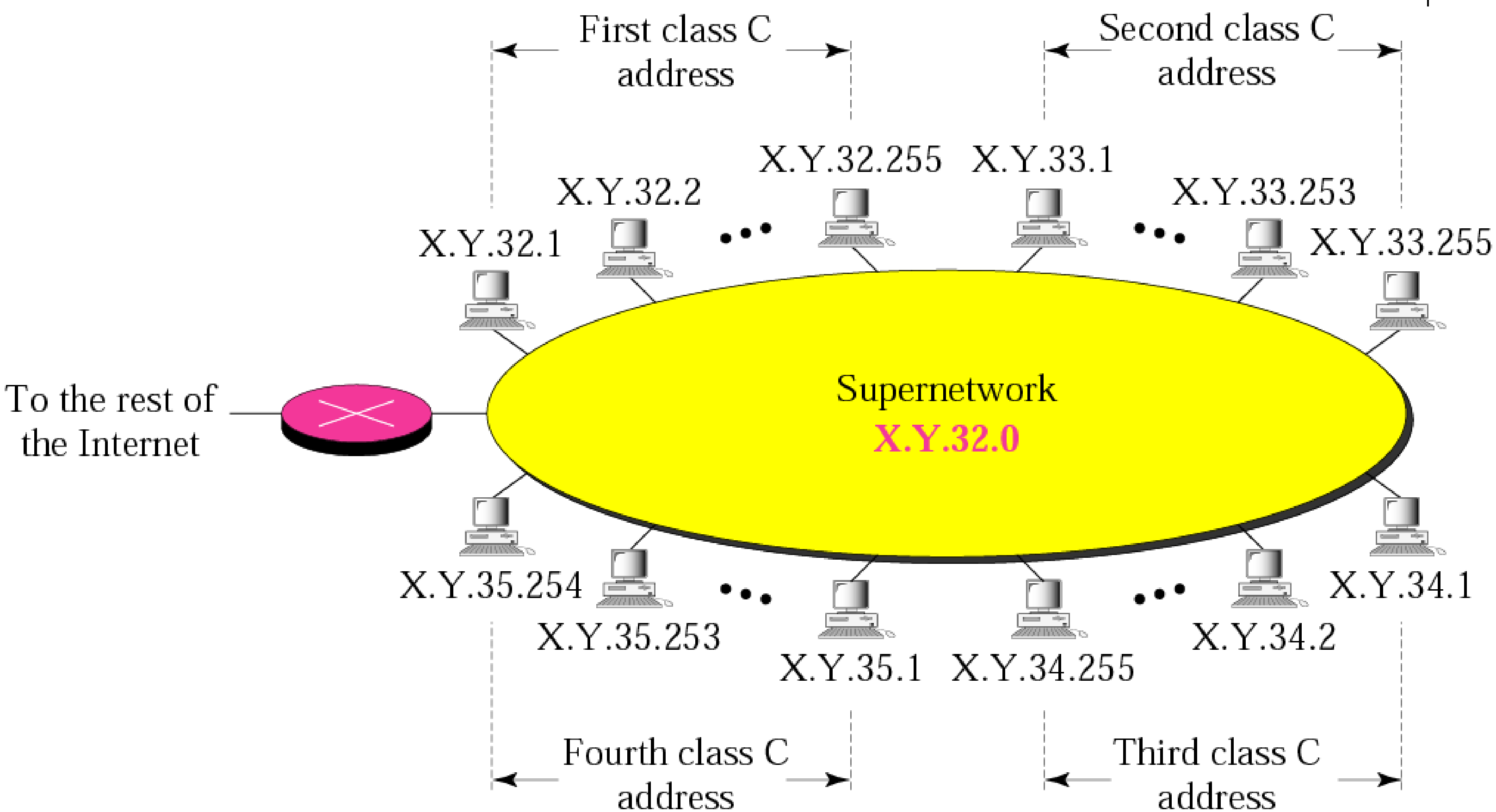
In Supernetting, an organization can combine several blocks to create a larger range of addresses.

Supernet Mask

- A supernet mask is the reverse of a subnet mask.
- A subnet mask for a class has more 1s than the default mask for this class.
- A supernet mask for a class has less 1s than the default mask for this class.



SUPERNETTING



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

In supernetting, the number of class addresses that can be combined to make a supernet needs to be a power of 2.

The length of the supernetid can be found as

n_{super} – length of the supernetid in bits and

c – number of class blocks that are combined

Supernetting provided two new problems:

- First, the number of blocks to combine needs to be a power of 2, which means an organization that needs seven blocks should be granted at least eight blocks (address wasting).
- Second, supernetting and subnetting really complicated the routing of packets in the Internet.

Suppose 4 small networks of class C:

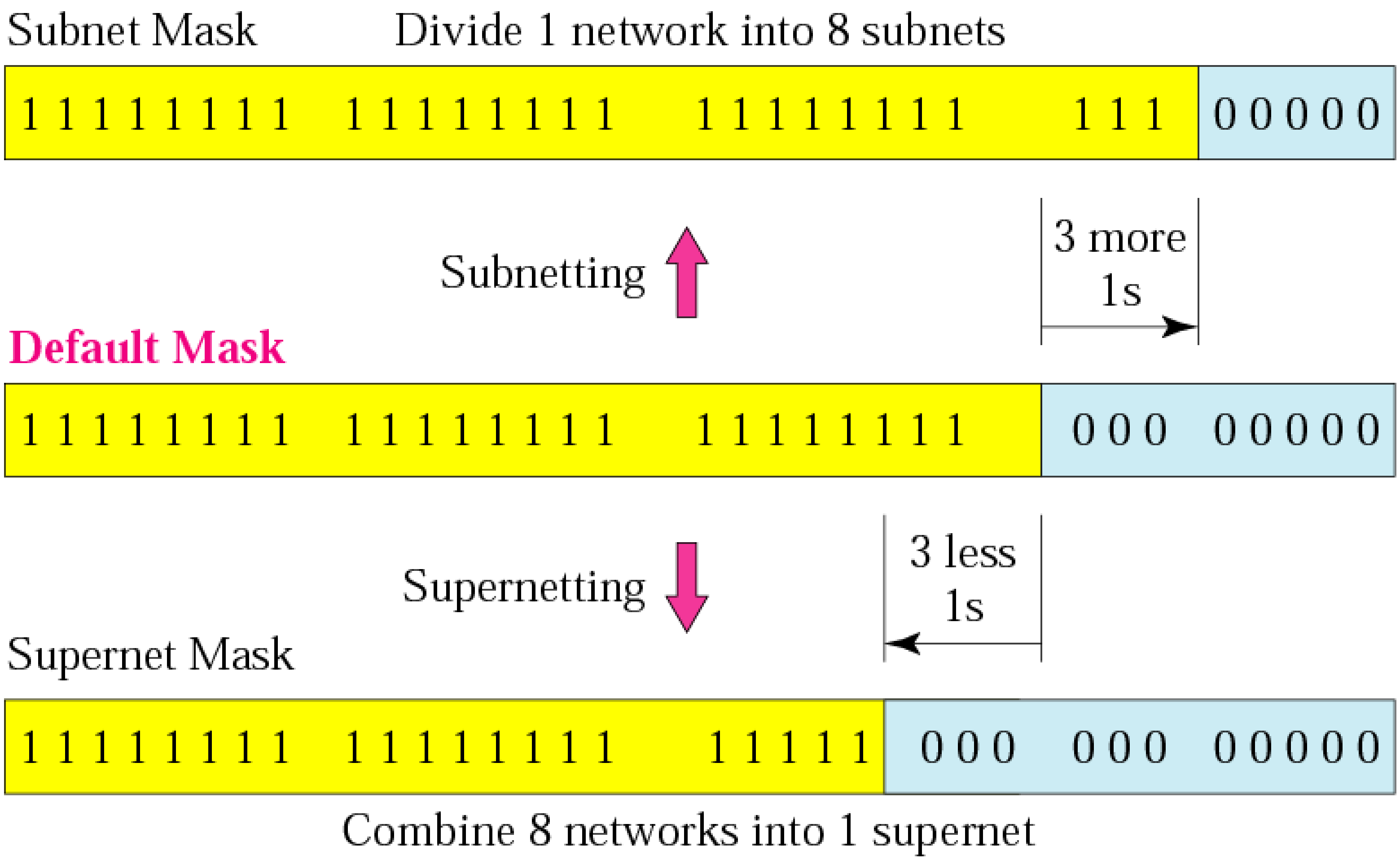
200.1.0.0,
200.1.1.0,
200.1.2.0,
200.1.3.0

Build a bigger network that has a single Network Id.

A company needs 600 addresses. Which of the following set of class 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



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

- 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?

- 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?

Network address translation

- NAT
- Blocks of addresses are allotted to ISP's and organizations
  - Classes of IP Addresses
- What happens when we have more computers than IP Addresses?
  - We have a Class C address – allows 253 computers
  - Our organization has 1000 computers
  - What do we do???

Solution?

- Reserve a range of IP addresses to build your own IP network
  - 10.x.y.z - un-routable IP addresses
  - 172.16.y.z
  - 192.168.y.z
- How to connect these machines to Internet?

Network Address Translation

- Use a gateway /router to map invalid addresses to valid IP addresses
  - Translates your local address to a routable address
  - Router receives one IP Address
    - Either dynamically assigns addresses to all the nodes behind the router, or it is assigned statically using non-routable addresses
      - If dynamic, uses DHCP (Dynamic Host Configuration Protocol)
    - When someone inside the network wants to access a computer outside the local network (the internet), the request is sent to the router, which uses NAT to send the request to the internet

NAT and security?

- Does NAT improve security?
  - It hides internal IP addresses from hacker
  - NAT must be combined with “firewalls” for optimum security