

Network Layer & IPv4 (Part II)



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Outline

- Network Layer
- IP Fundamental Operation
- Internet Protocol
- Addressing

IP Address

VER 4 bits	HLEN 4 bits	Service type 8 bits	Total length 16 bits	
Identification 16 bits			Flags 3 bits	Fragmentation offset 13 bits
Time to live 8 bits		Protocol 8 bits	Header checksum 16 bits	
Source IP address			32 bits	
Destination IP address			32 bits	
Option				



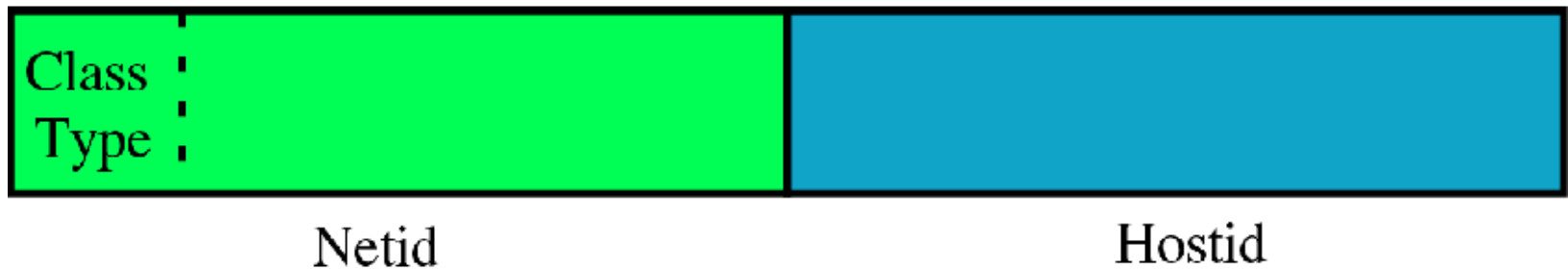
IP Address

- Address space of IPv4 (32 bits)
 - $2^{32} = 4,294,967,296$
- Unique and Universal
 - Local & Global Sense
- Assigned by National Registries
- Subset from Internet Corporation for Assigned Names and Number (ICANN)
- Does an IP address represent a machine ?

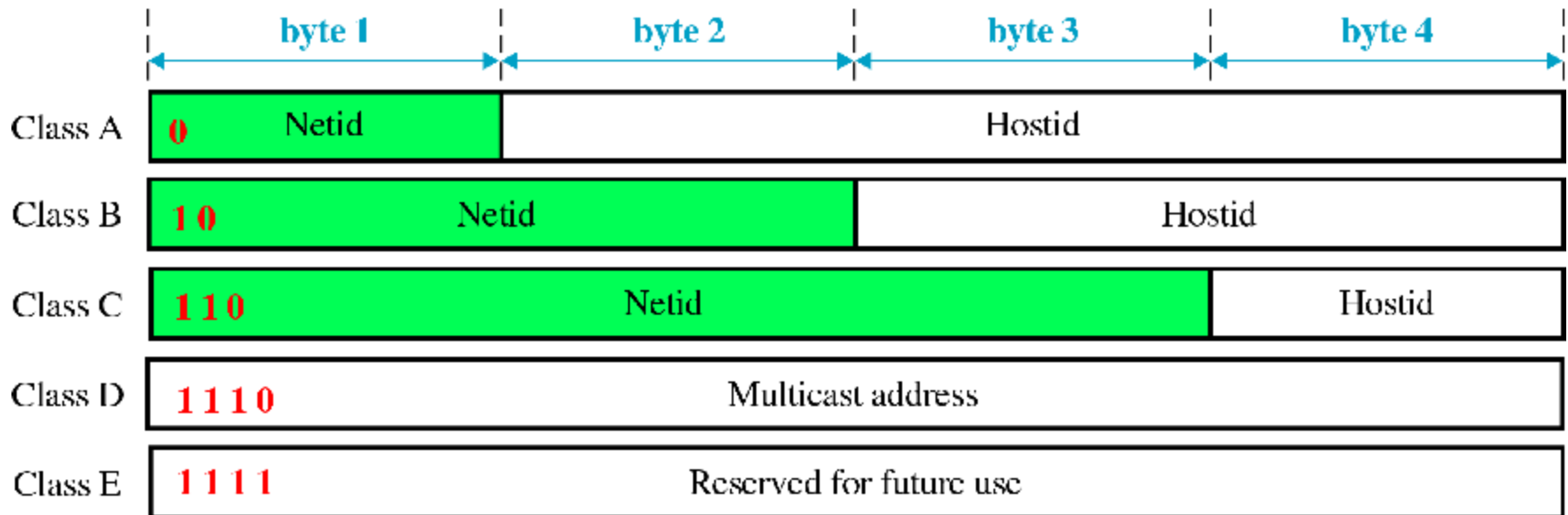


Internet Address

An Internet address is made of four bytes (32 bits) that define a host's connection to a network.



Internet Classes



Classfull Addressing

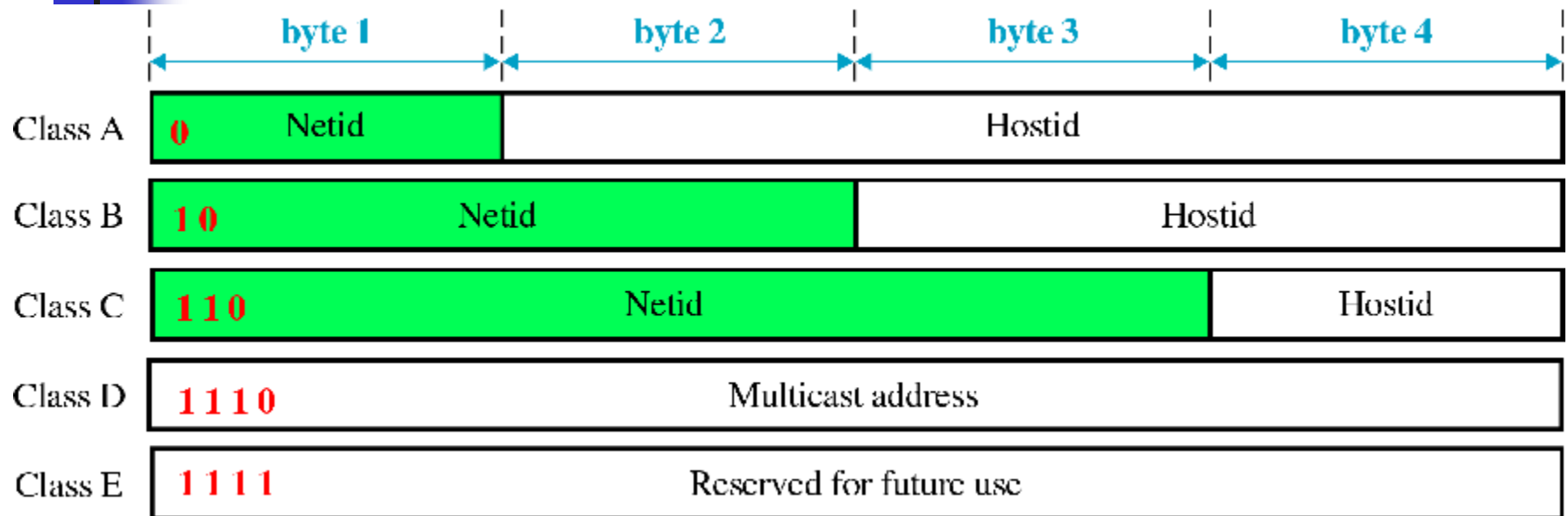


IP Address Class

Class A	0 Netid
Class B	10 Netid
Class C	110
Class D	1110
Class E	1111

First Four Bits Of Address	Table Index (in decimal)	Class of Address
0000	0	A
0001	1	A
0010	2	A
0011	3	A
0100	4	A
0101	5	A
0110	6	A
0111	7	A
1000	8	B
1001	9	B
1010	10	B
1011	11	B
1100	12	C
1101	13	C
1110	14	D
1111	15	E

Amount of Networks and Hosts

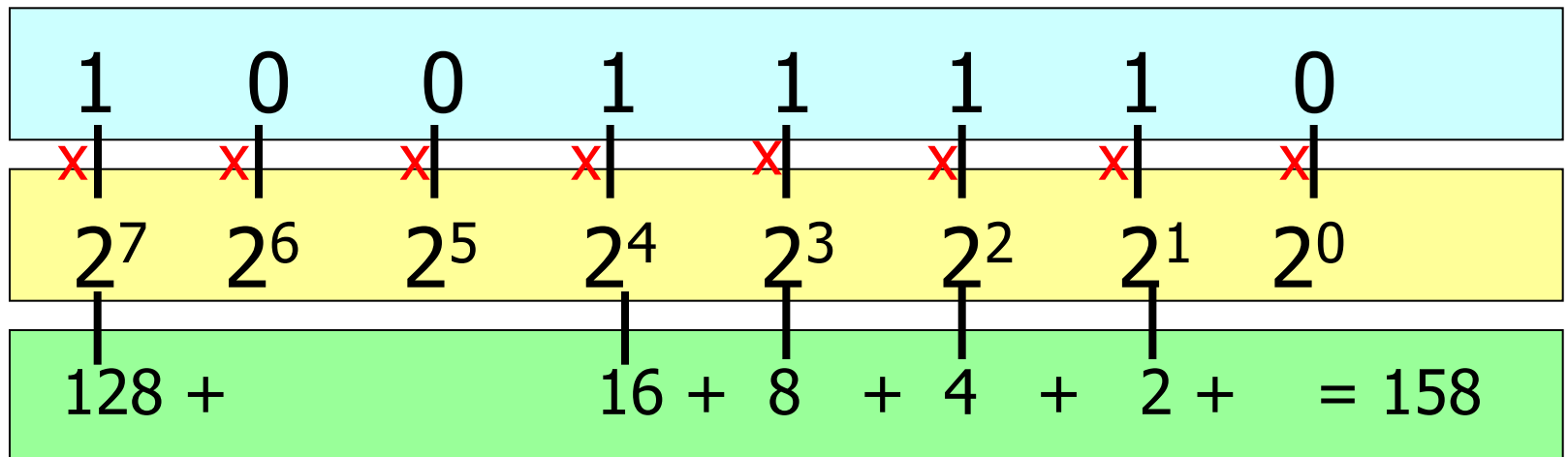


Address Class	Bits In Prefix	Maximum Number of Networks	Bits In Suffix	Maximum Number Of Hosts Per Network
A	7	128	24	16777216
B	14	16384	16	65536
C	21	2097152	8	256

IP address in decimal notation

10011110 01101100 00000010 00111101

158.108.2.61



IP address practice

10011110 01101100 00100000 00010010

#1

00001100 00011001 00000001 00010111

#2

#3

201.125.137.213

32-bit Binary Number				Equivalent Dotted Decimal
1000001	00110100	00000110	00000000	129 . 52 . 6 . 0
11000000	00000101	00110000	00000011	192 . 5 . 48 . 3
00001010	00000010	00000000	00100101	10 . 2 . 0 . 37
10000000	00001010	00000010	00000011	128 . 10 . 2 . 3
10000000	10000000	11111111	00000000	128 . 128 . 255 . 0

IP address in decimal notation

10011110 01101100 00000010 00111101

158.108.2.61

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How about **iwing.cpe.ku.ac.th** ?



Class Ranges

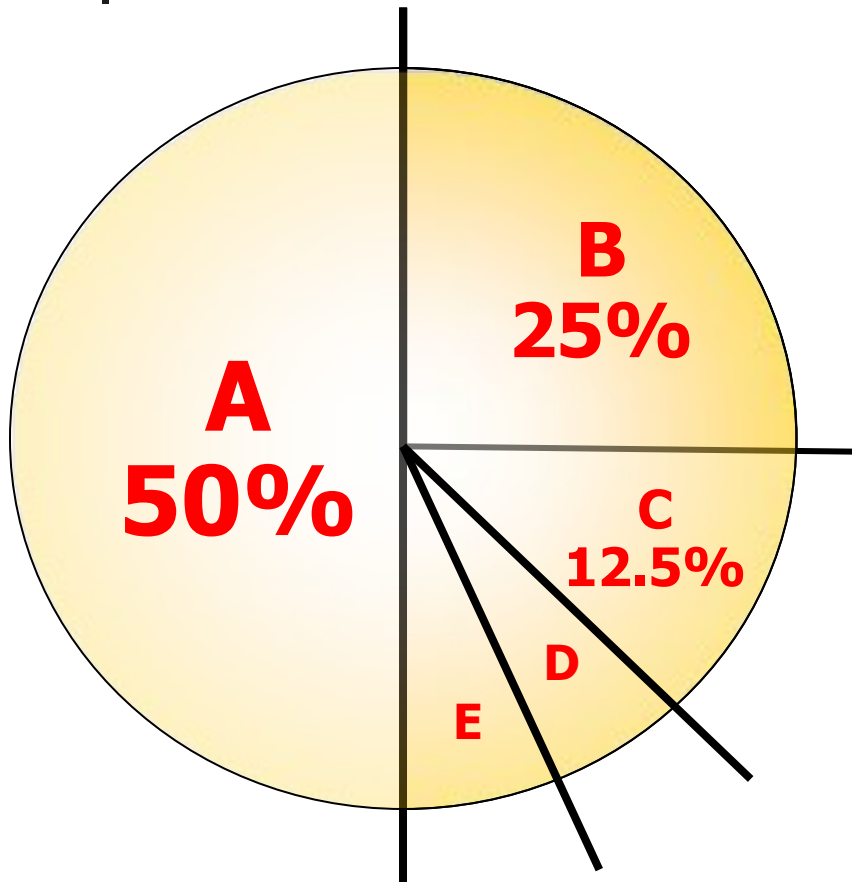
	Octet 1	Octet 2	Octet 3	Octet 4
Class A	0.....			
Class B	10.....			
Class C	110.....			
Class D	1110....			
Class E	1111....			

Binary notation

	Byte 1	Byte 2	Byte 3	Byte 4
Class A	0–127			
Class B	128–191			
Class C	192–223			
Class D	224–299			
Class E	240–255			

Dotted-decimal notation

IP Address Class



Class A	0 Netid
Class B	10 Netid
Class C	110
Class D	1110
Class E	1111

Class A: $2^{31} = 2,147,483,648$ addresses, 50%

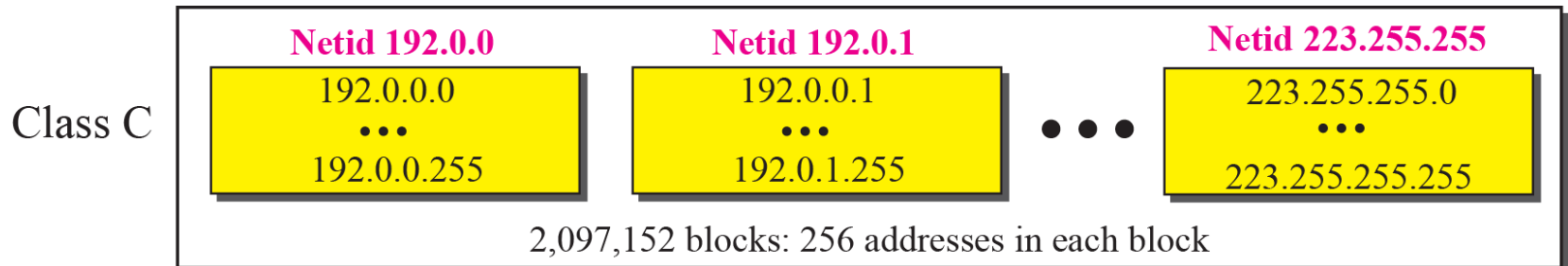
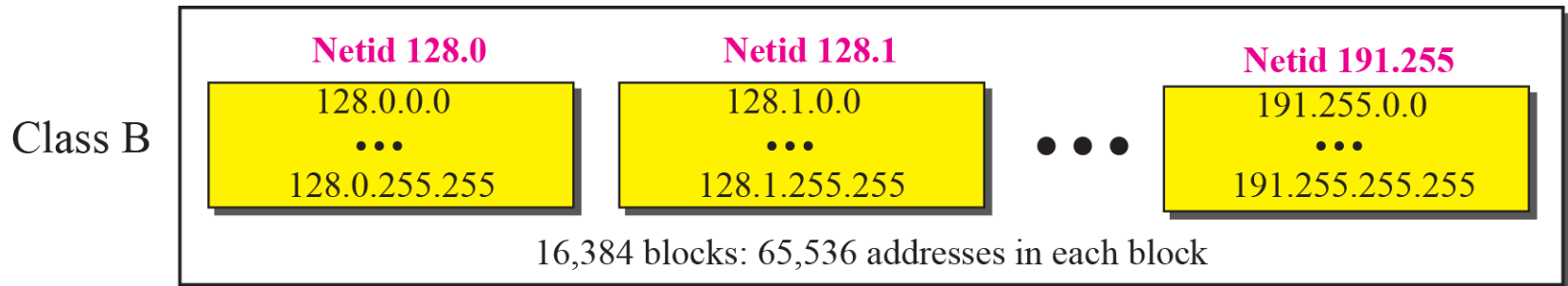
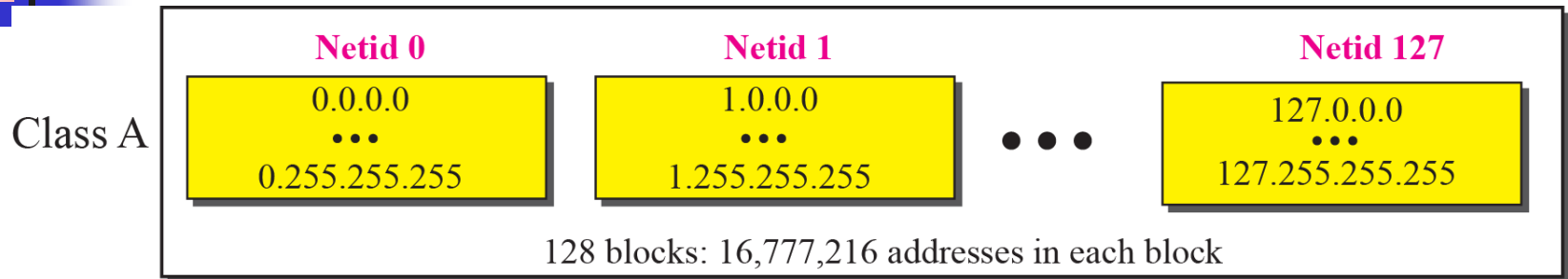
Class B: $2^{30} = 1,073,741,824$ addresses, 25%

Class C: $2^{29} = 536,870,912$ addresses, 12.5%

Class D: $2^{28} = 268,435,456$ addresses, 6.25%

Class E: $2^{28} = 268,435,456$ addresses, 6.25%

IP Address Blocks



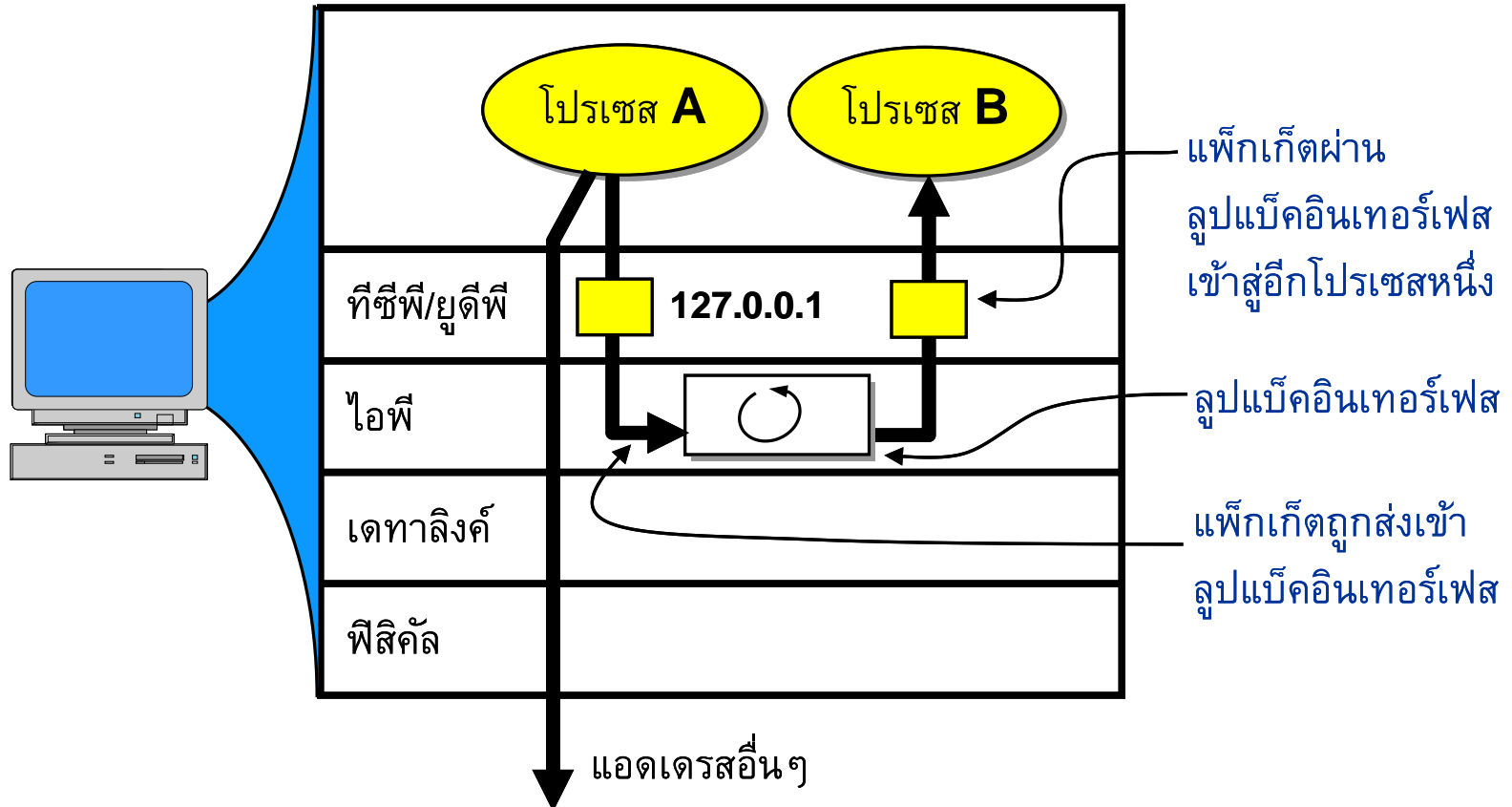


Special IP Addresses

- This computer Address
(all 0; e.g. 0.0.0.0)
- Loopback Address
- Broadcast Address
- Private IP Address
- Network Address

Special IP Address: **Loopback** Address

127.0.0.0/8 → 127.0.0.1





Special IP Address: **Broadcast** Address

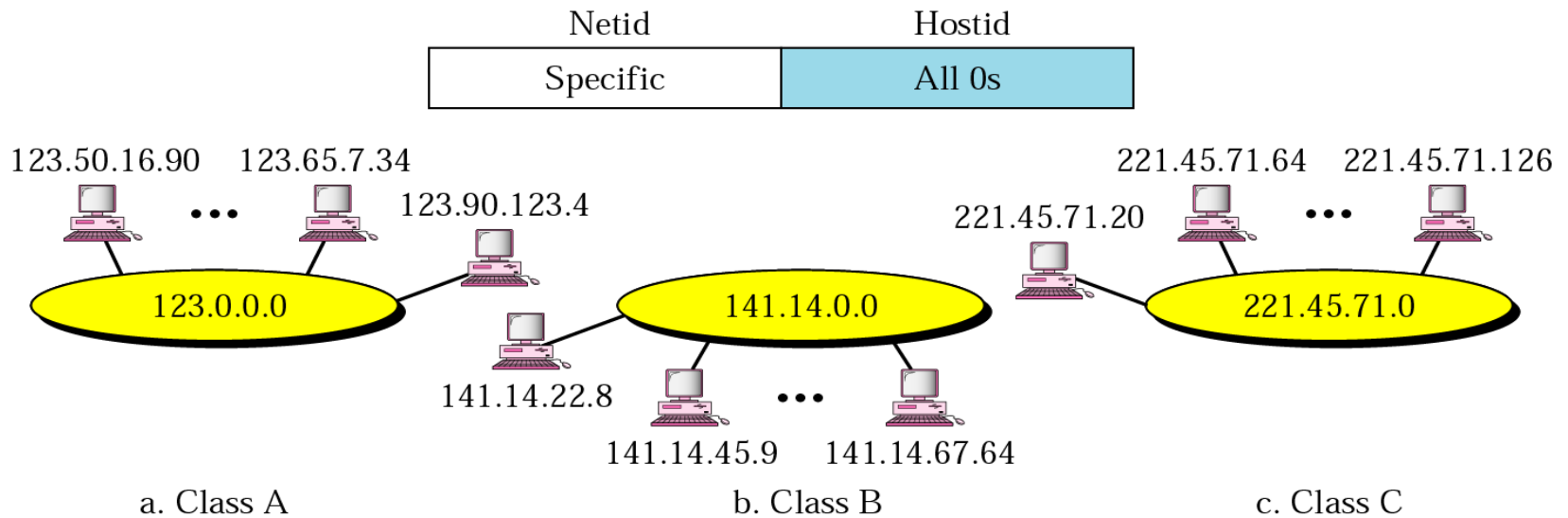
- Ending with 255
- Use for sending to all nodes in class range
- Directed Broadcast Address
 - all hosts = 1
 - Class A broadcast: 10.255.255.255
 - Class B broadcast: 158.108.255.255
 - Class C broadcast: 202.100.15.255
- Limited Broadcast Address
 - all 1; e.g. 255.255.255.255



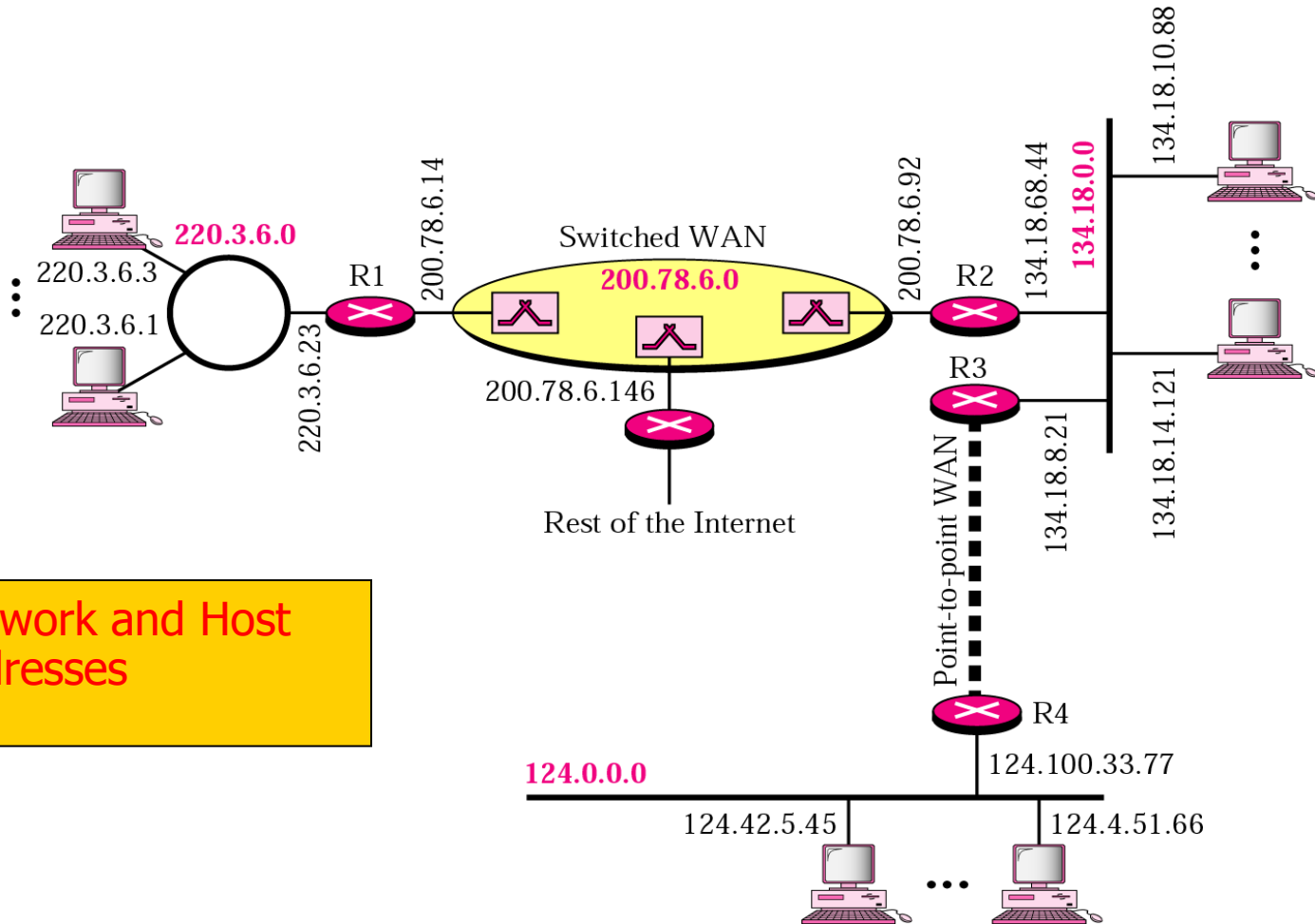
Special IP Address: **Private IP** Address

- Class A (1 group)
 - 10.0.0.0 – 10.255.255.255
- Class B (16 groups)
 - 172.16.0.0 – 172.31.255.255
- Class C (256 groups)
 - 192.168.0.0 – 192.168.255.255

Special IP Address: **Network** Address

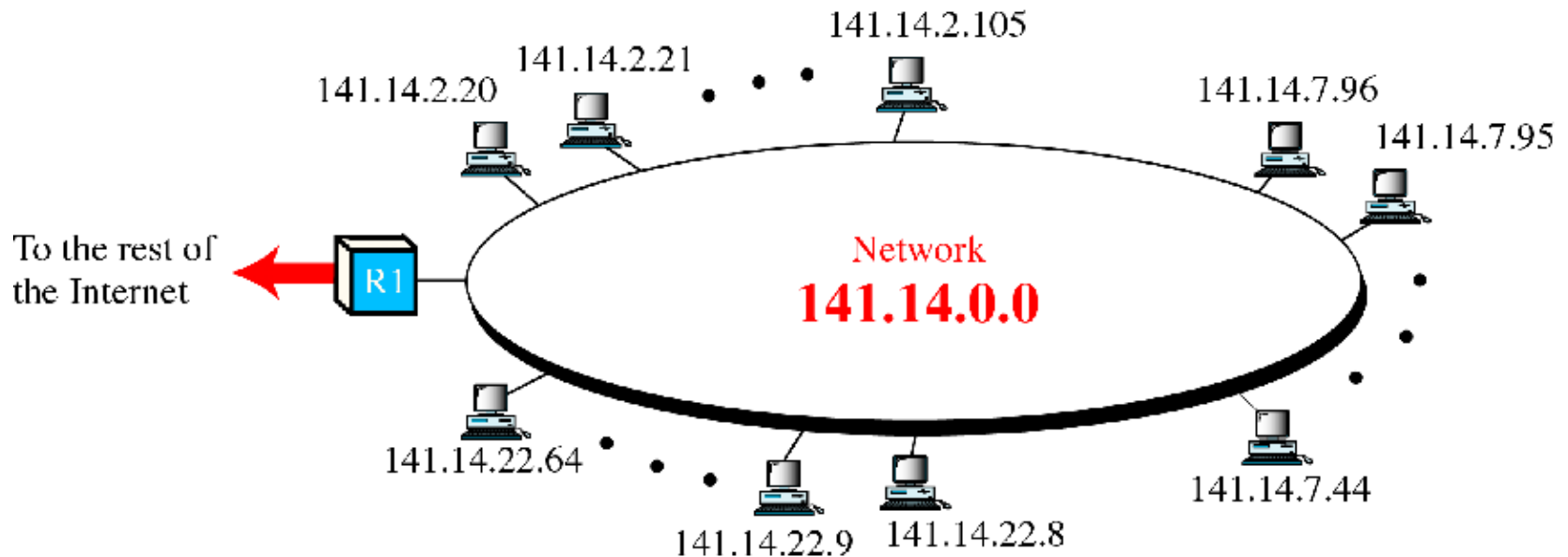


Sample internet

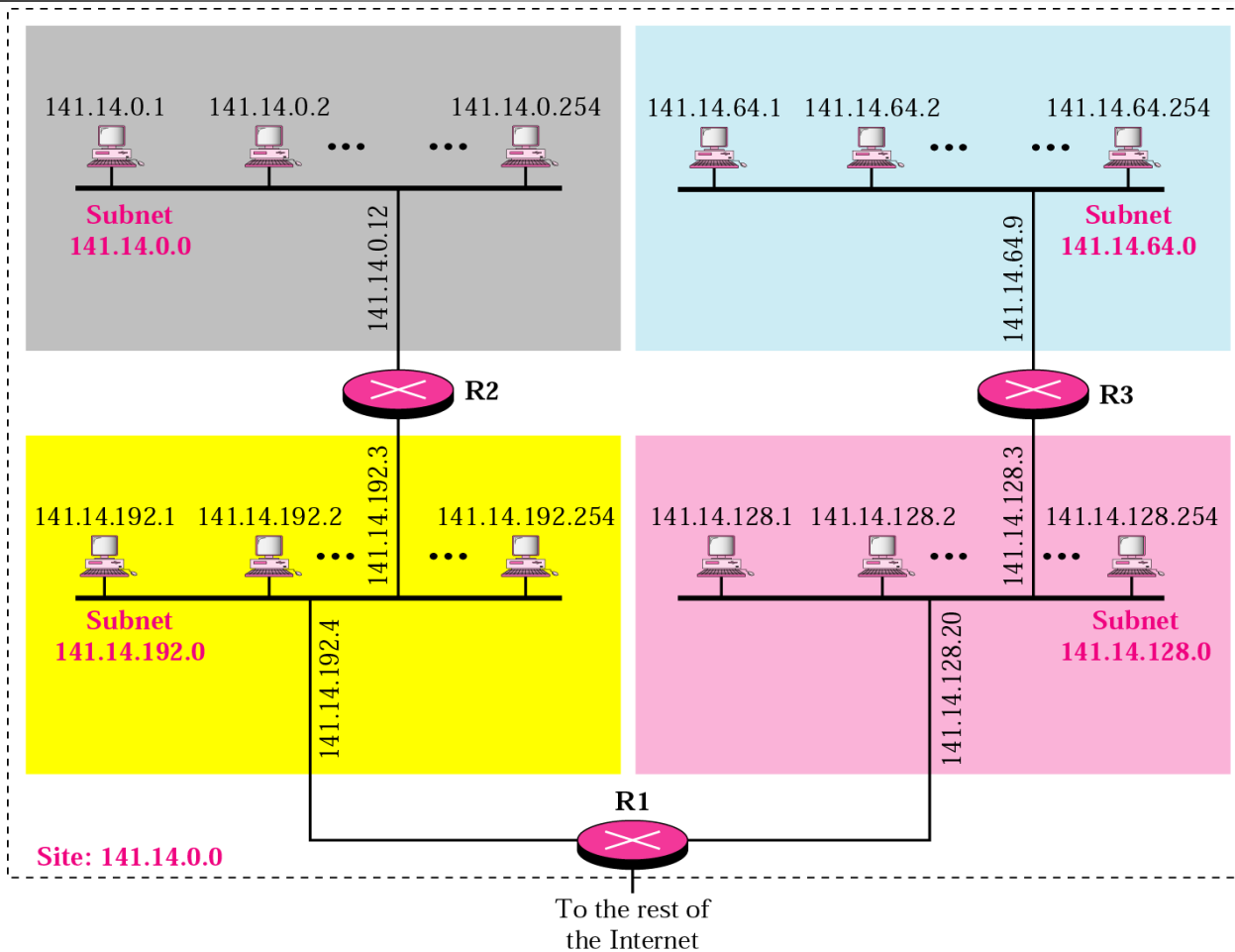


Network and Host addresses

A Network with Two Levels of Hierarchy

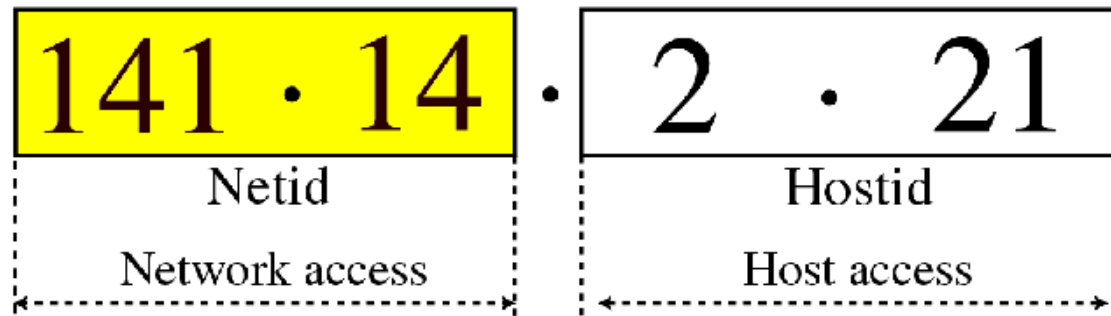


A Network with Three Levels of Hierarchy

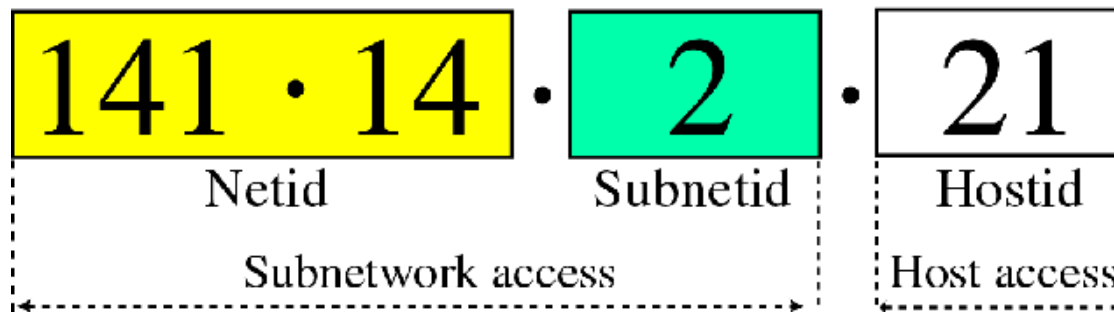


Addresses

with and without Subnetting

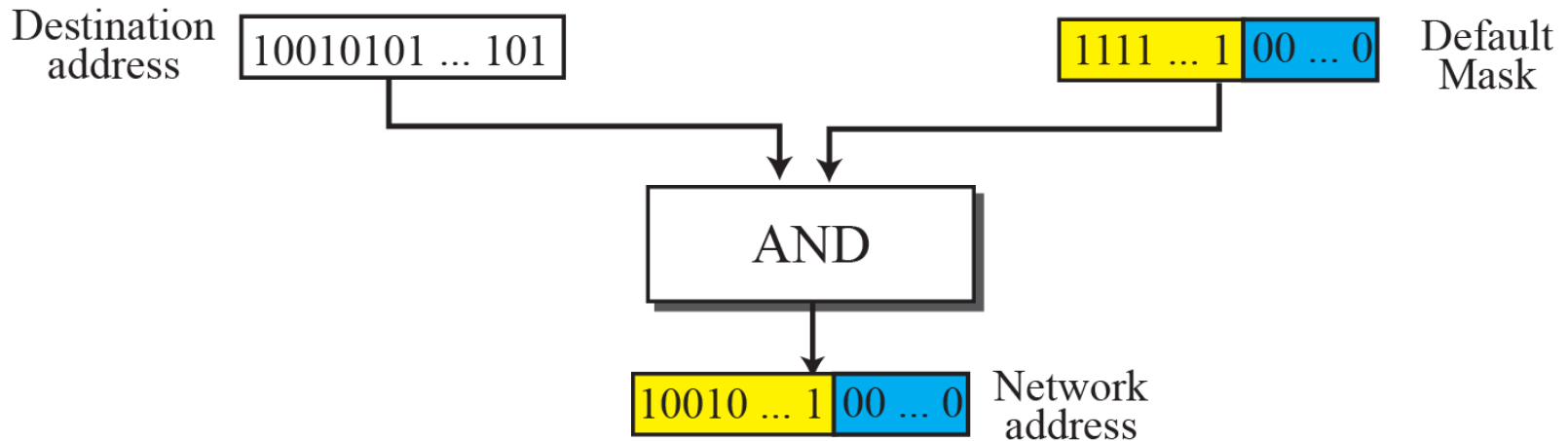


a. Without subnetting

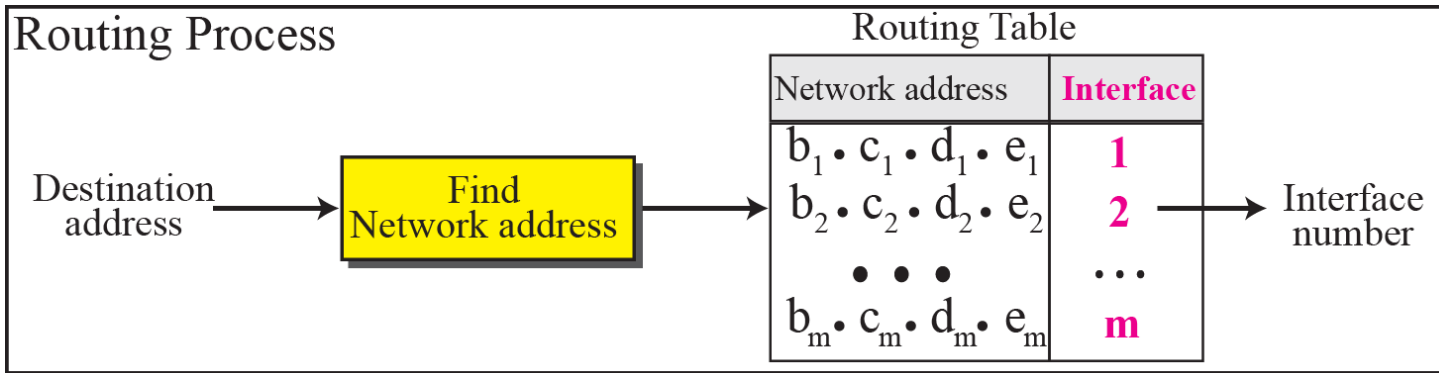
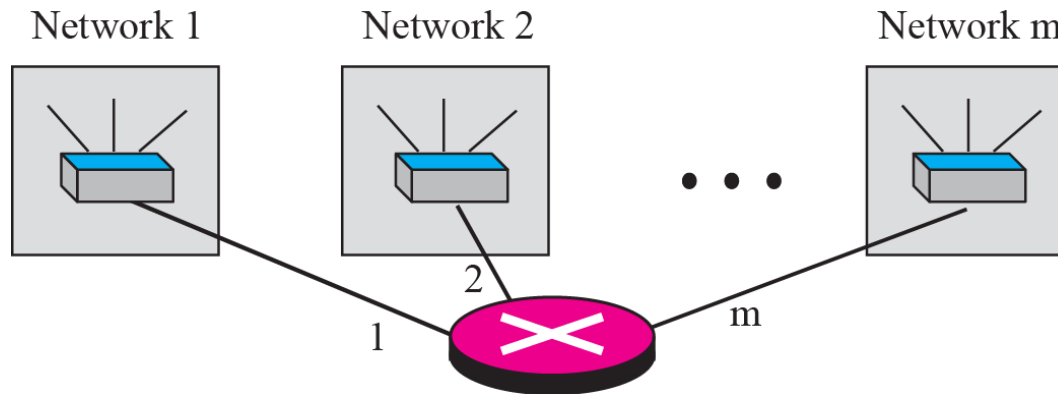


b. With subnetting

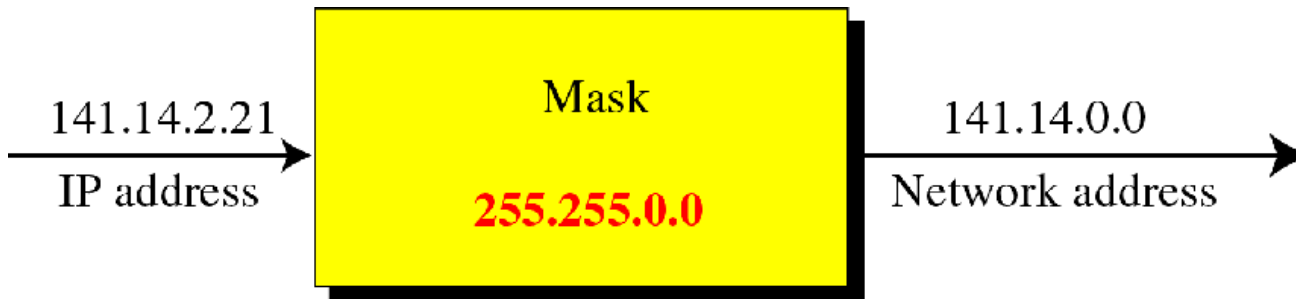
Finding a Network Address



Network Address



Masking (without subnet)



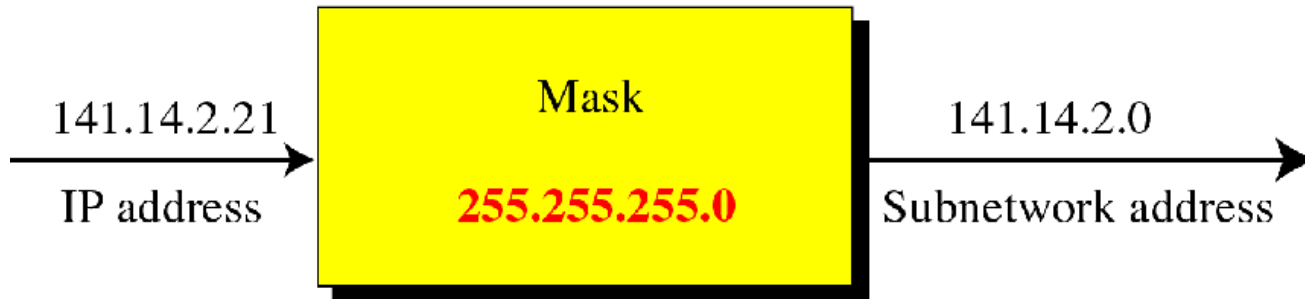
IP Address: 141 . 14 . 2 . 21
Binary IP Address: 1000 1101 . 0000 1110 . 0000 0010 . 0001 0101

Mask: 255 . 255 . 0 . 0
Binary Mask: 1111 1111 . 1111 1111 . 0000 0000 . 0000 0000

Network Address: 141 . 14 . 0 . 0
Binary IP Address: 1000 1101 . 0000 1110 . 0000 0000 . 0000 0000

&

Masking (with subnet)



IP Address: 141 . 14 . 2 . 21
Binary IP Address: 1000 1101 . 0000 1110 . 0000 0010 . 0001 0101

Mask: 255 . 255 . **255** . 0
Binary Mask: 1111 1111 . 1111 1111 . **1111 1111** . 0000 0000

Network Address: 141 . 14 . **2** . 0
Binary IP Address: 1000 1101 . 0000 1110 . 0000 0010 . 0000 0000

&



Default Mask

Class	<i>In Binary</i>	<i>In Dotted-Decimal</i>	<i>Using Slash</i>
A	11111111 00000000 00000000 00000000	255.0.0.0	/8
B	11111111 11111111 00000000 00000000	255.255.0.0	/16
C	11111111 11111111 11111111 00000000	255.255.255.0	/24

Example

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

Solution

Class C → default mask = 255.255.255.0

Destination address	→	201	.	24	.	67	.	32
Default mask	→	255	.	255	.	255	.	0
Network address	→	201	.	24	.	67	.	0



Subnet Design

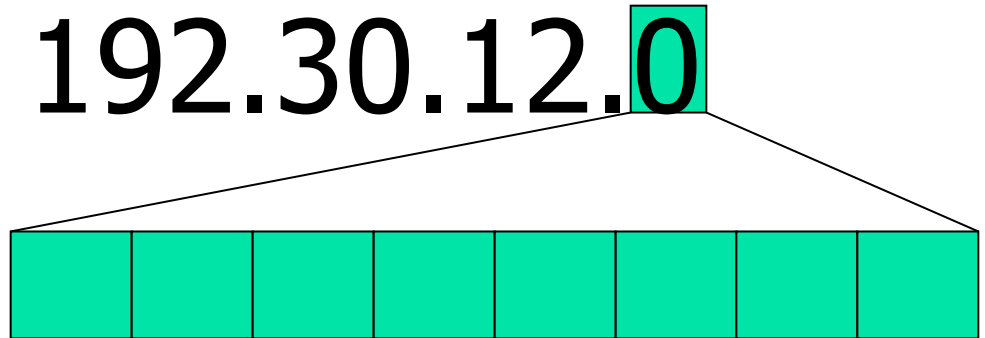
- Given a network 194.30.12.0 with 16 hosts in each subnetwork
- Find the following:
 - The number of subnetworks
 - Sub-network ID / Broadcast Address
 - Sub-netmask
 - First/Last address that can be used for each subnet

Subnet Design

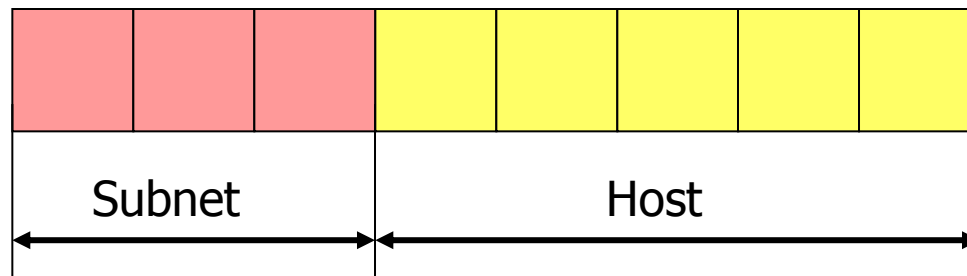
Class C IP address

192.30.12.0

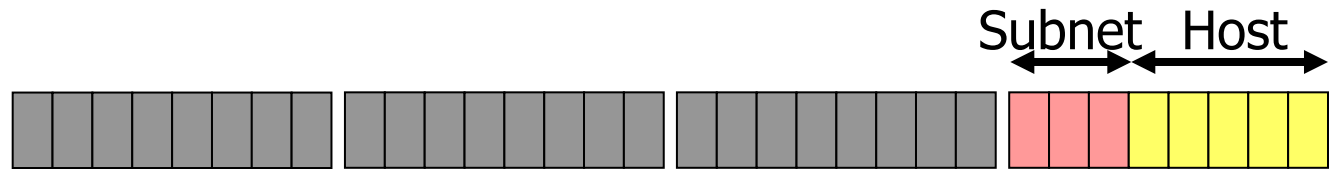
Last Byte(Host ID)



- 16 Hosts → $2^4 = 16$ is not enough (subnetID and broadcast)
- $2^5 = 32$ → total of 30 hosts
- 5 bits for Host and 3 bits for subnet



Subnet Design



Subnet Mask	255	.	255	.	255	.	1 1 1 0 0 0 0 0
	255	.	255	.	255	.	224
Subnet ID	194	.	30	.	12	.	000 00000 = 0
	194	.	30	.	12	.	001 00000 = 32
	194	.	30	.	12	.	010 00000 = 64
	194	.	30	.	12	.	011 00000 = 96
	194	.	30	.	12	.	100 00000 = 128
	194	.	30	.	12	.	101 00000 = 160
	194	.	30	.	12	.	110 00000 = 192
	194	.	30	.	12	.	111 00000 = 224



Subnet Design

Subnet	Subnet ID	1 st Add	Last Add	Broadcast
0	192.30.12.0	192.30.12.1	192.30.12.30	192.30.12.31
1	192.30.12.32	192.30.12.33	192.30.12.62	192.30.12.63
2	192.30.12.64	192.30.12.65	192.30.12.94	192.30.12.95
3	192.30.12.96	192.30.12.97	192.30.12.126	192.30.12.127
4	192.30.12.128	192.30.12.129	192.30.12.158	192.30.12.159
5	192.30.12.160	192.30.12.161	192.30.12.190	192.30.12.191
6	192.30.12.192	192.30.12.193	192.30.12.222	192.30.12.223
7	192.30.12.224	192.30.12.225	192.30.12.254	192.30.12.255