



# Network Layer & IPv4 (Part II)

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# Outline

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

# IP Address

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



# IP Address

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- 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 ?



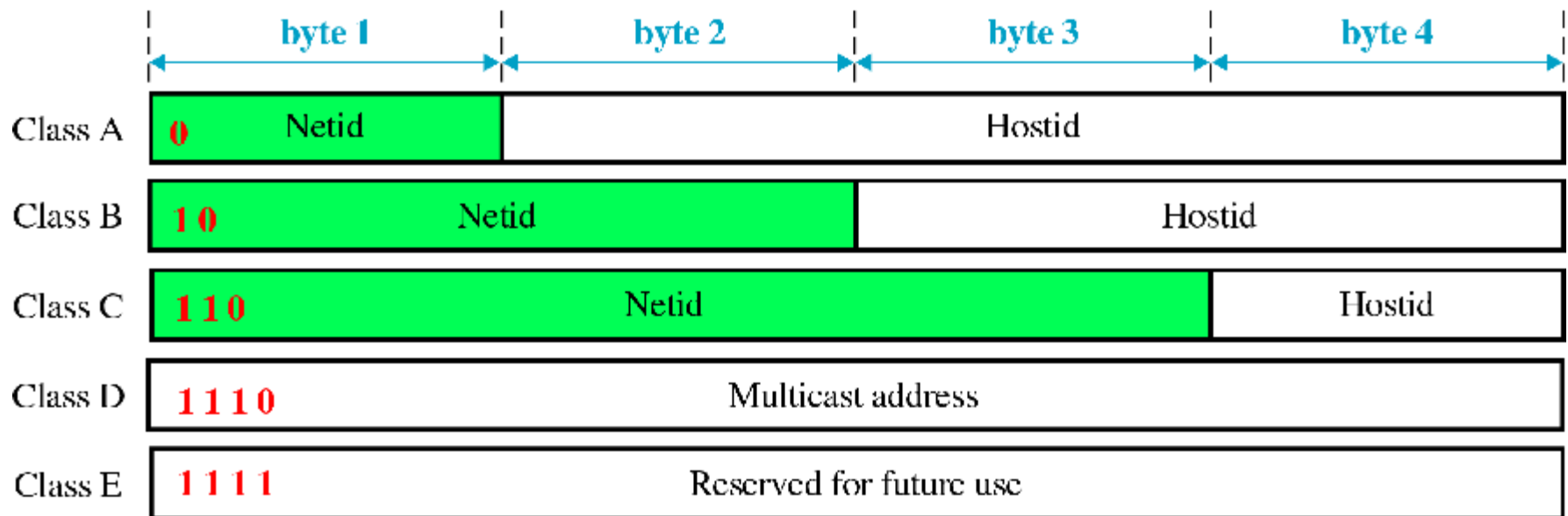
# Internet Address

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



# Internet Classes



**Classfull Addressing**

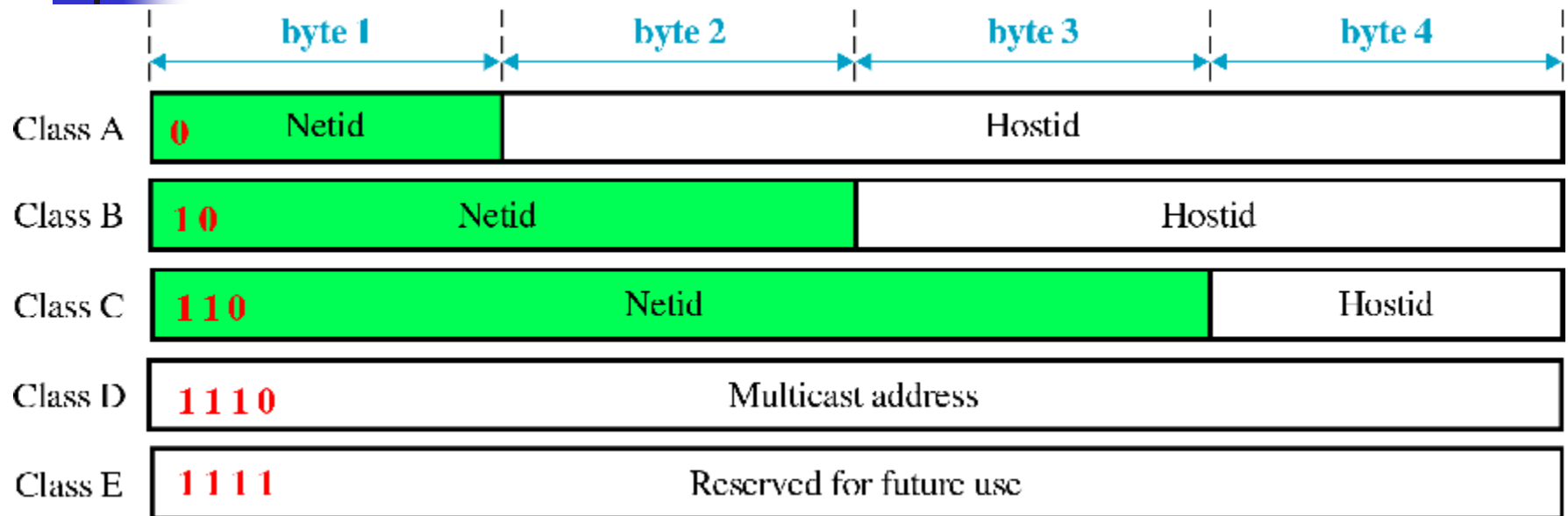


# IP Address Class

Class A	<b>0</b> Netid
Class B	<b>10</b> Netid
Class C	<b>110</b>
Class D	<b>1110</b>
Class E	<b>1111</b>

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



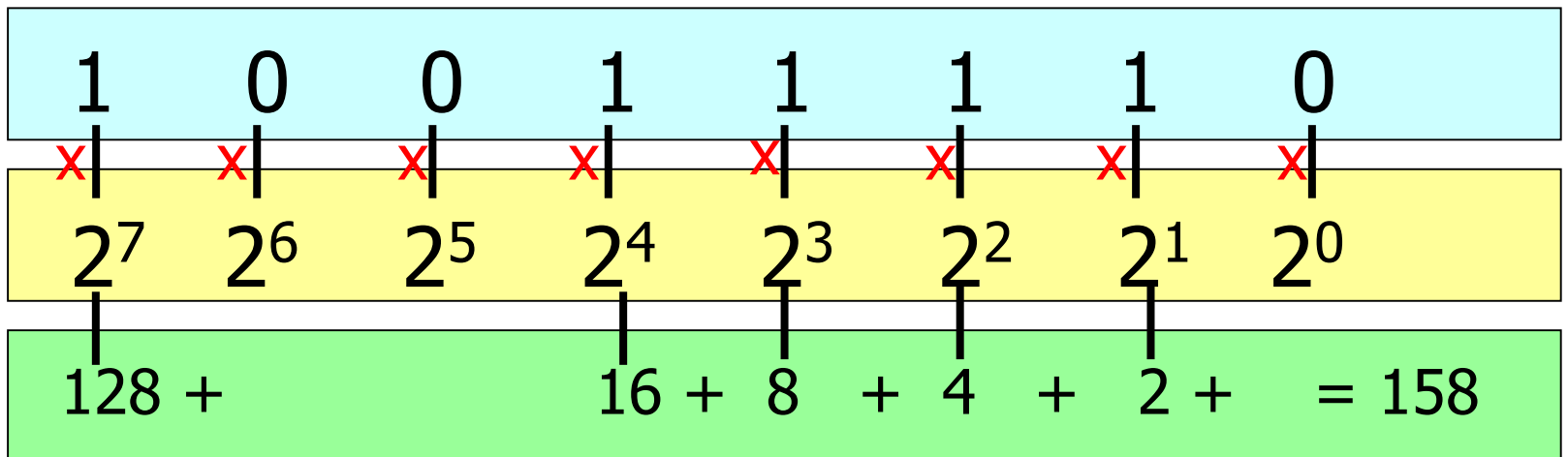
Address Class	Bits In Prefix	Maximum Number of Networks	Bits In Suffix	Maximum Number Of Hosts Per Network
A	7	128	24	16777216
B	14	16384	16	65536
C	21	2097152	8	256



# 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
10000001	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~~

~~www.ku.ac.th~~

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



# Class Ranges

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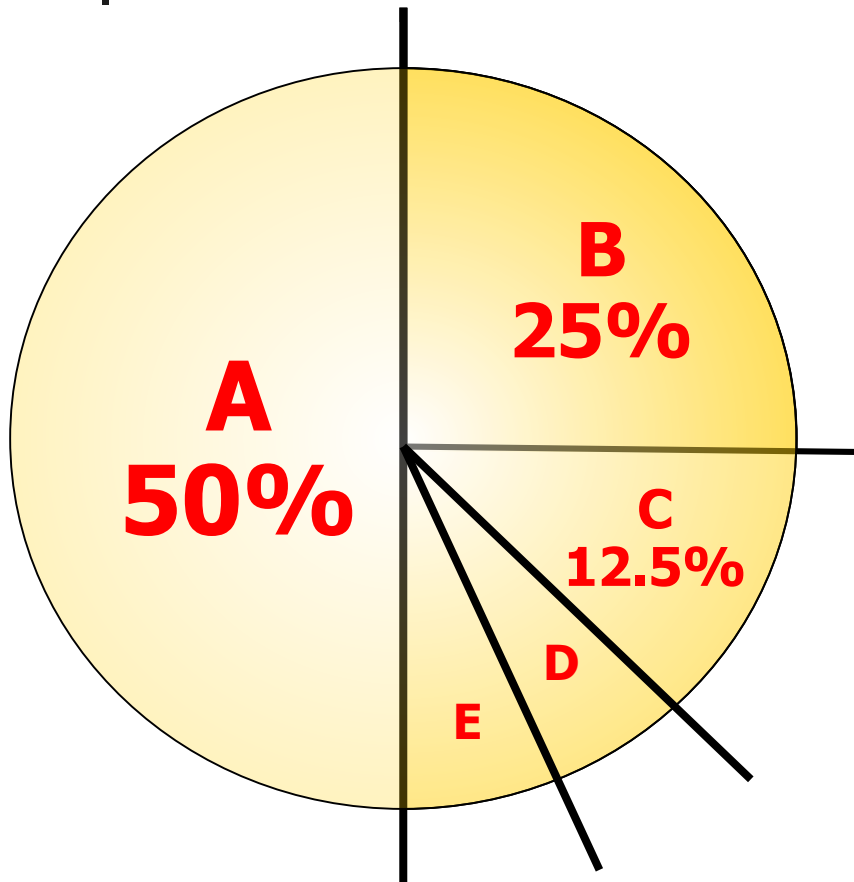
	Octet 1	Octet 2	Octet 3	Octet 4
Class A	0.....			
Class B	10.....			
Class C	110.....			
Class D	1110....			
Class E	1111....			

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	<b>0</b> Netid
Class B	<b>1 0</b> Netid
Class C	<b>1 1 0</b>
Class D	<b>1 1 1 0</b>
Class E	<b>1 1 1 1</b>

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

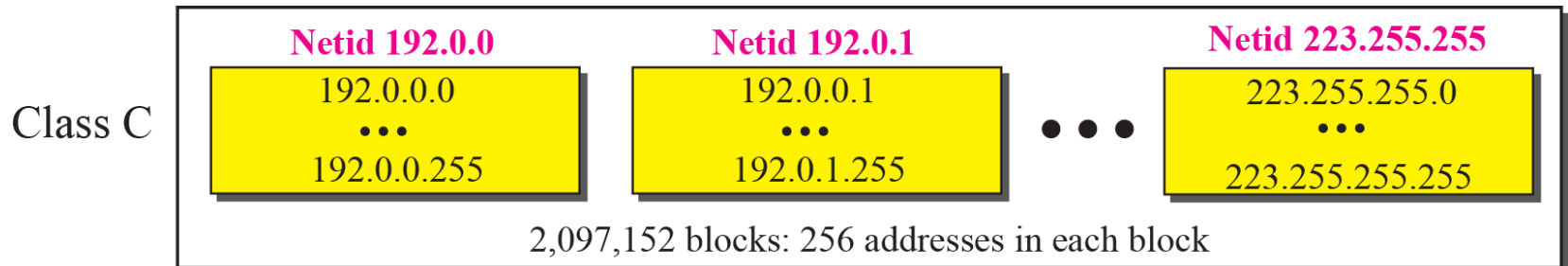
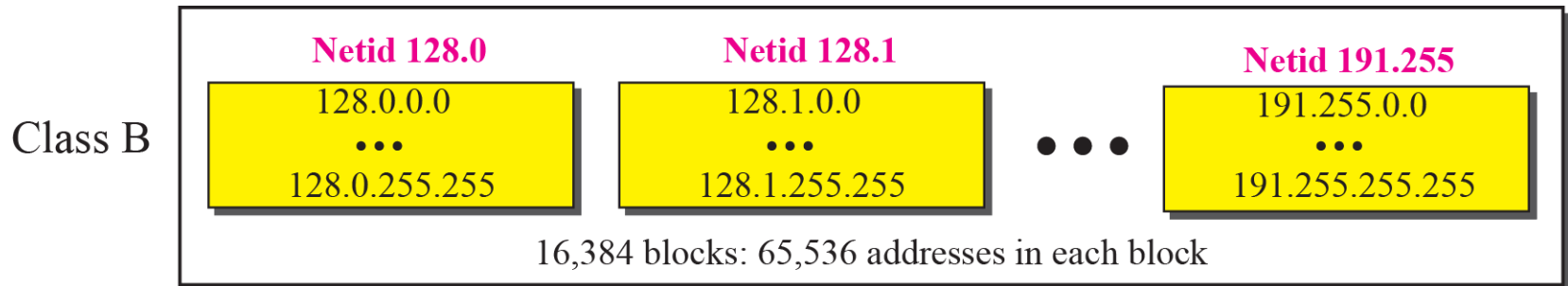
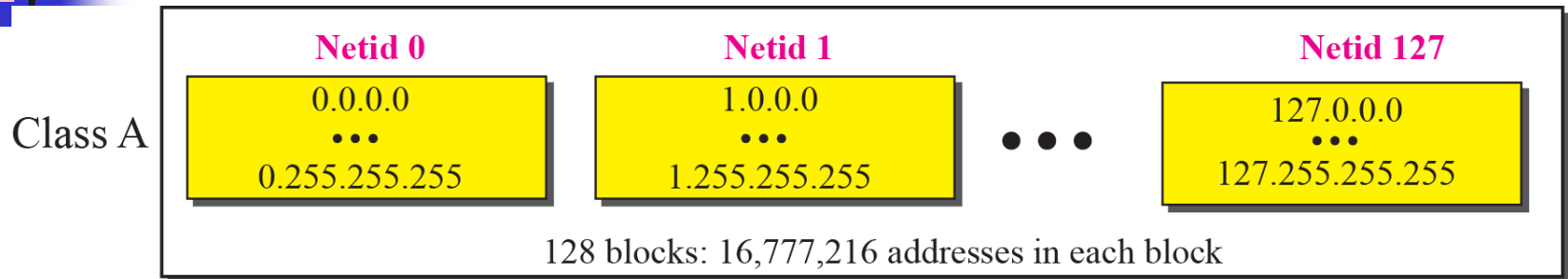
Class B:  $2^{30} = 1,073,741,824$  addresses, 25%

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





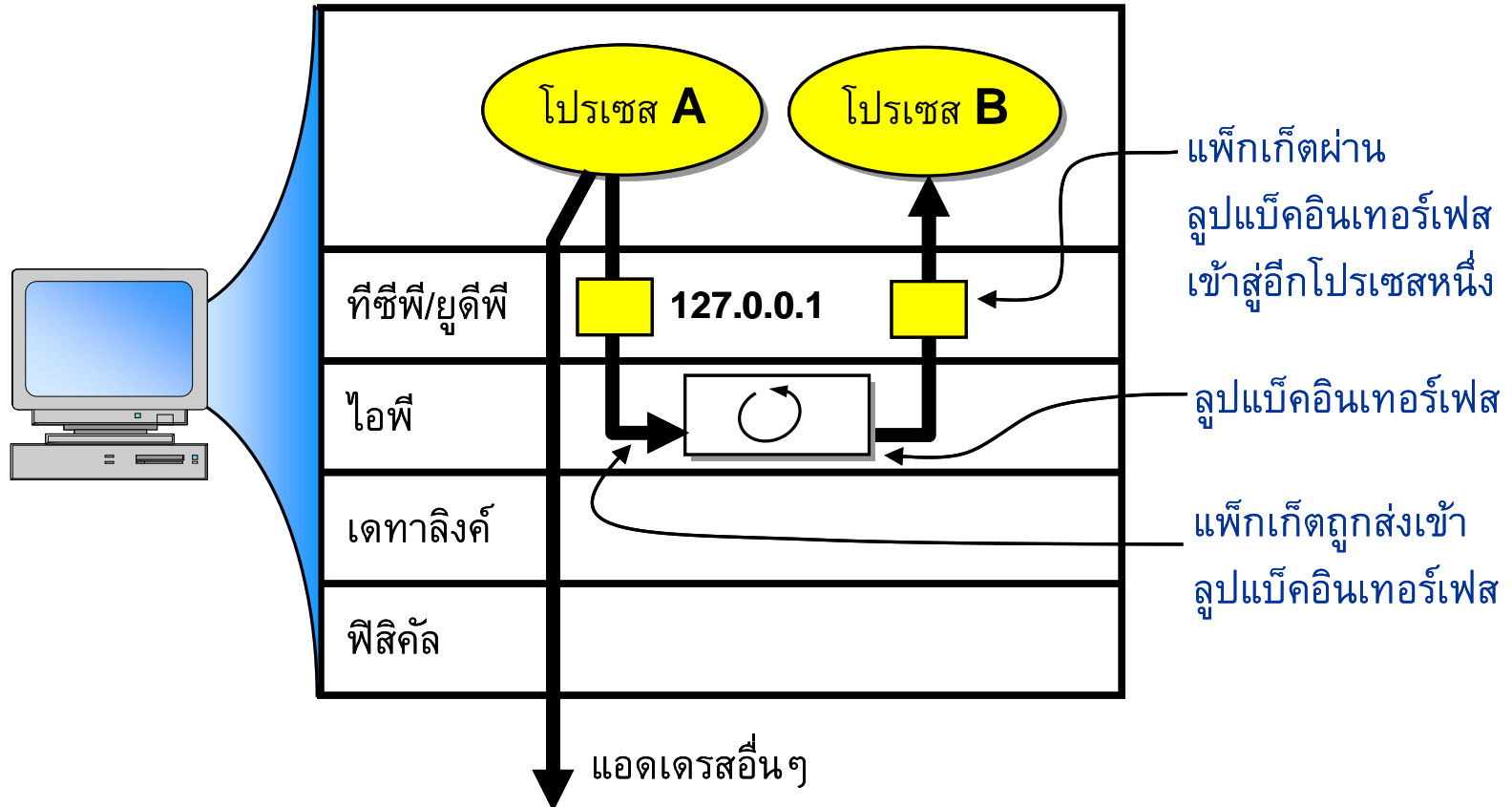
# Special IP Addresses

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- 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

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- Ending with 255 – *"Not always 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

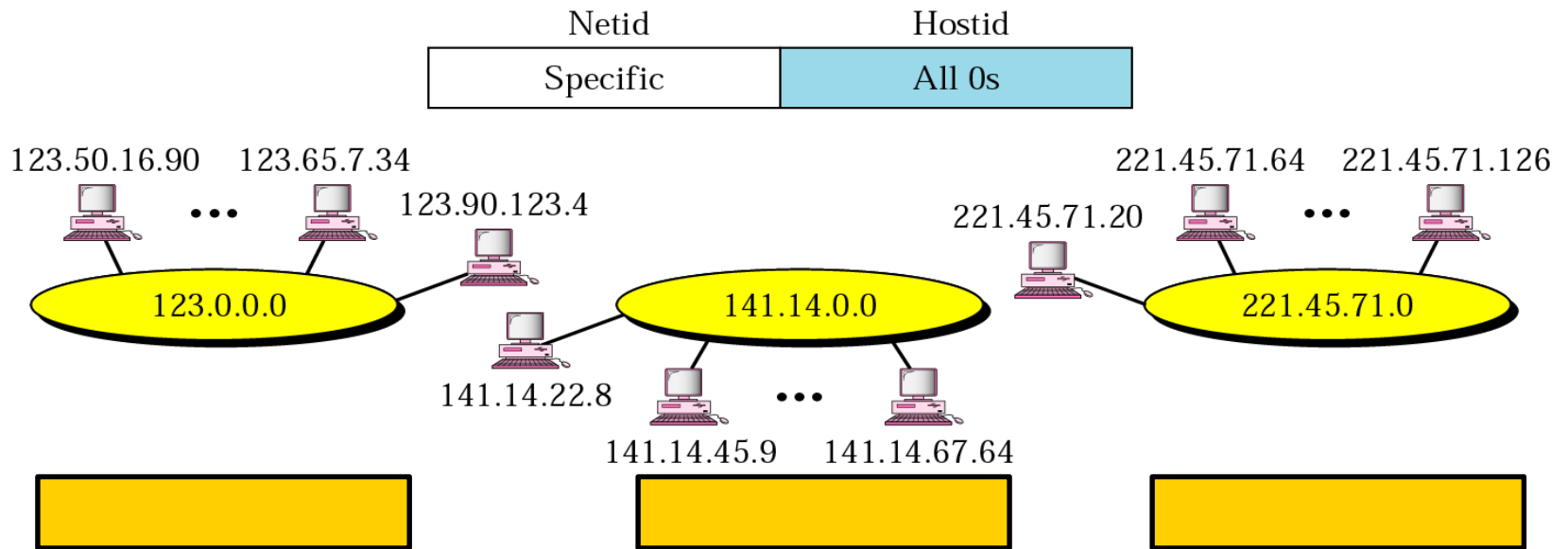


## Special IP Address: **Private IP** Address

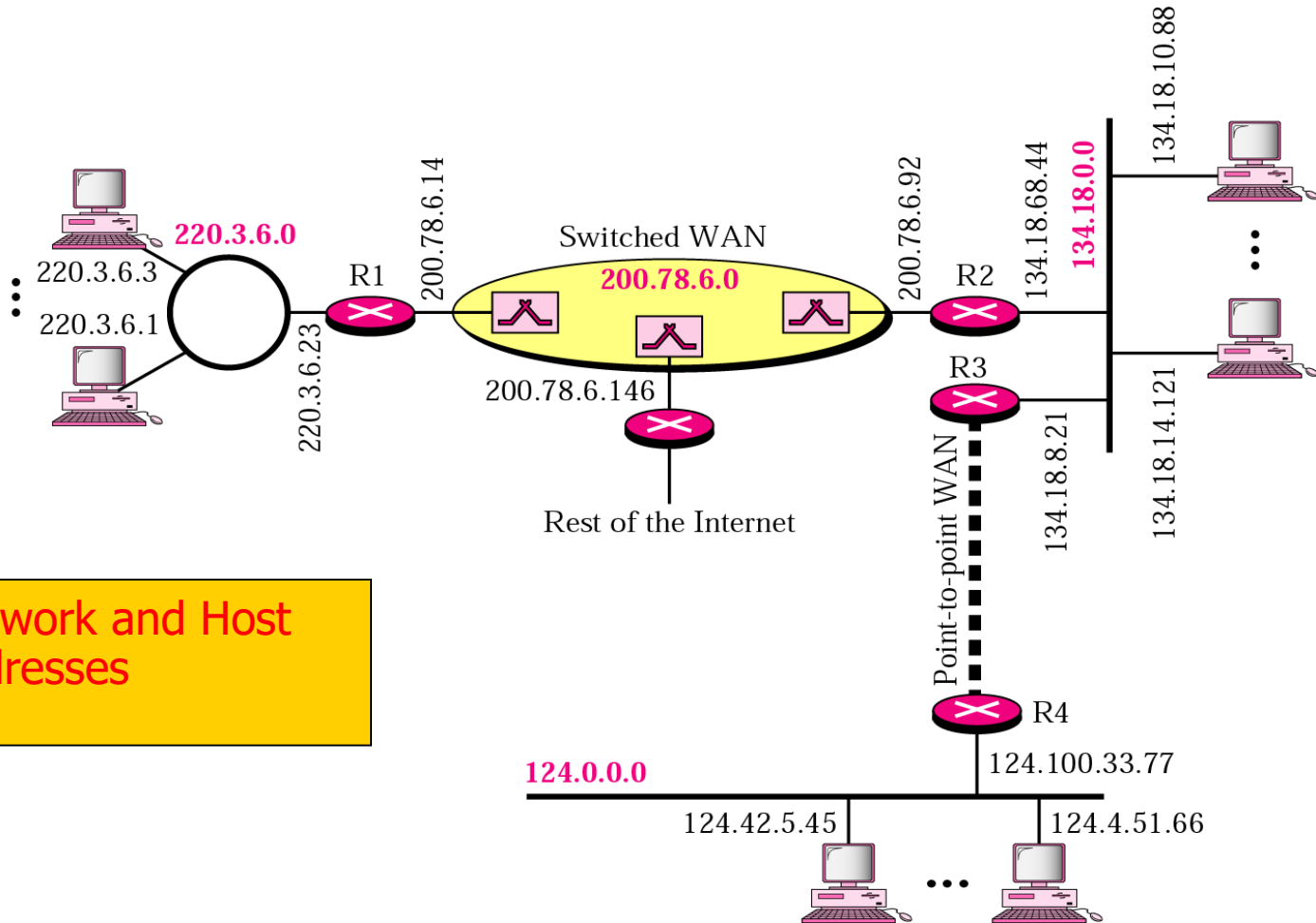
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- Class A (1 group)
  - 10.0.0.0 – 10.255.255.255
- Class B (16 groups)
  - 172.16.0.0 – 172.31.255.255
- Class C (256 groups)
  - 192.168.0.0 – 192.168.255.255

# Special IP Address: **Network** Address

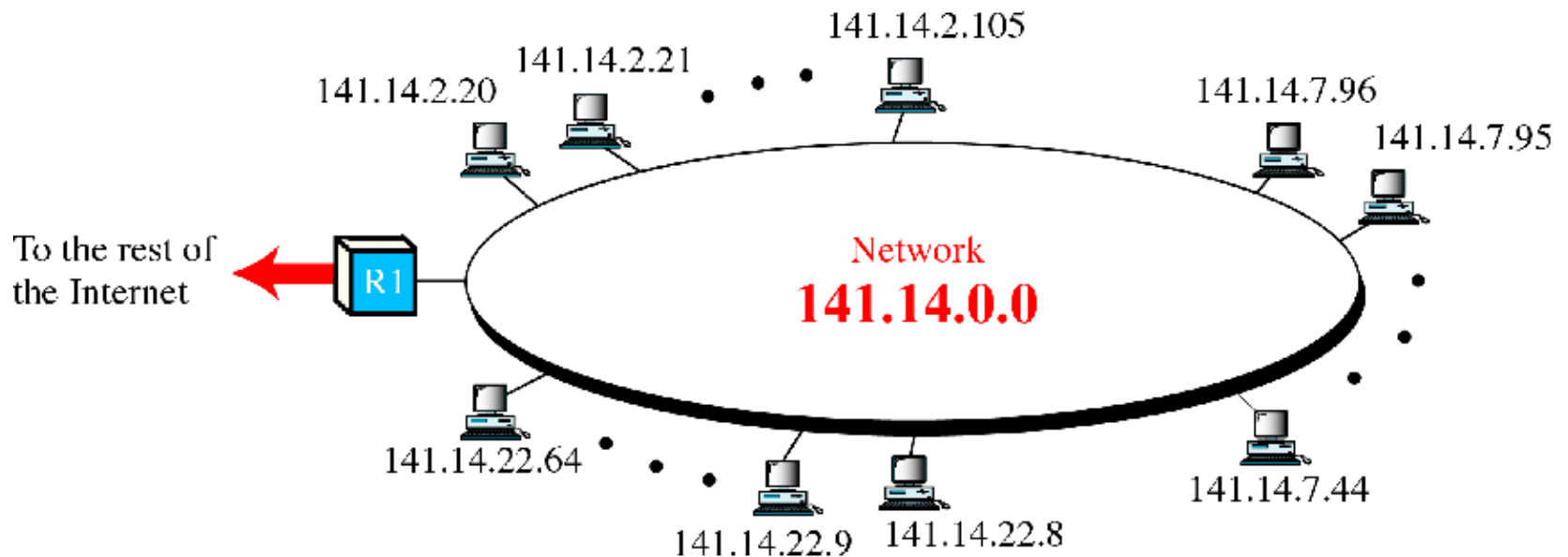


# Sample internet

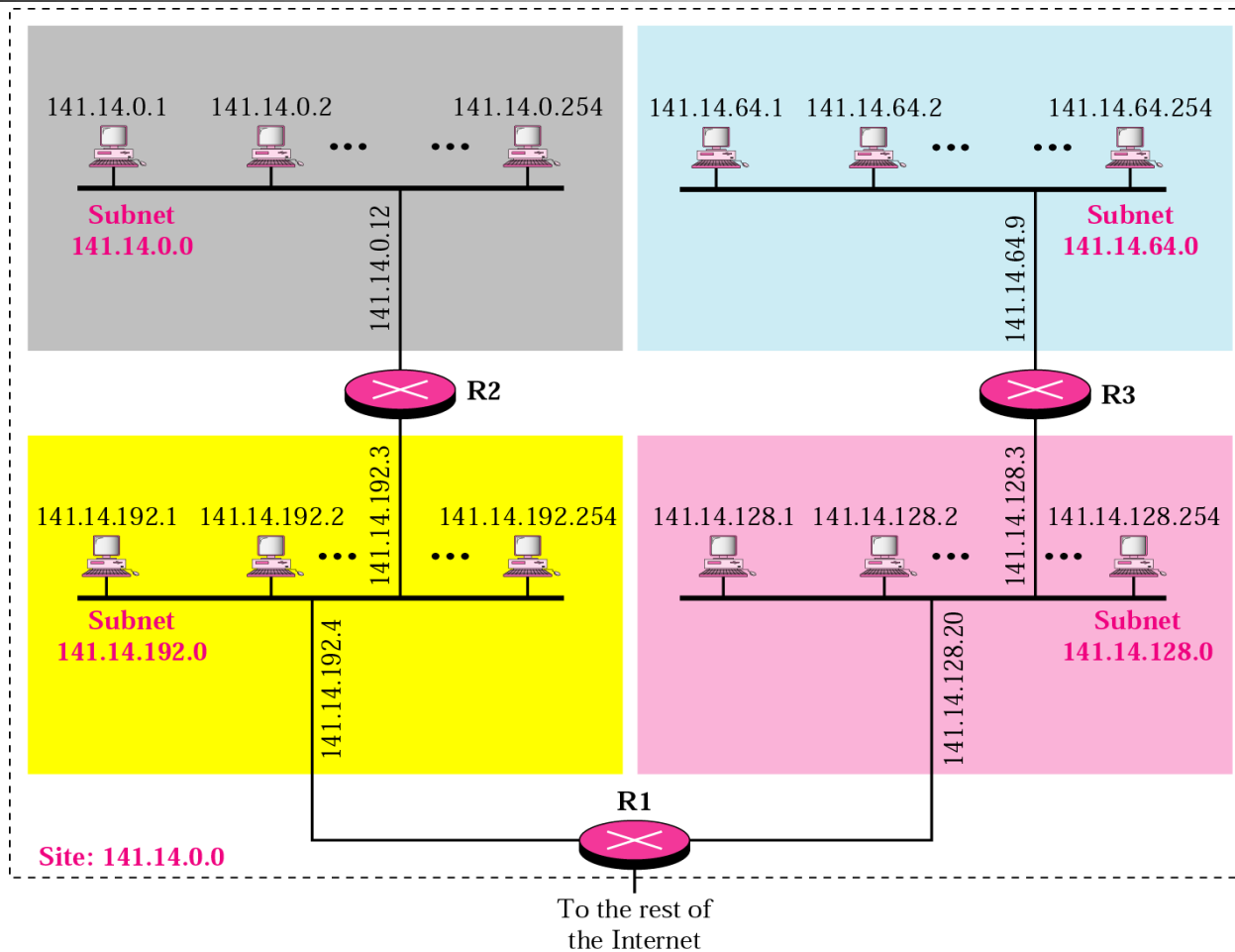


Network and Host addresses

# A Network with Two Levels of Hierarchy

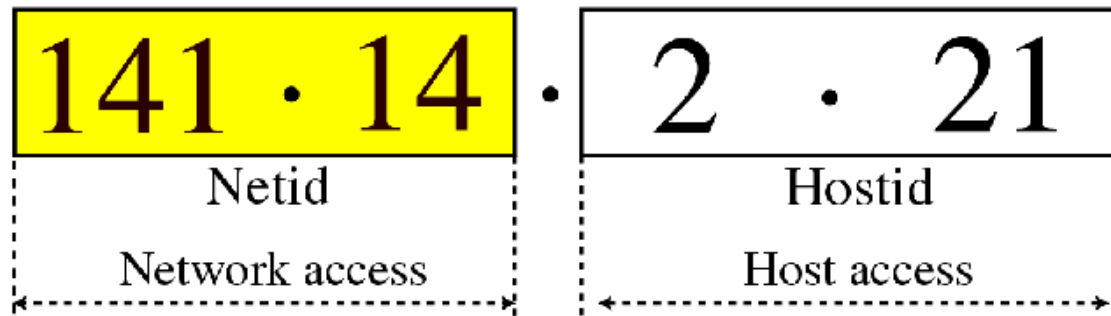


# A Network with Three Levels of Hierarchy

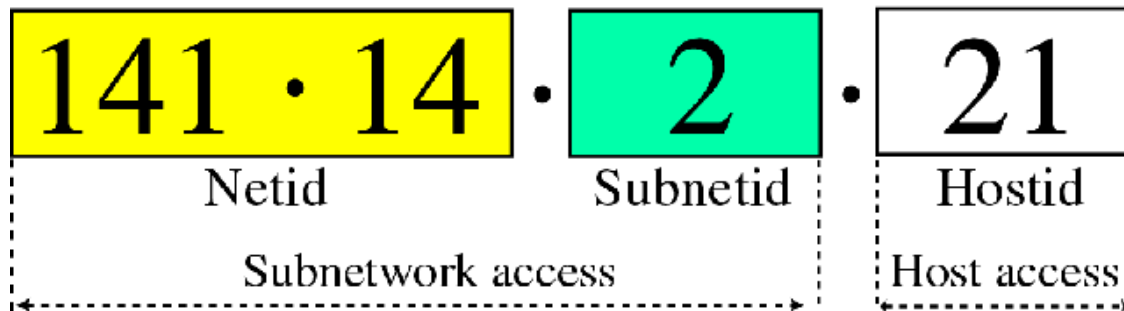


# Addresses

## with and without Subnetting

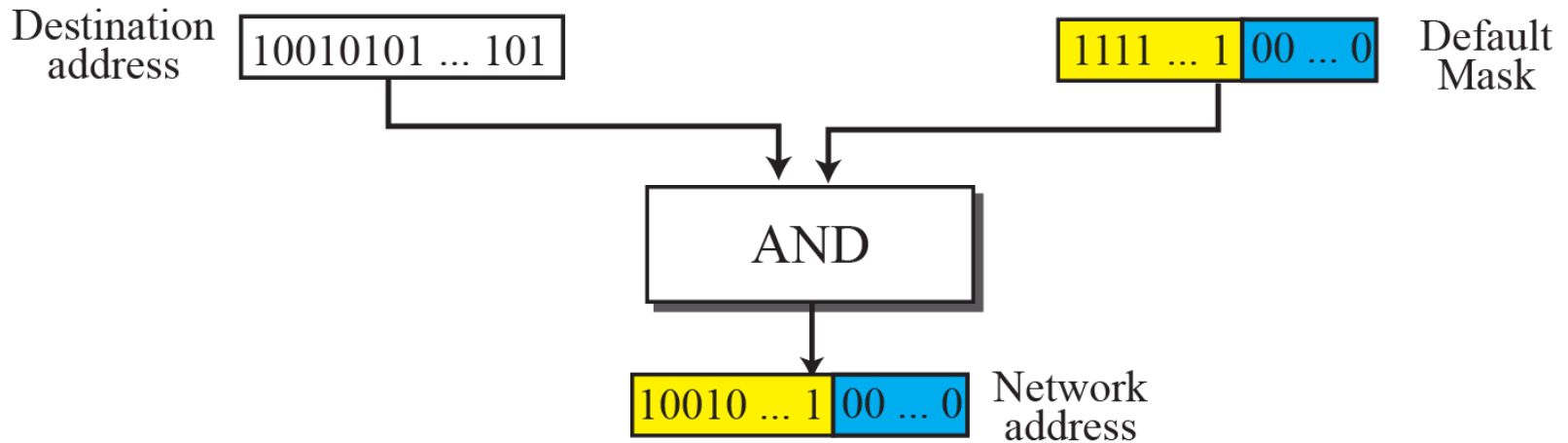


a. Without subnetting



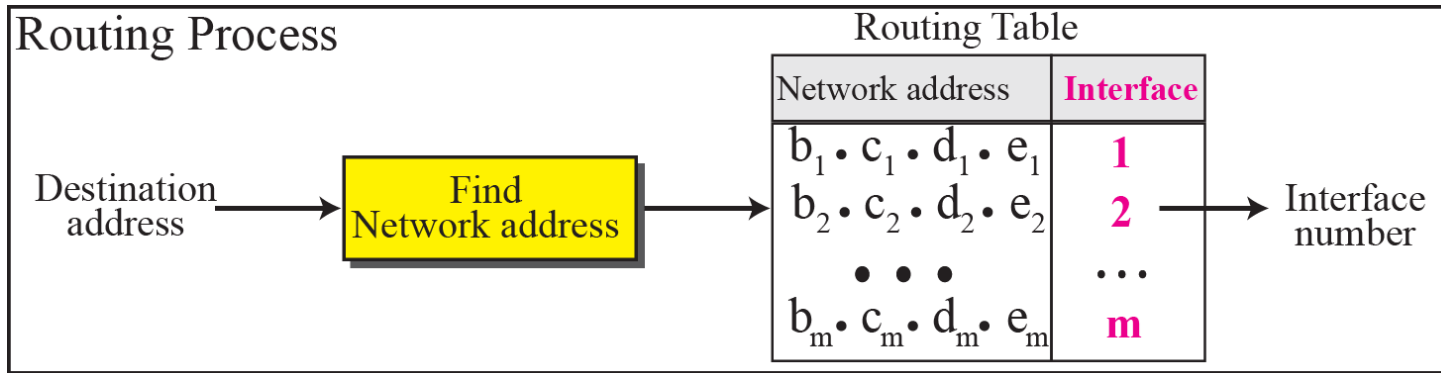
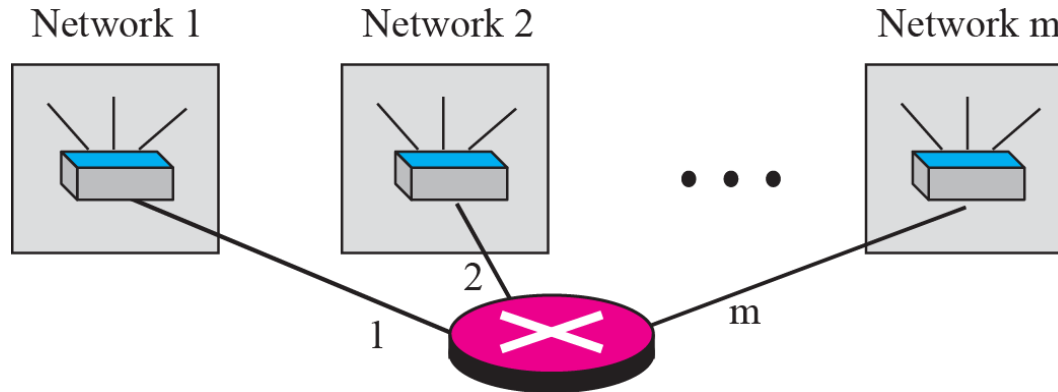
b. With subnetting

# Finding a Network Address

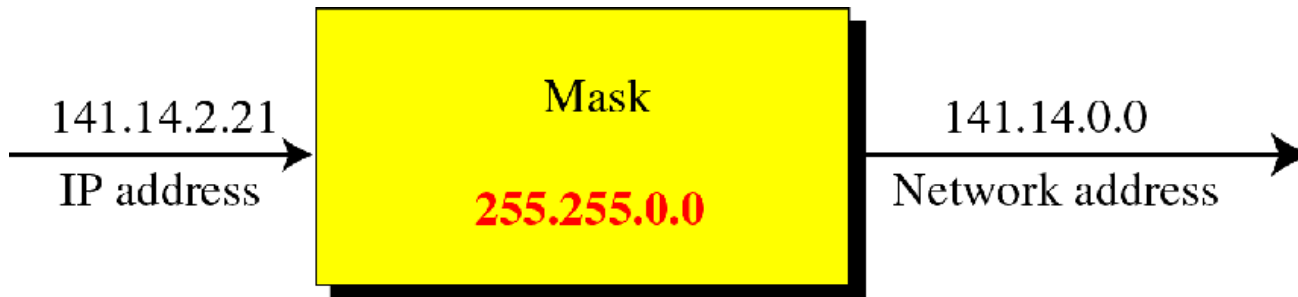




# Network Address



# Masking (without subnet)



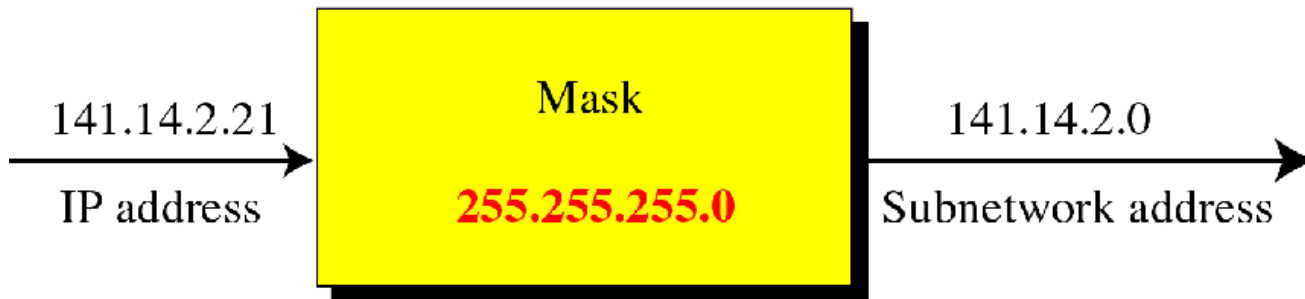
IP Address: 141 . 14 . 2 . 21  
Binary IP Address: 1000 1101 . 0000 1110 . 0000 0010 . 0001 0101

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

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

# 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

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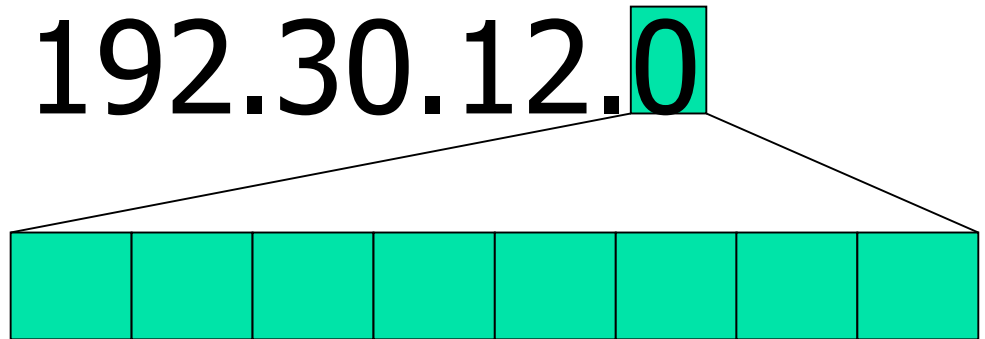
- Given a network 194.30.12.0 with 16 hosts in each subnetwork
- Find the following:
  - The number of subnetworks
  - Sub-network ID / Broadcast Address
  - Sub-netmask
  - First/Last address that can be used for each subnet

# Subnet Design

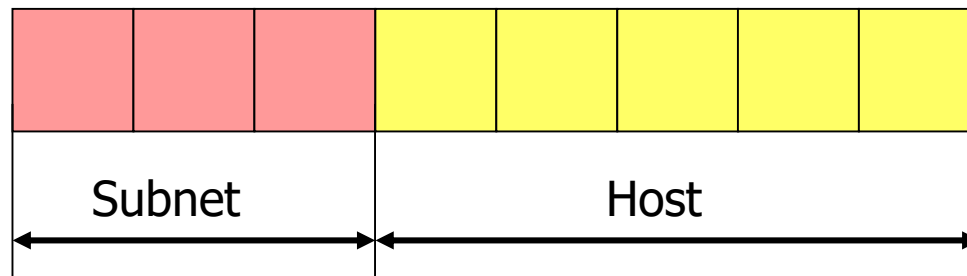
Class C IP address

192.30.12.0

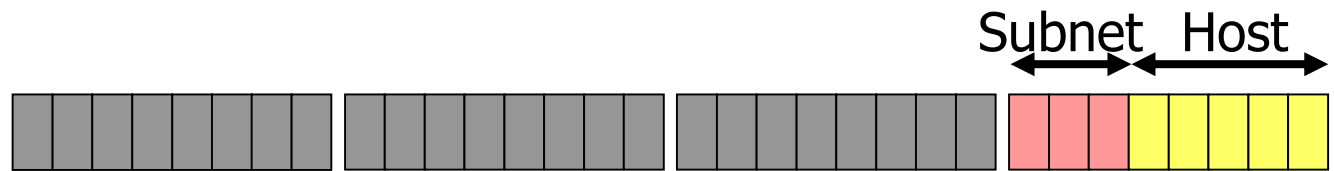
Last Byte(Host ID)



- 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	.	<b>1 1 1 0 0 0 0 0</b>
	255	.	255	.	255	.	224
Subnet ID	194	.	30	.	12	.	▪ <b>000</b> 00000 = 0
	194	.	30	.	12	.	▪ <b>001</b> 00000 = 32
	194	.	30	.	12	.	▪ <b>010</b> 00000 = 64
	194	.	30	.	12	.	▪ <b>011</b> 00000 = 96
	194	.	30	.	12	.	▪ <b>100</b> 00000 = 128
	194	.	30	.	12	.	▪ <b>101</b> 00000 = 160
	194	.	30	.	12	.	▪ <b>110</b> 00000 = 192
	194	.	30	.	12	.	▪ <b>111</b> 00000 = 224





# Subnet Design

Subnet	Subnet ID	1 <sup>st</sup> 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