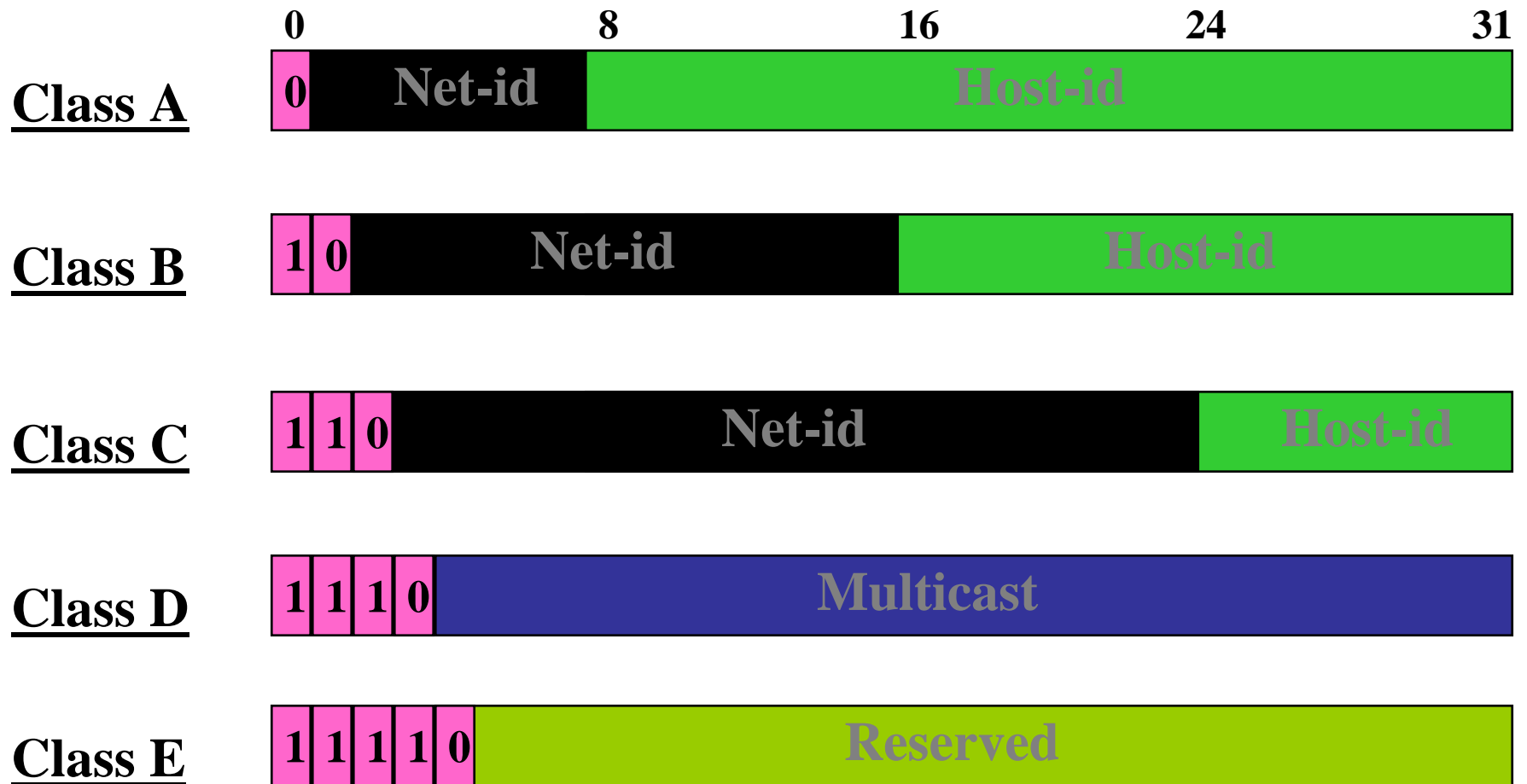


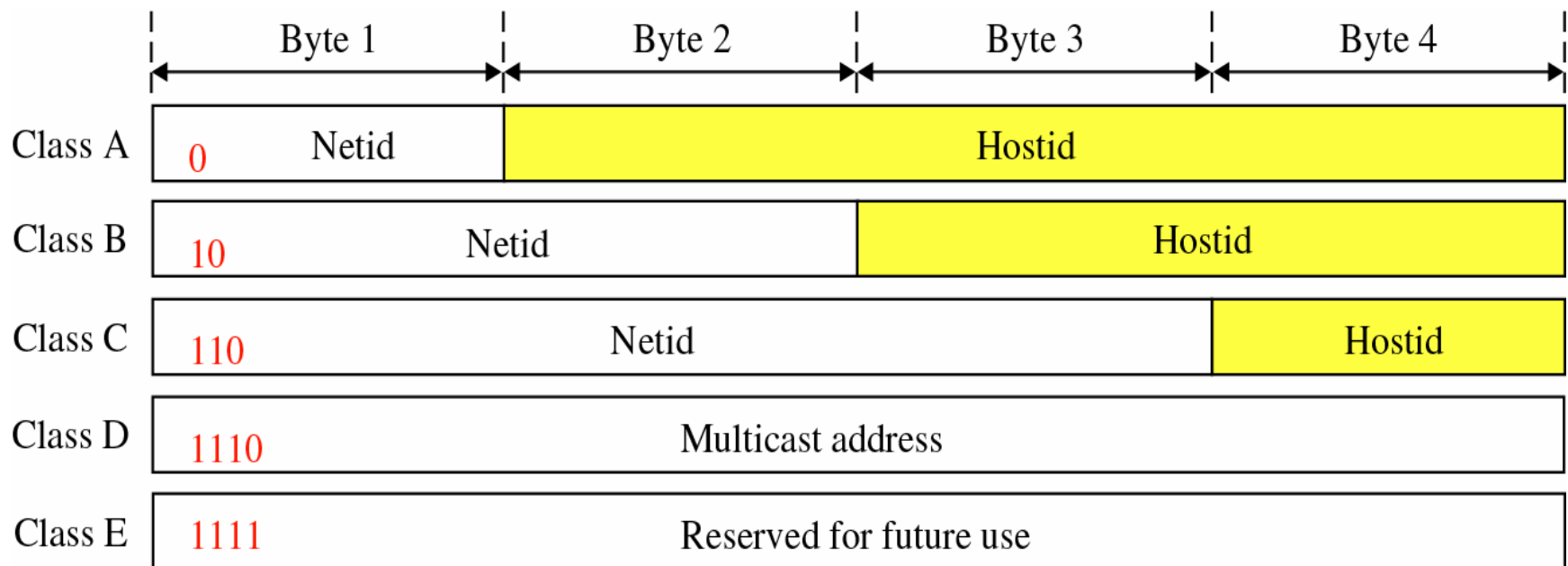
IP Classes

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



IP Classes





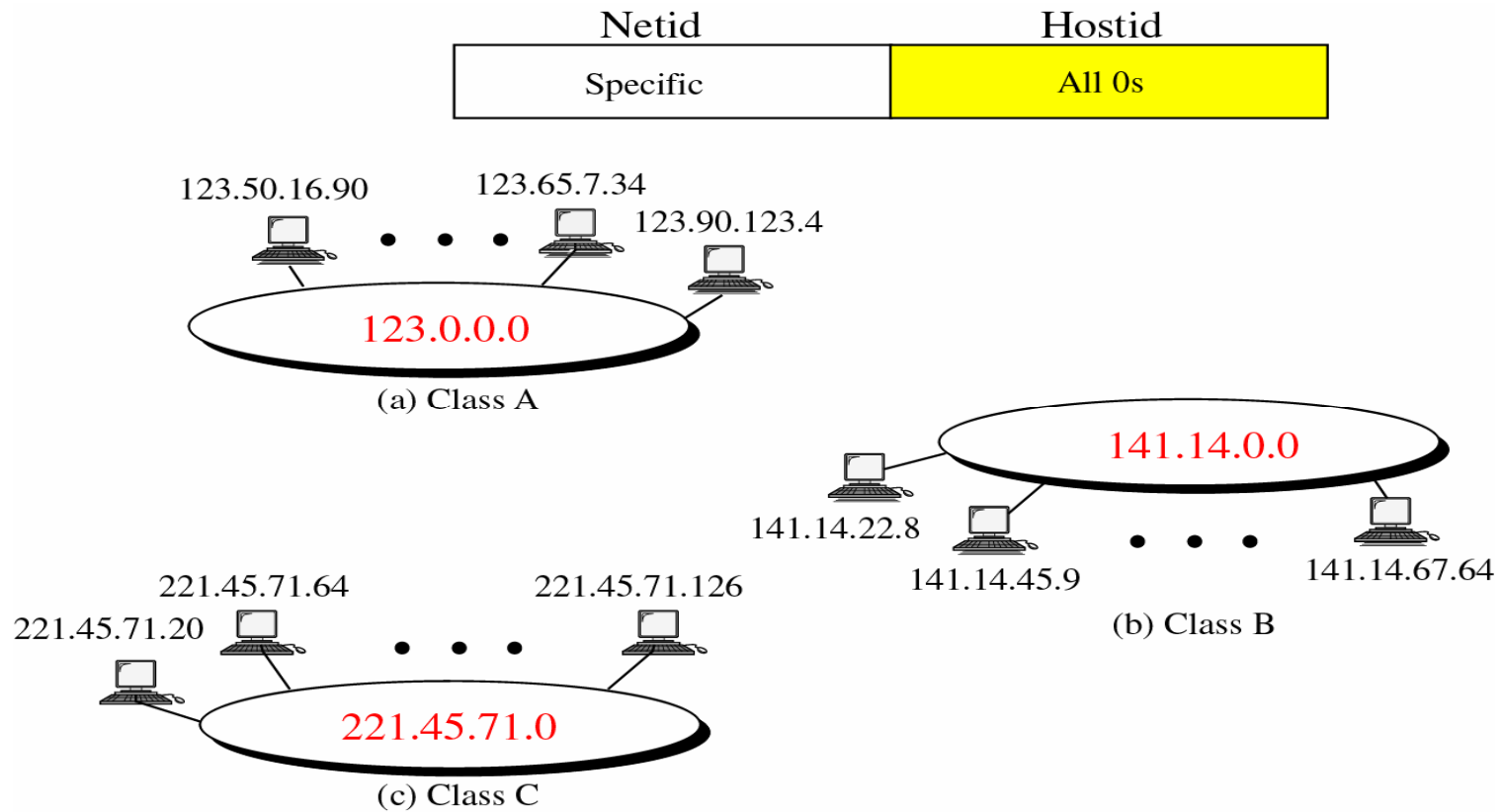
IP Classes

	From	To								
Class A	<table border="1"><tr><td>0</td><td>.0.0.0</td></tr><tr><td>Netid</td><td>Hostid</td></tr></table>	0	.0.0.0	Netid	Hostid	<table border="1"><tr><td>127</td><td>.255.255.255</td></tr><tr><td>Netid</td><td>Hostid</td></tr></table>	127	.255.255.255	Netid	Hostid
0	.0.0.0									
Netid	Hostid									
127	.255.255.255									
Netid	Hostid									
Class B	<table border="1"><tr><td>128</td><td>.0.0.0</td></tr><tr><td>Netid</td><td>Hostid</td></tr></table>	128	.0.0.0	Netid	Hostid	<table border="1"><tr><td>191</td><td>.255.255.255</td></tr><tr><td>Netid</td><td>Hostid</td></tr></table>	191	.255.255.255	Netid	Hostid
128	.0.0.0									
Netid	Hostid									
191	.255.255.255									
Netid	Hostid									
Class C	<table border="1"><tr><td>192</td><td>.0.0.0</td></tr><tr><td>Netid</td><td>Hostid</td></tr></table>	192	.0.0.0	Netid	Hostid	<table border="1"><tr><td>223</td><td>.255.255.255</td></tr><tr><td>Netid</td><td>Hostid</td></tr></table>	223	.255.255.255	Netid	Hostid
192	.0.0.0									
Netid	Hostid									
223	.255.255.255									
Netid	Hostid									
Class D	<table border="1"><tr><td>224</td><td>.0.0.0</td></tr><tr><td colspan="2">Multicast Address</td></tr></table>	224	.0.0.0	Multicast Address		<table border="1"><tr><td>239</td><td>.255.255.255</td></tr><tr><td colspan="2">Multicast Address</td></tr></table>	239	.255.255.255	Multicast Address	
224	.0.0.0									
Multicast Address										
239	.255.255.255									
Multicast Address										
Class E	<table border="1"><tr><td>240</td><td>.0.0.0</td></tr><tr><td colspan="2">Reserved</td></tr></table>	240	.0.0.0	Reserved		<table border="1"><tr><td>255</td><td>.255.255.255</td></tr><tr><td colspan="2">Reserved</td></tr></table>	255	.255.255.255	Reserved	
240	.0.0.0									
Reserved										
255	.255.255.255									
Reserved										

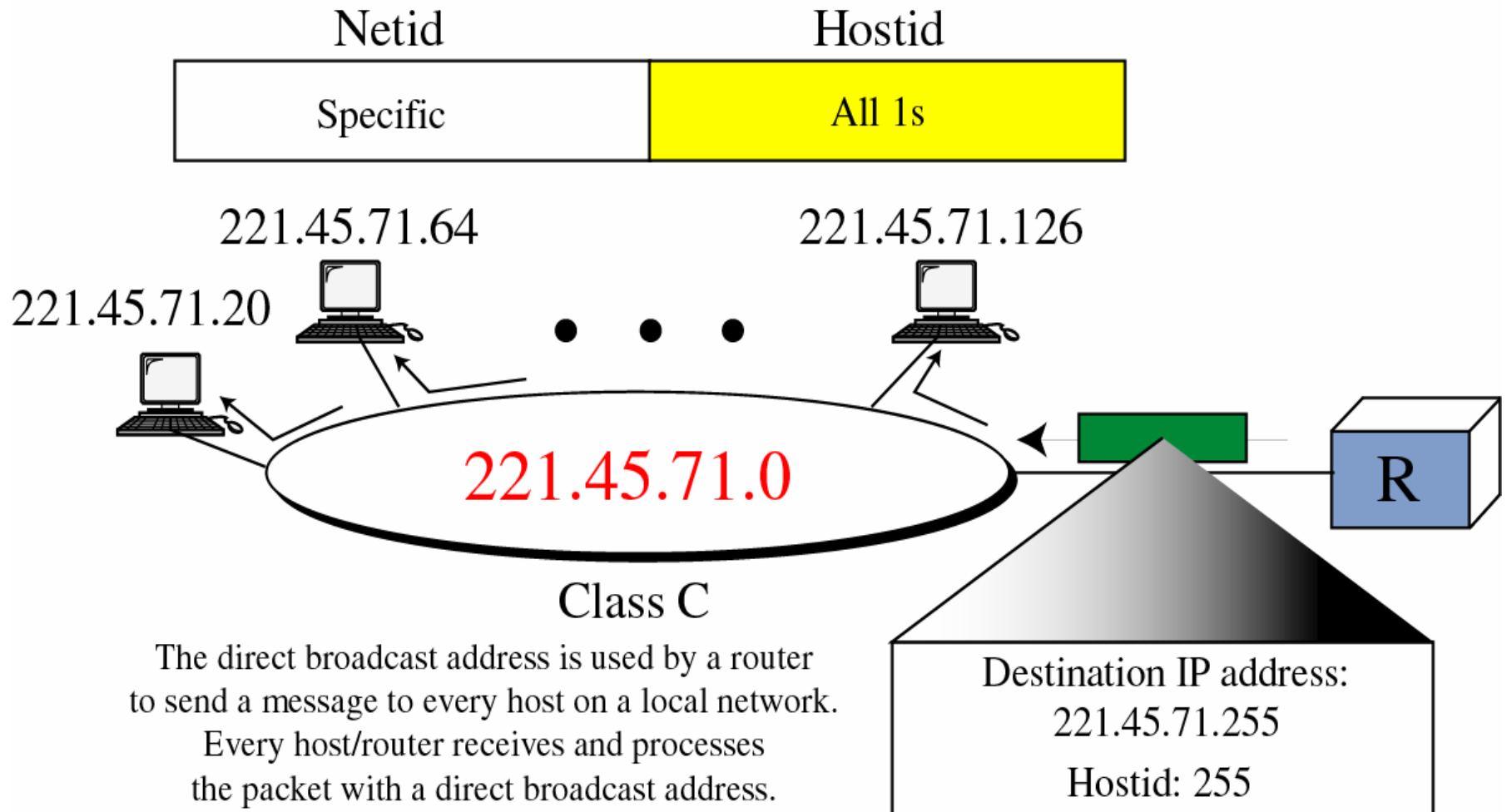
Special IP Addresses

- Network address
- Direct broadcast address
- Limited broadcast address
- Loop back address

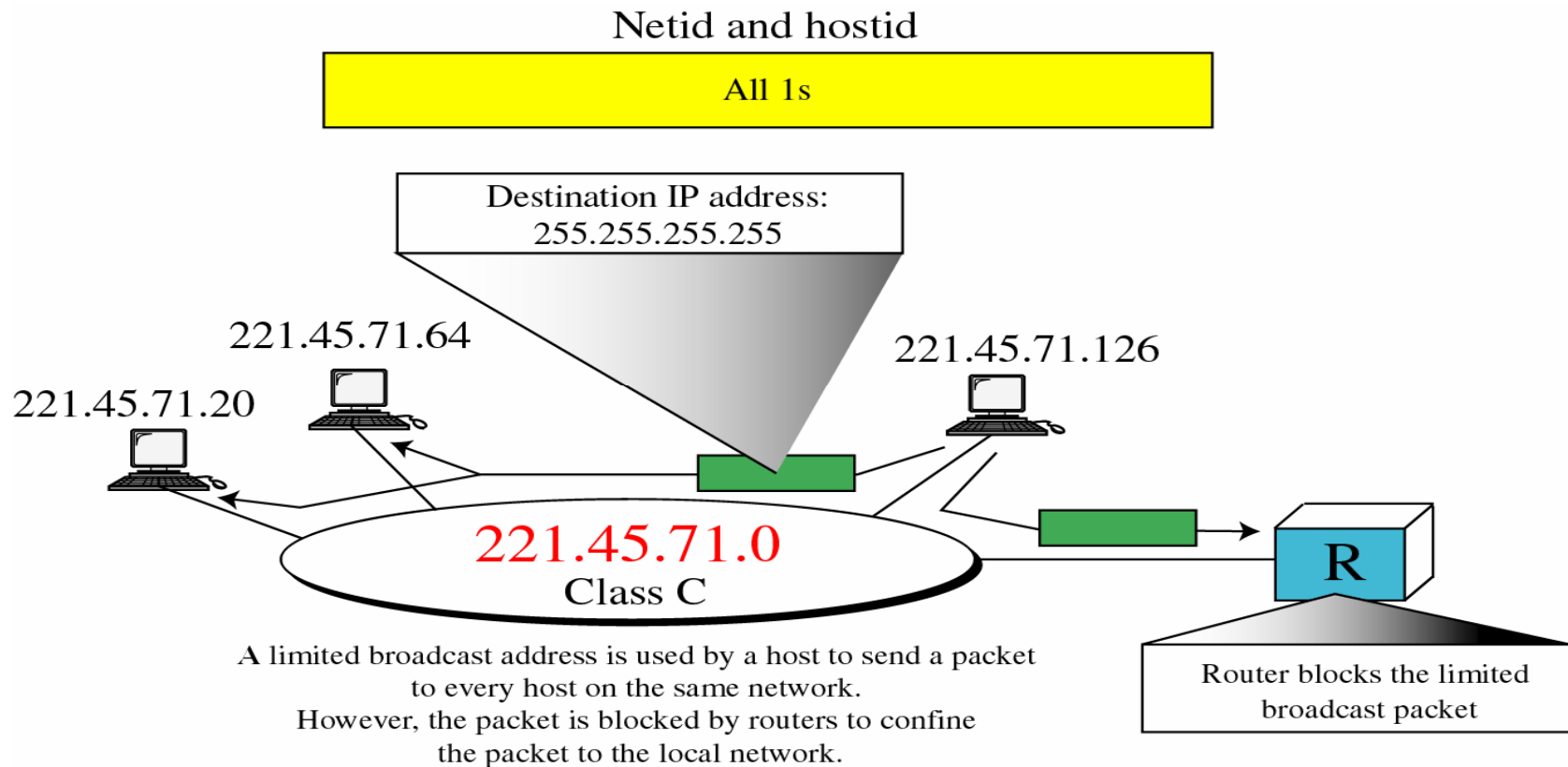
Network Address



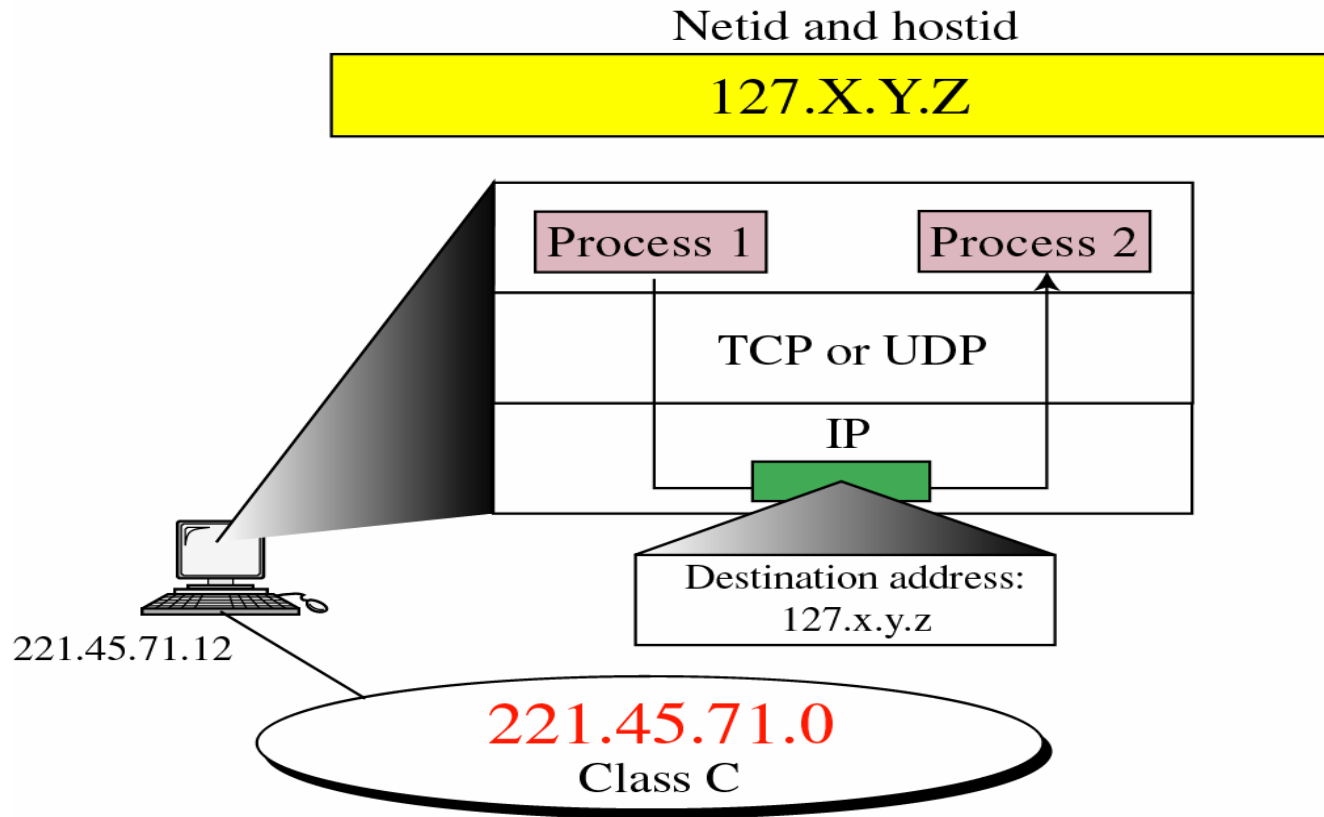
Direct Broadcast Address



Limited Broadcast Address



Loop back Address



A packet with a loopback address
will not reach the network.

Subnetting

- In subnetting, a network is divided into smaller subnets with each subnet having its own subnet address.

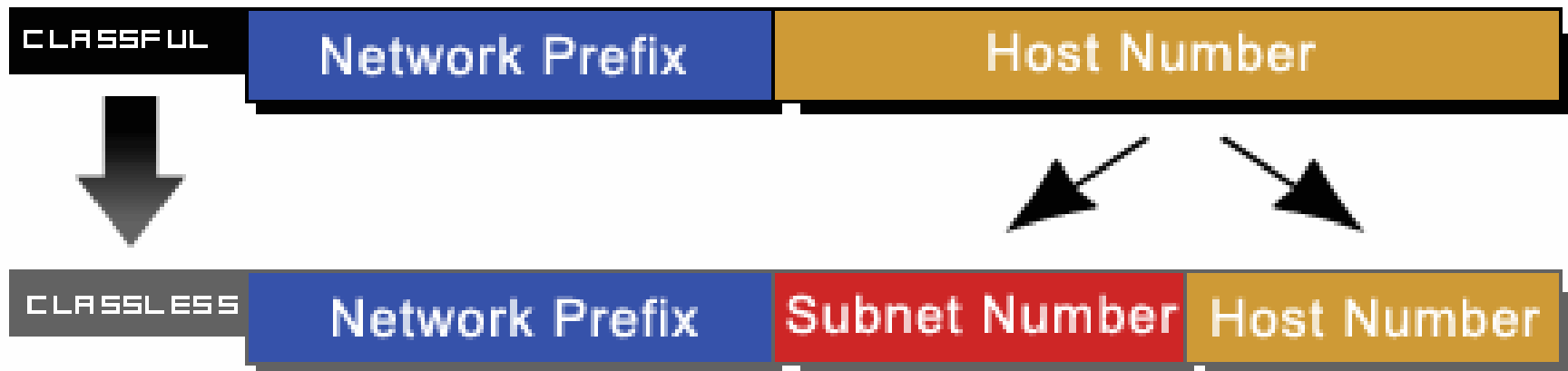
Reasons for Subnetting

- **Imagine a Network Class A with over 16 millions of hosts or a Class B Network with 65 thousand hosts, it is impractical...**
- **Most IP address assignments were not used very efficiently.**
- **Broadcast problem.**
- **Many sites were requesting multiple network numbers due to variable amounts of networks at their sites.**

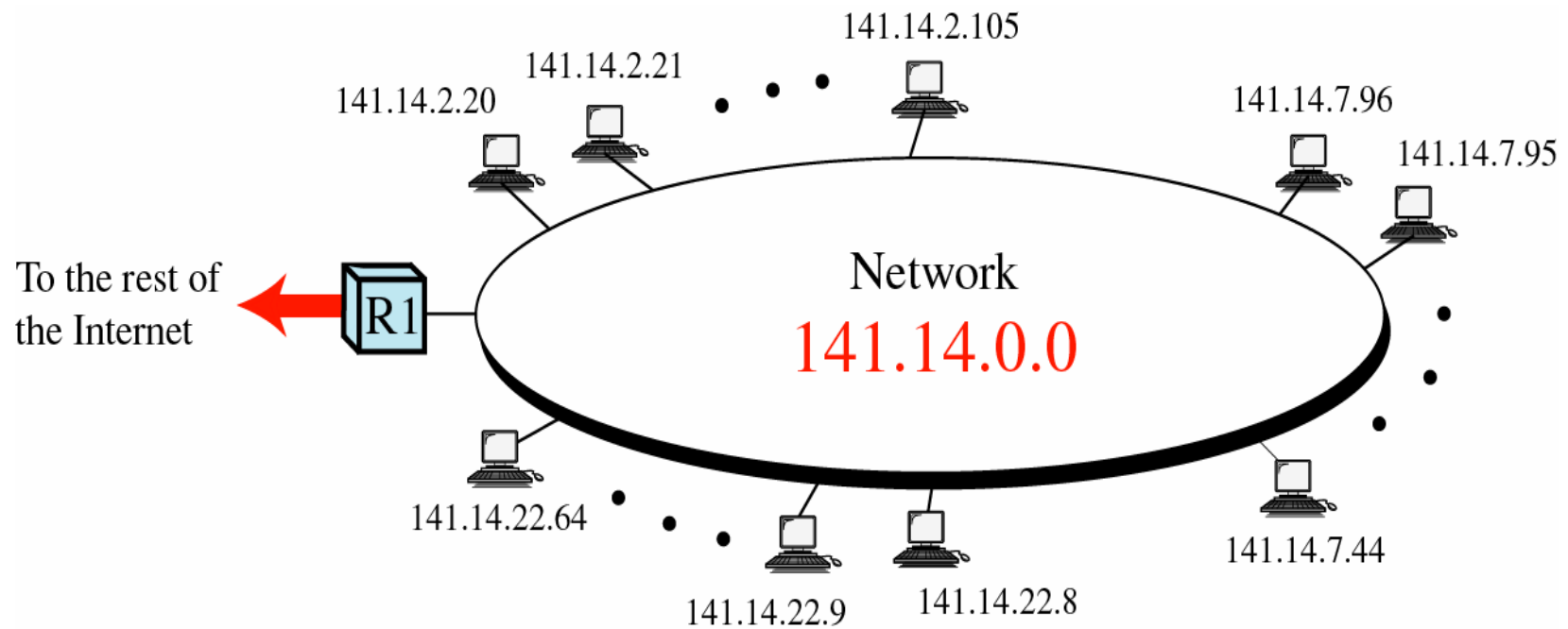
Benefits of subnetting

- Reduced network traffic
- Simplified management
- Smaller broadcast domains

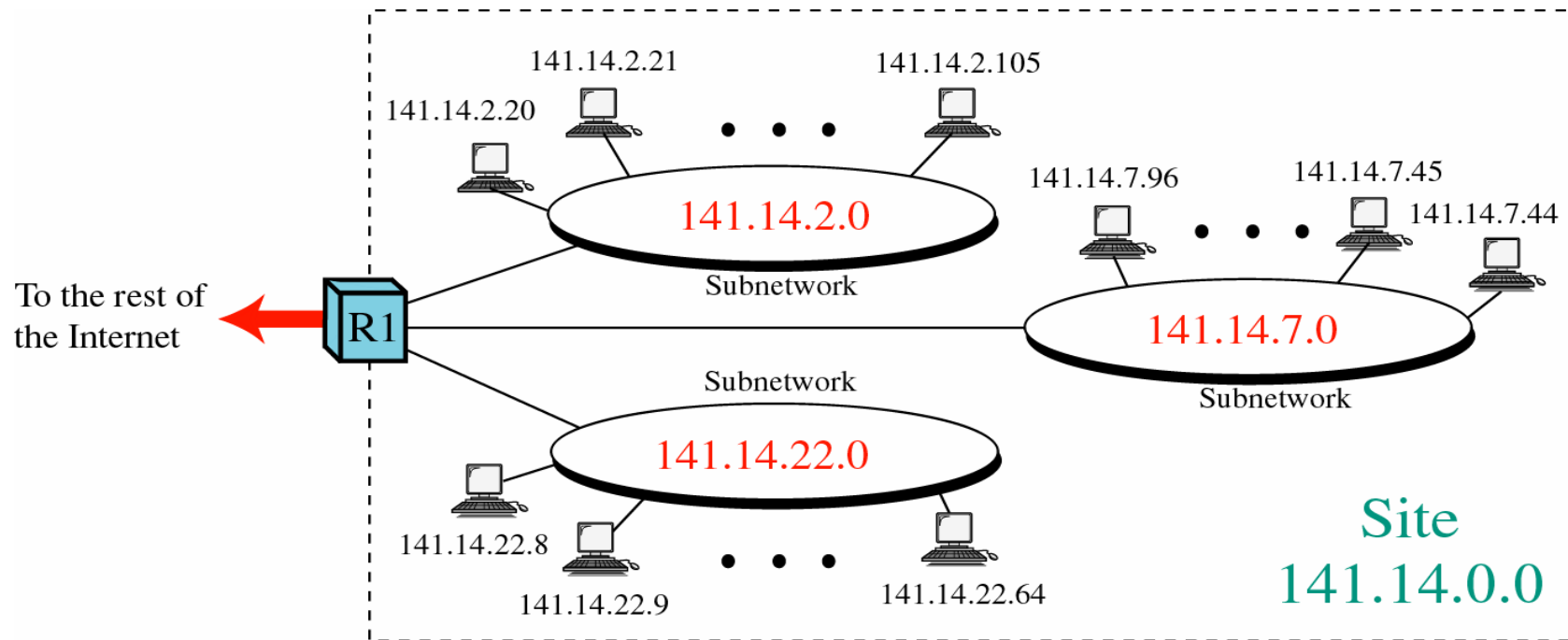
Subnetting



Network Before Subnetting



Network After Subnetting



Subnet Mask

- Question is: how do we determine the entire subnets inside our network?

Subnet mask is used to distinguish the network ID from the host ID

Example

	Dot-decimal Address	Binary
Full Network Address	192.168.5.10	11000000.10101000.00000101.00001010
Subnet Mask	255.255.255.0	11111111.11111111.11111111.00000000
Network Portion	192.168.5.0	11000000.10101000.00000101.00000000
Host Portion	0.0.0.10	00000000.00000000.00000000.00001010

Subnet Mask

Example

	Dot-decimal Address	Binary
Full Network Address	192.168.5.130	11000000.10101000.00000101.10000010
Subnet Mask	255.255.255.192	11111111.11111111.11111111.11000000
Network Portion	192.168.5.128	11000000.10101000.00000101.10000000

How to know network is subnetted

Address Class	Bits for Subnet Mask	Network Prefix
Class A	11111111 00000000 00000000 00000000	/8
Class B	11111111 11111111 00000000 00000000	/16
Class C	11111111 11111111 11111111 00000000	/24

IP Address: 192.168.2.1

Subnet Mask: 255.255.255.0

With Prefix Notation: 192.168.2.1/24

Prefix Notation

IP Address: 132.168.64.3/18

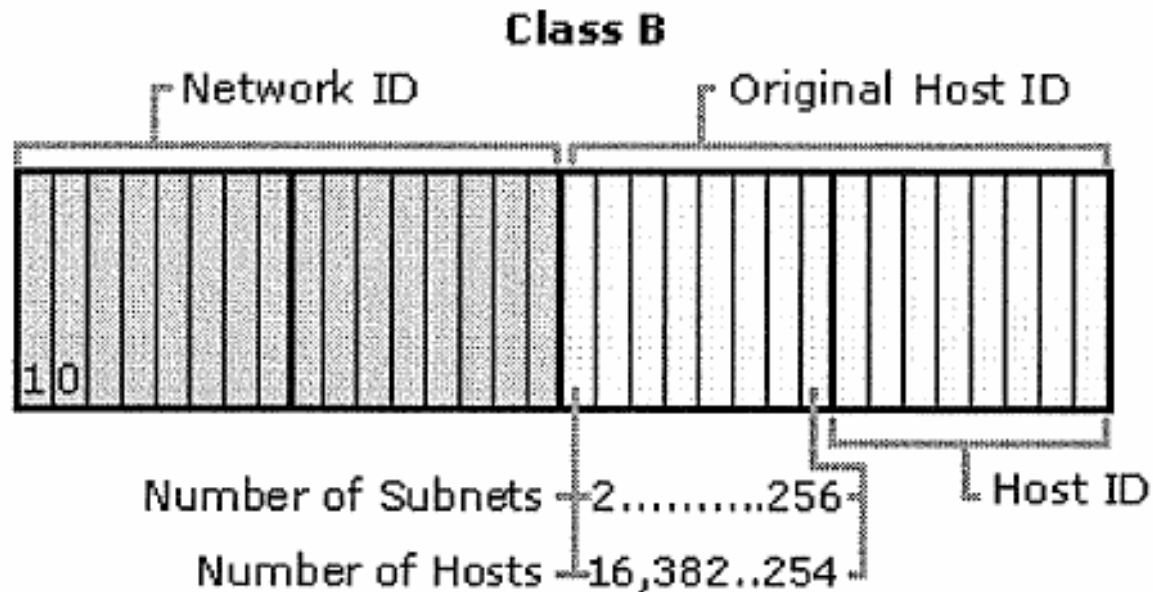
Subnet Mask: 255.255.192.0

Subnetting: how to?

- Number of host bits used for subnetting
- What are the subnetted Network IDs
- What are the IP Addresses for each new subnet?

Number of host bits used for subnetting

- How many subnets I will have in the future
- Use more bits to overcome the change overhead.



Example

Network	Network (binary)	Broadcast address
192.168.5.0/26	11000000.10101000.00000101. 00 000000	192.168.5.63
192.168.5.64/26	11000000.10101000.00000101. 01 000000	192.168.5.127
192.168.5.128/26	11000000.10101000.00000101. 10 000000	192.168.5.191
192.168.5.192/26	11000000.10101000.00000101. 11 000000	192.168.5.255

Possible subnets for a /24 prefix (traditional Class C)

CIDR notation	Network Mask	Available Networks	Available Hosts per network	Total usable hosts
/24	255.255.255.0	1	254	254
/25	255.255.255.128	2	126	252
/26	255.255.255.192	4	62	248
/27	255.255.255.224	8	30	240
/28	255.255.255.240	16	14	224
/29	255.255.255.248	32	6	192
/30	255.255.255.252	64	2	128
/31	255.255.255.254	128	2 *	256

Another Example

- Network ID: 191.168.0.0
- Use 3 bits
- Subnet Mask: 255.255.224.0

Subnets of the previous example

	Subnet Binary Representation	Subnetted Network ID
1	10111111.10101000. <u>00000000</u> .00000000	191.168.0.0/19
2	10111111.10101000. <u>00100000</u> .00000000	191.168.32.0/19
3	10111111.10101000. <u>01000000</u> .00000000	191.168.64.0/19
4	10111111.10101000. <u>01100000</u> .00000000	191.168.96.0/19
5	10111111.10101000. <u>10000000</u> .00000000	191.168.128.0/19
6	10111111.10101000. <u>10100000</u> .00000000	191.168.160.0/19
7	10111111.10101000. <u>11000000</u> .00000000	191.168.192.0/19
8	10111111.10101000. <u>11100000</u> .00000000	191.168.224.0/19

How many hosts allowed for each subnet of the previous example?

Subnet Binary Representation		Range of IP Addresses	
1	10111111.10101000. <u>00000000</u> .00000001 10111111.10101000. <u>000</u> 11111.11111110	191.168.0.1	- 191.168.31.254
2	10111111.10101000. <u>001</u> 00000.00000001 10111111.10101000. <u>001</u> 11111.11111110	191.168.32.1	- 191.168.63.254
3	10111111.10101000. <u>010</u> 00000.00000001 10111111.10101000. <u>010</u> 11111.11111110	191.168.64.1	- 191.168.95.254
4	10111111.10101000. <u>011</u> 00000.00000001 10111111.10101000. <u>011</u> 11111.11111110	191.168.96.1	- 191.168.127.254
5	10111111.10101000. <u>100</u> 00000.00000001 10111111.10101000. <u>100</u> 11111.11111110	191.168.128.1	- 191.168.159.254
6	10111111.10101000. <u>101</u> 00000.00000001 10111111.10101000. <u>101</u> 11111.11111110	191.168.160.1	- 191.168.191.254
7	10111111.10101000. <u>110</u> 00000.00000001 10111111.10101000. <u>110</u> 11111.11111110	191.168.192.1	- 191.168.223.254
8	10111111.10101000. <u>111</u> 00000.00000001 10111111.10101000. <u>111</u> 11111.11111110	191.168.224.1	- 191.168.255.254

Variable Length Subnetting VLS

Static Subnetting

- All subnets in the subnetted network use the same subnet mask
- Easy to implement
- Waste IP Addresses

Variable Subnetting

- Subnets use different subnet masks
- Real world environments
- No wasting of IP addresses

Variable Subnetting Example

- Network ID: 135.41.0.0/16
- 24 subnets are required as follows:
 - One subnet with up to 32000 hosts
 - 15 subnets with up to 2000 hosts
 - 8 subnets with up to 250 hosts

One subnet with up to 32000 hosts

- I need one bit only to subnet
- Subnet ID options:

Subnet ID (Decimal)	Subnet ID (Binary)	Subnet Mask
135.41.0.0/17	10000111.00101001.00000000.00000000	255.255.128.0
135.41.128.0/17	10000111.00101001.10000000.00000000	255.255.128.0

15 subnets with up to 2000 hosts

- I need 4 bits to subnet
- Subnet ID options:

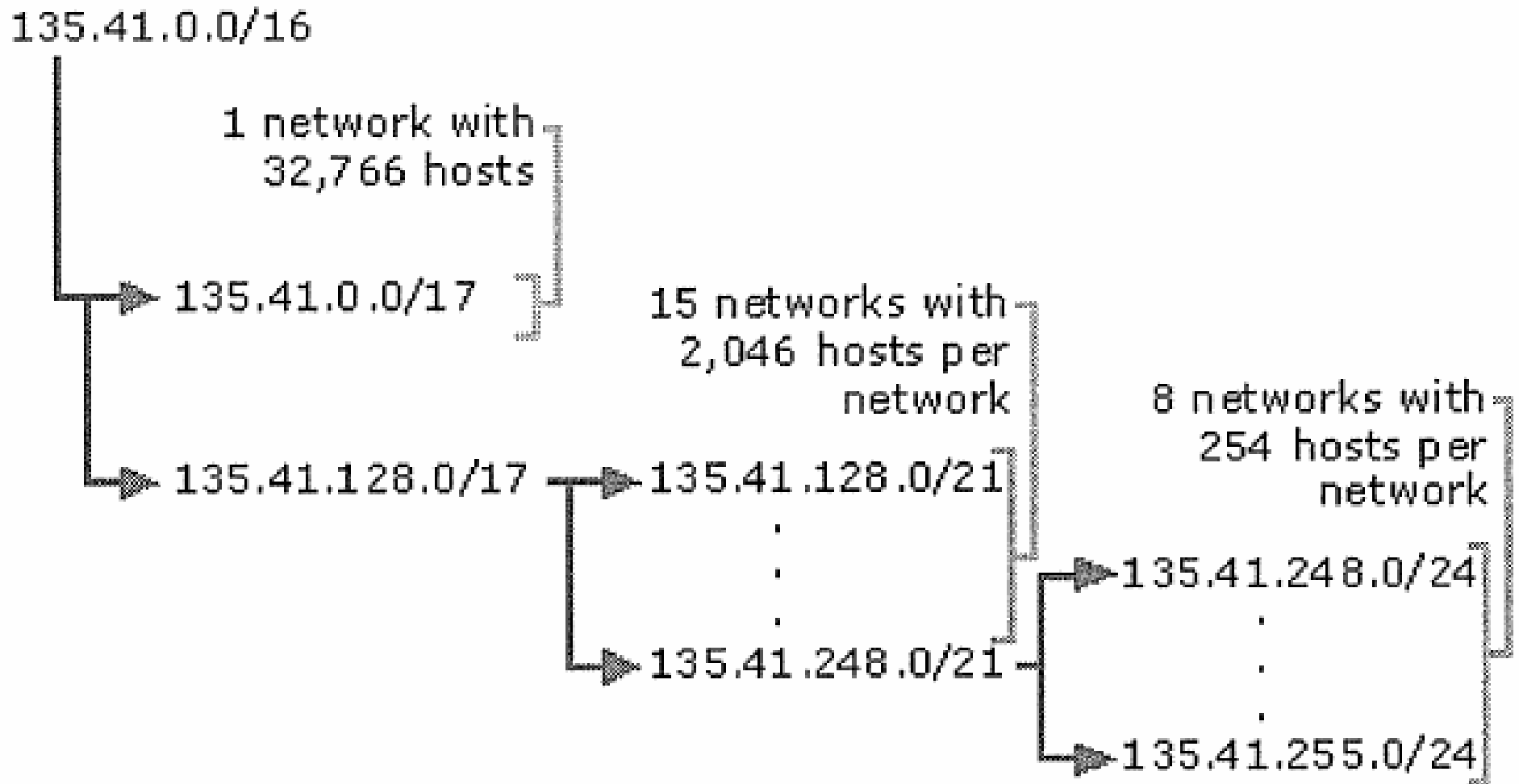
Subnet ID (Decimal)	Subnet ID (Binary)	Subnet Mask
135.41.128.0/21	10000111.00101001.10000000.00000000	255.255.248.0
135.41.136.0/21	10000111.00101001.10001000.00000000	255.255.248.0
135.41.144.0/21	10000111.00101001.10010000.00000000	255.255.248.0
-	-	-
-	-	-
-	-	-
135.41.240.0/21	10000111.00101001.11110000.00000000	255.255.248.0

8 subnets with up to 250 hosts

- I need 3 bits to subnet
- Subnet ID options:

Subnet ID (Decimal)	Subnet ID (Binary)	Subnet Mask
135.41.248.0/24	10000111.00101001.11111000.00000000	255.255.255.0
135.41.249.0/24	10000111.00101001.11111001.00000000	255.255.255.0
135.41.250.0/24	10000111.00101001.11111010.00000000	255.255.255.0
135.41.251.0/24	10000111.00101001.11111011.00000000	255.255.255.0
-	-	-
-	-	-
-	-	-
135.41.255.0/24	10000111.00101001.11111111.00000000	255.255.255.0

Variable Subnetting of 135.41.0.0/16



Exercise

- A corporation is assigned a Class C network 195.214.32.0, and it has the requirement to split this address range into five separate networks. The required number of hosts for each subnet is as follows:
 - Subnet No. 1: 50 hosts
 - Subnet No. 2: 50 hosts
 - Subnet No. 3: 50 hosts
 - Subnet No. 4: 30 hosts
 - Subnet No. 5: 30 hosts