Chapter 2

IP Addressing

Huynh Nguyen Chinh

# Internet Protocol Characteristics

- Operates at network layer of OSI
- Connectionless protocol
- Packets treated independently
- Hierarchical addressing
- Best-effort delivery
- No data-recovery features

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Why IP Addresses?

- They uniquely identify each device on an IP network.

- Every host (computer, networking device, peripheral) must have a unique address.

- Host ID:

  - Identifies the individual host

  - Is assigned by organizations to individual devices

Network.Host

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IP PDU Header
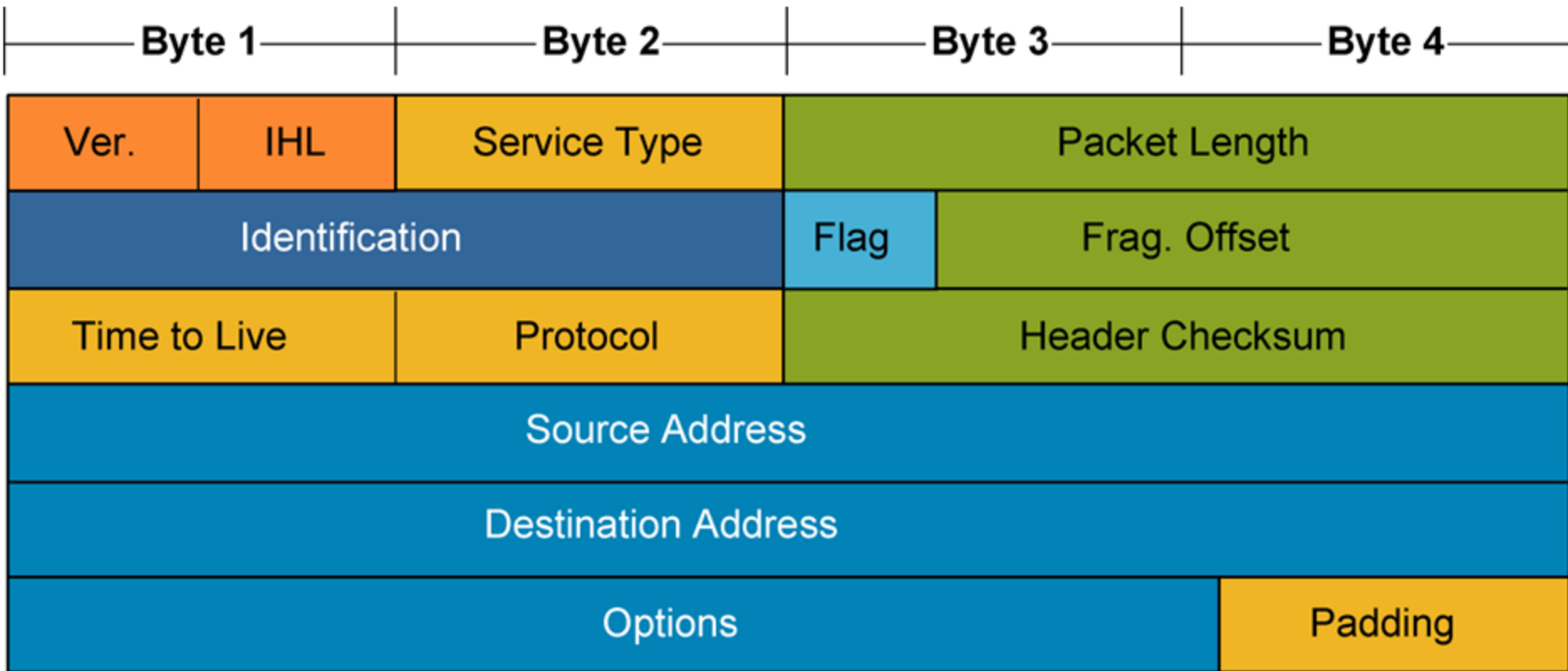
IP Address Format: Dotted Decimal Notation

	Example			
An IP address is a 32-bit binary number	10101100 00010000 10000000 00010001			
For readability, the 32-bit binary number can be divided into four 8-bit octets	10101100	00010000	10000000	00010001
Each octet (or byte) can be converted to decimal	172	16	128	17
The address can be written in dotted decimal notation	172.	16.	128.	17

The binary-to-decimal and decimal-to-binary conversion will be detailed later in this course.

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IP Address Classes: The First Octet

A B C … Easy as 1 2 3

Class A … First 1 bit fixed | <u>0</u> x x x x x x x . Host . Host . Host

Class B … First 2 bits fixed | <u>1 0</u> x x x x x x . Network . Host . Host

Class C … First 3 bits fixed | <u>1 1 0</u> x x x x x . Network . Network . Host

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IP Address Ranges

| IP Address Class	First Octet Binary Value	First Octet Decimal Value	Possible Number of Hosts
Class A	1-126	00000001 to 01111110*	16,777,214
Class B	128-191	10000000 to 10111111	65,534
Class C	192-223	11000000 to 11011111	254

*127 (01111111) is a Class A address reserved for loopback testing and cannot be assigned to a network.

Reserved Address

- Network Addresses

← 32 Bits →

| Network | 0000000000000000 |

- Broadcast Addresses

← 32 Bits →

| Network | 1111111111111111 |
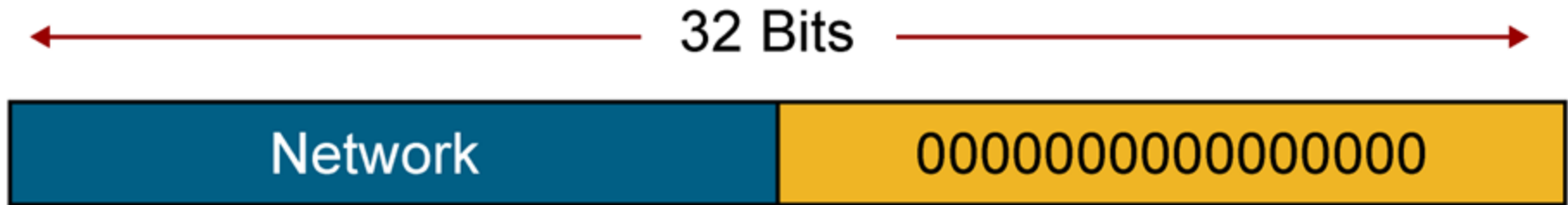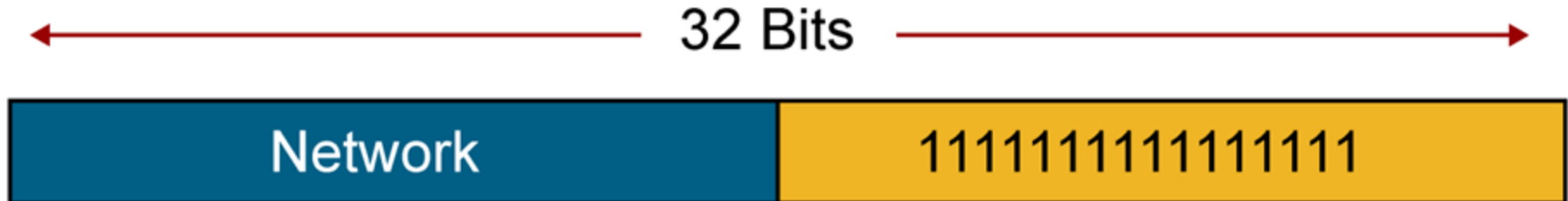
Public IP Addresses

Class	Public IP Ranges
A	1.0.0.0 to 9.255.255.255 11.0.0.0 to 126.255.255.255
B	128.0.0.0 to 172.15.255.255 172.32.0.0 to 191.255.255.255
C	192.0.0.0 to 192.167.255.255 192.169.0.0 to 223.255.255.255

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Private IP Addresses

Class	Private Address Range
A	10.0.0.0 to 10.255.255.255
B	172.16.0.0 to 172.31.255.255
C	192.168.0.0 to 192.168.255

DHCP

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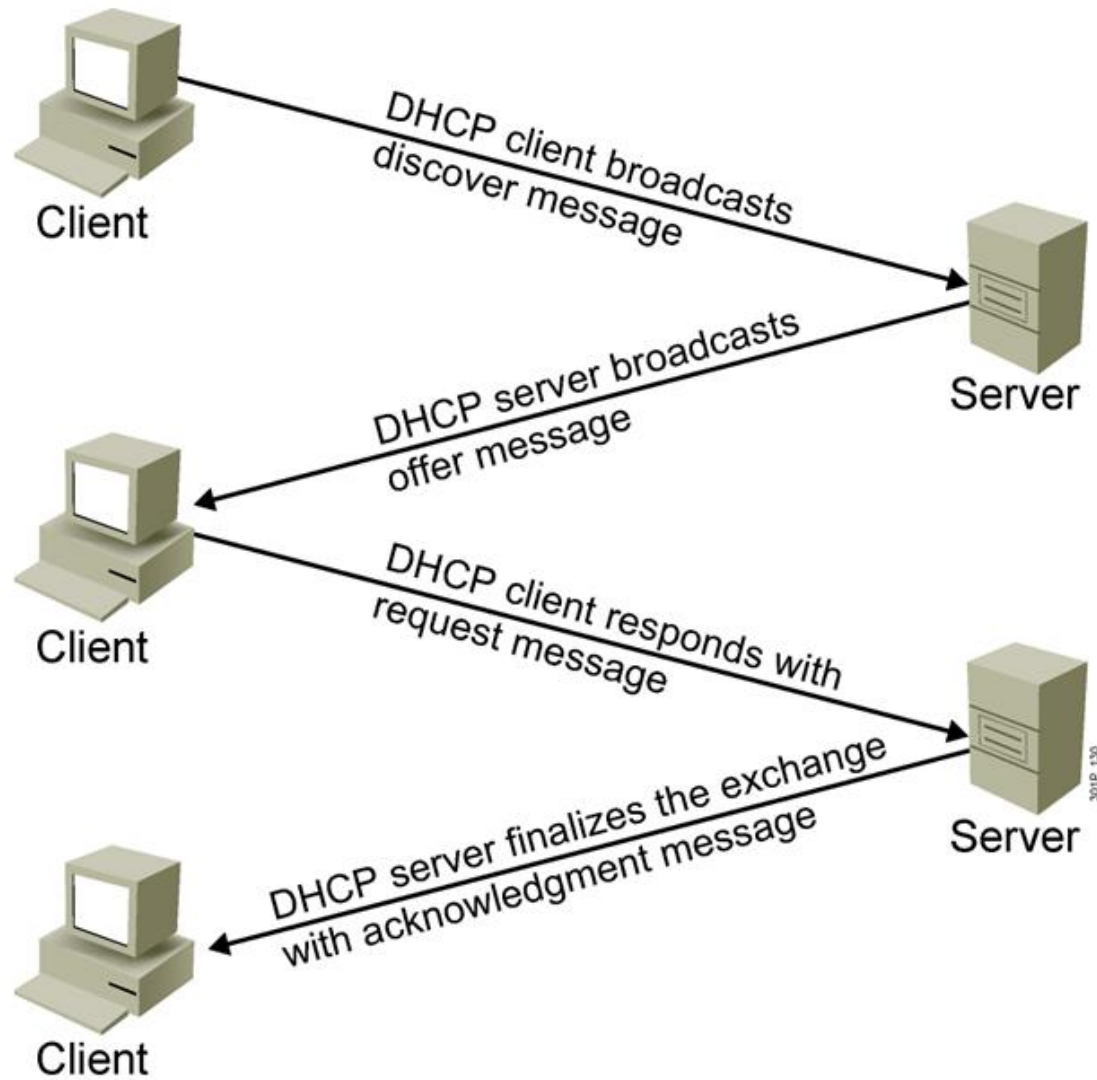
DNS
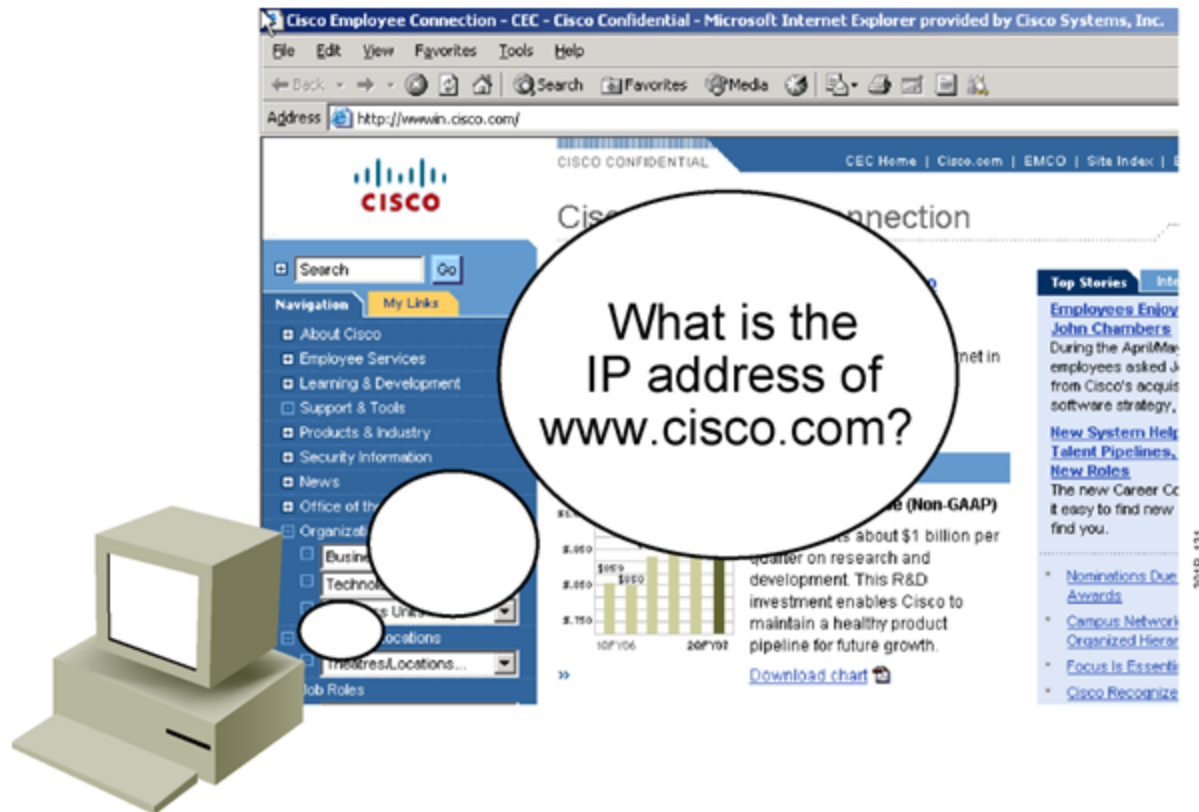
- Application specified in the TCP/IP suite
- A way to translate human-readable names into IP addresses

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Network Connection

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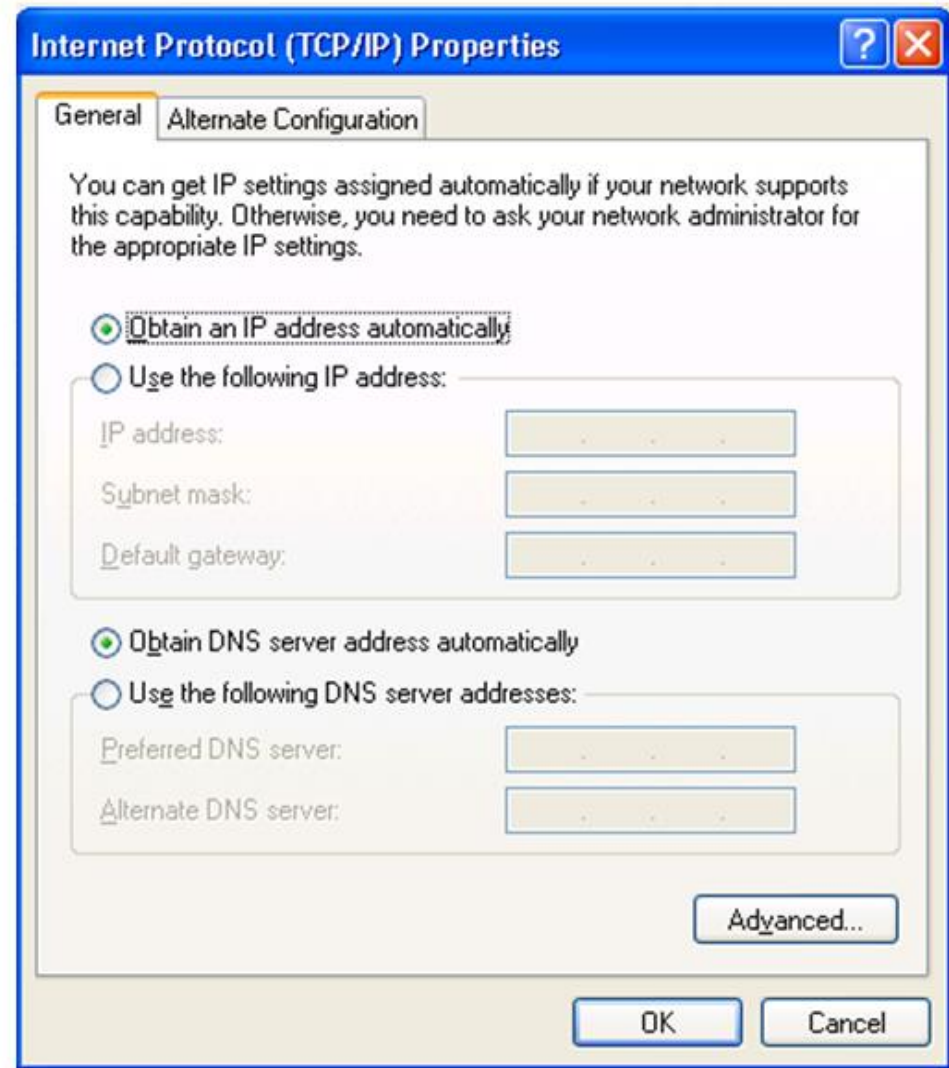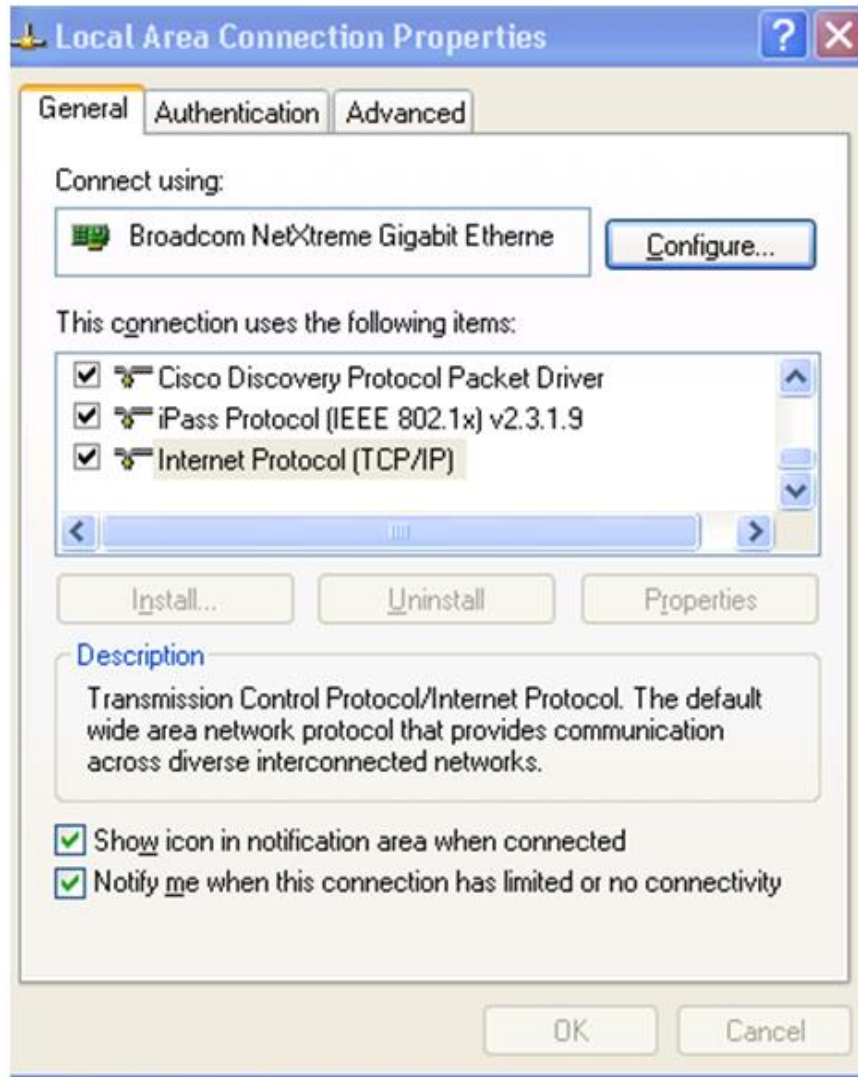
ipconfig

```
C:\WINDOWS\system32\cmd.exe                                              _ □ ×

C:\Documents and Settings>ipconfig /all

Windows IP Configuration

        Host Name . . . . . . . . . . . . : PCUSER
        Primary Dns Suffix  . . . . . . . :
        Node Type . . . . . . . . . . . . : Hybrid
        IP Routing Enabled. . . . . . . . : No
        WINS Proxy Enabled. . . . . . . . : No
        DNS Suffix Search List. . . . . . :

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
        Description . . . . . . . . . . . : Intel(R) PRO/1000 PL Network Connection
        Physical Address. . . . . . . . . : 00-15-58-2F-21-E6
        Dhcp Enabled. . . . . . . . . . . : Yes
        Autoconfiguration Enabled . . . . : Yes
        IP Address. . . . . . . . . . . . : 192.168.1.102
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 192.168.1.1
        DHCP Server . . . . . . . . . . . : 192.168.1.1
        DNS Servers . . . . . . . . . . . : 127.107.241.185
                                            127.135.250.69
        Lease Obtained. . . . . . . . . . : Wednesday, April 25, 2007 12:27:51 AM
        Lease Expires . . . . . . . . . . : Thursday, April 26, 2007 12:27:51 AM
```
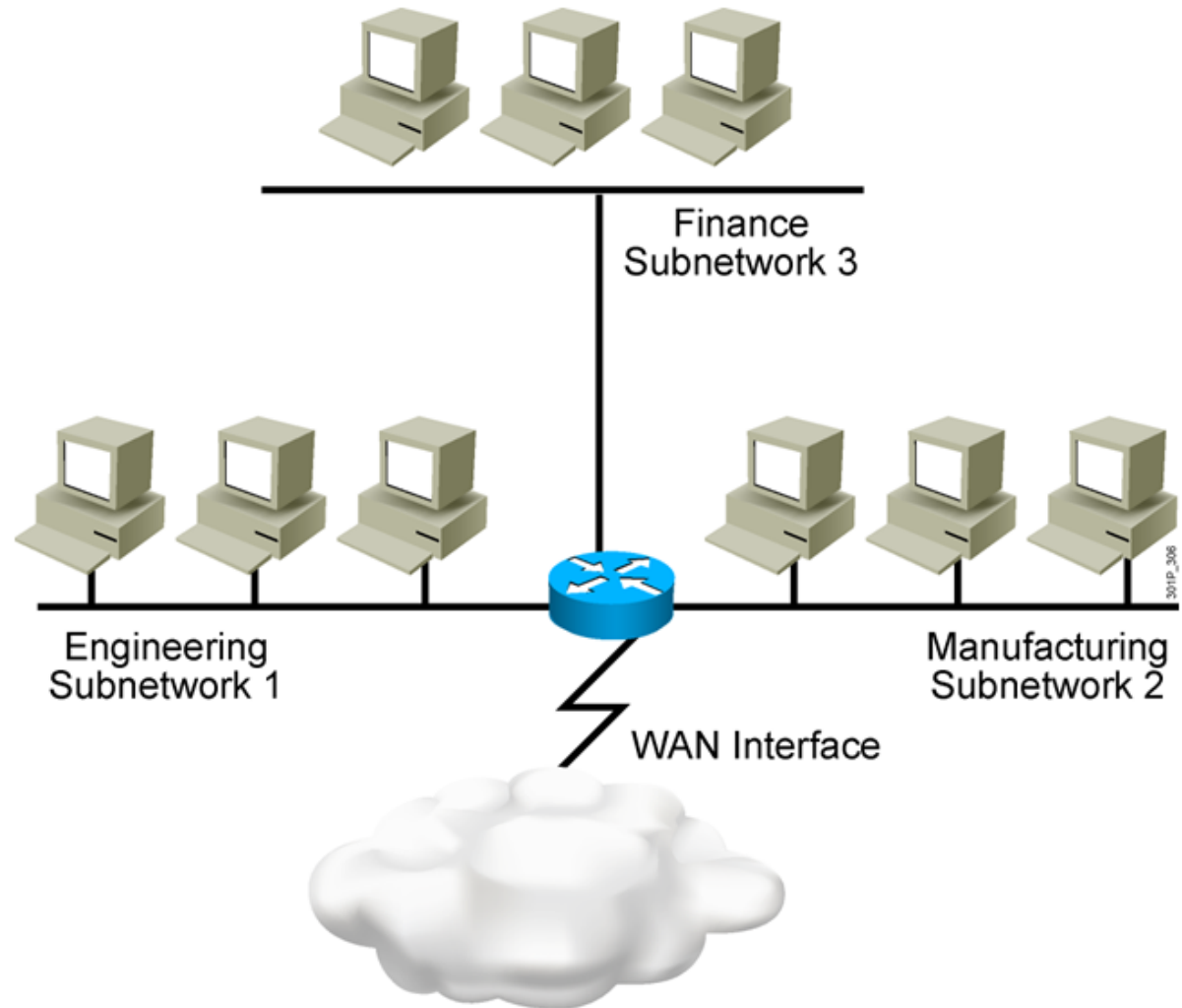
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Subnetworks

- Smaller networks are easier to manage.

- Overall traffic is reduced.

- You can more easily apply network security policies.

Finance
Subnetwork 3

Engineering
Subnetwork 1

Manufacturing
Subnetwork 2

WAN Interface

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Possible Subnets and Hosts for a Class C Network

Network . Network . Network .

Bits to Borrow
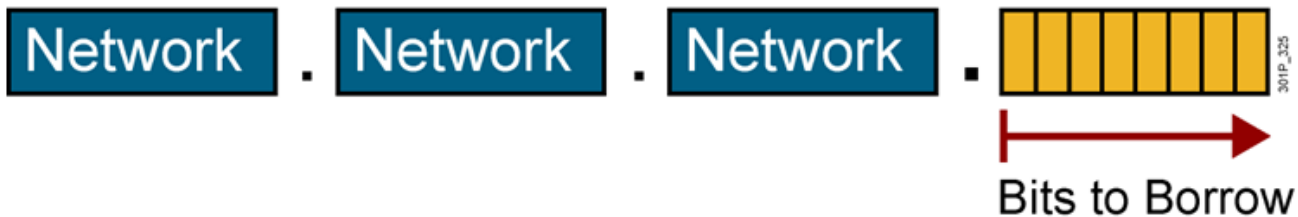
Number of Bits Borrowed (s)	Number of Subnets Possible (2^s)	Number of Bits Remaining in Host ID (8 - s = h)	Number of Hosts Possible Per Subnet ($2^h - 2$)
1	2	7	126
2	4	6	62
3	8	5	30
4	16	4	14
5	32	3	6
6	64	2	2
7	128	1	2

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Possible Subnets and Hosts for a Class B Network

Bits to Borrow

Number of Bits Borrowed (s)	Number of Subnets Possible (2^s)	Number of Bits Remaining in Host ID $(16 - s = h)$	Number of Hosts Possible Per Subnet $(2^h - 2)$
1	2	15	32,766
2	4	14	16,382
3	8	13	8,190
4	16	12	4,094
5	32	11	2,046
6	64	10	1,022
7	128	9	510
…	…	…	…

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Possible Subnets and Hosts for a Class A Network

Network . [yellow bit blocks] . [yellow bit blocks] . [yellow bit blocks]

Bits to Borrow
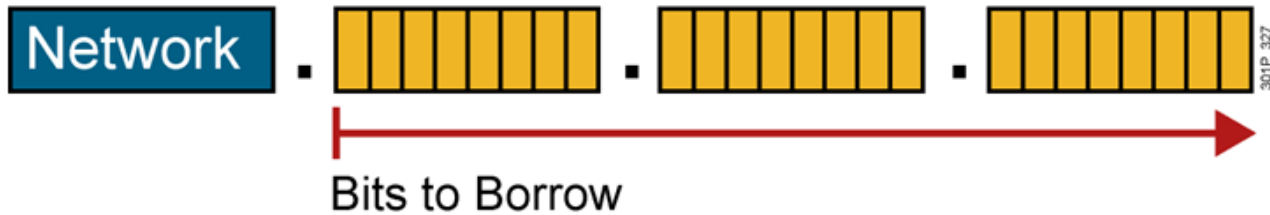
Number of Bits Borrowed (s)	Number of Subnets Possible (2^s)	Number of Bits Remaining in Host ID ($24 - s = h$)	Number of Hosts Possible Per Subnet ($2^h - 2$)
1	2	23	8,388,606
2	4	22	4,194,302
3	8	21	2,097,150
4	16	20	1,048,574
5	32	19	524,286
6	64	18	262,142
7	128	17	131,070
…	…	…	…

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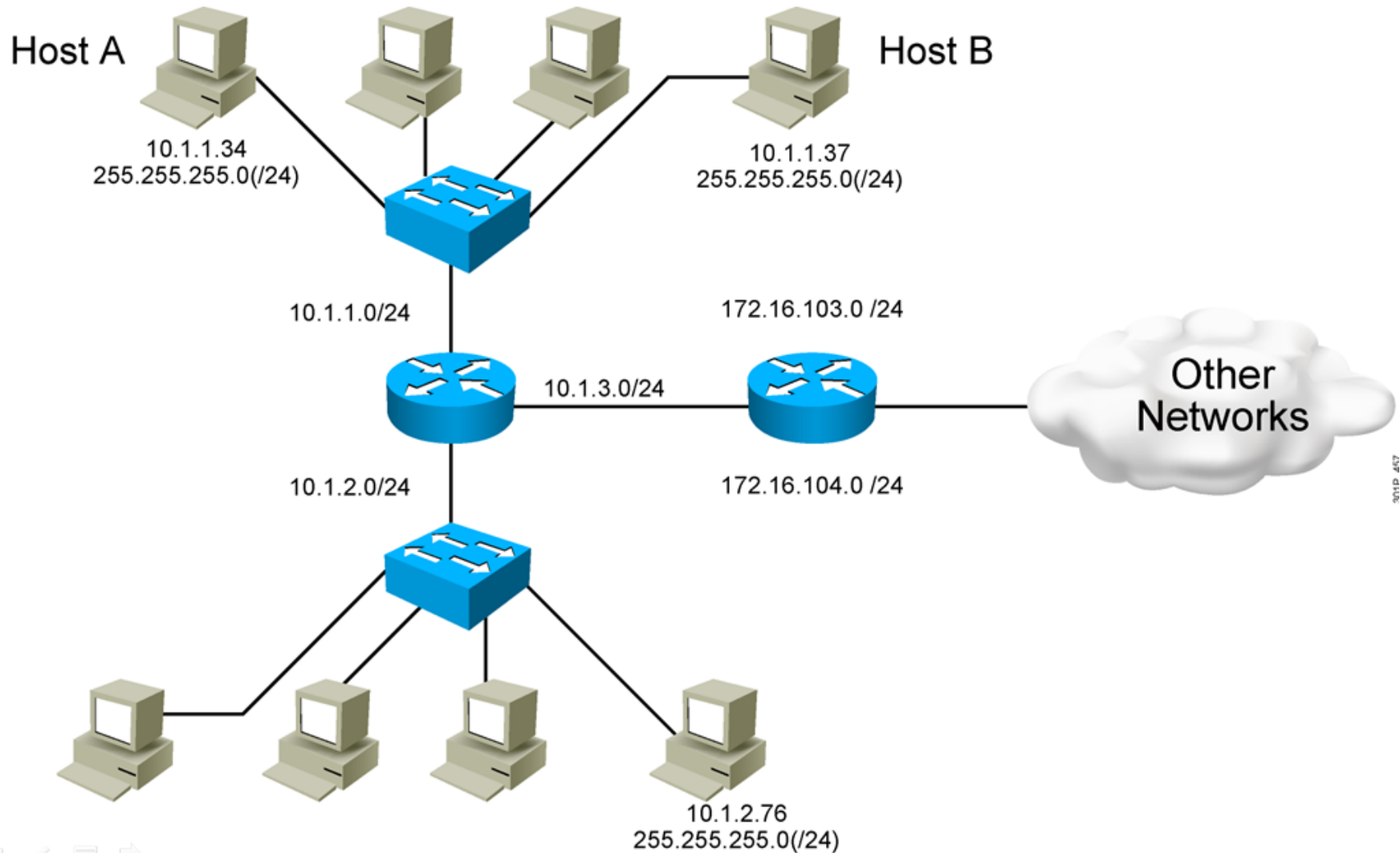
How Routers Use Subnet Masks

Host A
10.1.1.77/24

Host B
10.3.1.23/24

10.3.1.23

10.1.1.0 fa0/2

10.3.1.0 fa0/2

fa0/0

fa0/1

fa0/0

10.2.2.0

10.3.2.1/24

Router A

Router B

Route Table A
10.1.1.0/24 fa0/2
10.2.2.0/24 fa0/0
10.3.1.0/24   fa0/0
10.3.2.0/24   fa0/0

Route Table B
10.1.1.0/24 fa0/1
10.2.2.0/24 fa0/1
10.3.1.0/24   fa0/2
10.2.2.0/24 fa0/1

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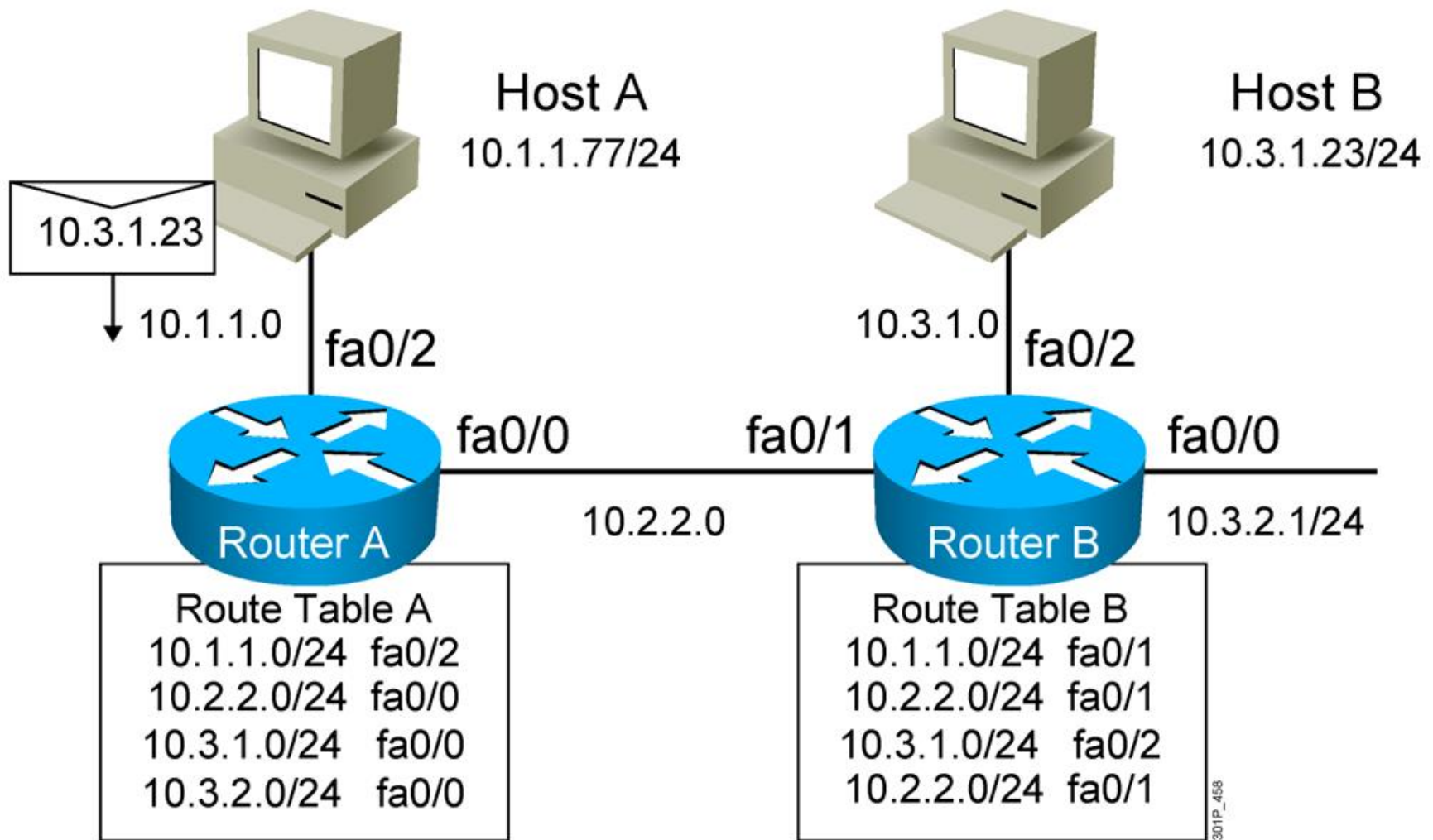
Applying the Subnet Address Scheme
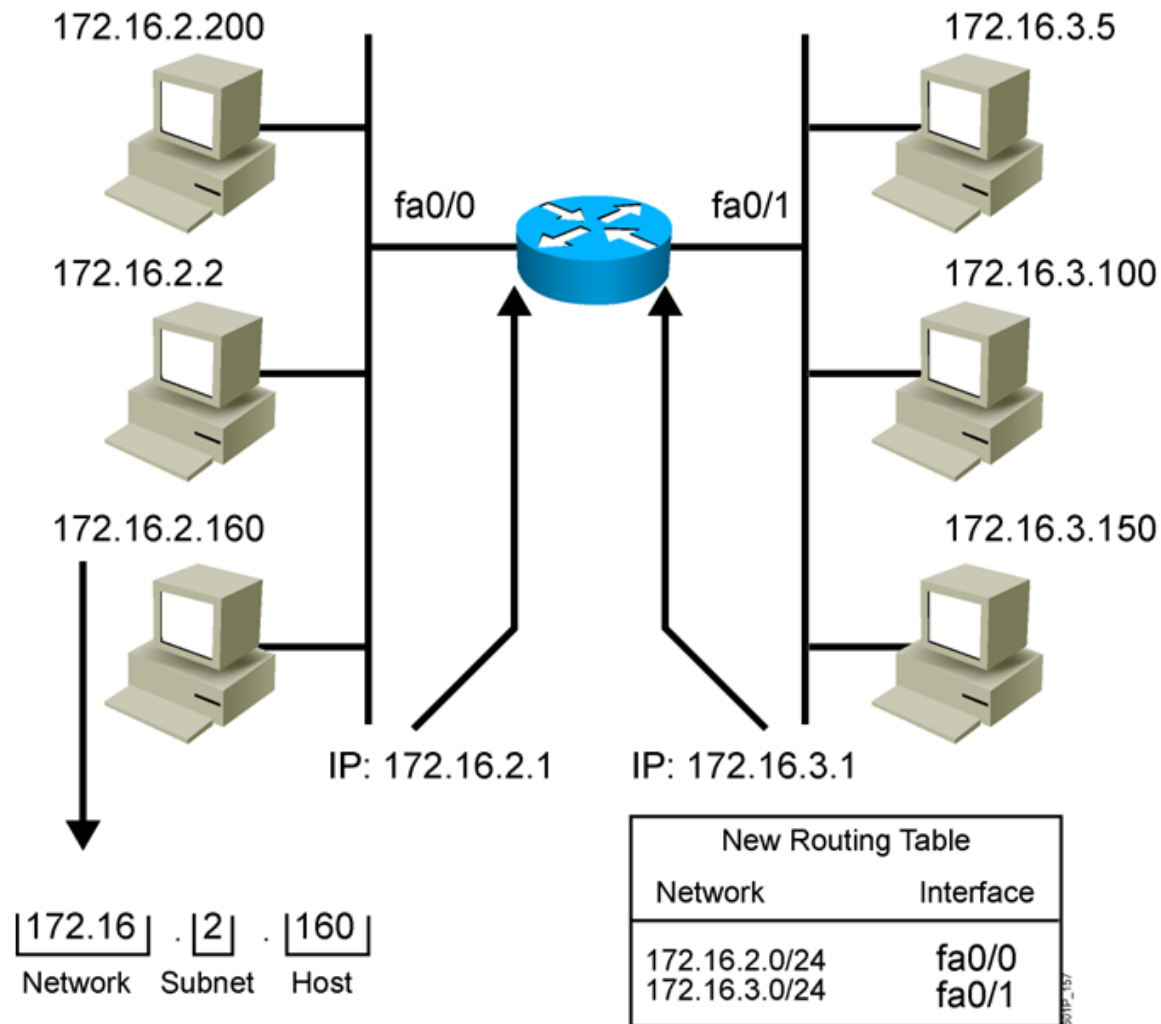
Octet Values of a Subnet Mask

128	64	32	16	8	4	2	1		
1	0	0	0	0	0	0	0	=	128
1	1	0	0	0	0	0	0	=	192
1	1	1	0	0	0	0	0	=	224
1	1	1	1	0	0	0	0	=	240
1	1	1	1	1	0	0	0	=	248
1	1	1	1	1	1	0	0	=	252
1	1	1	1	1	1	1	0	=	254
1	1	1	1	1	1	1	1	=	255

Subnet masks, like IP addresses, are represented in the dotted decimal format like 255.255.255.0

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Default Subnet Masks

Example Class A address (decimal):	10.0.0.0
Example Class A address (binary):	00001010.00000000.00000000.00000000
Default Class A mask (binary):	11111111.00000000.00000000.00000000
Default Class A mask (decimal):	255.0.0.0
Default classful prefix length:	/8

Example Class B address (decimal):	172.16.0.0
Example Class B address (binary):	10010001.10101000.00000000.00000000
Default Class B mask (binary):	11111111.11111111.00000000.00000000
Default Class B mask (decimal):	255.255.0.0
Default classful prefix length:	/16

Example Class C address (decimal):	192.168.42.0
Example Class C address (binary):	11000000.10101000.00101010.00000000
Default Class C mask (binary):	11111111.11111111.11111111.00000000
Default Class C mask (decimal):	255.255.255.0
Default classful prefix length:	/24

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Procedure for Implementing Subnets

1. Determine the IP address assigned by the registry authority.

2. Based on the organizational and administrative structure, determine the number of subnets required.

3. Based on the address class and required number of subnets, determine the number of bits you need to borrow from the host ID.

4. Determine the binary and decimal value of the subnet mask.

5. Apply the subnet mask to the network IP address to determine the subnet and host addresses.

6. Assign subnet addresses to specific interfaces.

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Eight Easy Steps for Determining Subnet Addresses

IP Address: 192.168.221.37   Subnet Mask /29

Step	Description	Example
1.	Write the octet that is being split in binary.	Fourth octet: 00100101
2.	Write the mask or classful prefix length in binary.	Assigned mask: 255.255.255.248 (/29) Fourth octet: 11111000
3.	Draw a line to delineate the significant bits in the assigned IP address. Cross out the mask so you can view the significant bits in the IP address.	Split octet (binary): 00100101 Split mask (binary): 11111000

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Step	Description	Example
4.	Copy the significant bits four times.	00100 000 (network address) 00100 001 (first address in subnet) 00100 110 (last address in subnet) 00100 111 (broadcast address)?
5.	In the first line, define the network address by placing all zeros in the significant bits.	**Completed Subnet Addresses** Network address: 192.168.221.32 Subnet mask: 255.255.255.248 First subnet: 192.168.221.32 First host address: 192.168.221.33 Last host address: 192.168.221.38 Broadcast address: 192.168.221.39 Next subnet: 192.168.221.40
6.	In the last line, define the broadcast address by placing all ones in the significant bits.	
7.	In the middle lines, define the first and last host number.	
8.	Increment the subnet bits by one.	00101 000 (next subnet)

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Example: Applying a Subnet Mask for a Class C Address

IP Address 192.168.5.139   Subnet Mask 255.255.255.224

IP Address	192	168	5	139	
IP Address	11000000	10101000	00000101	10001011	
Subnet Mask	11111111	11111111	11111111	11100000	/27
Subnetwork	11000000	10101000	00000101	10000000	
Subnetwork	192	168	5	128	
First Host	192	168	5	10000001=129	
Last Host	192	168	5	10011110=158	
Directed Broadcast	192	168	5	10011111=159	
Next Subnet	192	168	5	10100000=160	

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Example: Applying a Subnet Mask for a Class B Address

IP Address 172.16.139.46   Subnet Mask /20

	172	16	139	46	
IP Address	10101100	00010000	10001011	00101110	
Subnet Mask	11111111	11111111	11110000	00000000	/20
Subnetwork	10101100	00010000	10000000	00000000	
Subnetwork	172	16	128	0	
First Host	172	16	10000000	00000001=128.1	
Last Host	172	16	10001111	11111110=143.254	
Directed Broadcast	172	16	10001111	11111111=143.255	
Next Subnet	172	16	10010000	00000000=144.0	

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Example: Applying a Subnet Mask for a Class A Address

IP Address 10.172.16.211   Subnet Mask /18

IP Address	10	172	16	211	
IP Address	00001010	10101100	00010000	11010011	
Subnet Mask	11111111	11111111	11000000	00000000	/18
Subnetwork	00001010	10101100	00000000	00000000	
Subnetwork	10	172	0	0	
First Host	10	172	00000000	00000001=0.1	
Last Host	10	172	00111111	11111110=63.254	
Directed Broadcast	10	172	00111111	11111111=63.255	
Next Subnet	10	172	01000000	00000000=64.0	

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Recognize these features:

☞ **Class of IP address**

☞ **Public or Private**

☞ **Default Subnet Mask**

Exercises: IP Class Recognize

Apply to the following IP address:

a. 171.10.1.1

b. 172.31.1.1

c. 6.12.2.1

d. 10.22.22.10

e. 192.168.1.10

f. 221.222.200.1

g. 129.6.5.4

h. 172.18.16.1

I. 191.168.1.1

j. 166.64.12.12

Subnetting

Pls determine these features:

- ☞ **Default SM and Current SM**
- ☞ **Number of network bit**
- ☞ **Number of host bit**
- ☞ **Number of Subnet bit**
- ☞ **Number of usable subnet**
- ☞ **Number of usable host per subnet**

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Apply to the following IP address:

a.192.160.1.0/24

Borrow 3 bits

c.10.16.1.0/8

Borrow 20 bits

e.179.18.0.0/16

Borrow 11 bits

g.66.65.0.0/28

b.171.16.0.0/16

Borrow 6 bits

d.198.10.10.0/29

f.192.169.12.0/24

Borrow 3 bits

h.191.172.0.0/20

i.126.172.0.0/30

Exercises

Question 1

The IP address 131.107.0.0 is a class B address.
What is the range of binary values for the first octet in
this address class?

A. 10000000 - 11111111
B. 00000000 - 10111111
C. 10000000 - 10111111
D. 10000000 - 11011111
E. 11000000 - 11101111

Exercises

Question 2

What is the network address for a host with the IP address 123.200.8.68/28?

A. 123.200.8.0
B. 123.200.8.32
C. 123.200.8.64
D. 123.200.8.65
E. 123.200.8.31
F. 123.200.8.1

Exercises

Question 3

Using **a class C** address range 192.168.21.12 your network needs **twenty-eight subnets**. Which **subnet mask** should you use?

A. 255.255.0.28
B. 255.255.255.0
C. 255.255.255.28
D. 255.255.255.248
E. 255.255.255.252

Question 4

You need to configure an IP address for workstation TestKingA. Based on the information shown above, what IP address should be assigned to this host?

A. 192.168.1.159/28
B. 192.168.1.145/28
C. 192.168.1.160/28
D. 192.168.1.144/28   Answer: B
E. 192.168.1.143/28

Exercises

Question 5

Which of the following addresses can be assigned to a host when using a subnet mask of 255.255.254.0? (Select three)

A. 113.10.4.0
B. 186.54.3.0
C. 175.33.3.255
D. 26.35.2.255
E. 152.135.7.0
F. 17.35.36.0

Answer: B, D, E

Question 6

Answer: C

Based on the information above, which IP address should be assigned to the host?
A. 192.168.5.5   B. 192.168.5.32
C. 192.168.5.40   D. 192.168.5.63
E. 192.168.5.75   F. None of the above

Question 7

If a host on a network has the address 172.16.45.14/30, what is the address of the subnetwork to which this host belongs?

A. 172.16.45.0
B. 172.16.45.4
C. 172.16.45.8
D. 172.16.45.12
E. 172.16.45.18

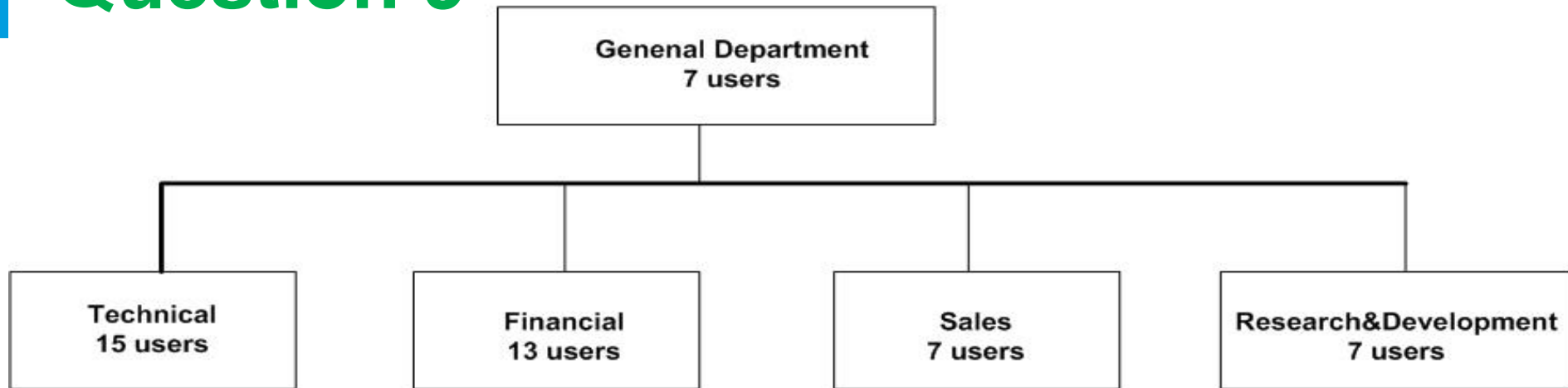**Answer: D**

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Exercises

Question 8

Give the following IP: 172.16.80.92/20, 172.16.32.100/20 and 172.16.65.100/20.
What are the broadcast addresses of the subnets in which these IP address belong to?
(Select three options.)

A. 172.16.82.255
B. 172.16.95.255
C. 172.16.64.255
D. 172.16.32.255
E. 172.16.47.255
F. 172.16.79.255

Correct Answer : B , E , F

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Question 9

ABC.com.vn

Genenal Department
7 users

| Technical 15 users | Financial 13 users | Sales 7 users | Research&Development 7 users |

ABC company is acquiring a new Class C IP network.
Which of the following <u>subnet masks</u> will provide one useful subnet for each department while still making allowance for enough usable host addresses per department as specified in the graphic?

A. 255.255.255.128
B. 255.255.255.192
C. 255.255.255.224
D. 255.255.255.240
E. 255.255.255.248
F. 255.255.255.252

Correct Answer : C

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Question 10

You are a network technician at NewStar.vn. Your company has a larger 172.12.0.0 network that you want to divide into subnets. You want each subnet to support 459 hosts. You also want to provide the maximum number of subnets.
Which network mask should you use?

A. 255.255.0.0
B. 255.255.128.0
C. 255.255.224.0
D. 255.255.254.0

Correct Answer : D

Question 11

 You are a network administrator at Seibels. You must configure a new subnetwork at the Seibels branch office in Berlin. You have been provided with the subnet mask of 255.255.255.224. You want to assign IP addresses to hosts on the subnet.

Which of the following IP addresses would you use? (Choose all that apply.)

A. 16.23.118.63
B. 87.45.16.159
C. 92.11.178.93
D. 134.178.18.56
E. 192.168.16.87
F. 217.168.166.192

Correct Answer : C, D, E

Question 12

 You are a network technician at Zysese company. You have subnetted the **210.106.14.0** network with a **/24** mask.

Your supervisor asks you **how many usable subnetworks** and **usable host addresses per subnet** this would
make provision for.

What would your response be?

A. 1 network with 254 hosts
B. 4 networks with 128 hosts
C. 2 networks with 24 hosts
D. 6 networks with 64 hosts
E. 8 networks with 36 hosts

Correct Answer : A

Exercises

Question 13

You have subnetted the **213.105.72.0** network with a **/28** mask. How many usable **subnetworks** and usable **host addresses per subnet** will be provided?

A. 2 networks with 62 hosts
B. 6 networks with 30 hosts
C. 16 networks and 16 hosts
D. 62 networks and 2 hosts
E. 16 networks and 14 hosts

Correct Answer : E

Question 14

You are a network technician at Fravo, Inc. You are planning a network installation for the company. The design requires 100 separate subnetworks, resulting in the acquisition of a Class B network address. Which of the following subnet masks will provide the 100 subnetworks required, if 500 usable host addresses are required per subnet?

A. 255.255.0.0
B. 255.255.224.0
C. 255.255.254.0
D. 255.255.255.0
E. 255.255.255.224
F. 255.255.255.254

Correct Answer : C

Question 15

You are a network technician at company. Company has a **class C** network license. The company requires **5 usable subnets**. Each subnet must accommodate **at least 18 hosts**.
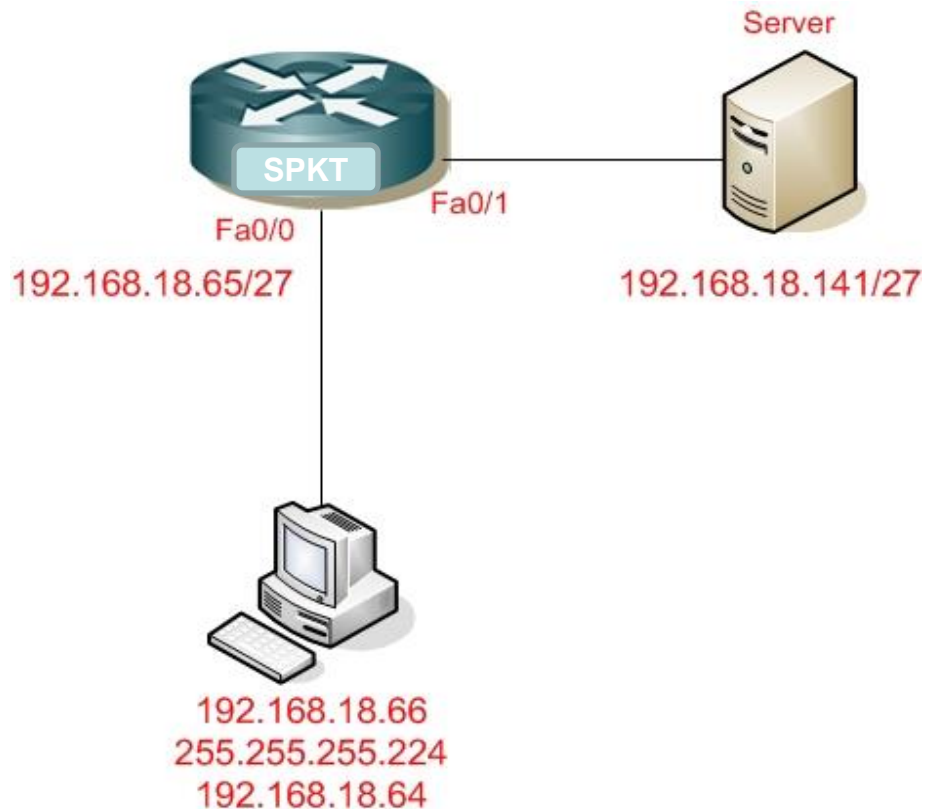
Which network mask should you use?

A. 225.225.224.0
B. 225.225.240.0
C. 225.225.255.0
D. 255.255.255.224
E. 225.225.255.240

Correct Answer : D

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Exercises

Question 16

Server

SPKT

Fa0/1

Fa0/0

192.168.18.65/27

192.168.18.141/27

192.168.18.66
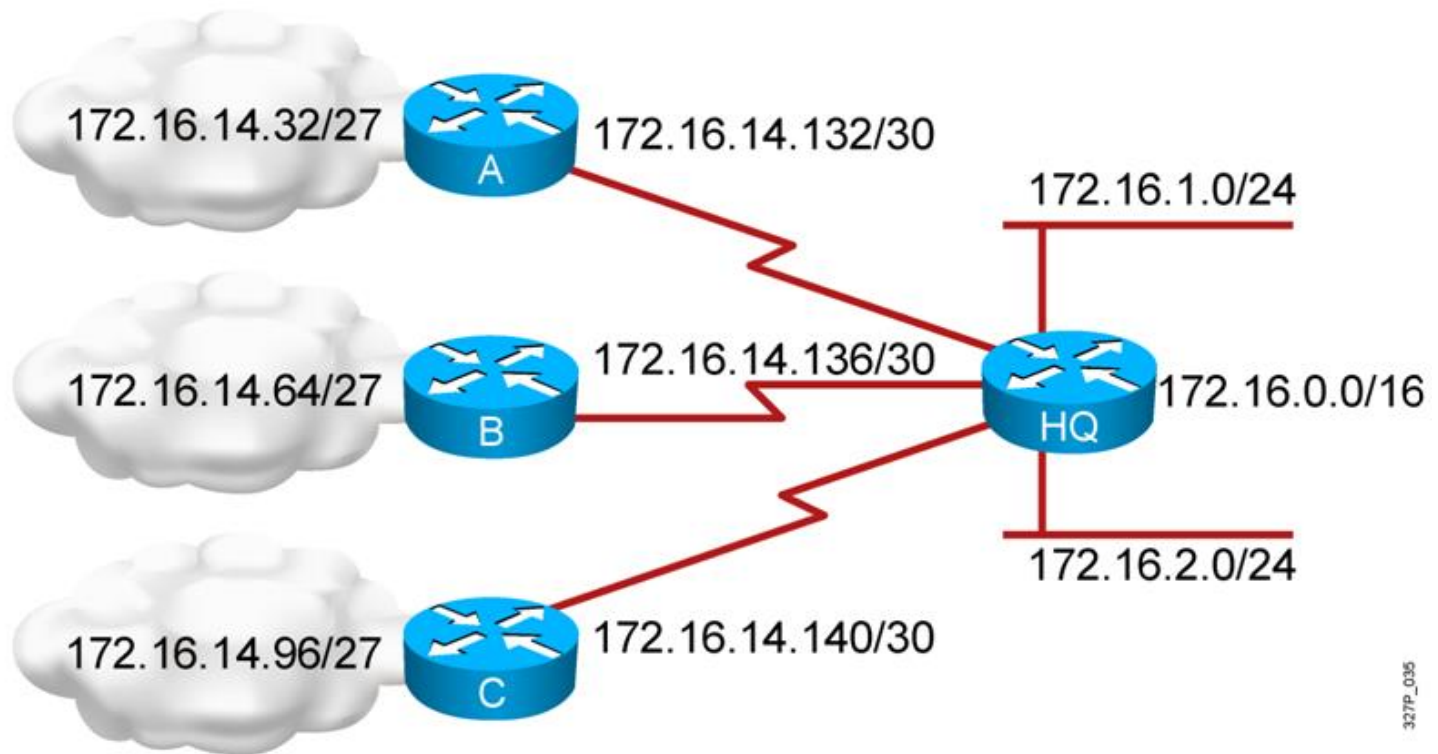255.255.255.224
192.168.18.64

Correct Answer : C

 You are a network technician at NEWSTAR company. **You add a new workstation to the network to accommodate a new employee**. The relevant section of the network is shown in the beside exhibit.

The employee is unable to connect to the server at IP address 192.168.18.141/27.

Can you identify the incorrectly configured network parameter in the workstation configuration?

A. IP address of the Ethernet 0 router interface
B. Server
C. Workstation default gateway
D. Workstation subnet mask
E. Workstation IP address

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Variable-length Subnet Mask

172.16.14.32/27
172.16.14.132/30
A
172.16.1.0/24
172.16.14.64/27
172.16.14.136/30
B
172.16.0.0/16
HQ
172.16.2.0/24
172.16.14.96/27
172.16.14.140/30
C

327P_035
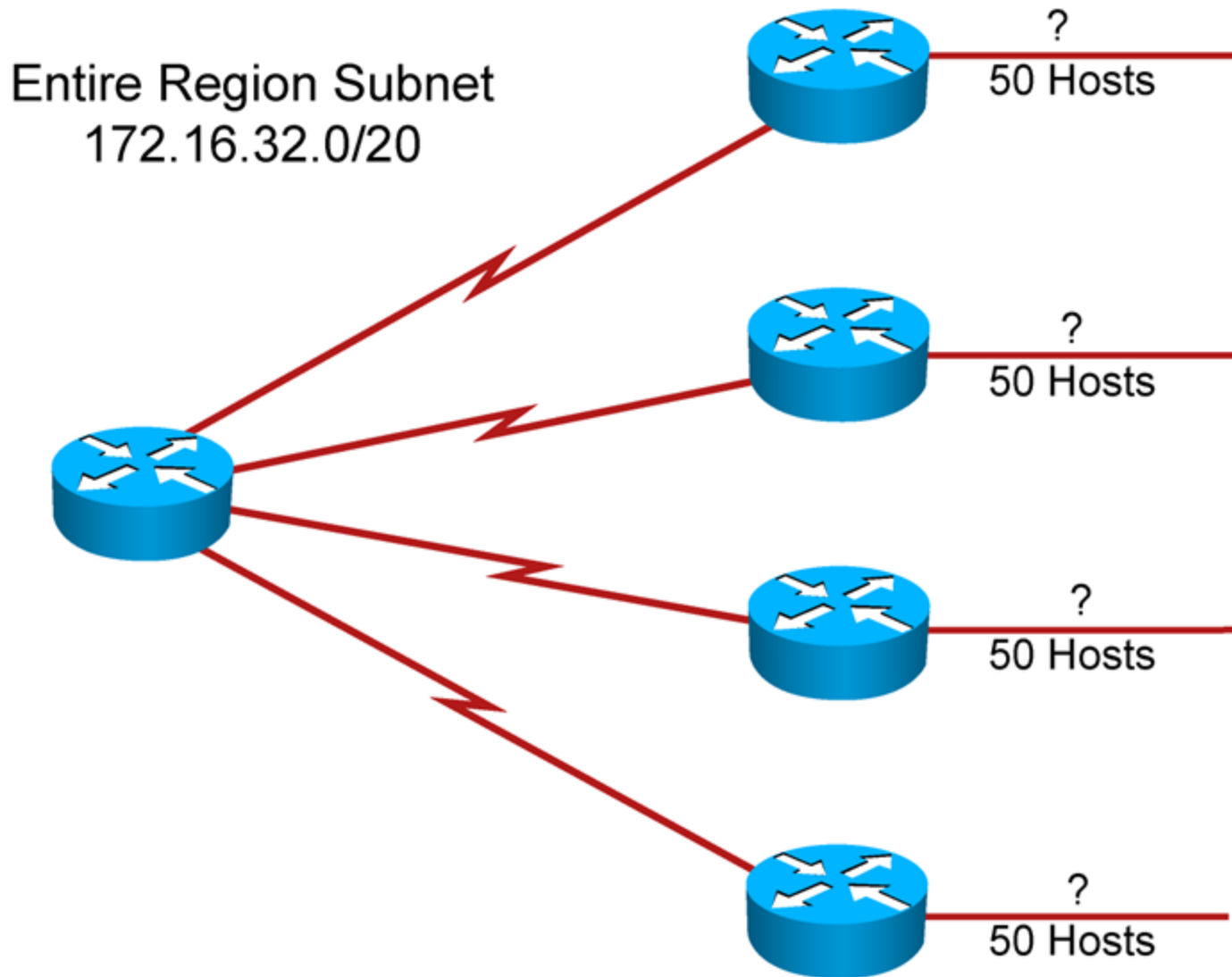
Subnet 172.16.14.0/24 is divided into smaller subnets.

– Subnet with one mask (/27).
– Then further subnet one of the unused /27 subnets into multiple /30 s

Variable-length Subnet Mask

Entire Region Subnet
172.16.32.0/20

? 50 Hosts

? 50 Hosts

? 50 Hosts

? 50 Hosts

327P_608

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Variable-length Subnet Mask

Subnetted Address: 172.16.32.0/20
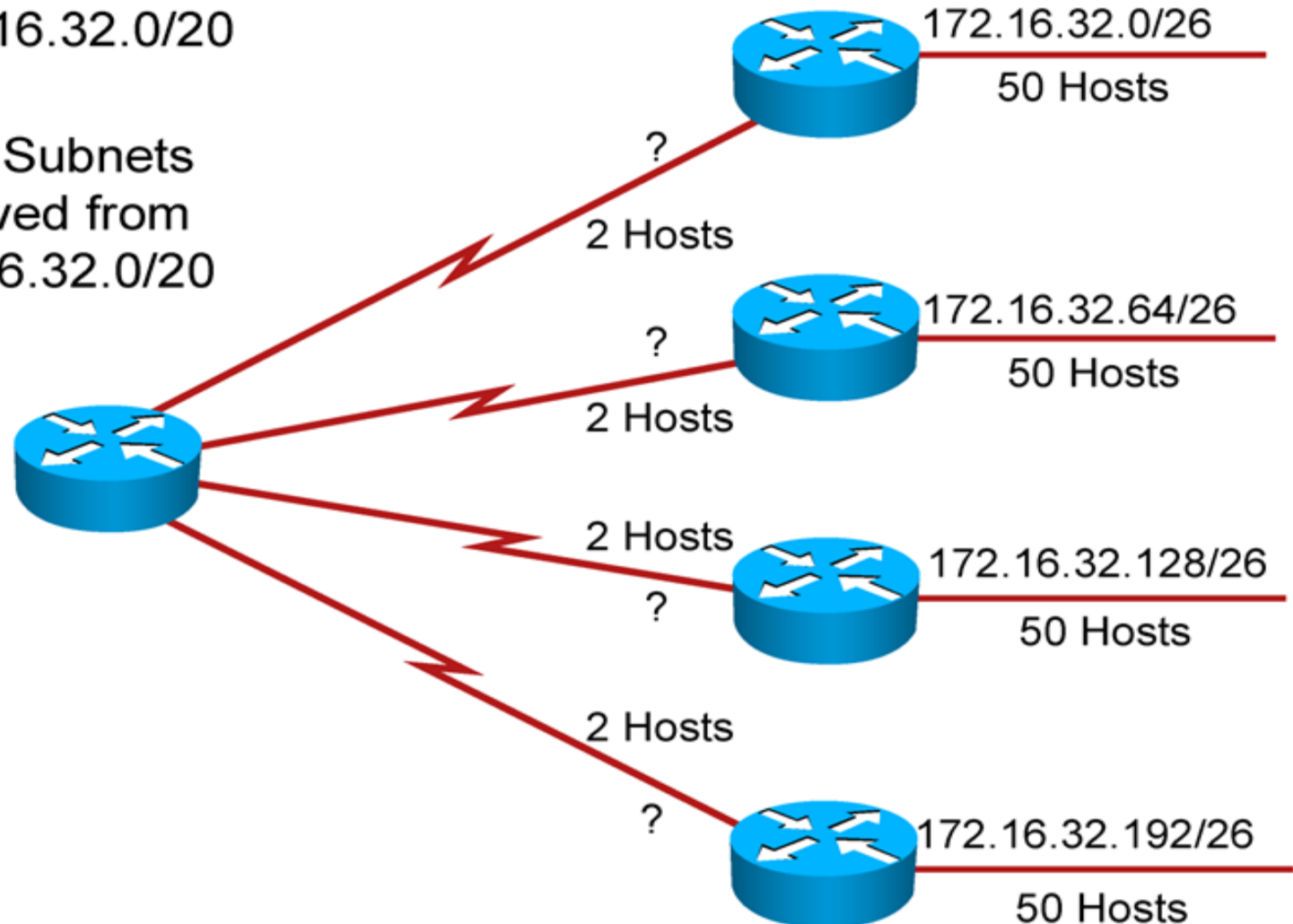In Binary   10101100. 00010000.0010 0000.00000000

VLSM Address: 172.16.32.0/26
In Binary   10101100. 00010000.0010 0000.00 000000

	Network		Subnet	VLSM Subnet	Host
1st subnet:	172 .	16	.0010	0000.00	000000=172.16.32.0/26
2nd subnet:	172 .	16	.0010	0000.01	000000=172.16.32.64/26
3rd subnet:	172 .	16	.0010	0000.10	000000=172.16.32.128/26
4th subnet:	172 .	16	.0010	0000.11	000000=172.16.32.192/26
5th subnet:	172 .	16	.0010	001.00	000000=172.16.33.0/26

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Variable-length Subnet Mask

Entire Region Subnet
172.16.32.0/20

LAN Subnets
Derived from
172.16.32.0/20

? 2 Hosts

172.16.32.0/26
50 Hosts

? 2 Hosts

172.16.32.64/26
50 Hosts

2 Hosts ?

172.16.32.128/26
50 Hosts

2 Hosts ?

172.16.32.192/26
50 Hosts

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Variable-length Subnet Mask

Entire Region Subnet
172.16.32.0/20

LAN Subnets
Derived from
172.16.32.0/20

172.16.33.0/30
2 Hosts

172.16.33.4/30
2 Hosts

2 Hosts
172.16.33.8/30

WAN Subnets
Derived from
172.16.33.0/26

2 Hosts
172.16.33.12/30

172.16.32.0/26
50 Hosts

172.16.32.64/26
50 Hosts

172.16.32.128/26
50 Hosts

172.16.32.192/26
50 Hosts

Huynh Nguyen Chinh