



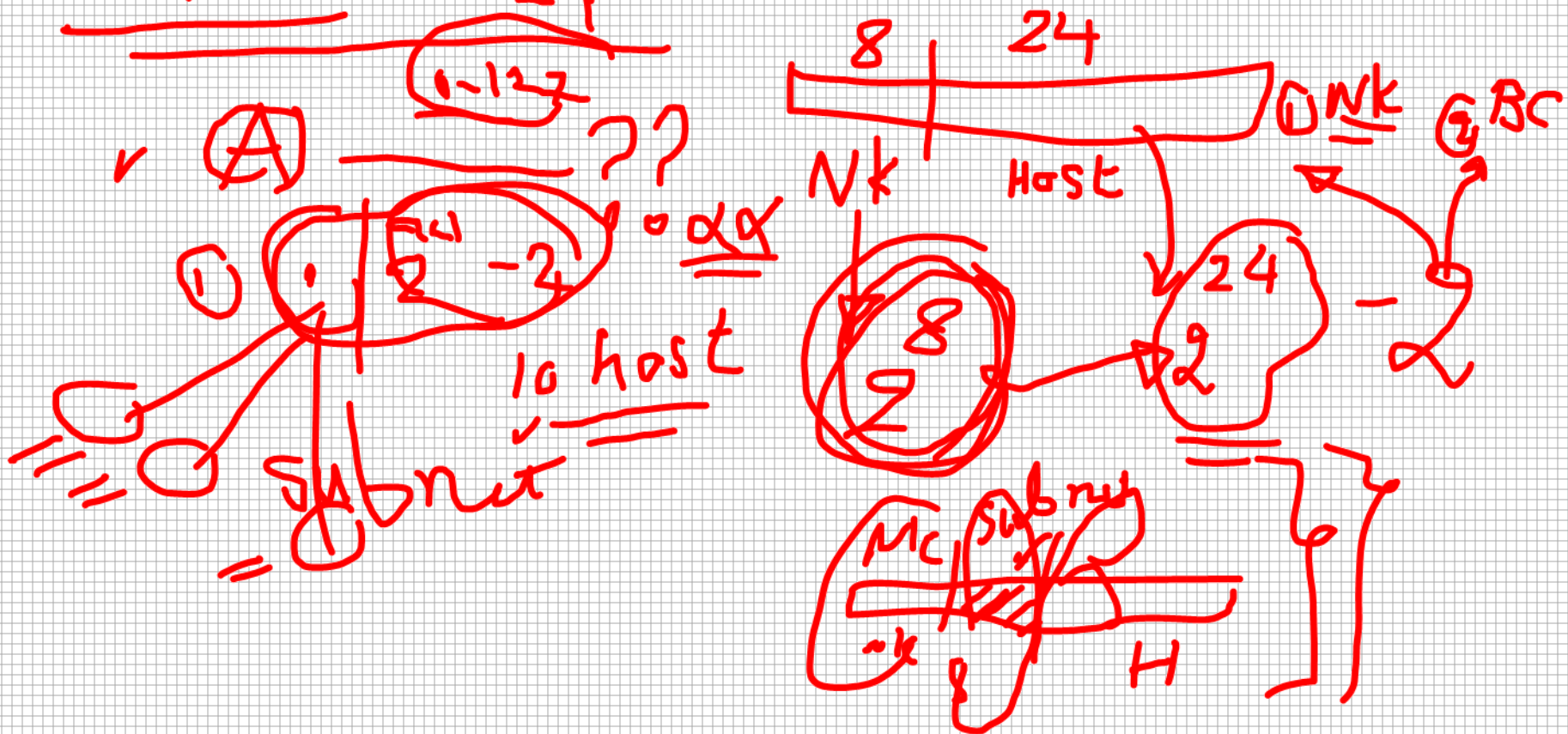
Sybex CCNA 640-803

**Chapter 3: Subnetting, VLSM and
Troubleshooting**

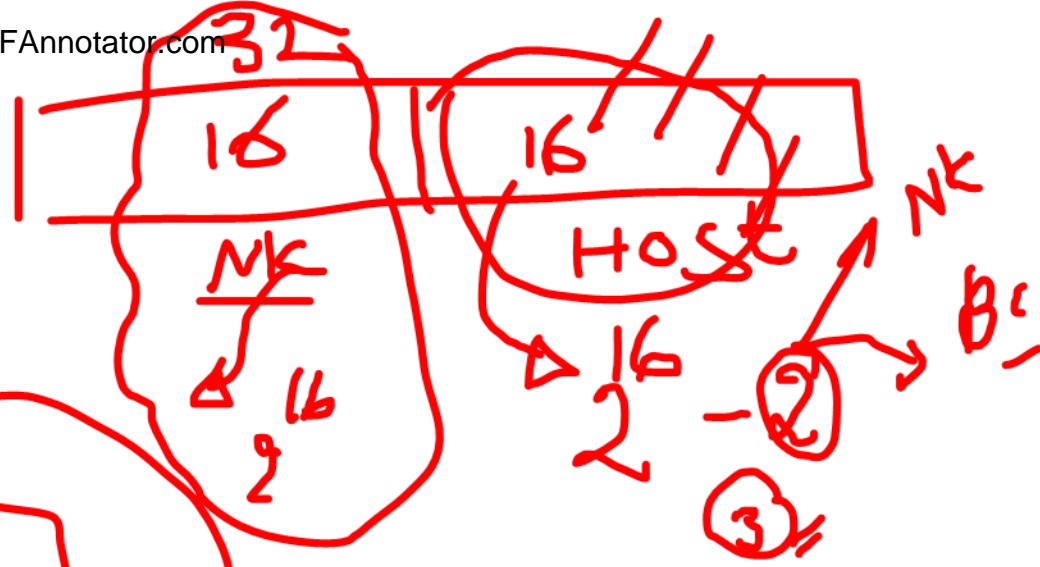
Instructor & Todd Lammle

Class.

Ip (32)

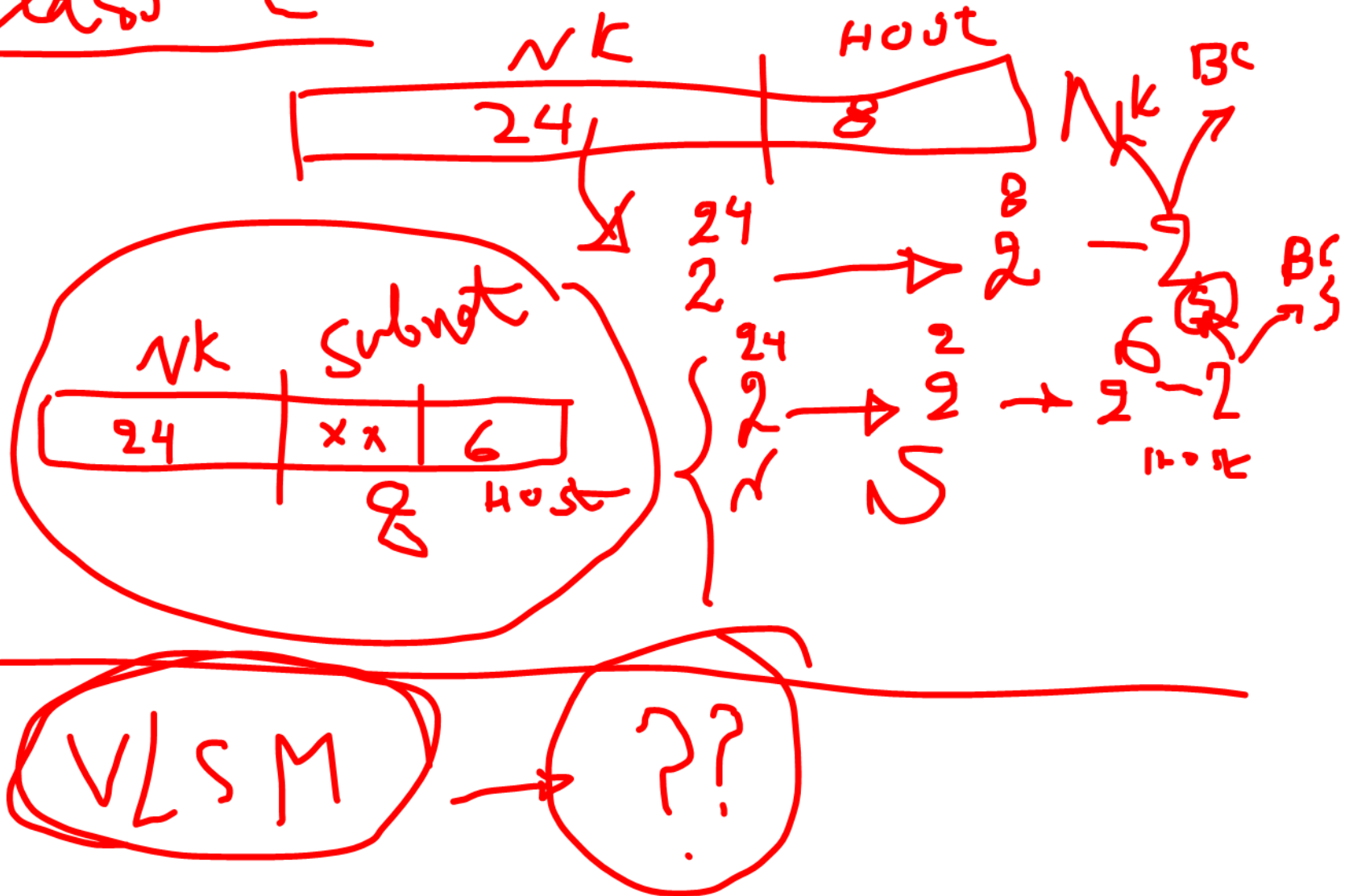


class B



2^{16} NK
 $\sqrt{2^4} = 16$
 $2^{12} - 2$

class C



A
B
C

22 mask

4 host

A

Nk	Host
8	24

10.50.70.10
255.0.0.0

mask

zeros

and

10.0.0.0

LSM

$1 \cdot x = x$
 $0 \cdot x = 0$

255.0.0.0

18

Nk

18

128 64 32 16 8 4 2 1
| | | | | | | |
9

$= (255)_{10}$

A (0 - 127) →

default
mask



IP host A

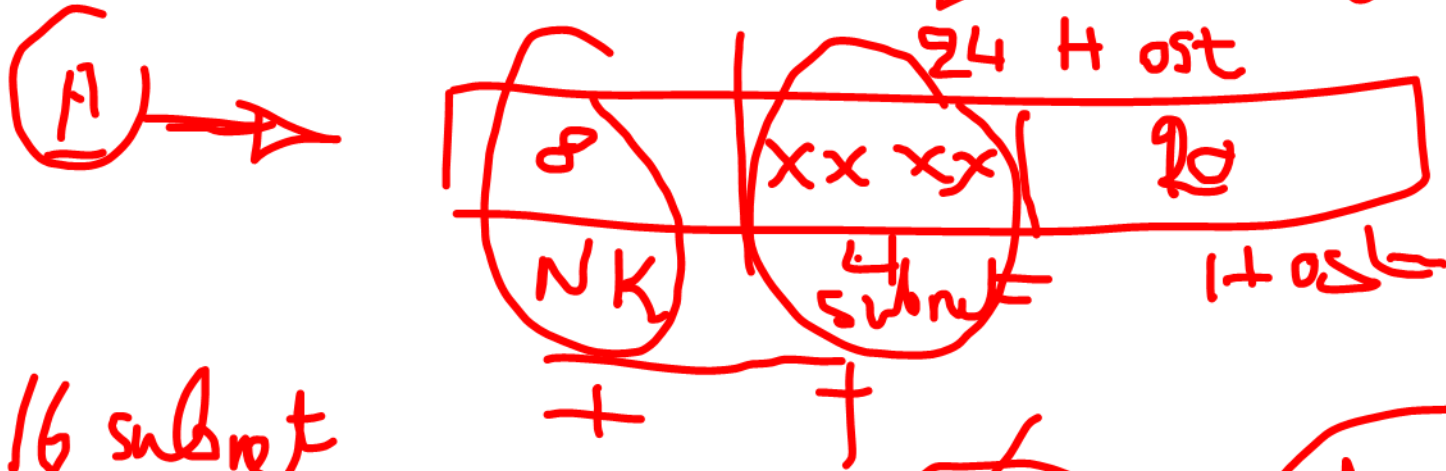
$M_{\text{addr}} = \downarrow \bullet \text{mask}$

8 24
Nk test

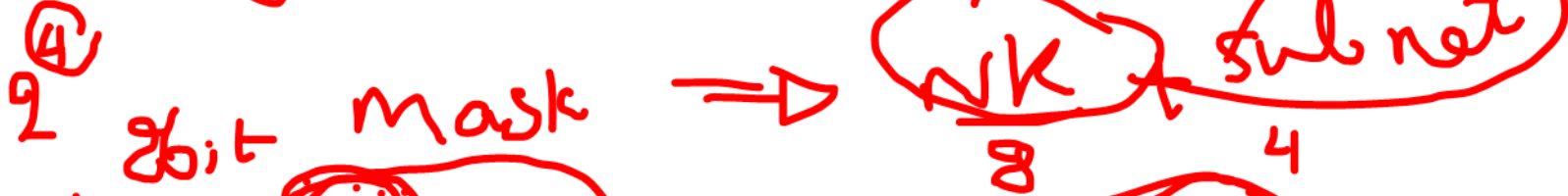
||||| zero
Nk

255.0.0.0 ≈ {/8}

class → subnets



16 subnets



||||| . ||||| 0000 . 0000 . 0000

↓ 8

255. 240. 0. 0

4 bit subnets

(/12)

classless

$$\frac{4}{2} = 16$$

Ex

(A)

(18)

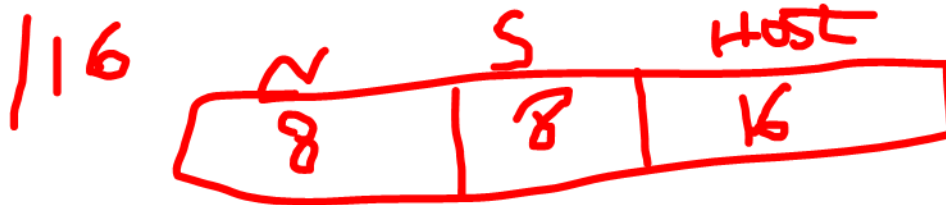
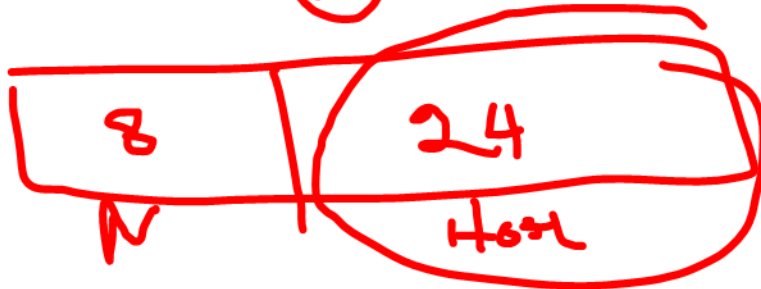
16

class

$$Nk = 2^8$$

$$\text{Subnet} = 2$$

$$\text{Host} = 2^{16-2} = 2^{14}$$



19

(19)

$I_p =$
Host

126.10.15.19/18

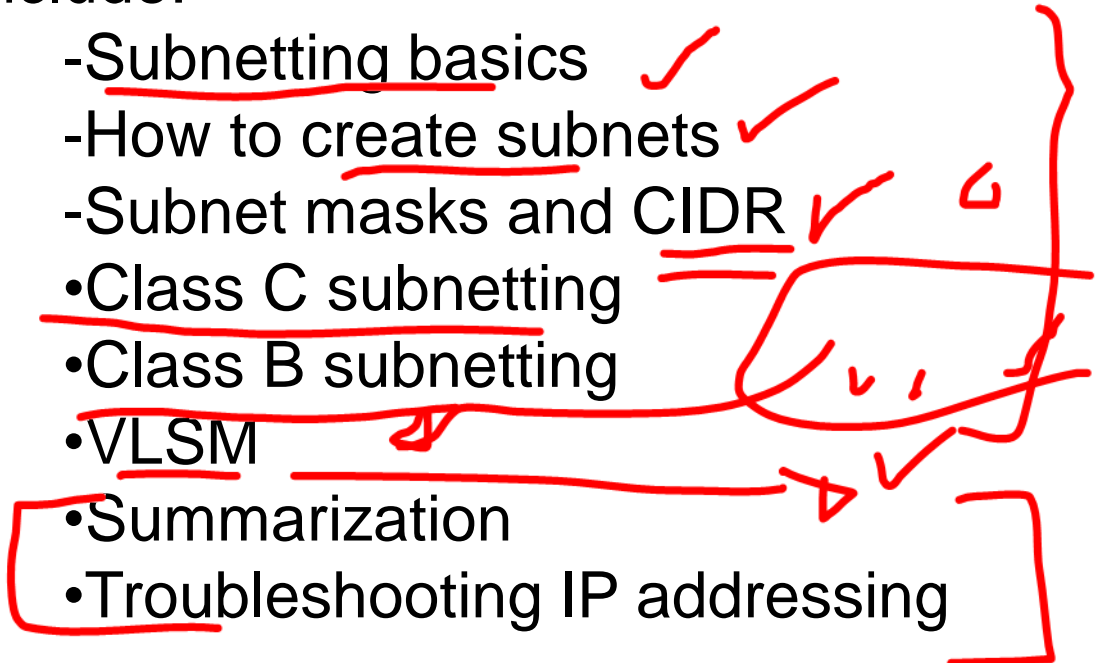
$Nk = ?$
+ 16

$$\begin{array}{r} 11000000 \\ 00001111 \\ \hline 00000000 = 0 \end{array}$$

$$\begin{array}{r} 11111111.11111111.11111111.11111111 \\ 126.10.19.0 \\ \hline 126.10.19.0 \end{array}$$

Chapter 3 Objectives

The CCNA Topics Covered in this chapter include:

- Subnetting basics ✓
 - How to create subnets ✓
 - Subnet masks and CIDR ✓
 - Class C subnetting
 - Class B subnetting
 - VLSM
 - Summarization
 - Troubleshooting IP addressing
- 

(A)

def
18

mask class

19... 130

Host

(12)

8
~12

+ 4
5

11111111.11110000 (ex?)

(خلاس)
(X X)

0	✓	✓	2
0	✓	→	10
0	0	→	30

VLSM

Variable length

○ 2 host

○ 30 host

I 90



⑦ $\rightarrow 1/12$

Mask = 126 . 10 . 10 . 2

- ① Subnet
- ② 120 st
- ③ valid hostname IP

① $1/12 \rightarrow 8$ Mask $\rightarrow 4$ sub \Rightarrow

1111 1111 . 1111 0000 . 0 . 0

$2^{20} - 2$

16
sub

126 . 126 . 126 . 126

0000 0000 . 0000 0000 . 0000 0000 . 0000 0000

126 . 0 . 0 . 0

8 Mask - sub

4 bit

$11 = 2^4 = 16$

126 . 1111 0000 . 1111 0000 . 1111 0000

8 sub
valid host
BC



Network Addressing

Subdividing an IP address into a network and node address is determined by the class designation of one's network. This figure summarizes the three classes of networks

	8 bits	8 bits	8 bits	8 bits
0-127	Class A:	Network	Host	Host
128 - 191	Class B:	Network	Network	Host
192-223	Class C:	Network	Network	Network
224 - 239	Class D:	Multicast		
240 - 255	Class E:	Research		

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Private Addressing

<u>Address Class</u>	<u>Reserved Address Space</u>
Class A	10.0.0.0 through 10.255.255.255
Class B	172.16.0.0 through 172.31.255.255
Class C	192.168.0.0 through 192.168.255.255



Subnetting Basics

- Benefits of subnetting include:
 - Reduced network traffic
 - Optimized network performance
 - Simplified management
 - Facilitated spanning of large geographical distances.



How To Create Subnets

Take bits from the host portion of the IP address and reserve the to divine the subnet address.

1. Determine the number of required network IDs:
 - One for each subnet
 - One for each wide area network connection
2. Determine the number of required host IDs per subnet:
 - One for each TCP/IP host
 - One for each router interface
3. Based on the above requirement, create the following:
 - One subnet mask for your entire network
 - A unique subnet ID for each physical segment
 - A range of host IDs for each subnet

Understanding the Powers of 2

Understanding the Powers of 2

Powers of 2 are important to understand and memorize for use with IP subnetting. To review powers of 2, remember that when you see a number with another number to its upper right (called an exponent), this means you should multiply the number by itself as many times as the upper number specifies. For example, 2^3 is $2 \times 2 \times 2$, which equals 8. Here's a list of powers of 2 you should commit to memory:

$$2^1 = 2$$

$$2^3 = 8$$

$$2^5 = 32$$

$$2^7 = 128$$

$$2^2 = 4$$

$$2^4 = 16$$

$$2^6 = 64$$

$$2^8 = 256$$



Subnet Masks

- Used to define which part of the host address will be used as the subnet address.
- A 32-bit value that allows the recipient of IP packets to distinguish the network ID portion of the IP address from the host ID portion.



Default Subnet Masks

Class	Format	Default Subnet Mask
A	<i>network.node.node.node</i> 18	255.0.0.0
B	<i>network.network.node.node</i> 16	255.255.0.0
C	<i>network.network.network.node</i> 24	255.255.255.0

Examples

you've got to keep at least 2 bits for host ID.

Take, for example, a Class A default subnet mask, which is 255.0.0.0. This means that the first byte of the subnet mask is all ones (1s), or 11111111. When referring to a slash notation, you need to count all the 1s bits to figure out your mask. The 255.0.0.0 is considered a /8 because it has 8 bits that are 1s—that is, 8 bits that are turned on.

A Class B default mask would be 255.255.0.0, which is a /16 because 16 bits are ones (1s): 11111111.11111111.00000000.00000000.

Classless Inter-Domain Routing (CIDR)



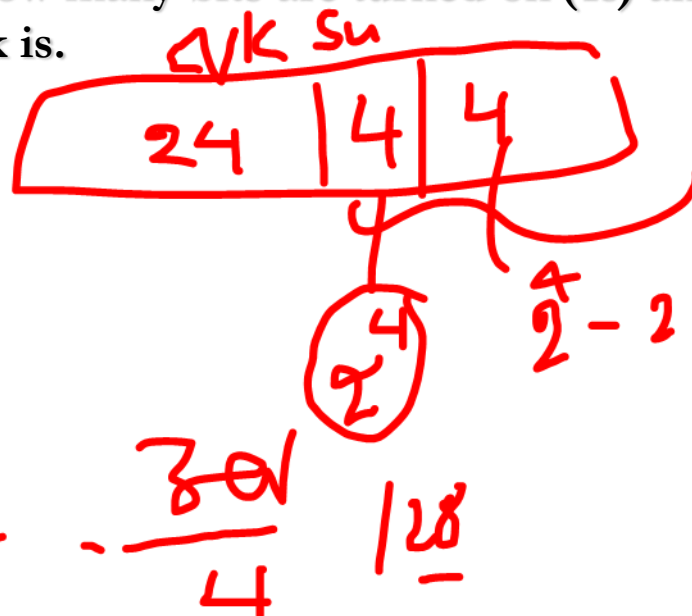
Used to allocate an amount of IP address space to a given entity (company, home, customer, etc).

Example: 192.168.10.32/28

HOST

The slash notation (/) means how many bits are turned on (1s) and tells you what your subnet mask is.

0-127 A
128-141 B
142-155 C



28

30
4
128



CIDR Values

Subnet Mask	CIDR Value
255.0.0.0	/8
255.128.0.0	/9
255.192.0.0	/10
255.224.0.0	/11
255.240.0.0	/12
255.248.0.0	/13
255.252.0.0	/14
255.254.0.0	/15
255.255.0.0	/16
255.255.128.0	/17
255.255.192.0	/18
255.255.224.0	/19
255.255.240.0	/20
255.255.248.0	/21

Subnet Mask	CIDR Value
255.255.252.0	/22
255.255.254.0	/23
255.255.255.0	/24
255.255.255.128	/25
255.255.255.192	/26
255.255.255.224	/27
255.255.255.240	/28
255.255.255.248	/29
255.255.255.252	/30

Binary	Decimal	CIDR
000000	= 128	/25
000000	= 192	/26
000000	= 224	/27
10000	= 240	/28
11000	= 248	/29
11100	= 252	/30

Handwritten red annotations:

- A large red bracket on the left side of the table, spanning from the first row to the last row.
- A red arrow pointing from the first row to the last row.
- A red circle around the first row.
- A red circle around the last row.
- A red circle around the second row.
- A red circle around the third row.
- A red circle around the fourth row.
- A red circle around the fifth row.
- A red circle around the sixth row.
- A red circle around the seventh row.
- A red circle around the eighth row.
- A red circle around the ninth row.
- A red circle around the tenth row.
- A red circle around the eleventh row.
- A red circle around the twelfth row.
- A red circle around the thirteenth row.
- A red circle around the fourteenth row.
- A red circle around the fifteenth row.
- A red circle around the sixteenth row.
- A red circle around the seventeenth row.
- A red circle around the eighteenth row.
- A red circle around the nineteenth row.
- A red circle around the twentieth row.
- A red circle around the twenty-first row.
- A red circle around the twenty-second row.
- A red circle around the twenty-third row.
- A red circle around the twenty-fourth row.
- A red circle around the twenty-fifth row.
- A red circle around the twenty-sixth row.
- A red circle around the twenty-seventh row.
- A red circle around the twenty-eighth row.
- A red circle around the twenty-ninth row.
- A red circle around the thirtieth row.
- A red circle around the thirty-first row.
- A red circle around the thirty-second row.
- A red circle around the thirty-third row.
- A red circle around the thirty-fourth row.
- A red circle around the thirty-fifth row.
- A red circle around the thirty-sixth row.
- A red circle around the thirty-seventh row.
- A red circle around the thirty-eighth row.
- A red circle around the thirty-ninth row.
- A red circle around the fortieth row.
- A red circle around the forty-first row.
- A red circle around the forty-second row.
- A red circle around the forty-third row.
- A red circle around the forty-fourth row.
- A red circle around the forty-fifth row.
- A red circle around the forty-sixth row.
- A red circle around the forty-seventh row.
- A red circle around the forty-eighth row.
- A red circle around the forty-ninth row.
- A red circle around the fiftieth row.
- A red circle around the fifty-first row.
- A red circle around the fifty-second row.
- A red circle around the fifty-third row.
- A red circle around the fifty-fourth row.
- A red circle around the fifty-fifth row.
- A red circle around the fifty-sixth row.
- A red circle around the fifty-seventh row.
- A red circle around the fifty-eighth row.
- A red circle around the fifty-ninth row.
- A red circle around the sixtieth row.
- A red circle around the sixty-first row.
- A red circle around the sixty-second row.
- A red circle around the sixty-third row.
- A red circle around the sixty-fourth row.
- A red circle around the sixty-fifth row.
- A red circle around the sixty-sixth row.
- A red circle around the sixty-seventh row.
- A red circle around the sixty-eighth row.
- A red circle around the sixty-ninth row.
- A red circle around the seventieth row.
- A red circle around the seventy-first row.
- A red circle around the seventy-second row.
- A red circle around the seventy-third row.
- A red circle around the seventy-fourth row.
- A red circle around the seventy-fifth row.
- A red circle around the seventy-sixth row.
- A red circle around the seventy-seventh row.
- A red circle around the seventy-eighth row.
- A red circle around the seventy-ninth row.
- A red circle around the eightieth row.
- A red circle around the eighty-first row.
- A red circle around the eighty-second row.
- A red circle around the eighty-third row.
- A red circle around the eighty-fourth row.
- A red circle around the eighty-fifth row.
- A red circle around the eighty-sixth row.
- A red circle around the eighty-seventh row.
- A red circle around the eighty-eighth row.
- A red circle around the eighty-ninth row.
- A red circle around the ninetieth row.
- A red circle around the ninety-first row.
- A red circle around the ninety-second row.
- A red circle around the ninety-third row.
- A red circle around the ninety-fourth row.
- A red circle around the ninety-fifth row.
- A red circle around the ninety-sixth row.
- A red circle around the ninety-seventh row.
- A red circle around the ninety-eighth row.
- A red circle around the ninety-ninth row.
- A red circle around the one hundredth row.



Class C 192 mask examples

Subnet	Host	Meaning
00	000000 = 0	The network (do this first)
00	000001 = 1	The first valid host
00	111110 = 62	The last valid host
00	111111 = 63	The broadcast address (do this second)

Subnet	Host	Meaning
01	000000 = 64	The network
01	000001 = 65	The first valid host
01	111110 = 126	The last valid host
01	111111 = 127	The broadcast address

Class C 192 mask examples

Subnet	Host	Meaning
10	000000 = 128	The subnet address
10	000001 = 129	The first valid host
10	111110 = 190	The last valid host
10	111111 = 191	The broadcast address

Subnet	Host	Meaning
11	000000 = 192	The subnet address
11	000001 = 193	The first valid host
11	111110 = 254	The last valid host
11	111111 = 255	The broadcast address

Subnetting Class C Addresses – Fast Method

Answer Five Simple Questions:

- How many subnets does the chosen subnet mask produce?
- How many valid hosts per subnet are available?
- What are the valid subnets?
- What's the broadcast address of each subnet?
- What are the valid hosts in each subnet?

How Many Subnets?

2^X = number of subnets.

- X is the number of masked bits, or the 1s.
- For example, in 11000000, the number of ones gives us 2^2 subnets. In this example there are 4 subnets.

How Many Hosts Per Subnet?

$2^y - 2$ = number of hosts per subnet.

- Y is the number of unmasked bits, or the 0s.
- For example, in 11000000, the number of zeros gives us $2^6 - 2$ hosts. In this example, there are 62 hosts per subnet.

What Are The Valid Subnets?

- 256-subnet mask = block size, or base number.
- For example $256-192=64$. 64 is the first subnet. The next subnet would be the base number plus itself or $64+64=128$, (the second subnet).

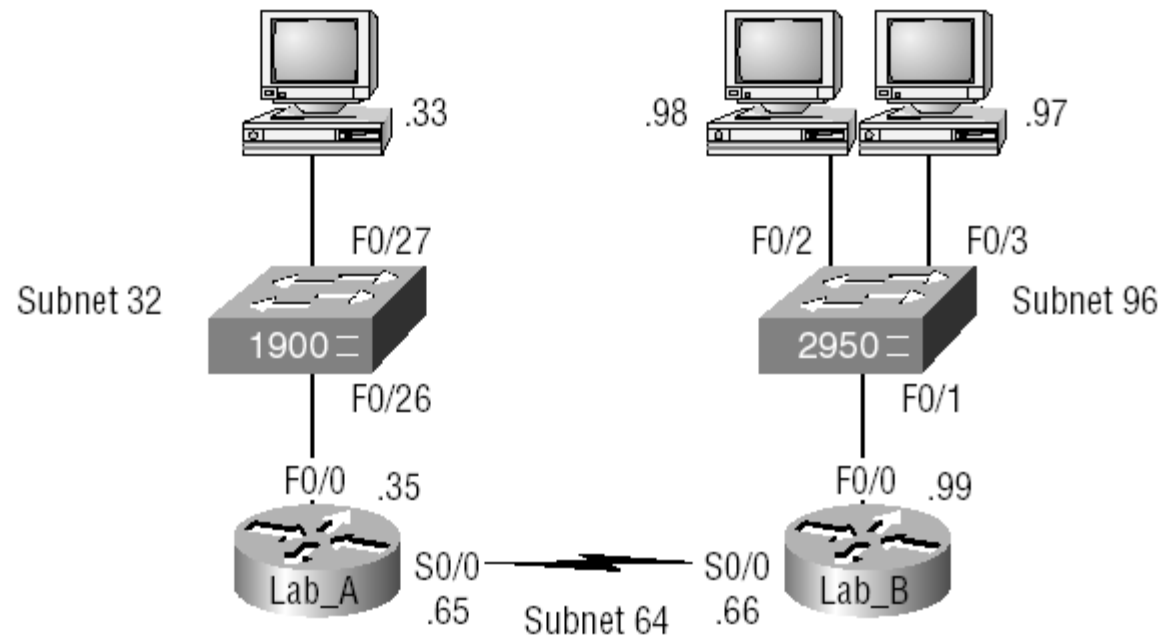
What's The Broadcast Address For Each Subnet?

- The broadcast address is all host bits turned on, which is the number immediately preceding the next subnet.

What Are The Valid Hosts?

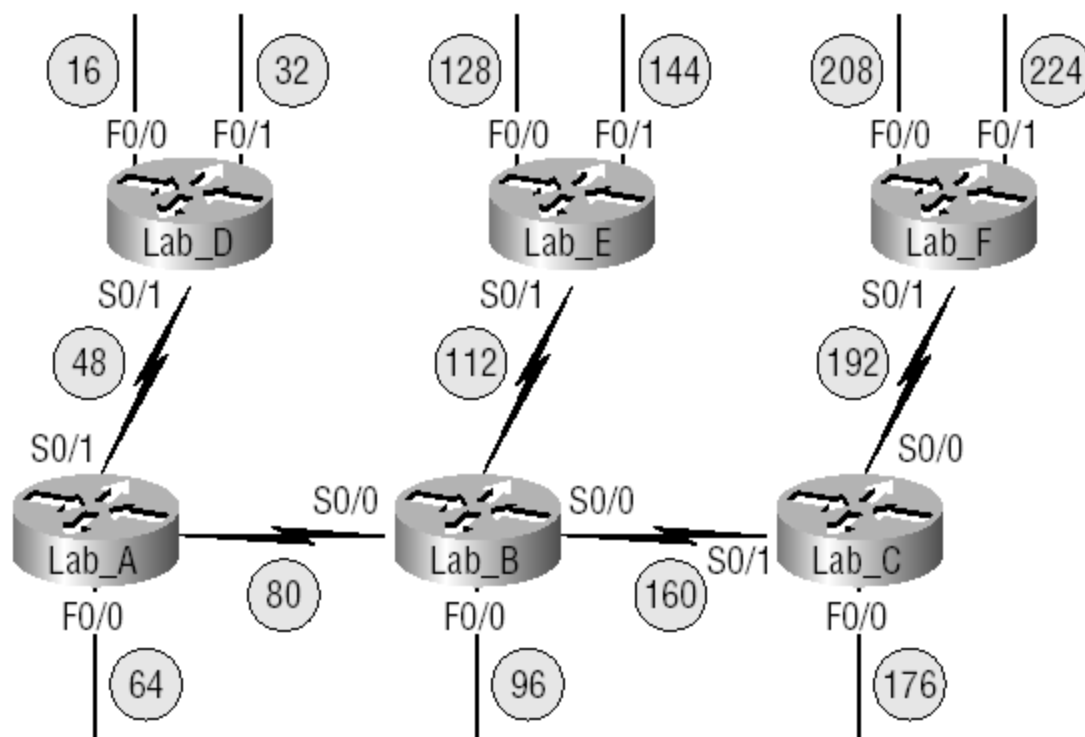
- Valid hosts are the number between the subnets, omitting all 0s and all 1s.

Variable Length Subnet Masks (VLSM)



Subnets with no VLSM applied

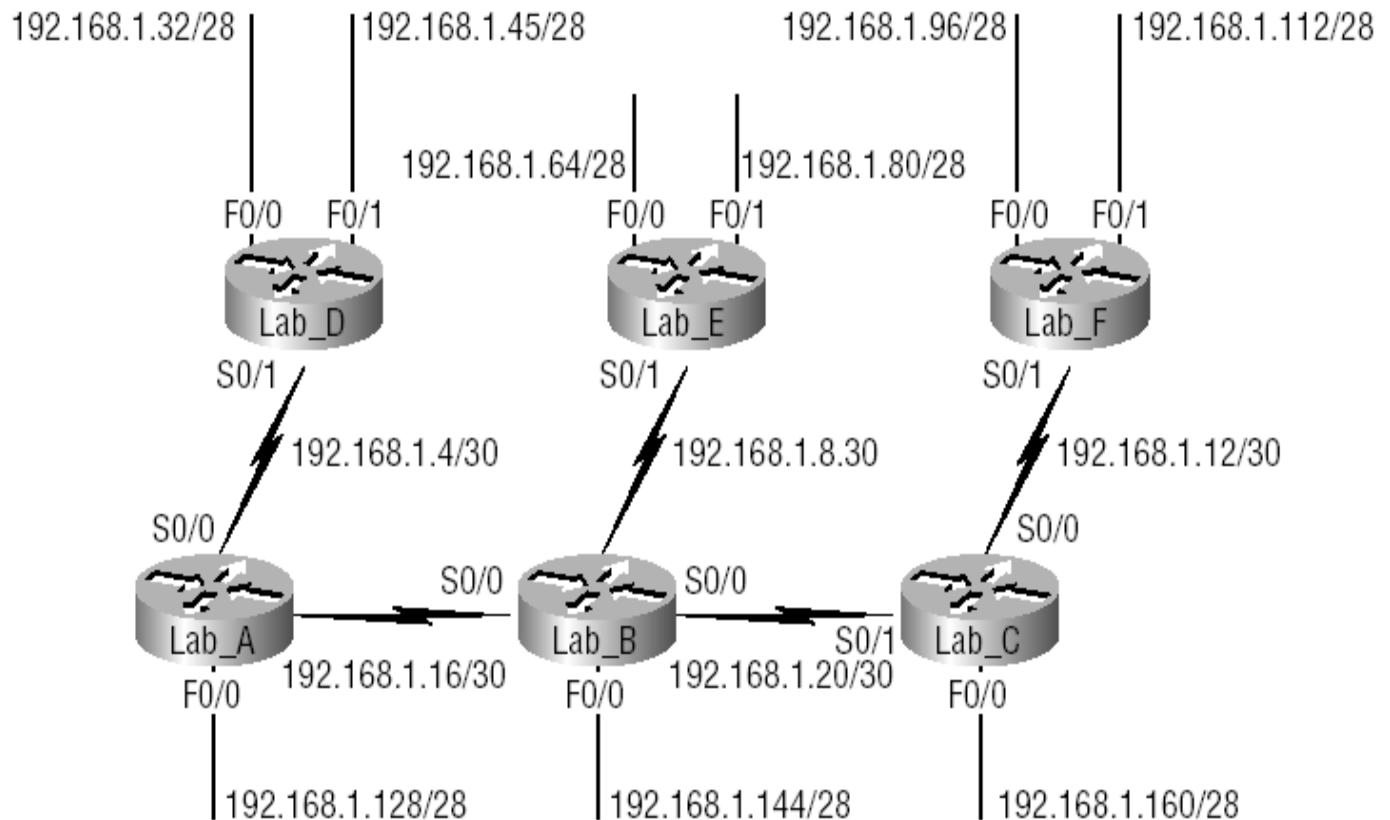
The mask of 255.255.255.240 (/28) provides 14 subnets, each with 14 hosts.
All hosts and router interfaces use the same subnet mask.



Subnets with VLSM applied

FIGURE 3.3 Fourteen subnets with VLSM applied

By using a VLSM design, we save address space!



Variable Length Subnet Masks Worksheet

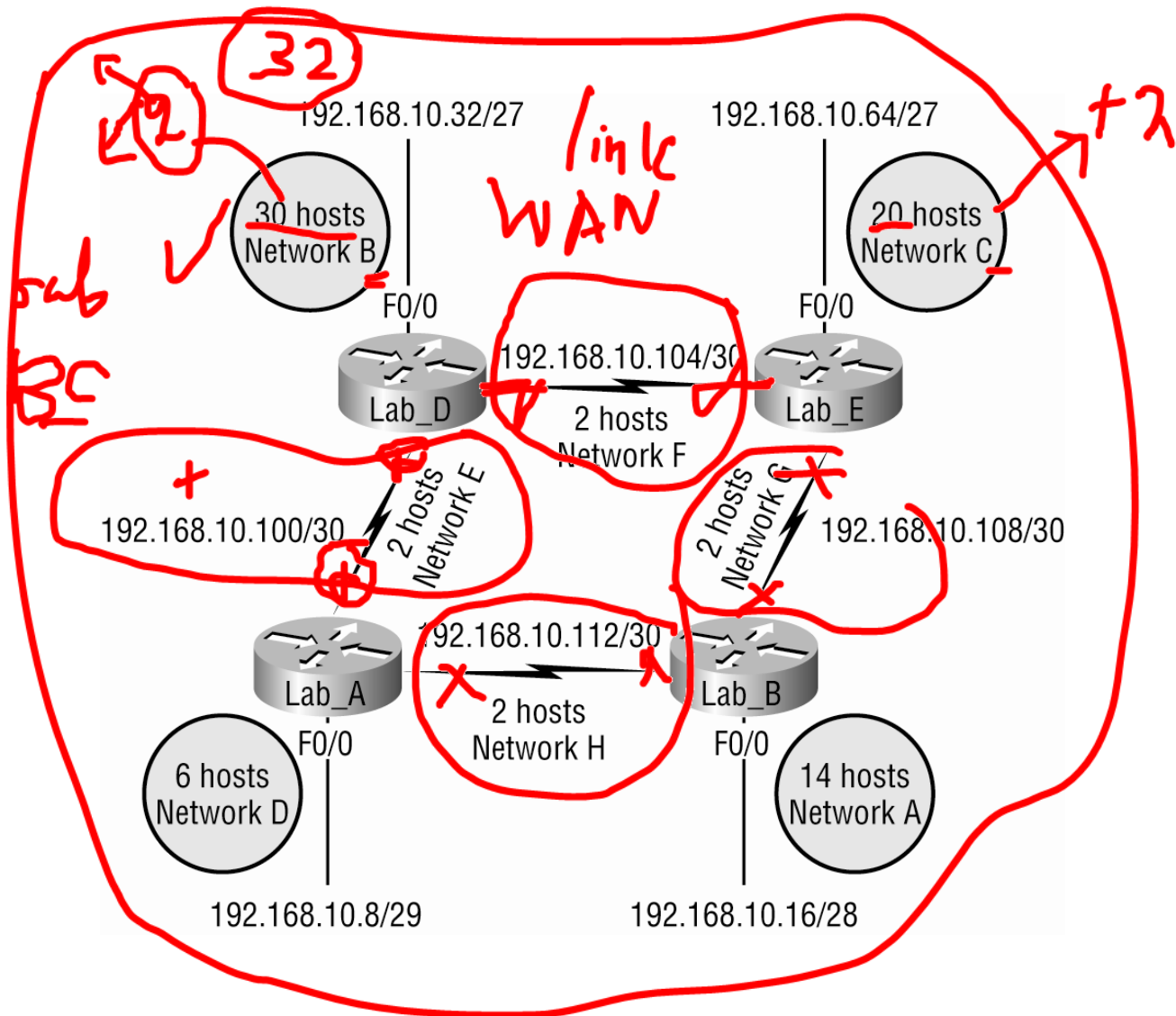
Subnet	Mask	Subnets	Hosts	Block
/26	192	4	62	64
/27	224	8	30	32
/28	240	16	14	16
/29	248	32	6	8
/30	252	64	2	4

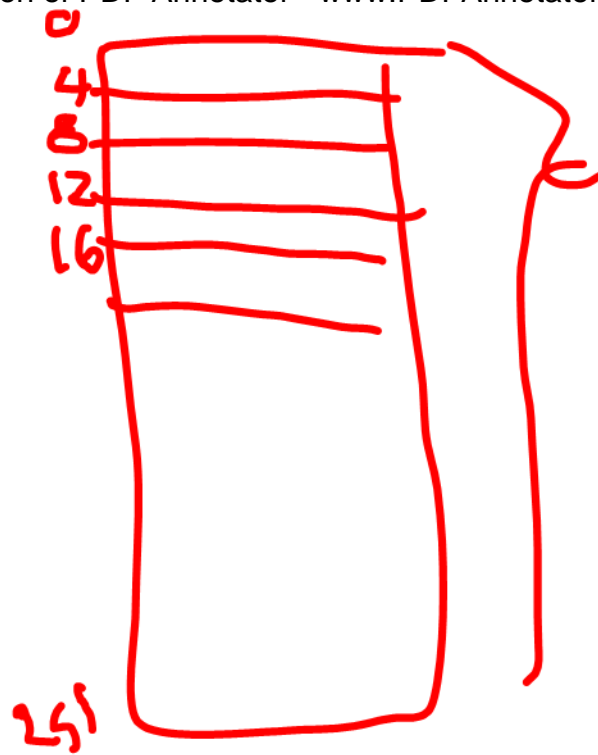
Class C Network 192.168.10.0

Network	Hosts	Block	Subnet	Mask
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				

0	
4	
8	
12	
16	
20	
24	
28	
32	
36	
40	
44	
48	
52	
56	
60	
64	
68	
72	
76	
80	
84	
88	
92	
96	
100	
104	
108	
112	
116	
120	
124	
128	
132	
136	
140	
144	
148	
152	
156	
160	
164	
168	
172	
176	
180	
184	
188	
192	
196	
200	
204	
208	
212	
216	
220	
224	
228	
232	
236	
240	
244	
248	
252	
256	

VSLM, Example 1





A_1, \dots, H



N 5 | 14i
x-x

10 hist
↓ + 2 = 12
~~11~~ ~~12~~ ~~13~~

17) $20 + 2 = 22$ $2 = 22$

Class C Network				192.16.10.0	
	Network	Hosts	Block	Subnet	Mask
1	A	12	16	/28	240
2	B	20	32	/27	224
3	C	25	32	/27	224
4	D	4	8	/29	248
5	E	2	4	/30	252
6	F	2	4	/30	252
7	G	2	4	/30	252
8	H	2	4	/30	252

0
4
8
12 D - 192.16.10.8/29
16
20
24 A - 192.16.10.16/28
28
32
36
40
44
48 B - 192.16.10.32/27
52
56
60
64
68
72
76
80 C - 192.16.10.64/27
84
88
92
96 E - 192.16.10.96/30
100 F - 192.16.10.100/30
104 G - 192.16.10.104/30
108 H - 192.16.10.108/30
112
116
120
124
128
132
136
140
144
148
152
156
160
154
158
172
176
180
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212
216
220
224
228
232
236
240
244
248
252
256

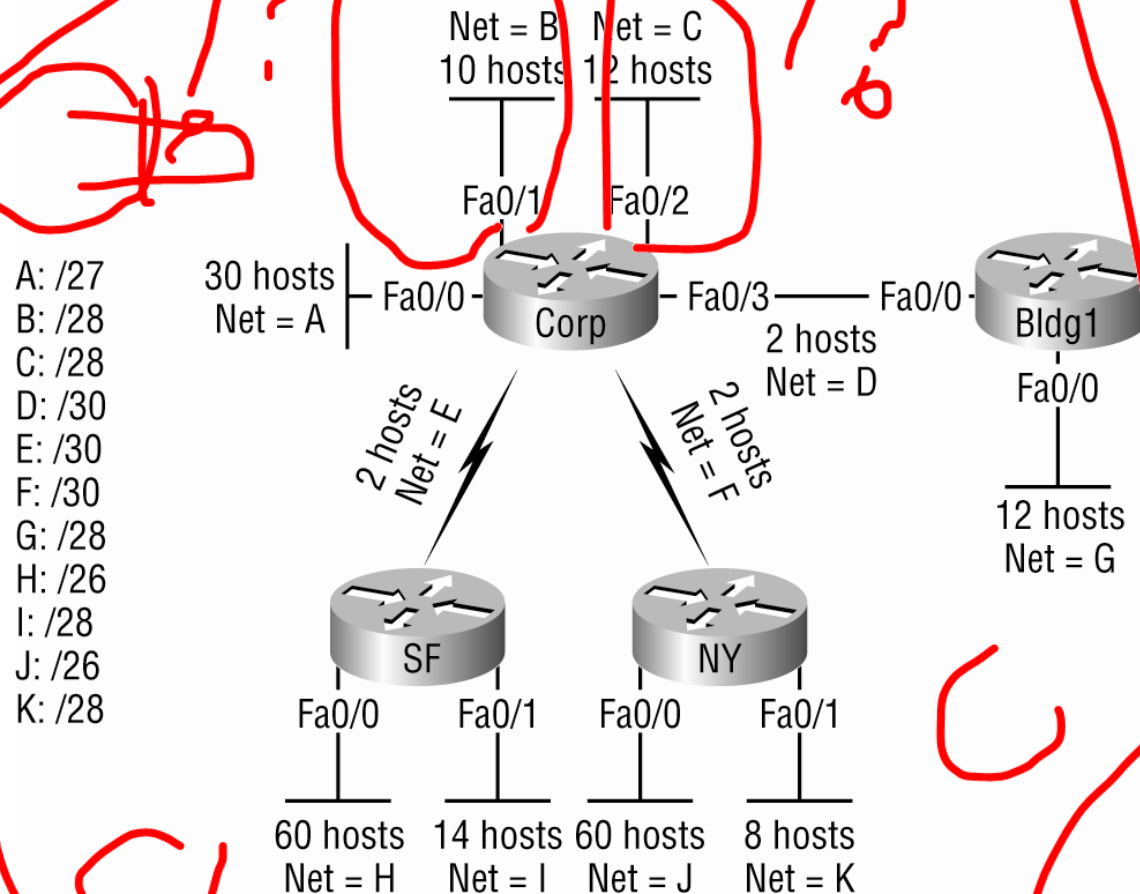
$$\begin{array}{r} 2 \\ 4 \\ 2^5 \\ 2 \\ 4 \\ 2 = 16 \\ = \end{array}$$

① NK

$A // (16) \Rightarrow \cancel{1}, \cancel{2}, \cancel{3}, \cancel{4}, \dots$
 $B \rightarrow (32) \Rightarrow \cancel{1}, \cancel{2}, \cancel{3}, \cancel{4}, \dots$
 $C \rightarrow 32 \Rightarrow \cancel{3}, \cancel{2}, (64) \dots$
 $D \rightarrow (8) \Rightarrow 0, (8), 16, 24, 32, \dots$
 $E \rightarrow 4 \Rightarrow 0, 4, 8, \dots$



h of PDF Annotator - www.PDFAnnotator.com





Subnet	Mask	Subnets	Hosts	Block
/26	192	4	62	64
/27	224	8	30	32
/28	240	16	14	16
/29	248	32	6	8
/30	252	64	2	4

visn
NK
host

Class C Network 192.168.10.0

Network	Hosts	Block	Subnet	Mask
A	30	32	32	224
B	10	16	0	240
C	12	16	16	240
D	2	4	244	252
E	2	4	248	252
F	2	4	252	252
G	12	16	208	240
H	60	64	64	192
I	14	16	192	240
J	60	64	128	192
K	8	16	224	240
L				
M				

0	
4	
8	B - 192.16.10.0/28
12	
16	
20	
24	C - 192.16.10.16/28
28	
32	
36	
40	
44	A - 192.16.10.32/27
48	
52	
56	
60	
64	
68	
72	
76	
80	
84	
88	
92	
96	H - 192.16.10.64/26
100	
104	
108	
112	
116	
120	
124	
128	
132	
136	
140	
144	
148	
152	
156	
160	J - 192.16.10.128/26
164	
168	
172	
176	
180	
184	
188	
192	
196	
200	I - 192.16.10.192/28
204	
208	
212	
216	G - 192.16.10.208/28
220	
224	
228	
232	K - 192.16.10.224/28
236	
240	
244	
248	D - 192.16.10.244/30
252	E - 192.16.10.248/30
256	F - 192.16.10.252/30

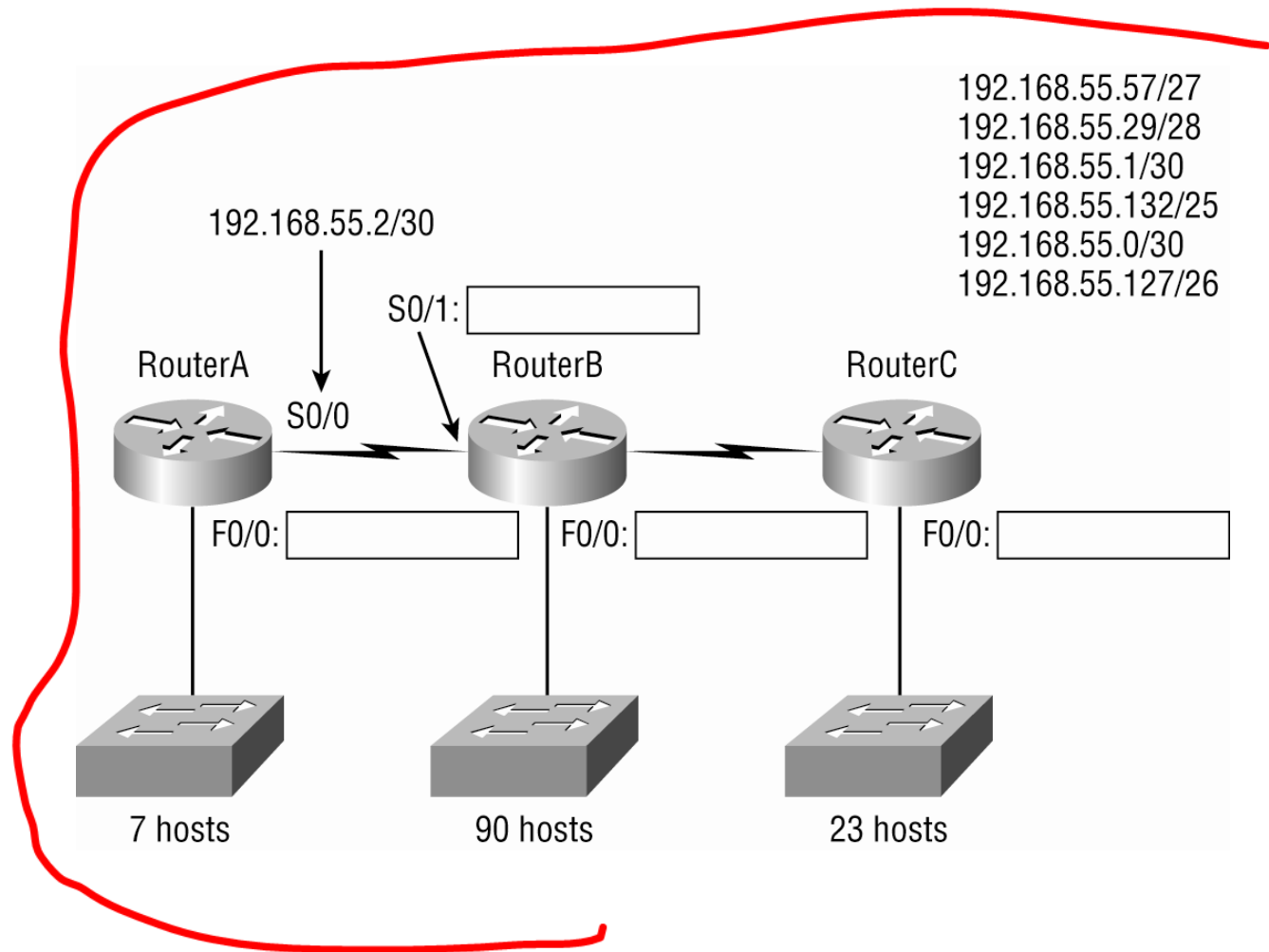
A 32 \Rightarrow 0, 32, 64, ...

B 16 \Rightarrow 0, 16, 32, 48, ...

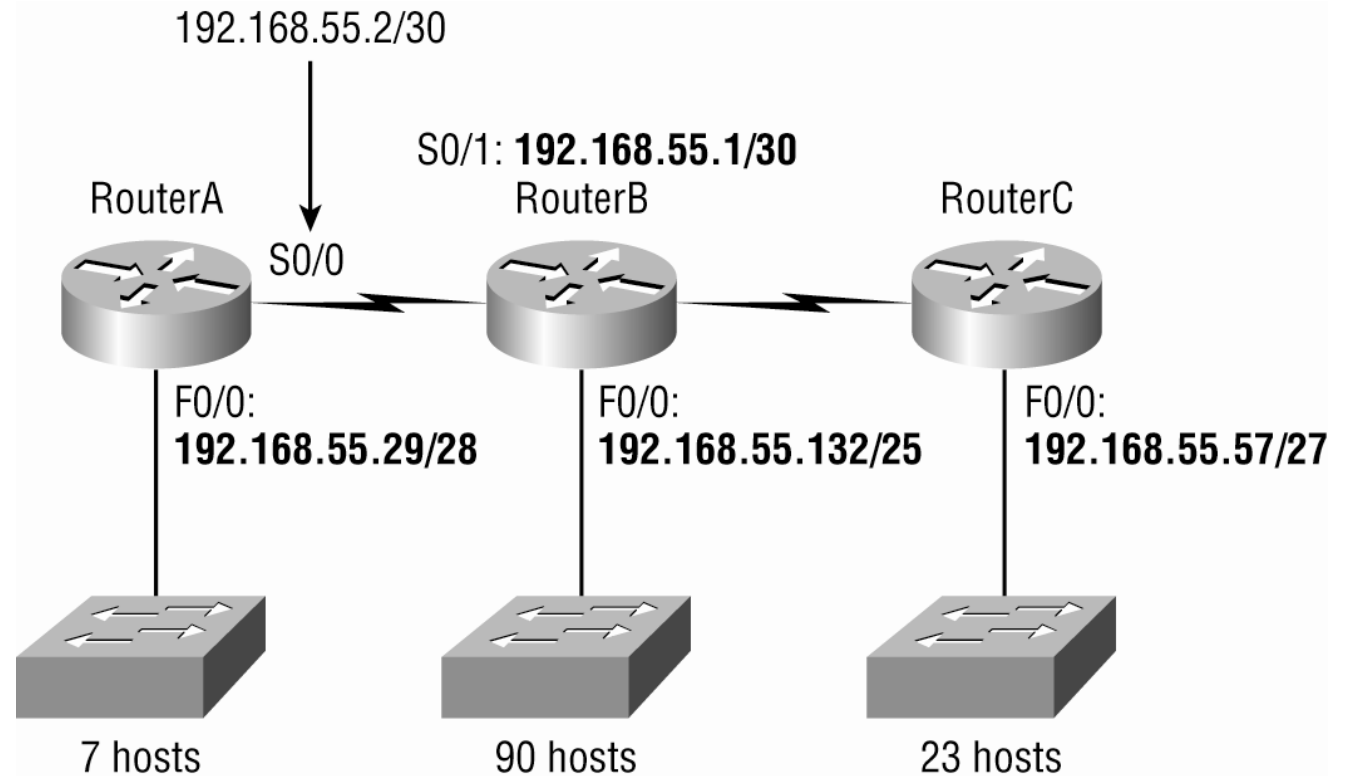
?

Nr	Host	Start
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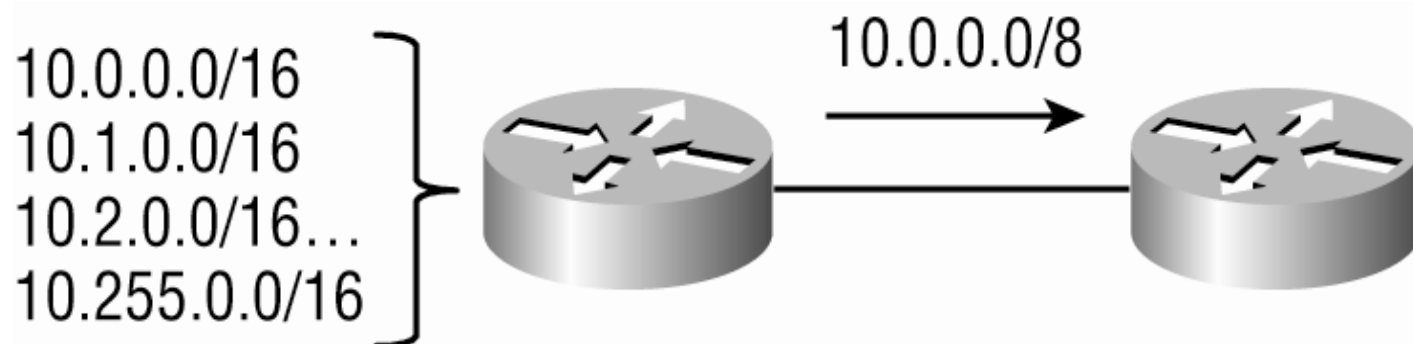
Which IP address will be placed in each router's FastEthernet 0/0 interface and serial 0/1 of RouterB?



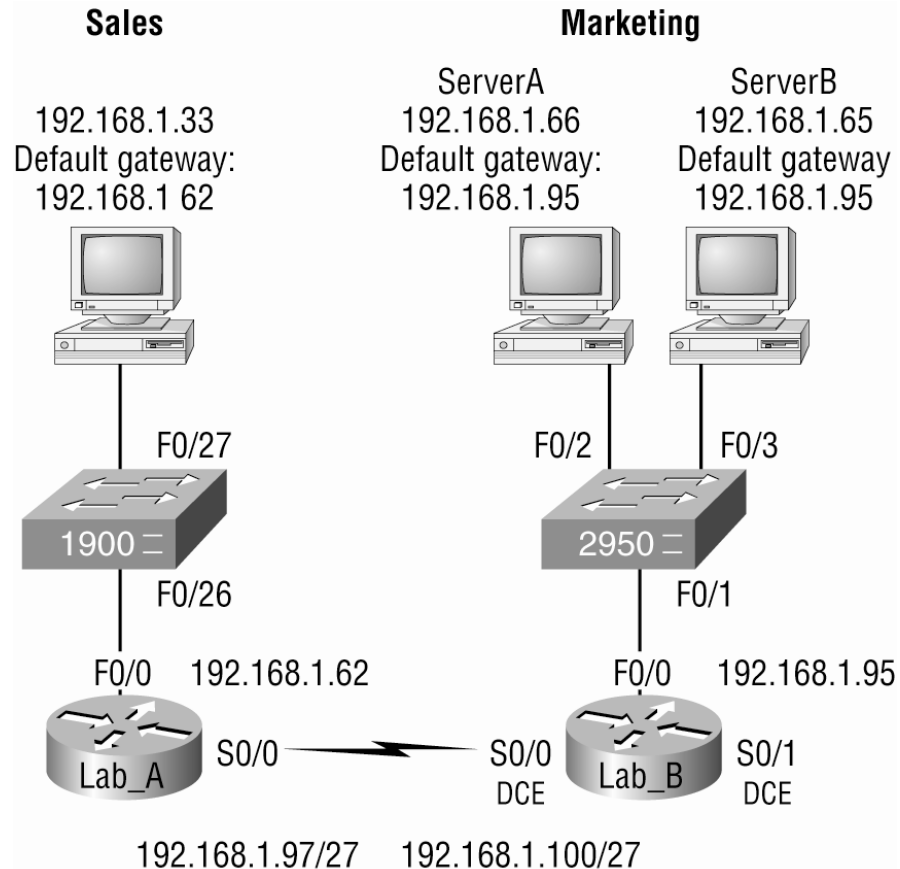
Answer



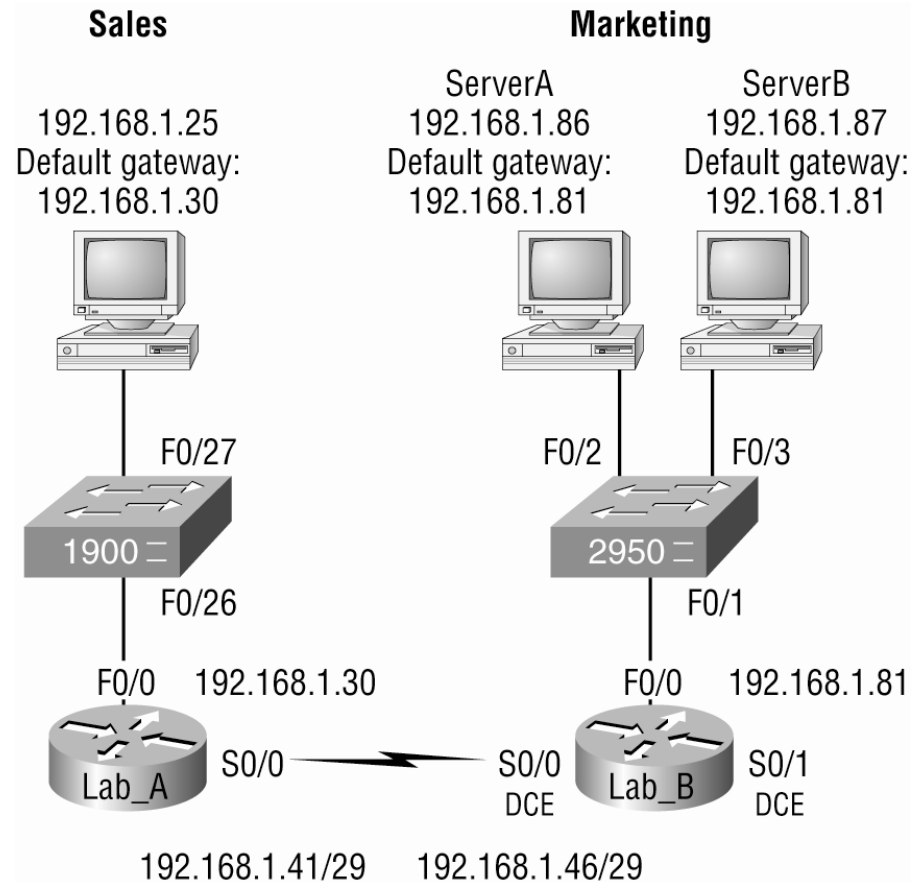
Summary Example



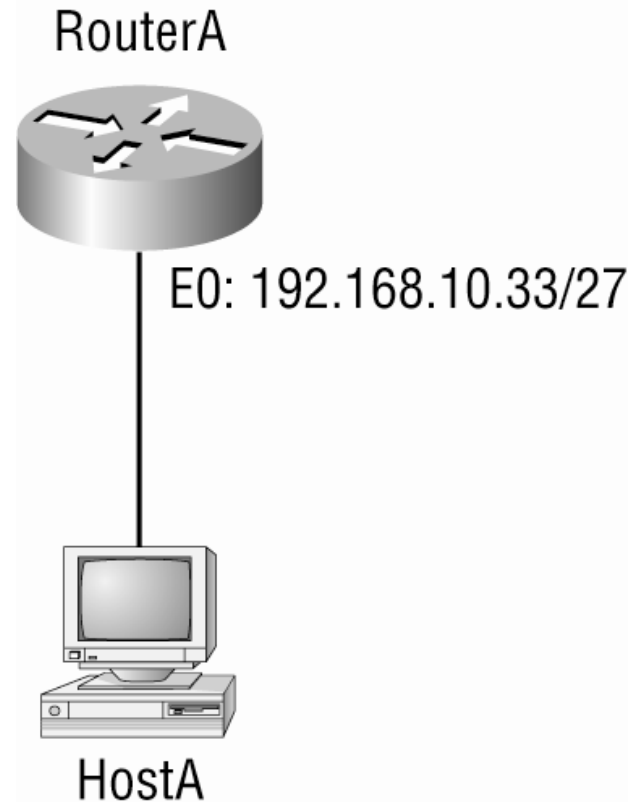
Why can't the Sales LAN get to Server A?



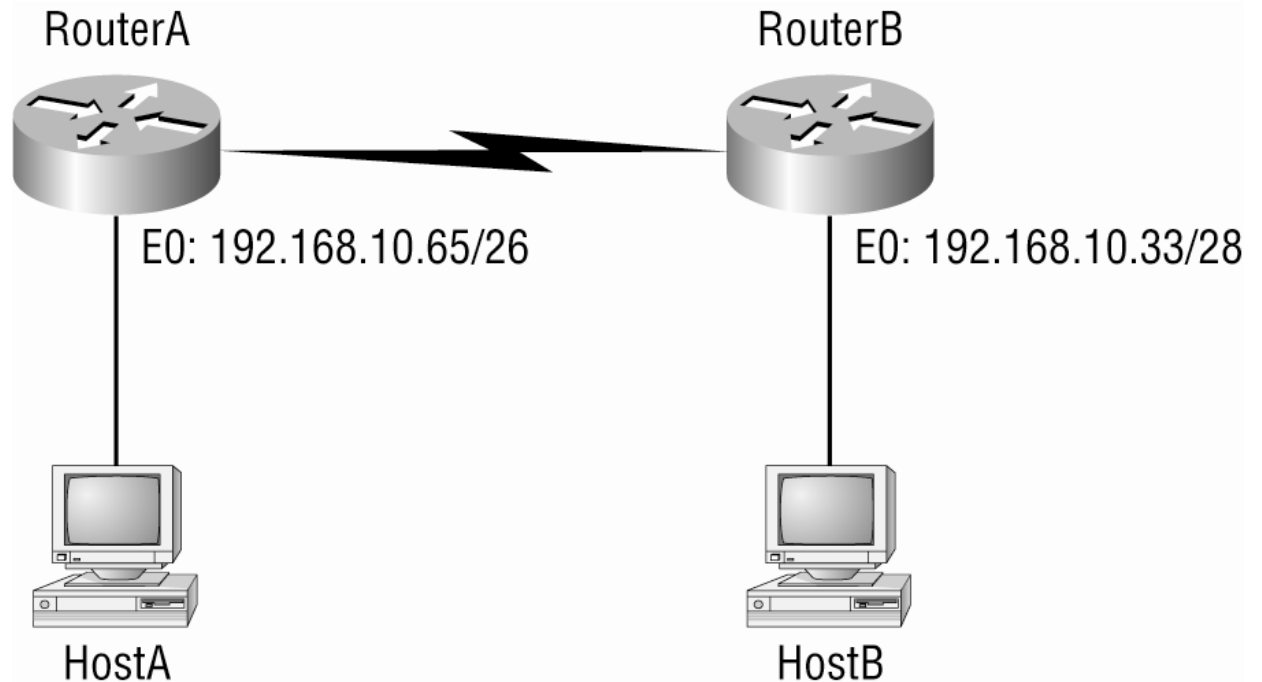
Why can't hosts in the Sales LAN get to Server B?



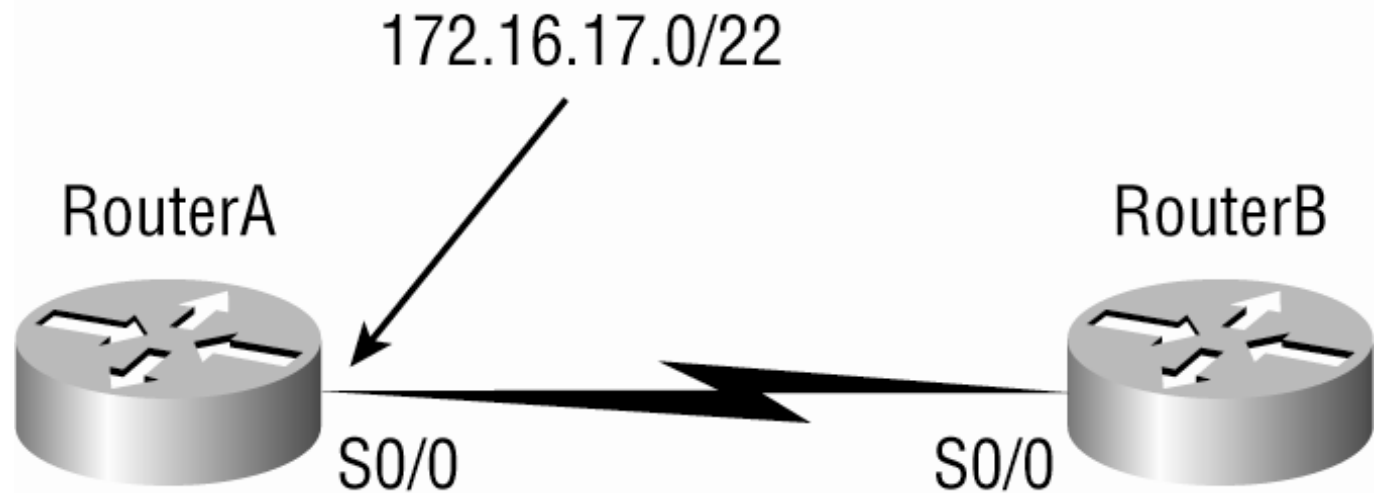
What can the host address be?



Which addresses can you assign to the hosts?



Which IP addresses can you assign?



Summary

- Go through all written and review questions
- Review answers in class