

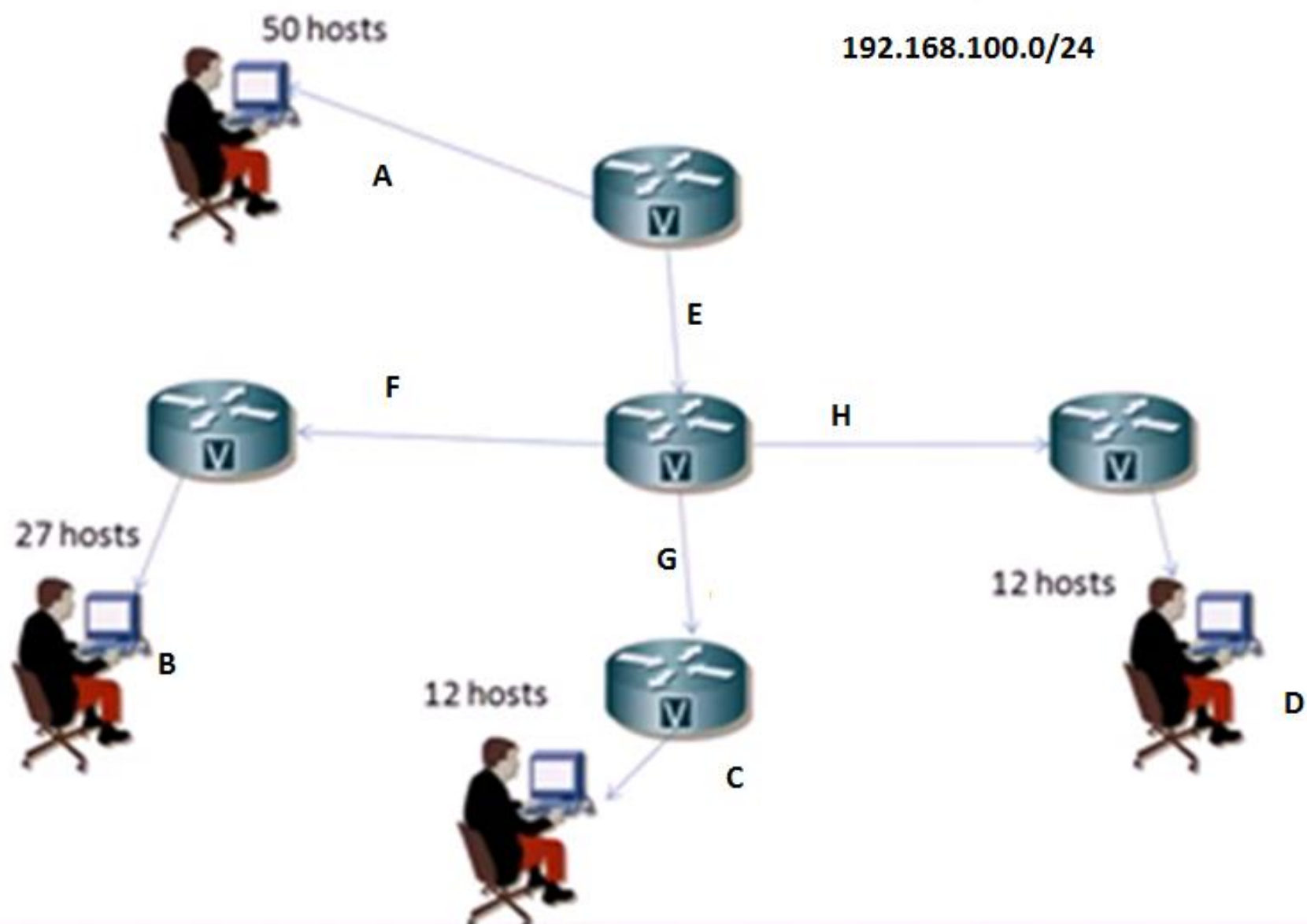
VLSM

Variable Length Subnet Mask

VLSM

If you borrow 4 bits on a Class C network, you end up with 14 valid subnets of 14 valid hosts. A serial link to another router only needs 2 hosts, but with classical subnetting, you end up wasting 12 of those hosts.

Variable-length subnet masking (VLSM) is the process of “subnetting a subnet” and using different subnet masks for different networks in your IP plan. What you have to remember is that you need to make sure that there is no overlap in any of the addresses.



The steps to create an IP plan using VLSM for the network as follows:

Step 1 Determine how many H bits will be needed to satisfy the largest network.

Step 2 Pick a subnet for the largest network to use.

Step 3 Pick the next largest network to work with.

Step 4 Pick the third largest network to work with.

Step 5 Determine network numbers for serial links.

Step 1 Determine How Many H Bits Will Be Needed to Satisfy the Largest Network

A is the largest network with 50 hosts.

If $2^H - 2 =$ Number of valid hosts per subnet

Then $2^H - 2 \geq 50$ Therefore $H = 6$ (6 is the smallest valid value for H)

Now have: NNHHHHHH

Step 2 Pick a Subnet for the Largest Network to Use

You have 2 N bits to work with, leaving you with 2^2 or 4 subnets to work with:

- NN = 00HHHHHH (The 6 H bits you need for Network A)

01HHHHHH

10HHHHHH

11HHHHHH

If you add all zeros to the H bits, you are left with the network numbers for the four subnets:

00000000 = .0

01000000 = .64

10000000 = .128

11000000 = .192

Two borrowed H bits means a subnet mask of

11111111.11111111.11111111.11000000

or

255.255.255.192

or

/26

Pick one of these subnets to use for Network A.

The rest of the networks will have to use the other three subnets.

00000000 =	.0	
01000000 =	.64	Network A
10000000 =	.128	
11000000 =	.192	

Step 3 Pick the Next Largest Network to Work With

Network B = 27 hosts

Determine the number of H bits needed for this network:

$$2^H - 2 \geq 27 \qquad H = 5$$

Pick one of the remaining /26 networks to work with Network B.

For the purposes of this example, select the .128/26 network:

10000000

But you need only 5 H bits, not 6. Therefore, you are left with

10N00000

you can create two smaller subnets from the original subnet:

10000000

10100000

Converted to decimal, these subnets are as follows:

10000000 = .128

10100000 = .160

The original subnet mask of /24 was changed into /26 for Network A. You then take one of these /26 networks and break it into two /27 networks:

10000000 and 10100000 both have 3 N bits and 5 H bits.

The mask now equals:

11111111.11111111.11111111.11100000

or

255.255.255.224

or

/27

Pick one of these new sub-subnets for Network B:

10000000 /27 = Network B

make sure the addresses are not overlapping with each other. So go back to the original table.

00000000 =	.0/26	
01000000 =	.64/26	Network A
10000000 =	.128/26	
11000000 =	.192/26	

You can now break the .128/26 network into two smaller /27 networks and assign Network B.

00000000 =	.0/26	
01000000 =	.64/26	Network A
10000000 =	.128/26	Cannot use because it has been subnetted
10000000 =	.128/27	Network B
10100000 =	.160/27	
11000000 =	.192/26	

Step 4 Pick the Third Largest Network to Work With

- Networks C and Network D = 12 hosts each

$$2^H - 2 \geq 12 \qquad H = 4$$

You need 4 H bits to satisfy the requirements of Network C and Network D

select the other /27 network—.160/27

101**00000** (The 1 in the third bit place is no longer bold, because it is part of the N bits.)

But you only need 4 H bits, not 5. Therefore, you are left with

101**N0000**

where

10 represents the original pattern of subnetting.

N represents the extra bit you have.

00000 represents the 5 H bits you need for Network B

Because you have this extra bit, you can create two smaller subnets from the original subnet:

$$10100000 = .160$$

$$10110000 = .176$$

These new sub-subnets will now have new subnet masks.

Each sub-subnet now has 4 N bits and 4 H bits, so their new masks will be

11111111.11111111.11111111.11110000

or

255.255.255.240

or

/28

Pick one of these new sub-subnets for Network C and one for Network D.

00000000 =	.0/26	
01000000 =	.64/26	Network A
10000000 =	.128/26	Cannot use because it has been subnetted
10000000 =	.128/27	Network B
10100000 =	.160/27	Cannot use because it has been subnetted
10100000	.160/28	Network C
10110000	.176/28	Network D
11000000 =	.192/26	

Step 5 Determine Network Numbers for Serial Links

- All serial links between routers have the same property in that they only need two addresses in a network—one for each router interface.

Determine the number of H bits needed for these networks:

$$2^H - 2 \geq 2$$

$$H = 2$$

You need 2 H bits to satisfy the requirements of Networks E, F, G, and H.

You have two of the original subnets left to work with.

For the purposes of this example, select the .0/26 network: **00000000**

But you need only 2 H bits, not 6. Therefore, you are left with

00NNNN00

where

00 represents the original pattern of subnetting.

NNNN represents the extra bits you have.

00 represents the 2 H bits you need for the serial links.

Because you have 4 N bits, you can create 16 sub-subnets from the original subnet:

$$00000000 = .0/30$$

$$00000100 = .4/30$$

$$00001000 = .8/30$$

$$00001100 = .12/30$$

$$00010000 = .16/30$$

...

$$00111000 = .56/30$$

$$00111100 = .60/30$$

You need only four of them. You can hold the rest for future expansion or recombine them for a new, larger subnet:

$$00010000 = .16/30$$

...

$$00111000 = .56/30$$

$$00111100 = .60/30$$

All these can be recombined into the following:

$$00010000 = .16/28$$

Going back to the original table, you now have the following:

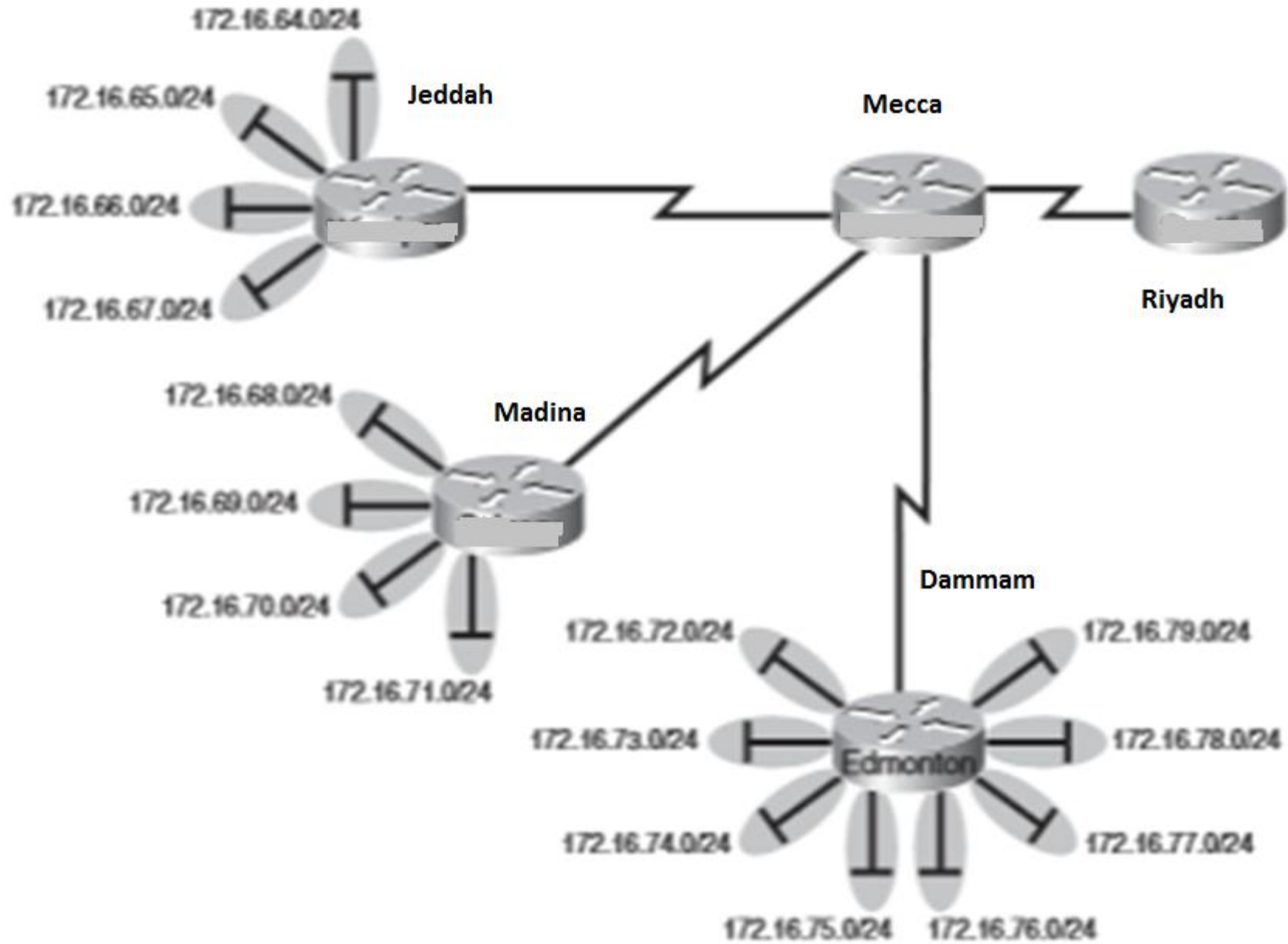
00000000 =	.0/26	Cannot use because it has been subnetted
00000000 =	.0/30	Network E
00000100 =	.4/30	Network F
00001000 =	.8/30	Network G
00001100 =	.12/30	Network H
00010000 =	.16/28	Future growth
01000000 =	.64/26	Network A
10000000 =	.128/26	Cannot use because it has been subnetted
10000000 =	.128/27	Network B
10100000 =	160/27	Cannot use because it has been subnetted
10100000	160/28	Network C
10110000	176/28	Network D
11000000 =	.192/26	Future growth

Looking at the plan, you can see that no number is used twice. You have now created an IP plan for the network and have made the plan as efficient as possible, wasting no addresses in the serial links and leaving room for future growth. This is the power of VLSM!

Route Summarization

A router that needs to advertise ten routes needs ten specific lines in its update packet. The more routes you have to advertise, the bigger the packet. The bigger the packet, the more bandwidth the update takes, reducing the bandwidth available to transfer data.

Four-City Network Without Route Summarization



Jeddah, Medina, and Dammam each have to advertise internal networks to the main router located in Mecca. Without route summarization, Mecca would have to advertise 16 networks to Riyadh. You want to use route summarization to reduce the burden on this upstream router.

Step 1: Summarize Jeddah's Routes

172.16.64.0 = 10101100.00010000.01000000.00000000

172.16.65.0 = 10101100.00010000.01000001.00000000

172.16.66.0 = 10101100.00010000.01000010.00000000

172.16.67.0 = 10101100.00010000.01000011.00000000

Common bits: 10101100.00010000.010000xx

172.16.64.0/22

- when sent to the upstream Mecca router, will tell Mecca: If you have any packets that are addressed to networks that have the first 22 bits in the pattern of
10101100.00010000.010000xx.xxxxxxxx
then send them to me here in Jeddah.

Step 2: Summarize Madina's Routes

172.16.68.0 = 10101100.00010000.01000100.00000000

172.16.69.0 = 10101100.00010000.01000101.00000000

172.16.70.0 = 10101100.00010000.01000110.00000000

172.16.71.0 = 10101100.00010000.01000111.00000000

Common bits: 10101100.00010000.010001xx

172.16.68.0/22

Step 3: Summarize Dammam's Routes

172.16.72.0 = 10101100.00010000.01001000.00000000

172.16.73.0 = 10101100.00010000.01001001.00000000

172.16.74.0 = 10101100.00010000 01001010.00000000

172.16.75.0 = 10101100.00010000 01001011.00000000

172.16.76.0 = 10101100.00010000.01001100.00000000

172.16.77.0 = 10101100.00010000.01001101.00000000

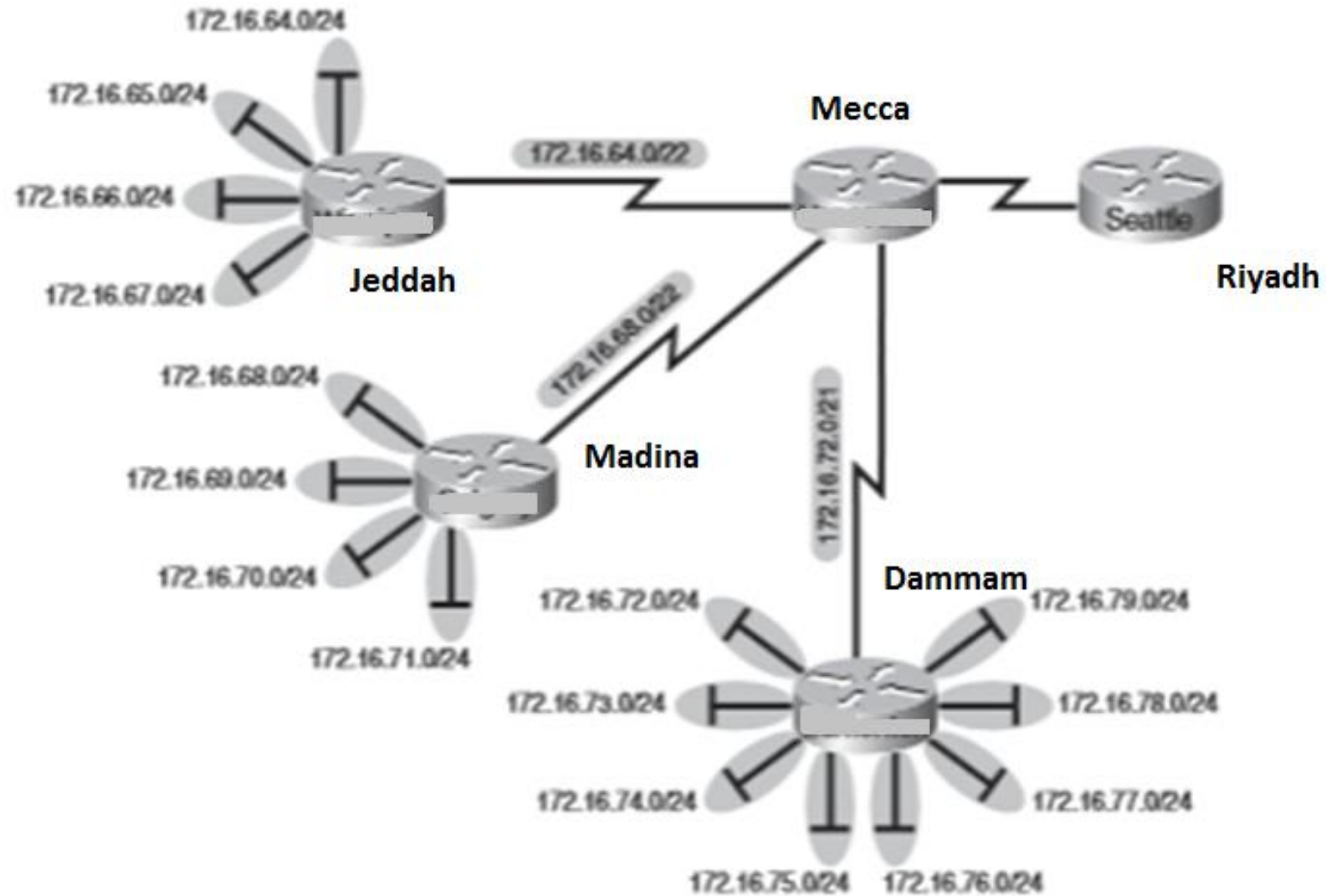
172.16.78.0 = 10101100.00010000.01001110.00000000

172.16.79.0 = 10101100.00010000.01001111.00000000

Common bits: 10101100.00010000.01001xxx

172.16.72.0/21

Four-City Network with Edge Cities Summarizing Routes



/21	/22	/23	/21	
172.16.64.0	172.16.64.0	172.16.64.0	172.16.64.0	
		172.16.64.0	172.16.65.0	
	172.16.68.0	172.16.64.0	172.16.66.0	
		172.16.64.0	172.16.67.0	
		172.16.64.0	172.16.68.0	
		172.16.64.0	172.16.69.0	
	172.16.72.0	172.16.72.0	172.16.64.0	172.16.70.0
			172.16.64.0	172.16.71.0
172.16.76.0		172.16.64.0	172.16.72.0	
		172.16.64.0	172.16.73.0	
		172.16.64.0	172.16.74.0	
		172.16.64.0	172.16.75.0	

Step 4: Summarize Mecca's Routes

Take the routes that Jeddah, Madina, and Dammam sent to Mecca, and look for common bit patterns:

172.16.64.0 = 10101100.00010000.01000000.00000000

172.16.68.0 = 10101100.00010000.01000100.00000000

172.16.72.0 = 10101100.00010000.01001000.00000000

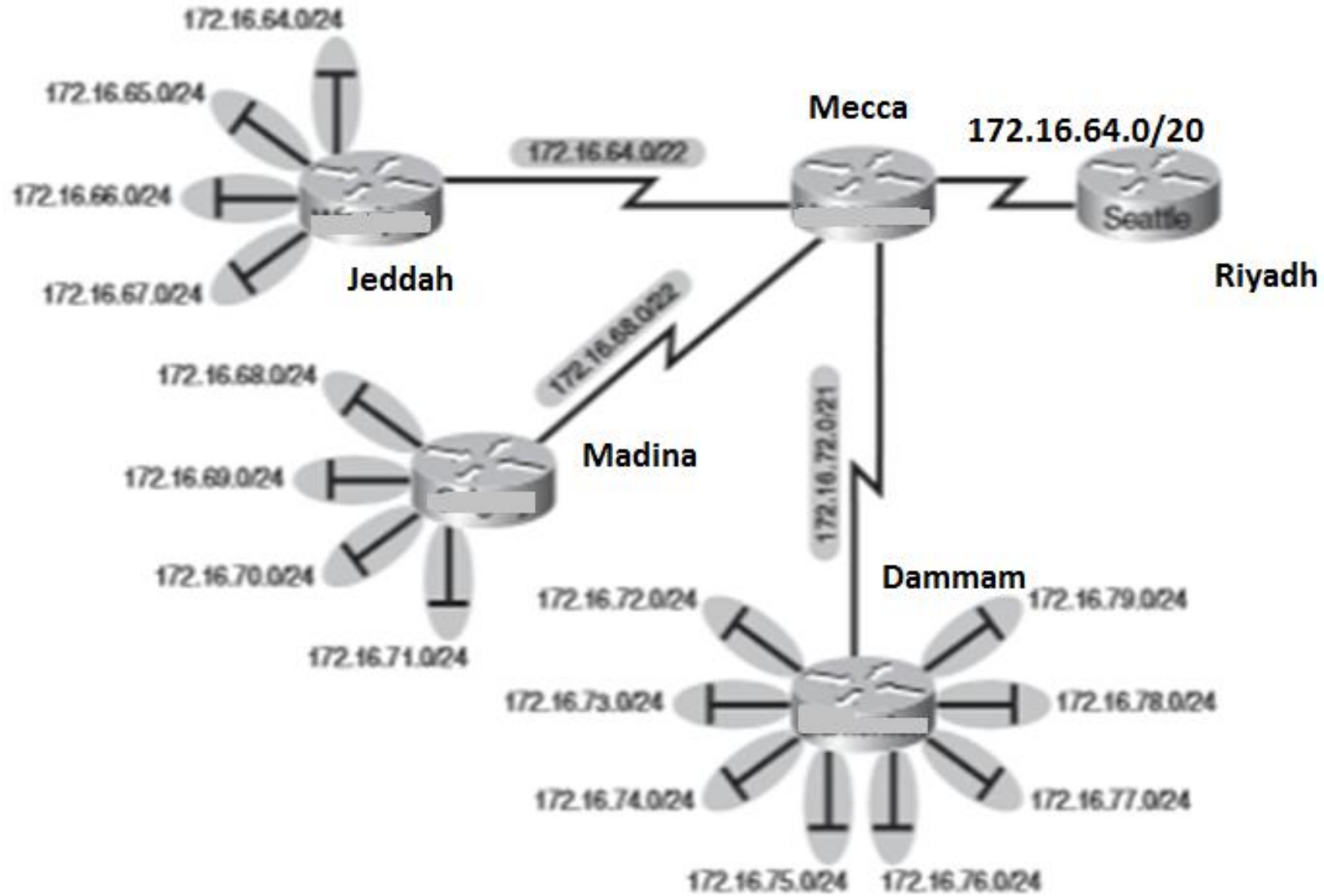
Common bits: 10101100.00010000.0100xxxx

you can create one summary route for Meccato send to Riyadh:

172.16.64.0/20

Mecca has now told Riyadh that in one line of a routing update, 16 different networks are being advertised.

Four-City Network with Complete Route Summarization



/20	/21	/22	/23	/24
172.16.64.0	172.16.64.0	172.16.64.0	172.16.64.0	172.16.64.0
		172.16.64.0	172.16.65.0	
		172.16.64.0	172.16.66.0	
		172.16.64.0	172.16.67.0	
		172.16.64.0	172.16.68.0	
		172.16.64.0	172.16.69.0	
	172.16.72.0	172.16.72.0	172.16.64.0	172.16.70.0
		172.16.64.0	172.16.71.0	
		172.16.72.0	172.16.64.0	172.16.72.0
		172.16.64.0	172.16.73.0	
		172.16.76.0	172.16.64.0	172.16.74.0
		172.16.64.0	172.16.75.0	
		172.16.64.0	172.16.76.0	
		172.16.64.0	172.16.77.0	

VLSM Subnetting Homework

In each question, find the best 3 efficient combinations of subnets.

1- You have network 192.168.1.0/24, and you want subnets to contain 100 hosts, 25 hosts and 6 hosts.

2- You have network 150.210.0.0/16, and you want subnets to contain 2000 hosts, 500 hosts and 100 hosts.

3- You have network 125.0.0.0/8, and you want subnets to contain 1000 hosts, 200 hosts and 100 hosts.

4- You have network 217.84.19.0/24, and you want subnets to contain 30 hosts, 10 hosts and 2 hosts.

5- You have network 180.32.64.0/23, and you want subnets to contain 120 hosts, 50 hosts and 10 hosts.

6- You have network 152.227.160.0/21, and you want subnets to contain 500 hosts, 80 hosts and 5 hosts.