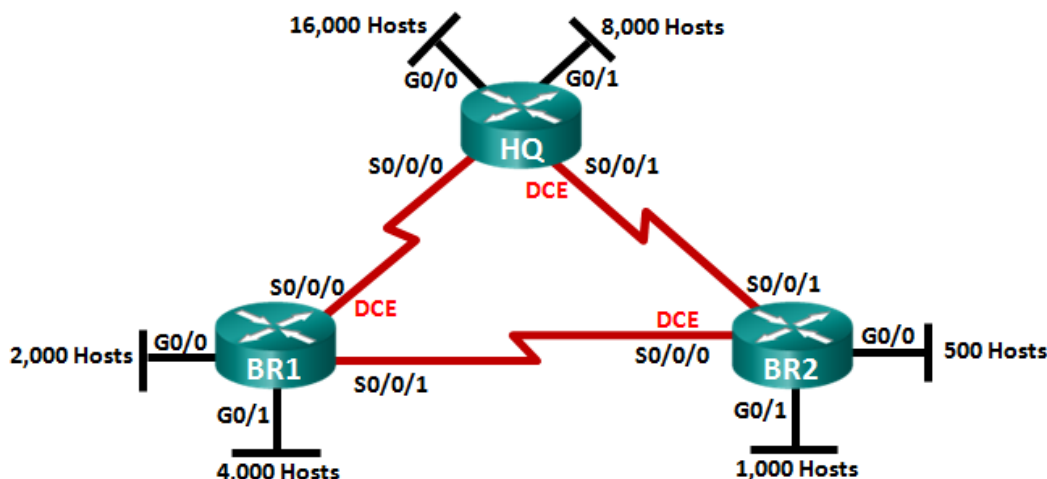# Lab – Designing and Implementing a VLSM Addressing Scheme
(Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology

Objectives

Part 1: Examine Network Requirements

Part 2: Design the VLSM Address Scheme

Part 3: Cable and Configure the IPv4 Network

Background / Scenario

Variable Length Subnet Mask (VLSM) was designed to avoid wasting IP addresses. With VLSM, a network is subnetted and then re-subnetted. This process can be repeated multiple times to create subnets of various sizes based on the number of hosts required in each subnet. Effective use of VLSM requires address planning.

In this lab, use the 172.16.128.0/17 network address to develop an address scheme for the network displayed in the topology diagram. VLSM is used to meet the IPv4 addressing requirements. After you have designed the VLSM address scheme, you will configure the interfaces on the routers with the appropriate IP address information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

This lab can be performed in multiple sessions if time is an issue. Parts 1 and 2 are paper based and can be assigned as homework. Part 3 is Hands-on and requires lab equipment.

It is worth noting to the students that as a network administrator, you would not have a single network with over 1000 hosts. You would break these down further in a production network.

Required Resources

- 3 routers (Cisco 1941 with Cisco IOS software, Release 15.2(4)M3 universal image or comparable)
- 1 PC (with terminal emulation program, such as Tera Term, to configure routers)
- Console cable to configure the Cisco IOS devices via the console ports
- Ethernet (optional) and serial cables, as shown in the topology
- Windows Calculator (optional)

Part 1: Examine Network Requirements

In Part 1, you will examine the network requirements to develop a VLSM address scheme for the network displayed in the topology diagram using the 172.16.128.0/17 network address.

Note: You can use the Windows Calculator application and the www.ipcalc.org IP subnet calculator to help with your calculations.

Step 1: Determine how many host addresses and subnets are available.

How many host addresses are available in a /17 network? _____ 32,766

What is the total number of host addresses needed in the topology diagram? _____ 31,506

How many subnets are needed in the network topology? _____ 9

Step 2: Determine the largest subnet.

What is the subnet description (e.g. BR1 G0/1 LAN or BR1-HQ WAN link)? _____ HQ G0/0 LAN

How many IP addresses are required in the largest subnet? _____ 16,000

What subnet mask can support that many host addresses?

_____ /18 or 255.255.192.0

How many total host addresses can that subnet mask support? _____ 16,382

Can you subnet the 172.16.128.0/17 network address to support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.128.0/18
_____ 172.16.192.0/18

Use the first network address for this subnet.

Step 3: Determine the second largest subnet.

What is the subnet description? _____ HQ G0/1 LAN

How many IP addresses are required for the second largest subnet? _____ 8,000

What subnet mask can support that many host addresses?

_____ /19 or 255.255.224.0

How many total host addresses can that subnet mask support? _____ 8,190

Can you subnet the remaining subnet again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.192.0/19

_____ 172.16.224.0/19

Use the first network address for this subnet.

Step 4: Determine the next largest subnet.

What is the subnet description? _____ BR1 G0/1 LAN

How many IP addresses are required for the next largest subnet? _____ 4,000

What subnet mask can support that many host addresses?

_____ /20 or 255.255.240.0

How many total host addresses can that subnet mask support? _____ 4,094

Can you subnet the remaining subnet again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.224.0/20

_____ 172.16.240.0/20

Use the first network address for this subnet.

Step 5: Determine the next largest subnet.

What is the subnet description? _____ BR1 G0/0 LAN

How many IP addresses are required for the next largest subnet? _____ 2,000

What subnet mask can support that many host addresses?

_____ /21 or 255.255.248.0

How many total host addresses can that subnet mask support? _____ 2,046

Can you subnet the remaining subnet again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.240.0/21

_____ 172.16.248.0/21

Use the first network address for this subnet.

Step 6: Determine the next largest subnet.

What is the subnet description? _____ BR2 G0/1 LAN

How many IP addresses are required for the next largest subnet? _____ 1,000

What subnet mask can support that many host addresses?

_____ /22 or 255.255.252.0

How many total host addresses can that subnet mask support? _____ 1,022

Can you subnet the remaining subnet again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.248.0/22

_____ 172.16.252.0/22

Use the first network address for this subnet.

Step 7: Determine the next largest subnet.

What is the subnet description? _____ BR2 G0/0 LAN

How many IP addresses are required for the next largest subnet? _____ 500

What subnet mask can support that many host addresses?

_____ /23 or 255.255.254.0

How many total host addresses can that subnet mask support? _____ 510

Can you subnet the remaining subnet again and still support this subnet? _____ yes

What are the two network addresses that would result from this subnetting?

_____ 172.16.252.0/23

_____ 172.16.254.0/23

Use the first network address for this subnet.

Step 8: Determine the subnets needed to support the serial links.

How many host addresses are required for each serial subnet link? _____ 2

What subnet mask can support that many host addresses?

_____ /30 or 255.255.255.252

a. Continue subnetting the first subnet of each new subnet until you have four /30 subnets. Write the first three network addresses of these /30 subnets below.

_____ 172.16.254.0/30

_____ 172.16.254.4/30

_____ 172.16.254.8/30

b. Enter the subnet descriptions for these three subnets below.

_____ HQ - BR1 Serial Link

_____ HQ - BR2 Serial Link

_____ BR1 - BR2 Serial Link

Part 2: Design the VLSM Address Scheme

Step 1: Calculate the subnet information.

Use the information that you obtained in Part 1 to fill in the following table.

Subnet Description	Number of Hosts Needed	Network Address /CIDR	First Host Address	Broadcast Address
HQ G0/0	16,000	172.16.128.0/18	172.16.128.1	172.16.191.255
HQ G0/1	8,000	172.16.192.0/19	172.16.192.1	172.16.223.255
BR1 G0/1	4,000	172.16.224.0/20	172.16.224.1	172.16.239.255
BR1 G0/0	2,000	172.16.240.0/21	172.16.240.1	172.16.247.255
BR2 G0/1	1,000	172.16.248.0/22	172.16.248.1	172.16.251.255
BR2 G0/0	500	172.16.252.0/23	172.16.252.1	172.16.253.255
HQ S0/0/0 – BR1 S0/0/1	2	172.16.254.0/30	172.16.254.1	172.16.254.3
HQ S0/0/1 – BR2 S0/0/1	2	172.16.254.4/30	172.16.254.5	172.16.254.7
BR1 S0/0/1 – BR2 S0/0/0	2	172.16.254.8/30	172.16.254.9	172.168.254.11

Step 2: Complete the device interface address table.

Assign the first host address in the subnet to the Ethernet interfaces. HQ should be given the first host address on the Serial links to BR1 and BR2. BR1 should be given the first host address for the serial link to BR2.

Device	Interface	IP Address	Subnet Mask	Device Interface
HQ	G0/0	172.16.128.1	255.255.192.0	16,000 Host LAN
	G0/1	172.16.192.1	255.255.224.0	8,000 Host LAN
	S0/0/0	172.16.254.1	255.255.255.252	BR1 S0/0/0
	S0/0/1	172.16.254.5	255.255.255.252	BR2 S0/0/1
BR1	G0/0	172.16.240.1	255.255.248.0	2,000 Host LAN
	G0/1	172.16.224.1	255.255.240.0	4,000 Host LAN
	S0/0/0	172.16.254.2	255.255.255.252	HQ S0/0/0
	S0/0/1	172.16.254.9	255.255.255.252	BR2 S0/0/0
BR2	G0/0	172.16.252.1	255.255.254.0	500 Host LAN
	G0/1	172.16.248.1	255.255.252.0	1,000 Host LAN
	S0/0/0	172.16.254.10	255.255.255.252	BR1 S0/0/1
	S0/0/1	172.16.254.6	255.255.255.252	HQ S0/0/1

Part 3: Cable and Configure the IPv4 Network

In Part 3, you will cable the network topology and configure the three routers using the VLSM address scheme that you developed in Part 2.

Step 1: Cable the network as shown in the topology.

Step 2: Configure basic settings on each router.

   a. Assign the device name to the router.

   b. Disable DNS lookup to prevent the router from attempting to translate incorrectly entered commands as though they were hostnames.

   c. Assign **class** as the privileged EXEC encrypted password.

   d. Assign **cisco** as the console password and enable login.

   e. Assign **cisco** as the VTY password and enable login.

   f. Encrypt the clear text passwords.

   g. Create a banner that will warn anyone accessing the device that unauthorized access is prohibited.

Step 3: Configure the interfaces on each router.

   a. Assign an IP address and subnet mask to each interface using the table that you completed in Part 2.

   b. Configure an interface description for each interface.

   c. Set the clocking rate on all DCE serial interfaces to 128000.

   ```
   HQ(config-if)# clock rate 128000
   ```

   d. Activate the interfaces.

Step 4: Save the configuration on all devices.

Step 5: Test Connectivity.

   a. From HQ, ping BR1's S0/0/0 interface address.

   b. From HQ, ping BR2's S0/0/1 interface address.

   c. From BR1, ping BR2's S0/0/0 interface address.

   d. Troubleshoot connectivity issues if pings were not successful.

Note: Pings to the GigabitEthernet interfaces on other routers will not be successful. The LANs defined for the GigabitEthernet interfaces are simulated. Because no devices are attached to these LANs they will be in down/down state. A routing protocol needs to be in place for other devices to be aware of those subnets. The GigabitEthernet interfaces also need to be in an up/up state before a routing protocol can add the subnets to the routing table. These interfaces will remain in a down/down state until a device is connected to the other end of the Ethernet interface cable. The focus of this lab is on VLSM and configuring the interfaces.

Reflection

Can you think of a shortcut for calculating the network addresses of consecutive /30 subnets?

_____

_____

_____

_____

Answers may vary. A /30 network has 4 address spaces: the network address, 2 host addresses, and a broadcast address. Another technique for obtaining the next /30 network address would be to take the network address of the previous /30 network and add 4 to the last octet.

Router Interface Summary Table

Router Interface Summary				
Router Model	**Ethernet Interface #1**	**Ethernet Interface #2**	**Serial Interface #1**	**Serial Interface #2**
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router BR1 (Final Configuration)

```
BR1#sh run
Building configuration...

Current configuration : 1555 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname BR1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
```

```
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 description LAN with 2,000 hosts.
 ip address 172.16.240.1 255.255.248.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 description LAN with 4,000 hosts.
 ip address 172.16.224.1 255.255.240.0
 duplex auto
 speed auto
!
interface Serial0/0/0
 description Connection to HQ S0/0/0.
 ip address 172.16.254.2 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 description Connection to BR2 S0/0/0.
 ip address 172.16.254.9 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
control-plane
!
!
banner motd ^C
 Warning: Unauthorzed access is prohibited!
^C
!
line con 0
 password 7 14141B180F0B
 login
line aux 0
line 2
```

```
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password 7 094F471A1A0A
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router HQ (Final Configuration)

```
HQ#sh run
Building configuration...

Current configuration : 1554 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname HQ
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
 no ip address
```

```
 shutdown
!
interface GigabitEthernet0/0
 description LAN with 16,000 hosts.
 ip address 172.16.128.1 255.255.192.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 description LAN with 8,000 hosts.
 ip address 172.16.192.1 255.255.224.0
 duplex auto
 speed auto
!
interface Serial0/0/0
 description Connection to BR1 S0/0/0.
 ip address 172.16.254.1 255.255.255.252
!
interface Serial0/0/1
 description Connection to BR2 S0/0/1.
 ip address 172.16.254.5 255.255.255.252
 clock rate 128000
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
control-plane
!
!
banner motd ^C
 Warning: Unauthorzed access is prohibited!
^C
!
line con 0
 password 7 02050D480809
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
```

```
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password 7 00071A150754
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router BR2 (Final Configuration)

```
BR2#sh run
Building configuration...

Current configuration : 1593 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname BR2
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 10
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 description LAN with 500 hosts.
 ip address 172.16.252.1 255.255.254.0
 duplex auto
```

```
 speed auto
!
interface GigabitEthernet0/1
 description LAN with 1,000 hosts.
 ip address 172.16.248.1 255.255.252.0
 duplex auto
 speed auto
!
interface Serial0/0/0
 description Connection to BR1 S0/0/1.
 ip address 172.16.254.10 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 description Connection to HQ S0/0/1.
 ip address 172.16.254.6 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
!
banner motd ^C
 Warning: Unauthorzed access is prohibited!
^C
!
line con 0
 password 7 070C285F4D06
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password 7 0822455D0A16
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```