

In this section, we will use a sample topology to practice allocating addresses to hosts.

The figure shows the network topology for this example. By starting with a given IP address and prefix (subnet mask) assigned by the network administrator, we can begin creating our network documentation.

The number and grouping of hosts are:

Student LAN                      Student Computers: 460

Router (LAN Gateway): 1

Switches (management): 20

**Total for student subnetwork: 481**

Instructor LAN                      Instructor Computers: 64

Router (LAN Gateway): 1      Switches (management): 4

**Total for instructor subnetwork: 69**

Administrator LAN                      Administrator Computers: 20

Server: 1            Router (LAN Gateway): 1            Switch (management): 1

**Total for administration subnetwork: 23**

WAN

Router - Router WAN: 2

Total for WAN: 2

Allocation Methods

There are two methods available for allocating addresses to an internetwork. We can use Variable Length Subnet Masking (VLSM), where we assign the prefix and host bits to each network based on the number of hosts in that network. Or, we can use a non-VLSM approach, where all subnets use the same prefix length and the same number of host bits.

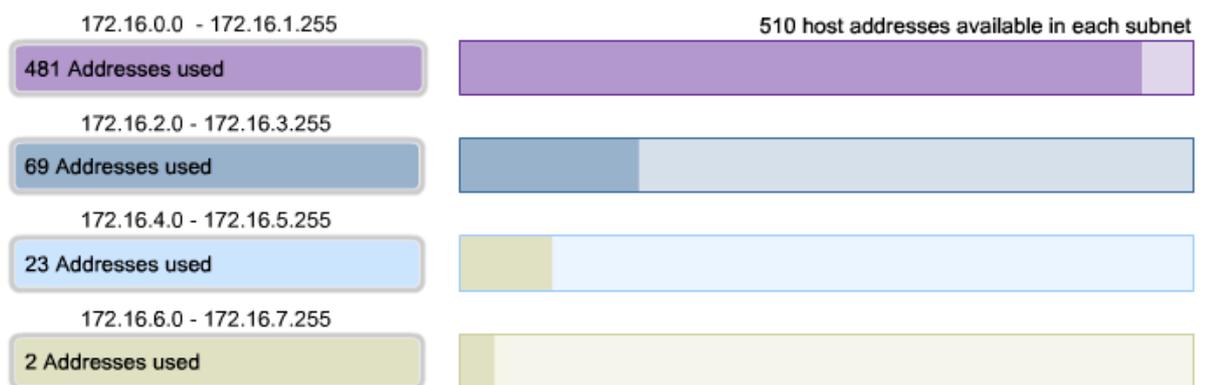
For our network example, we will demonstrate both approaches.



### Calculating Addresses **without** VLSM Address Ranges for Subnets

Case 1

Network	Subnet Address	Host Address Range		Broadcast Address
Student	172.16.0.0/23	172.16.0.1	172.16.1.254	172.16.1.255
Instructor	172.16.2.0/23	172.16.2.1	172.16.3.254	172.16.3.255
Administration	172.16.4.0/23	172.16.4.1	172.16.5.254	172.16.5.255
WAN	172.16.6.0/23	172.16.6.1	172.16.7.254	172.16.7.255



### Calculating and Assigning Addresses-without VLSM

When using the non-VLSM method of assigning addresses, all subnets have the same number of addresses assigned to them. In order to provide each network with an adequate number of

addresses, we base the number of addresses for all networks on the addressing requirements for the largest network.

In Case 1, the Student LAN is the largest network, requiring 481 addresses.

We will use this formula to calculate the number of hosts:

$$\text{Usable hosts} = 2^n - 2$$

We use 9 as the value for n because 9 is the first power of 2 that is over 481.

Borrowing 9 bits for the host portion yields this calculation:

$$2^9 = 512$$

$$512 - 2 = 510 \text{ usable host addresses}$$

This meets the current requirement for at least 481 addresses, with a small allowance for growth. This also leaves 23 network bits (32 total bits - 9 host bits).

Because there are four networks in our internetwork, we will need four blocks of 512 addresses each, for a total of 2048 addresses. We will use the address block 172.16.0.0 /23. This provides addresses in the range from 172.16.0.0 to 172.16.7.255.

Let's examine the address calculations for the networks:

Address: 172.16.0.0

In binary: 10101100.00010000.00000000.00000000 Mask: 255.255.254.0

23 bits in binary: 11111111.11111111.11111110.00000000

This mask will provide the four address ranges shown in the figure.

### **Student LAN**

For the Student network block, the values would be:

172.16.0.1 to 172.16.1.254 with a broadcast address of 172.16.1.255.

### **Instructor LAN**

The Instructor network requires a total of 69 addresses. The remaining addresses in this block of 512 addresses will go unused. The values for the Instructor network are:

172.16.2.1 to 172.16.3.254 with a broadcast address of 172.16.3.255.

## Administrator LAN

Assigning the 172.16.4.0 /23. block to the Administrator LAN, assigns an address range of:

172.16.4.1 to 172.16.5.254 with a broadcast address of 172.16.5.255.

Only 23 of the 512 addresses will actually be used in the Instructor LAN.

## WAN

In the WAN, we have a point-to-point connection between the two routers. This network only requires two IPv4 addresses for the routers on this serial link. As shown in the figure, assigning this address block to the WAN link wastes 508 addresses.

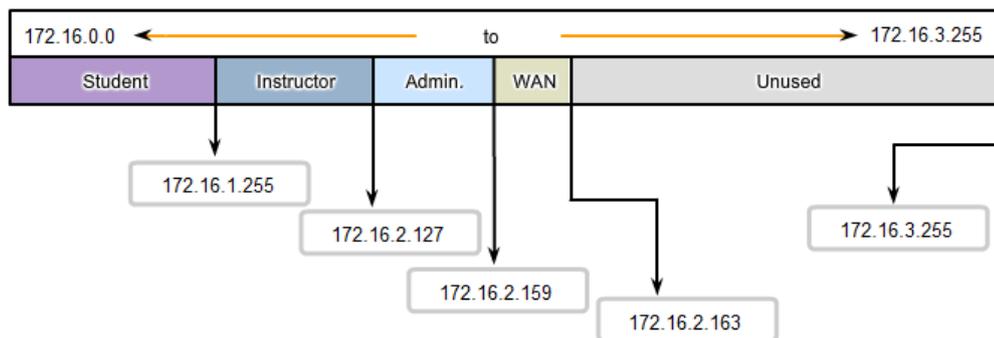
We can use VLSM in this internetwork to save addressing space, but using VLSM requires more planning. The next section demonstrates the planning associated with the use of VLSM.



Calculating Addresses with VLSM Address Ranges for Subnets

Case 1

Network	Subnet Address	Host Address Range		Broadcast Address
Student	172.16.0.0/23	172.16.0.1	172.16.1.254	172.16.1.255
Instructor	172.16.2.0/25	172.16.2.1	172.16.2.126	172.16.2.127
Administration	172.16.2.128/27	172.16.2.129	172.16.2.158	172.16.2.159
WAN	172.16.2.160/30	172.16.2.161	172.16.2.162	172.16.2.163
Unused	na	172.16.2.164	172.16.2.254	na



## Calculating and Assigning Addresses - with VLSM

For the VLSM assignment, we can allocate a much smaller block of addresses to each network, as appropriate.

The address block 172.16.0.0/22 (subnet mask 255.255.252.0) has been assigned to this internetwork as a whole. Ten bits will be used to define host addresses and sub networks. This yields a total of 1024 IPv4 local addresses in the range of 172.16.0.0 to 172.16.3.0.

## Student LAN

The largest subnetwork is the Student LAN requires 481 addresses.

Using the formula usable hosts =  $2^n - 2$ , borrowing 9 bits for the host portion gives  $512 - 2 = 510$  usable host addresses. This meets the current requirement, with a small allowance for growth.

Using 9 bits for hosts leaves 1 bit that can be used locally to define the subnet address. Using the lowest available address gives us a subnet address of 172.16.0.0 /23.

The Student subnet mask calculation is:

Address: 172.16.0.0

In binary: 10101100.00010000.00000000.00000000 Mask: 255.255.254.0

23 bits in binary: 11111111.11111111.11111110.00000000

In the Student network, the IPv4 host range would be:

172.16.0.1 through 172.16.1.254 with a broadcast address of 172.16.1.255.

Because the Student LAN has been assigned these addresses, they are not available for assignment to the remaining subnets: Instructor LAN, Administrator LAN, and the WAN. The addresses still to be assigned are in the range 172.16.2.0 to 172.16.3.255.

## Instructor LAN

The next largest network is the Instructor LAN. This network requires at least 69 addresses. Using 6 in the power of 2 formula,  $2^6 - 2$ , only provides 62 usable addresses. We must use an address block using 7 host bits. The calculation  $2^7 - 2$  will yield a block of 126 addresses. This leaves 25 bits to assign to network address. The next available block of this size is the 172.16.2.0 /25 network.

Address: 172.16.2.0

In binary: 10101100.00010000.00000100.00000000 Mask: 255.255.255.128

25 bits in binary: 11111111.11111111.11111111.10000000

This provides an IPv4 host range of:

172.16.2.1 to 172.16.2.126 with a broadcast address of 172.16.2.127.

From our original address block of 172.16.0.0 /22, we allocated addresses 172.16.0.0 to 172.16.2.127. The remaining addresses to be allocated are 172.16.2.128 to 172.16.3.255.

## Administrator LAN

For the Administrator LAN, we need to accommodate 23 hosts. This will require the use of 5 host bits using the calculation:  $2^5 - 2$ .

The next available block of addresses that can accommodate these hosts is the 172.16.2.128 /27 block.

Address: 172.16.2.128

In binary: 10101100.00010000.0000010.10000000 Mask: 255.255.255.224

26 bits in binary: 11111111.11111111.11111111.11100000

This provides an IPv4 host range of:

172.16.2.129 to 172.16.2.158 with a broadcast address of 172.16.2.159.

This yields 30 unique IPv4 addresses for the Administrator LAN.

## **WAN**

The last segment is the WAN connection, requiring 2 host addresses. Only 2 host bits will accommodate the WAN links.  $2^2 - 2 = 2$ .

This leaves 8 bits to define the local subnet address. The next available address block is 172.16.2.160 /30.

Address: 172.16.2.160

In binary: 10101100.00010000.0000010.10100000 Mask: 255.255.255.252

30 bits in binary: 11111111.11111111.11111111.11111100

This provides an IPv4 host range of:

172.16.2.161 to 172.16.2.162 with a broadcast address of 172.16.2.163.

This completes the allocation of addresses using VLSM for Case 1. If an adjustment is necessary to accommodate future growth, addresses in the range of 172.16.2.164 to 172.16.3.255 are still available.