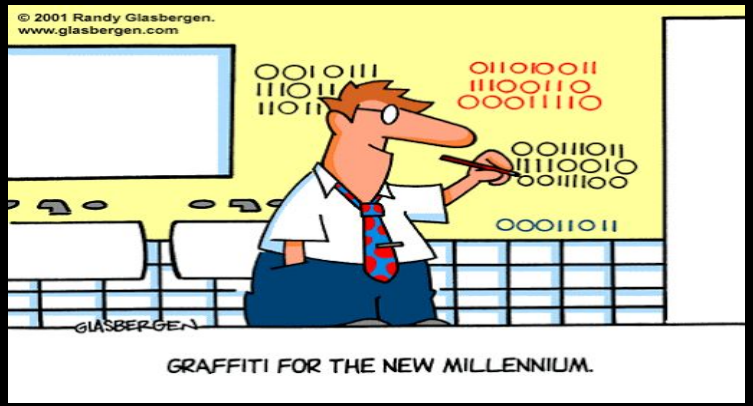
Concepts of Subnetting ..

Enterprise Network Engineering



Overview

To understand how the internetwork routes packets to that host, you must find key pieces of information about the subnet, specifically:

- Subnet ID
- Subnet broadcast address
- Subnet’s range of usable unicast IP addresses

Defining a Subnet

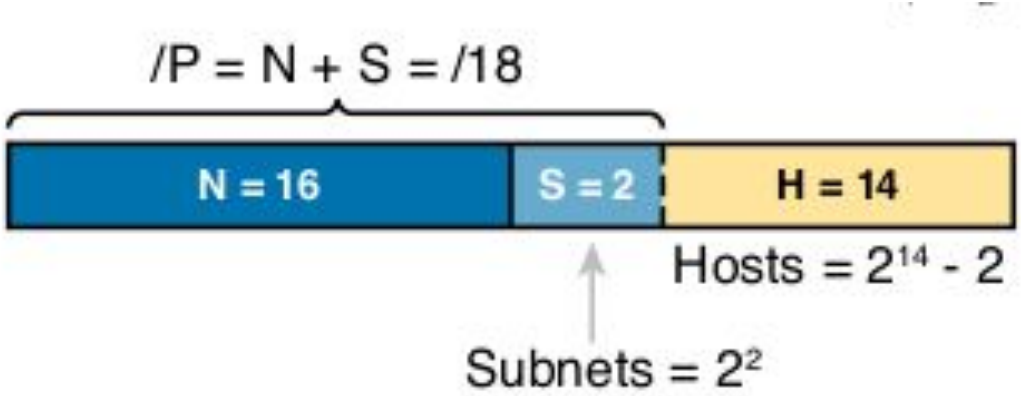
An IP subnet is a subset of a classful network, created by choice of some network engineer. However, that engineer cannot pick just any arbitrary subset of addresses; instead, the engineer must follow certain rules, such as the following:

1. The subnet contains a set of consecutive numbers.
2. The subnet holds 2 ^H numbers, where H is the number of host bits defined by the subnet mask.
3. Two special numbers in the range cannot be used as IP addresses:

   The first (lowest) number acts as an identifier for the subnet (subnet ID).

   The last (highest) number acts as a subnet broadcast address.

4. The remaining addresses, whose values sit between the subnet ID and subnet broadcast address, are used as unicast IP addresses.


/P = N + S = /18
N = 16
S = 2
H = 14
Hosts = 2^{14} - 2
Subnets = 2^2

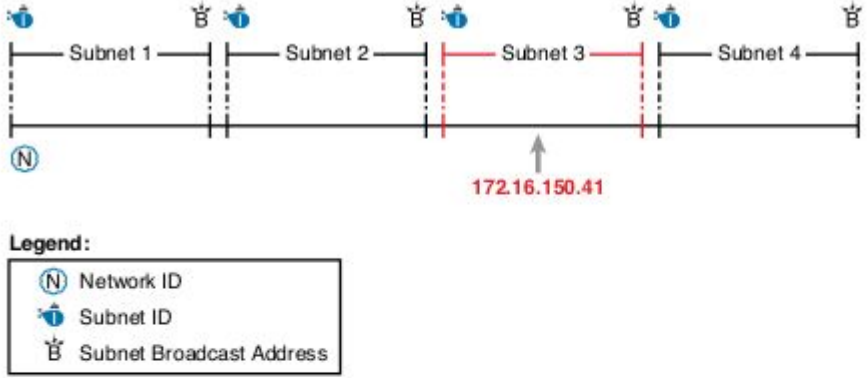


Figure 14-2 *Network 172.16.0.0, Divided into Four Equal Subnets*

The rest of this chapter focuses on how to take one IP address and mask and discover the details about that one subnet in which the address resides. In other words, you see how to find the resident subnet of an IP address. Again, using IP address 172.16.150.41 and mask 255.255.192.0 as an example, Figure 14-3 shows the resident subnet, along with the subnet ID and subnet broadcast address that bracket the subnet.

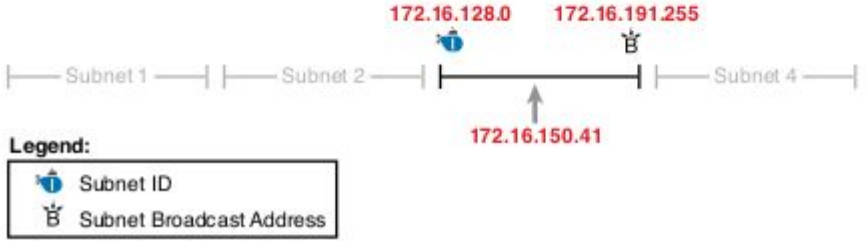


Figure 14-3 *Resident Subnet for 172.16.150.41, 255.255.192.0*

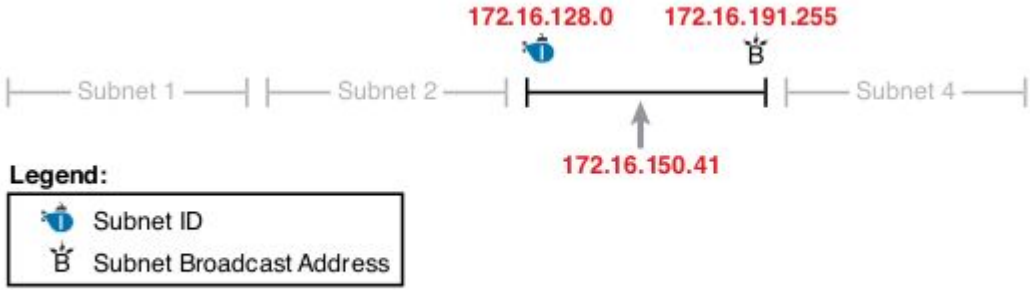


Figure 14-3 *Resident Subnet for 172.16.150.41, 255.255.192.0*

Table 14-1 Summary of Subnet ID Key Facts

Definition	Number that represents the subnet
Numeric Value	First (smallest) number in the subnet
Literal Synonyms	Subnet number, subnet address, prefix, resident subnet
Common-Use Synonyms	Network, network ID, network number, network address
Typically Seen In...	Routing tables, documentation

Table 14-2 Summary of Subnet Broadcast Address Key Facts

Definition	A reserved number in each subnet that, when used as the destination address of a packet, causes the routers to forward the packet to all hosts in that subnet
Numeric Value	Last (highest) number in the subnet
Literal Synonyms	Directed broadcast address
Broader-Use Synonyms	Network broadcast
Typically Seen In...	In calculations of the range of addresses in a subnet

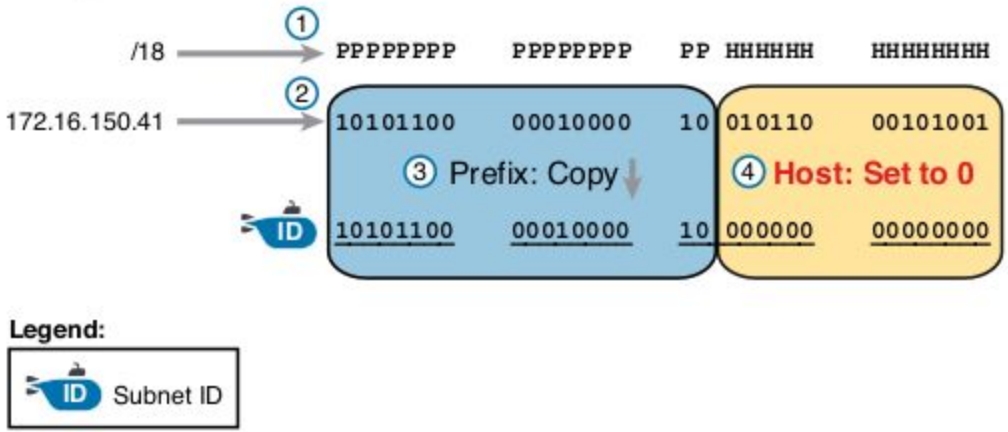


Figure 14-4 *Binary Concept: Convert the IP Address to the Subnet ID*

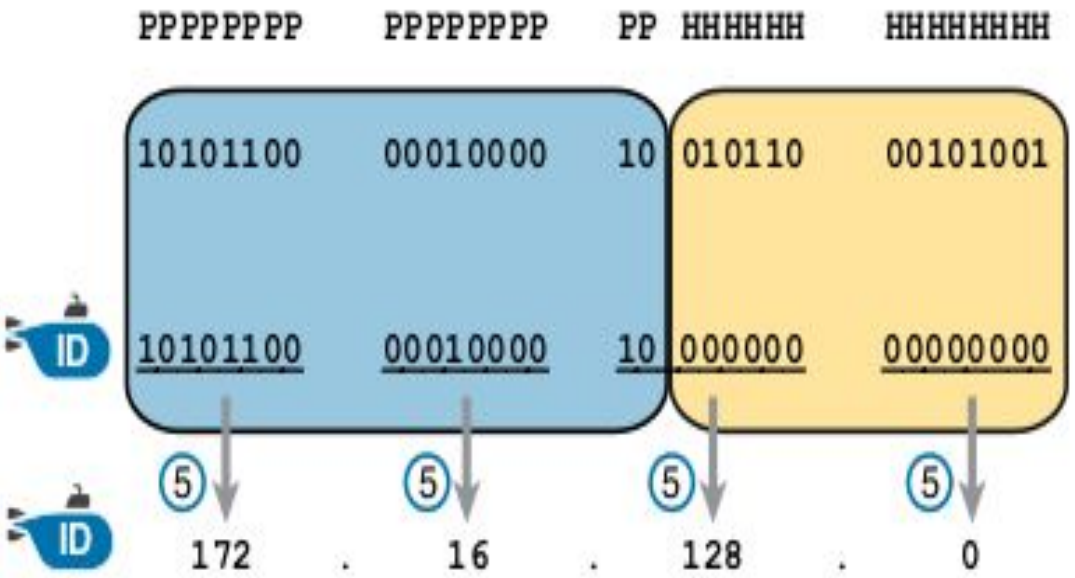


Figure 14-5 *Converting the Subnet ID from Binary to DDN*

Finding the Subnet Broadcast Address: Binary

Finding the subnet broadcast address uses a similar process. To find the subnet broadcast address, use the same binary process used to find the subnet ID, but instead of setting all the host bits to the lowest value (all binary 0s), set the host part to the highest value (all binary 1s). Figure 14-6 shows the concept.

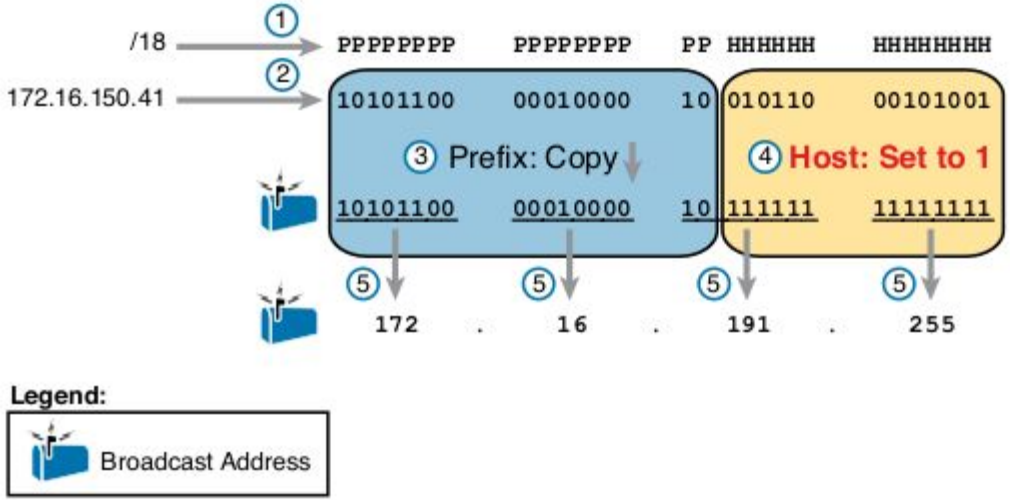


Figure 14-6 *Finding a Subnet Broadcast Address: Binary*

Binary Practice Problems

Figures 14-4 and 14-5 demonstrate a process to find the subnet ID using binary math. The following process summarizes those steps in written form for easier reference and practice:

Step 1. Convert the mask to prefix format to find the length of the prefix (/P) and the length of the host part (32 – P).

Step 2. Convert the IP address to its 32-bit binary equivalent.

Step 3. Copy the prefix bits of the IP address.

Step 4. Write down 0s for the host bits.

Step 5. Convert the resulting 32-bit number, 8 bits at a time, back to decimal.

The process to find the subnet broadcast address is exactly the same, except in Step 4, you set the bits to 1s, as seen in Figure 14-6.

Take a few moments and run through the following five practice problems on scratch paper. In each case, find both the subnet ID and subnet broadcast address. Also, record the prefix style mask:

1. 8.1.4.5, 255.255.0.0
2. 130.4.102.1, 255.255.255.0
3. 199.1.1.100, 255.255.255.0
4. 130.4.102.1, 255.255.252.0
5. 199.1.1.100, 255.255.255.224

Table 14-3 Subnet Analysis for Subnet with Address 8.1.4.5, Mask 255.255.0.0

Prefix Length	/16	11111111 11111111 **00000000 00000000**
Address	8.1.4.5	00001000 00000001 **00000100 00000101**
Subnet ID	8.1.0.0	00001000 00000001 **00000000 00000000**
Broadcast Address	8.1.255.255	00001000 00000001 **11111111 11111111**

Table 14-4 Subnet Analysis for Subnet with Address 130.4.102.1, Mask 255.255.255.0

Prefix Length	/24	11111111 11111111 11111111 **00000000**
Address	130.4.102.1	10000010 00000100 01100110 **00000001**
Subnet ID	130.4.102.0	10000010 00000100 01100110 **00000000**
Broadcast Address	130.4.102.255	10000010 00000100 01100110 **11111111**

Table 14-5 Subnet Analysis for Subnet with Address 199.1.1.100, Mask 255.255.255.0

Prefix Length	/24	11111111 11111111 11111111 **00000000**
Address	199.1.1.100	11000111 00000001 00000001 **01100100**
Subnet ID	199.1.1.0	11000111 00000001 00000001 **00000000**
Broadcast Address	199.1.1.255	11000111 00000001 00000001 **11111111**

Table 14-6 Subnet Analysis for Subnet with Address 130.4.102.1, Mask 255.255.252.0

Prefix Length	/22	11111111 11111111 11111**100** **00000000**
Address	130.4.102.1	10000010 00000100 01100**110** **00000001**
Subnet ID	130.4.100.0	10000010 00000100 01100**100** **00000000**
Broadcast Address	130.4.103.255	10000010 00000100 01100**111** **11111111**

Table 14-7 Subnet Analysis for Subnet with Address 199.1.1.100, Mask 255.255.255.224

Prefix Length	/27	11111111 11111111 11111111 111**00000**
Address	199.1.1.100	11000111 00000001 00000001 011**00100**
Subnet ID	199.1.1.96	11000111 00000001 00000001 011**00000**
Broadcast Address	199.1.1.127	11000111 00000001 00000001 011**11111**

Analysis with Easy Masks

With three easy subnet masks in particular, finding the subnet ID and subnet broadcast address requires only easy logic and literally no math. Three easy masks exist:

255.0.0.0

255.255.0.0

255.255.255.0

These easy masks have only 255 and 0 in decimal. In comparison, difficult masks have one octet that has neither a 255 nor a 0 in the mask, which makes the logic more challenging.

NOTE The terms *easy mask* and *difficult mask* are terms created for use in this book to describe the masks and the level of difficulty when working with each.

When the problem uses an easy mask, you can quickly find the subnet ID based on the IP address and mask in DDN format. Just use the following process for each of the four octets to find the subnet ID:

Step 1. If the mask octet = 255, copy the decimal IP address.

Step 2. If the mask octet = 0, write a decimal 0.

A similar simple process exists to find the subnet broadcast address, as follows:

Step 1. If the mask octet = 255, copy the decimal IP address.

Step 2. If the mask octet = 0, write a decimal 255.

Table 14-8 Practice Problems: Find Subnet ID and Broadcast, Easy Masks

	IP Address	Mask	Subnet ID	Broadcast Address
1	10.77.55.3	255.255.255.0		
2	172.30.99.4	255.255.255.0		
3	192.168.6.54	255.255.255.0		
4	10.77.3.14	255.255.0.0		
5	172.22.55.77	255.255.0.0		
6	1.99.53.76	255.0.0.0		

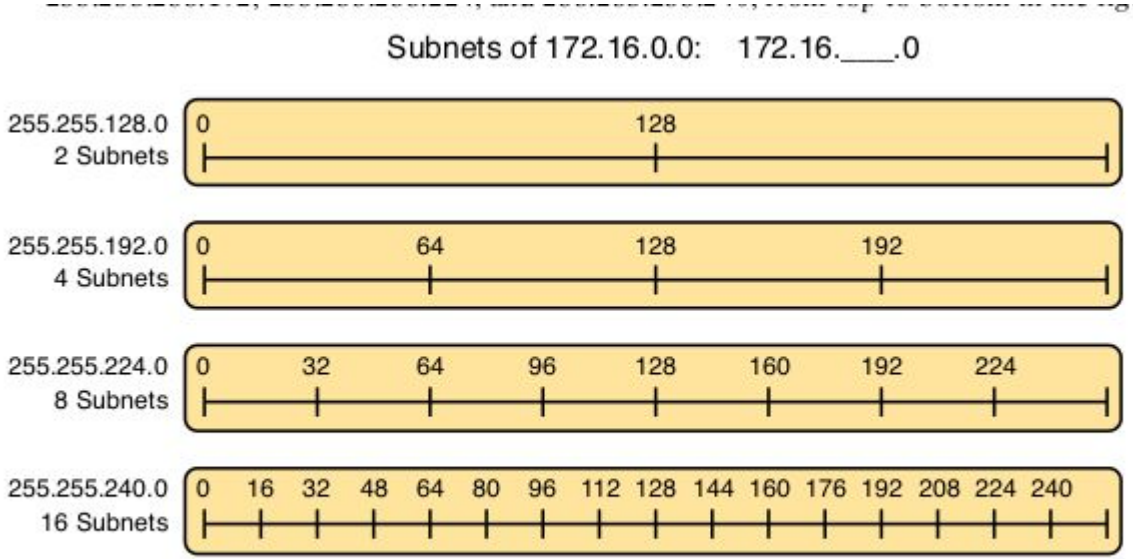
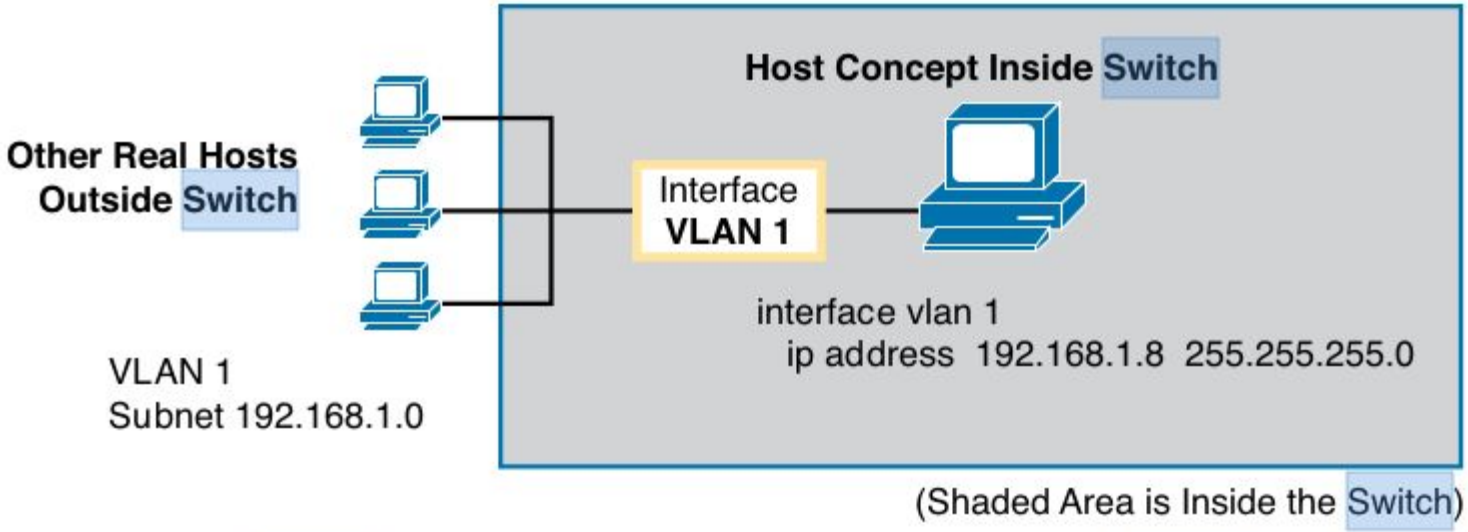


Figure 14-8 *Numeric Patterns in the Interesting Octet*


Host Concept Inside Switch
Other Real Hosts
Outside Switch
Interface
VLAN 1
interface vlan 1
ip address 192.168.1.8 255.255.255.0
VLAN 1
Subnet 192.168.1.0
(Shaded Area is Inside the Switch)

1. When thinking about an IP address using classful addressing rules, an address can have three parts: network, subnet, and host. If you examined all the addresses in one subnet, in binary, which of the following answers correctly states which of the three parts of the addresses will be equal among all addresses? Pick the best answer.

   A. Network part only

   B. Subnet part only

   C. Host part only

   D. Network and subnet parts

   E. Subnet and host parts

2. Which of the following statements are true regarding the binary subnet ID, subnet broadcast address, and host IP address values in any single subnet? (Choose two.)

   A. The host part of the broadcast address is all binary 0s.

   B. The host part of the subnet ID is all binary 0s.

   C. The host part of a usable IP address can have all binary 1s.

   D. The host part of any usable IP address must not be all binary 0s.

3. Which of the following is the resident subnet ID for IP address 10.7.99.133/24?

   A. 10.0.0.0

   B. 10.7.0.0

   C. 10.7.99.0

   D. 10.7.99.128

4. Which of the following is the resident subnet for IP address 192.168.44.97/30?

   A. 192.168.44.0

   B. 192.168.44.64

   C. 192.168.44.96

   D. 192.168.44.128

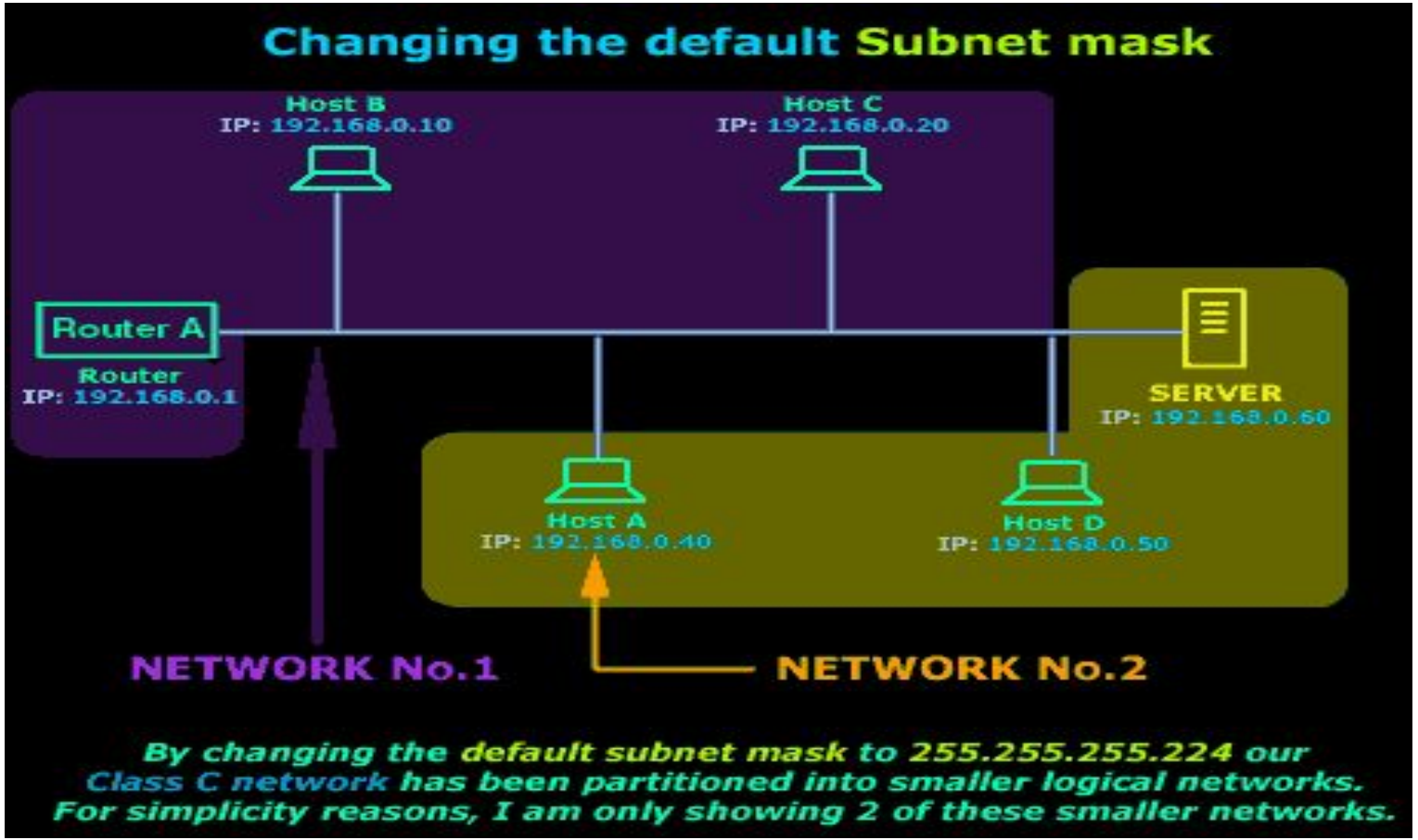
5. Which of the following is the subnet broadcast address for the subnet in which IP address 172.31.77.201/27 resides?

   A. 172.31.201.255

   B. 172.31.255.255

   C. 172.31.77.223

   D. 172.31.77.207


Changing the default Subnet mask
Host B
IP: 192.168.0.10
Host C
IP: 192.168.0.20
Router A
Router
IP: 192.168.0.1
SERVER
IP: 192.168.0.60
Host A
IP: 192.168.0.40
Host D
IP: 192.168.0.50
NETWORK No.1
NETWORK No.2
By changing the default subnet mask to 255.255.255.224 our
Class C network has been partitioned into smaller logical networks.
For simplicity reasons, I am only showing 2 of these smaller networks.

TASK TO COMPLETE : PRACTICE

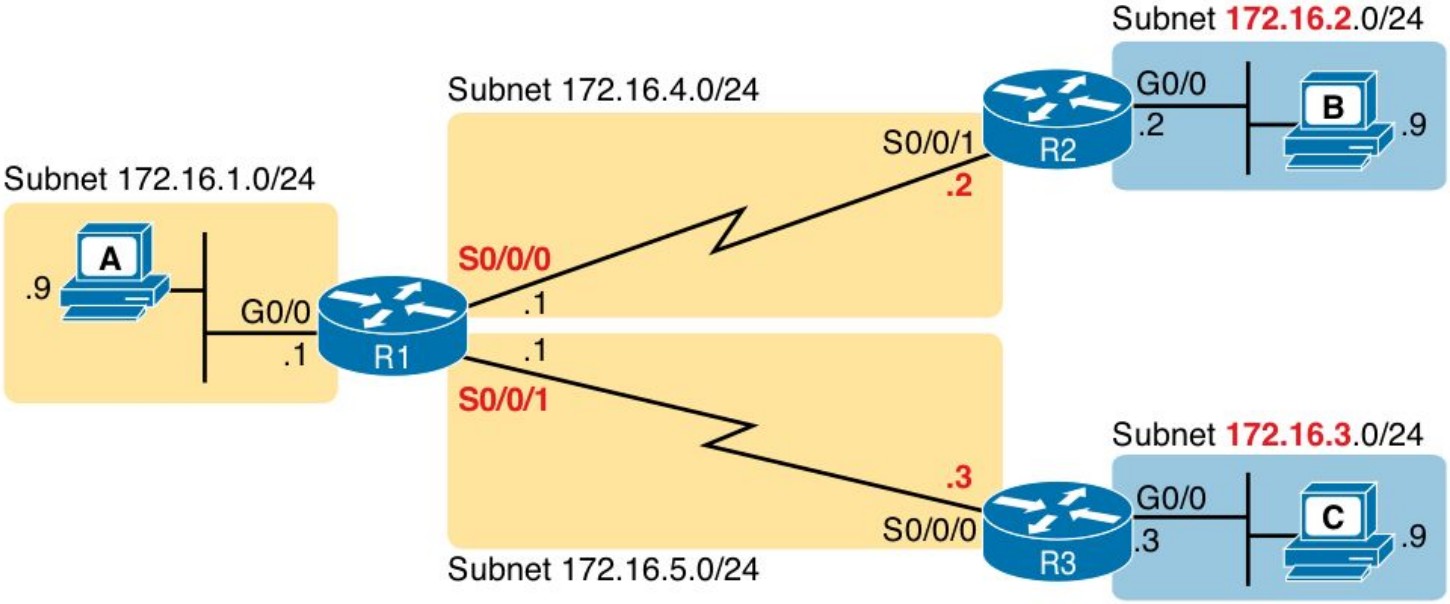


Figure 16-16 *Sample Network Used in Static Route Configuration Examples*

Example 16-9 *Static Routes Added to R1*

```
ip route 172.16.2.0 255.255.255.0 172.16.4.2
ip route 172.16.3.0 255.255.255.0 S0/0/1
```