Cisco Networking Academy

CCNA R&S: Introduction to Networks

Chapter 9:

Subnetting IP Networks

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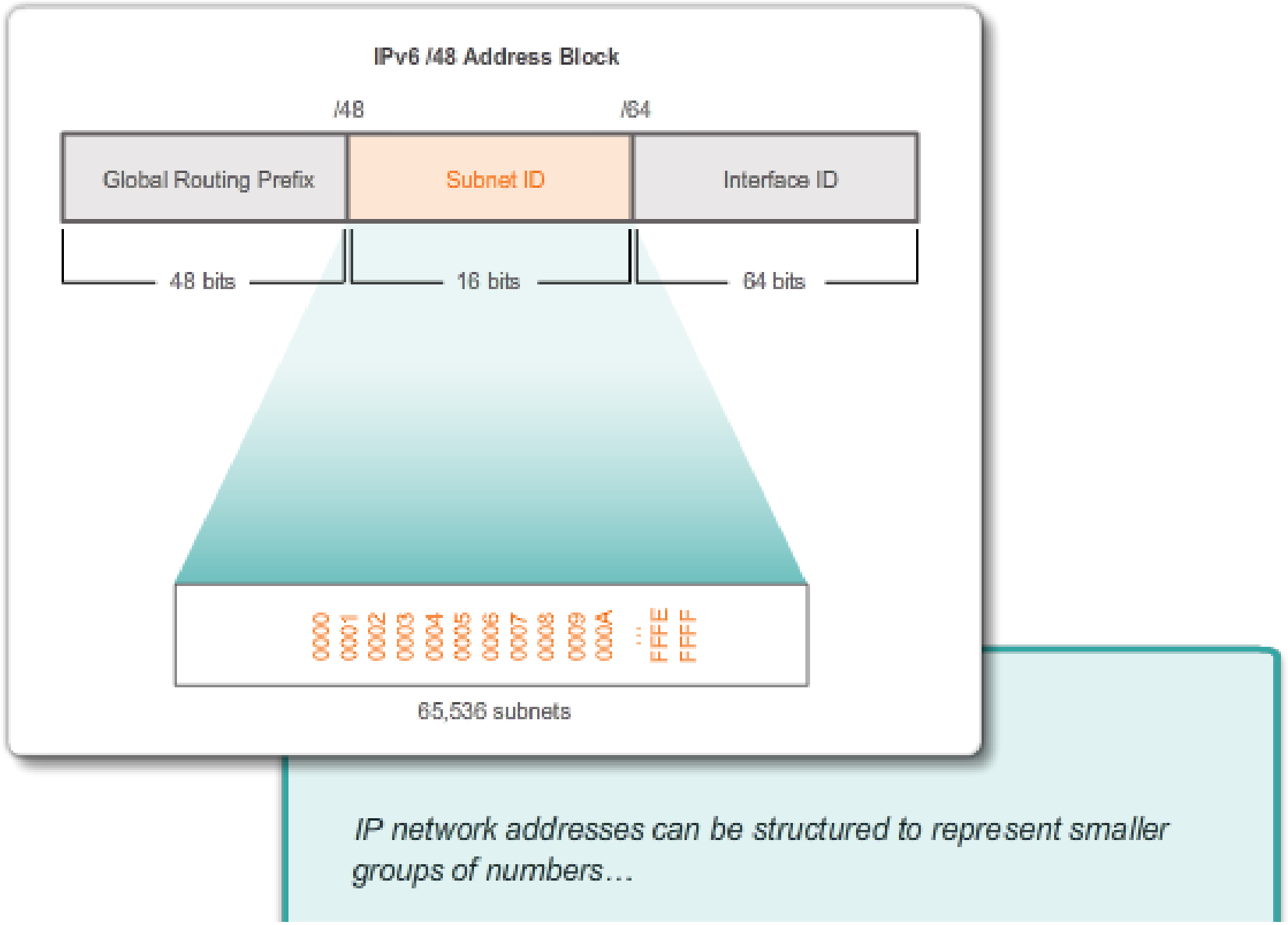
Upon completion of this chapter you will be able to:

- Explain why routing is necessary for hosts on different subnets to communicate.
- Describe IP as a communication protocol used to identify a single device on a network.
- Given a network and subnet mask, calculate the number of host addresses available.
- Calculate the necessary subnet mask in order to accommodate a given number of hosts.
- Describe the benefits of variable length subnet masking (VLSM).
- Design and implement a hierarchical addressing scheme.
- Explain how IPv6 address assignments are implemented in a business network.

Subnetting IP Networks

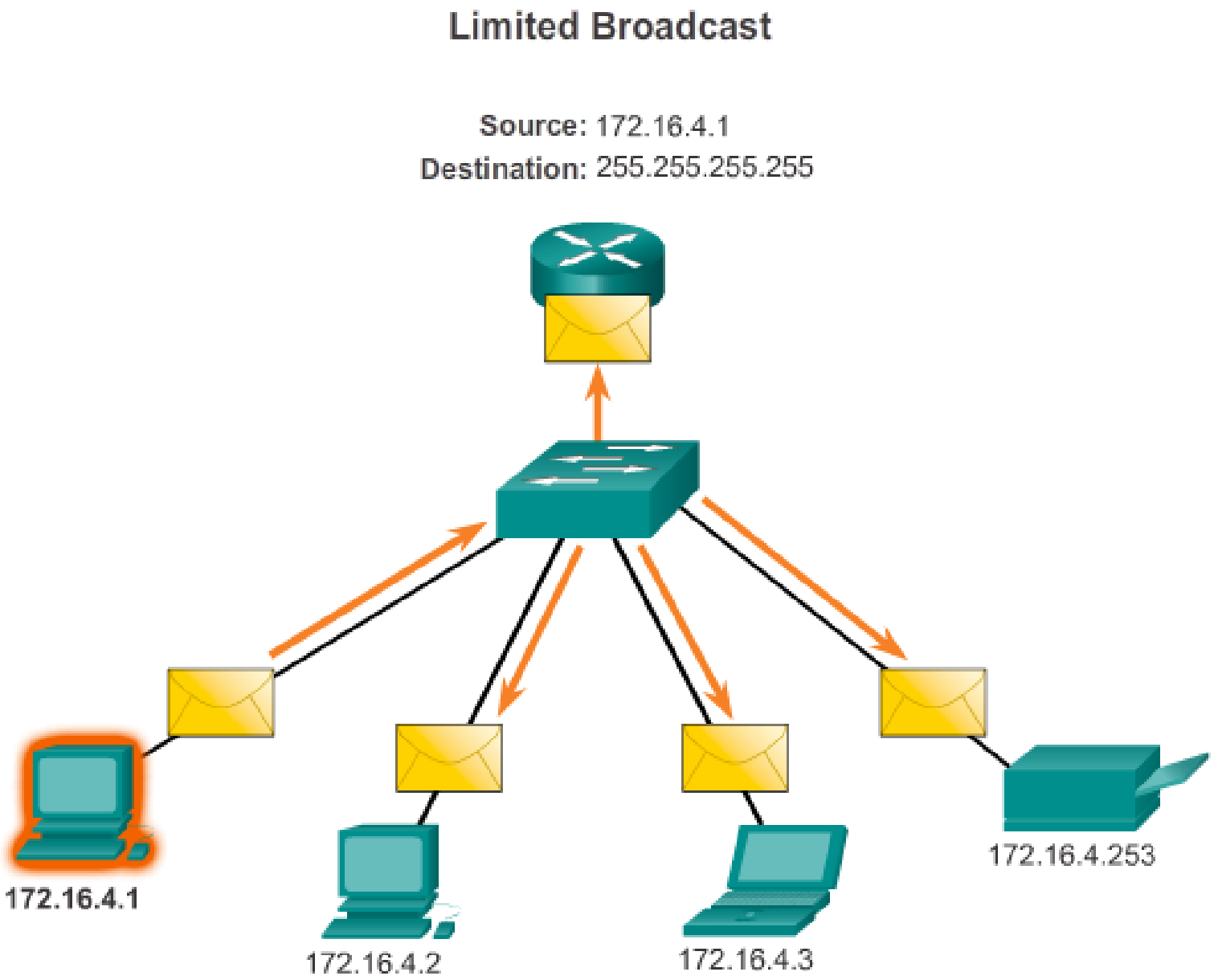


IP network addresses can be structured to represent smaller groups of numbers…

In this chapter, you will be learning how devices can be grouped into subnets, or smaller network groups, from a large network.

In this modeling activity, you are asked to think about a number you probably use every day, a number such as your telephone number. As you complete the activity, think about how your telephone number compares to strategies that network administrators might use to identify hosts for efficient data communication.

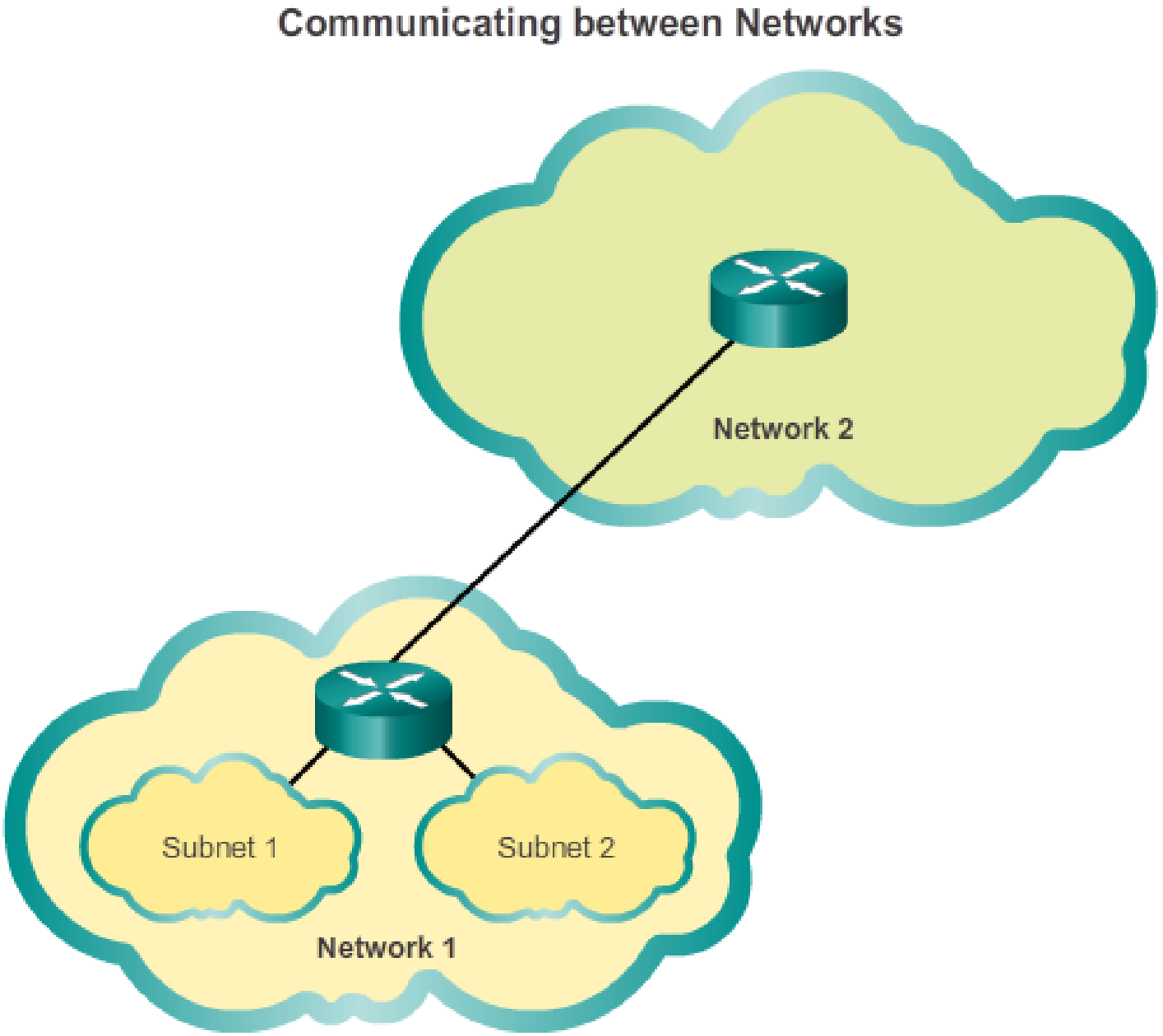
9.1.1.1 Reasons for Subnetting



The process of segmenting a network, by dividing it into multiple smaller network spaces, is called subnetting.

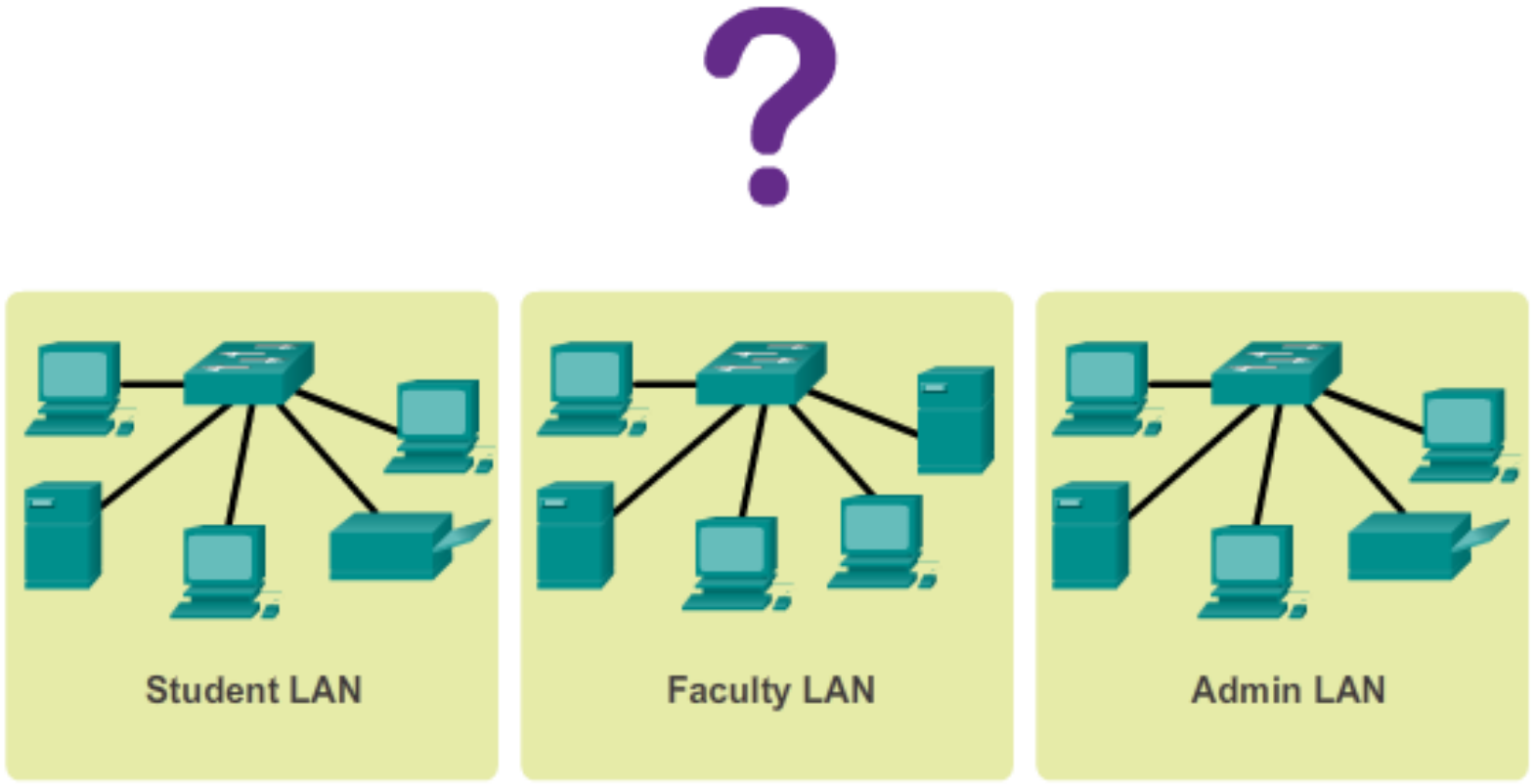
These sub-networks are called **subnets**. Network administrators can group devices and services into subnets that are determined by geographic location (perhaps the 3rd floor of a building), by organizational unit (perhaps the sales department), by device type (printers, servers, WAN), or any other division that makes sense for the network. Subnetting can reduce overall network traffic and improve network performance.

9.1.1.2 Communication Between Subnets



A router is necessary for devices on different networks to communicate. Devices on a network use the router interface attached to their LAN as their default gateway. Traffic that is destined for a device on a remote network will be processed by the router and forwarded toward the destination. To determine if traffic is local or remote, the router uses the subnet mask.

9.1.2.1 The Plan



Planning requires decisions on each subnet in terms of size, the number of hosts per subnet, and how host addresses will be assigned.

As discussed earlier, the private IP address range used on a LAN is the choice of the network administrator and needs careful consideration to be sure that enough host address will be available for the currently known hosts and for future expansion. Remember the private IP address ranges are:

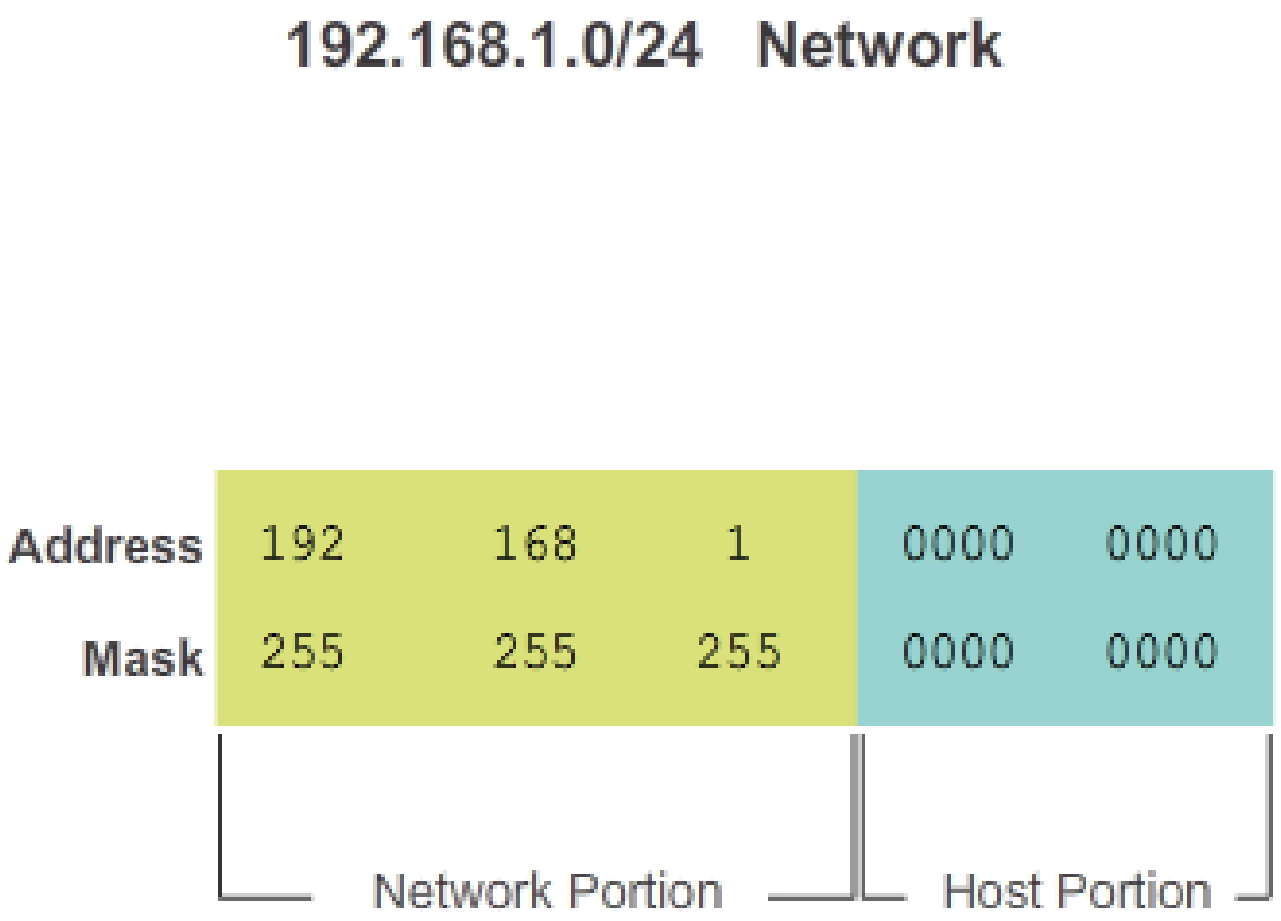
- 10.0.0.0 with a subnet mask of 255.0.0.0
- 172.16.0.0 with a subnet mask of 255.240.0.0
- 192.168.0.0 with a subnet mask of 255.255.0.0

Knowing your IP address requirements will determine the range or ranges of host addresses you implement. Subnetting the selected private IP address space will provide the host addresses to cover your network needs.

9.1.2.2 The Plan – Address Assignment

In the upcoming examples you will see subnetting based on address blocks that have subnet masks of 255.0.0.0, 255.255.0.0, and 255.255.255.0.

9.1.3.1 Basic Subnetting



With no host bits borrowed, the host portion of both the network address and mask are all 0 bits.

Figure 1, the 192.168.1.0/24 network has 24 bits in the network portion and 8 bits in the host portion, which is indicated with the subnet mask 255.255.255.0 or /24 notation.

With no subnetting, this network supports a single LAN interface. If an additional LAN is needed, the network would need to be subnetted.

9.1.3.1 Basic Subnetting

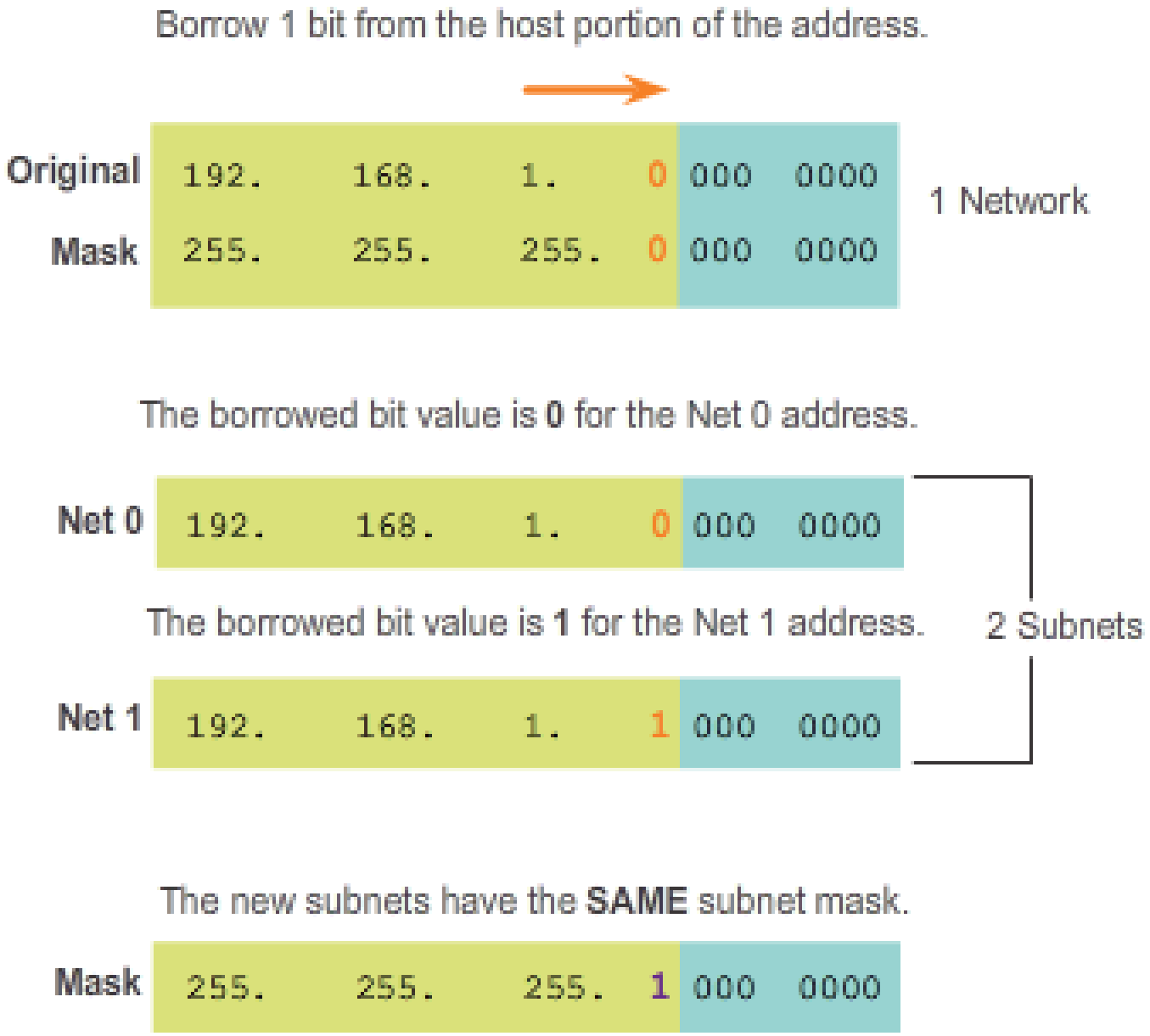
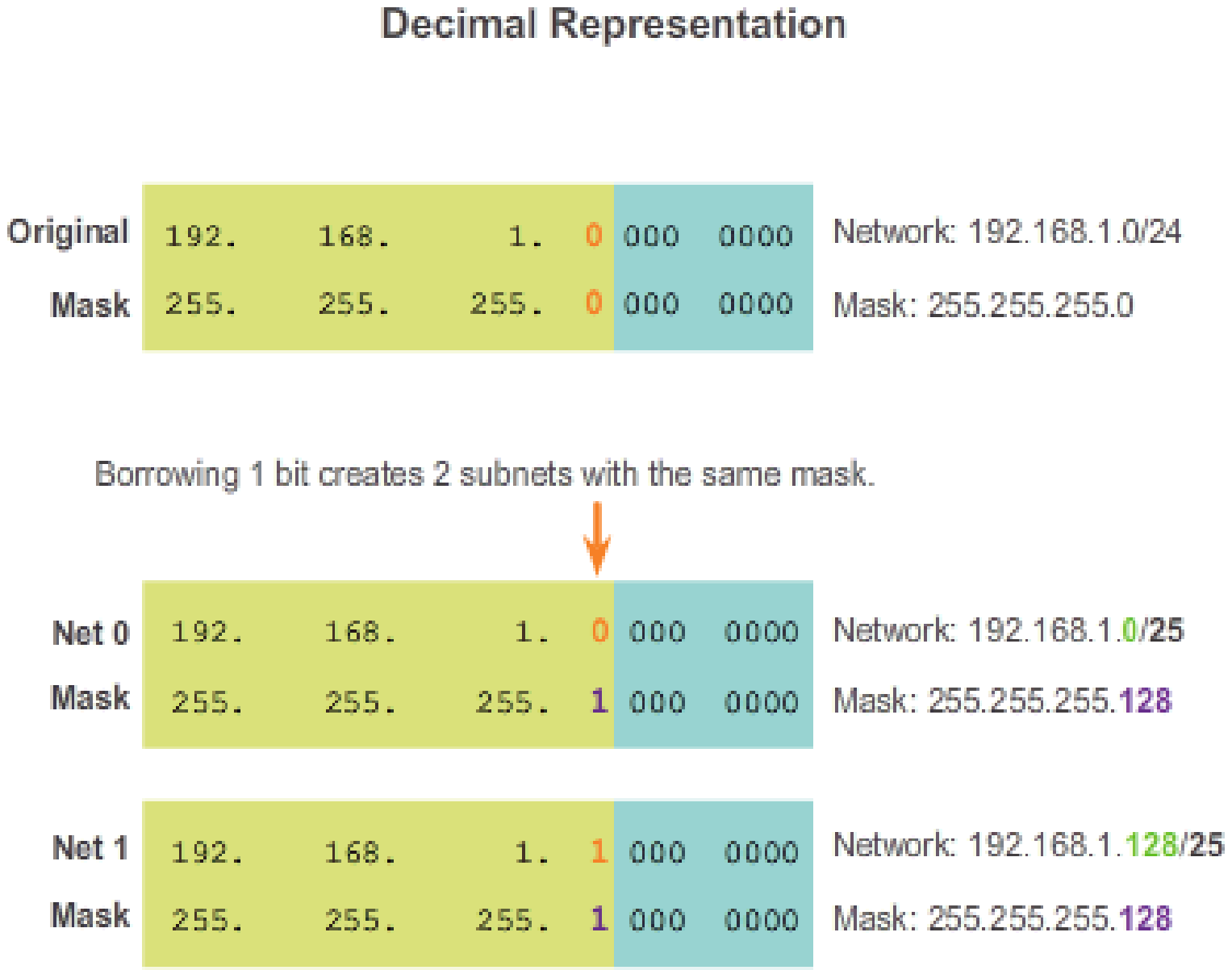


Figure 2, 1 bit is borrowed from the most significant bit (leftmost bit) in the host portion, thus extending the network portion to 25 bits.

This creates 2 subnets identified by using a 0 in the borrowed bit for the first network and a 1 in the borrowed bit for the second network.

The subnet mask for both networks uses a 1 in the borrowed bit position to indicate that this bit is now part of the network portion.

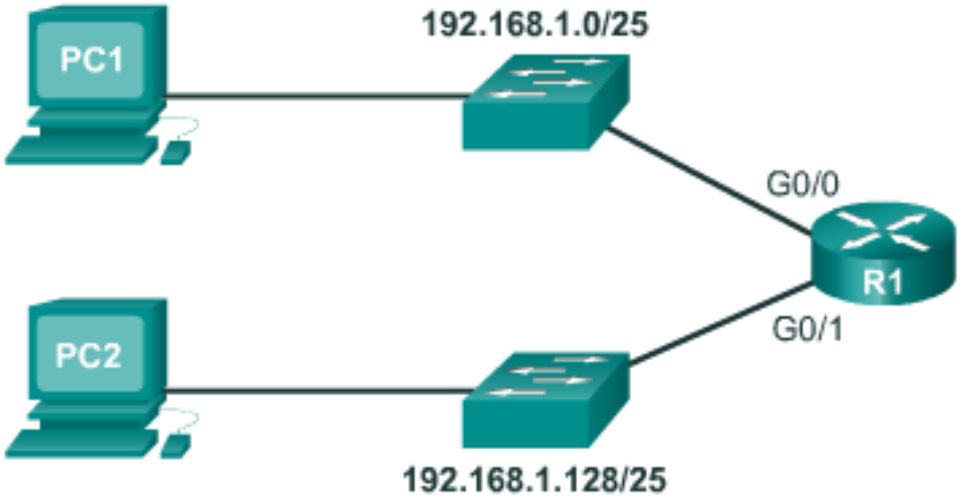
9.1.3.1 Basic Subnetting



in Figure 3, when we convert the binary octet to decimal we see that the first subnet address is 192.168.1.0 and the second subnet address is 192.168.1.128.

Because a bit has been borrowed, the subnet mask for each subnet is 255.255.255.128 or /25.

9.1.3.2 Subnets in Use



Address Range for 192.168.1.0/25 Subnet

Network Address

192.	168.	1.	0	000 0000	= 192.168.1.0

First Host Address

192.	168.	1.	0	000 0001	= 192.168.1.1

Last Host Address

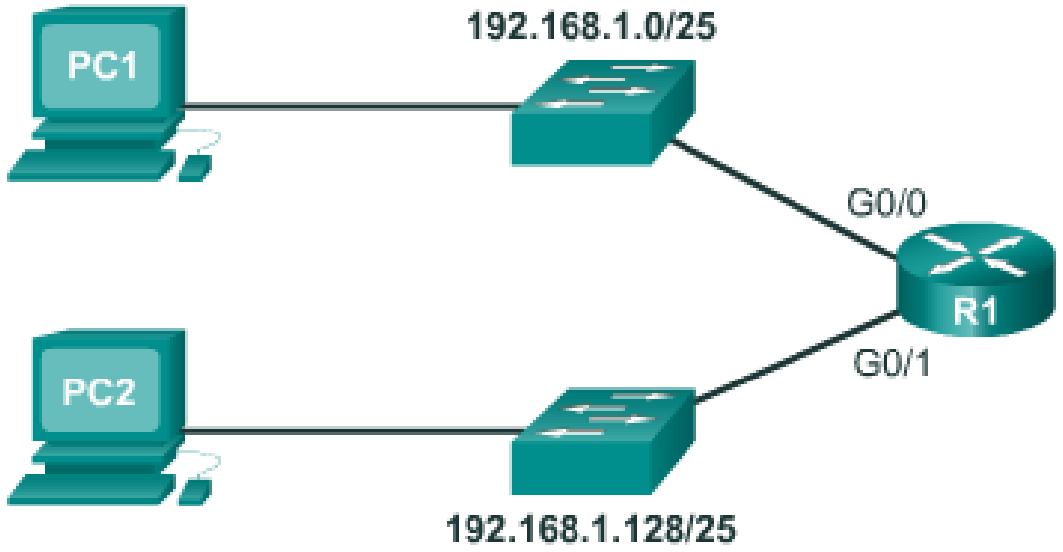
192.	168.	1.	0	111 1110	= 192.168.1.126

Broadcast Address

192.	168.	1.	0	111 1111	= 192.168.1.127

The first host address for the 192.168.1.0/25 network is 192.168.1.1, and the last host address is 192.168.1.126.

9.1.3.2 Subnets in Use



Address Range for 192.168.1.128/25 Subnet

Network Address

192.	168.	1.	1	000	0000	=	192.168.1.128

First Host Address

192.	168.	1.	1	000	0001	=	192.168.1.129

Last Host Address

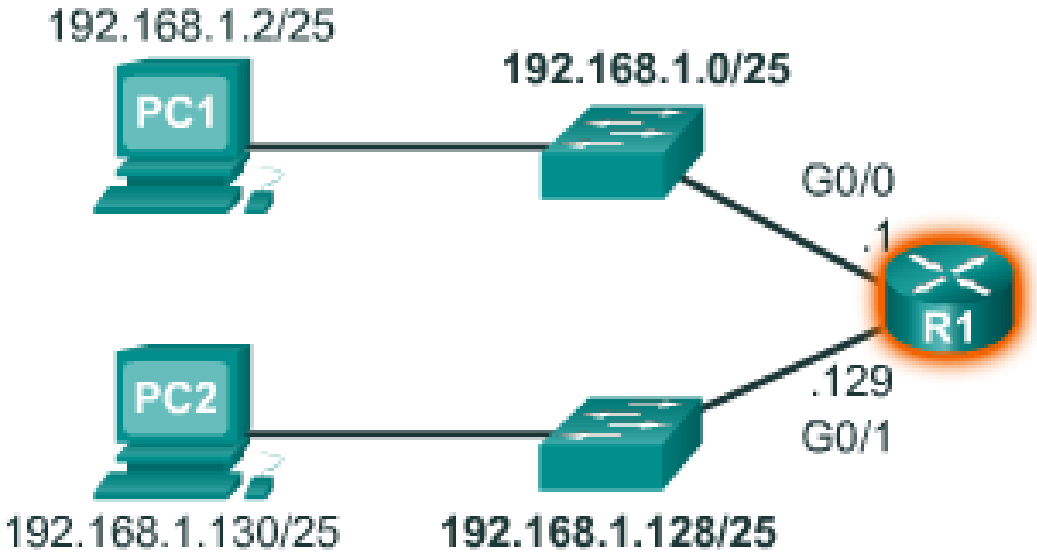
192.	168.	1.	1	111	1110	=	192.168.1.254

Broadcast Address

192.	168.	1.	1	111	1111	=	192.168.1.255

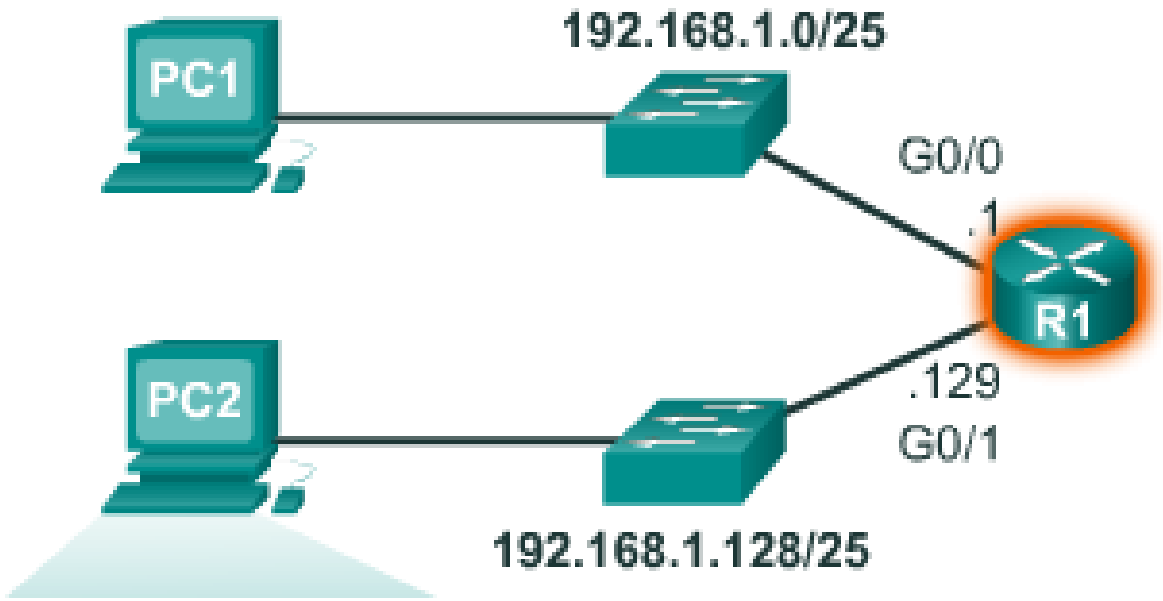
The first host address for the 192.168.1.128/25 network is 192.168.1.129, and the last host address is 192.168.1.254.

9.1.3.2 Subnets in Use



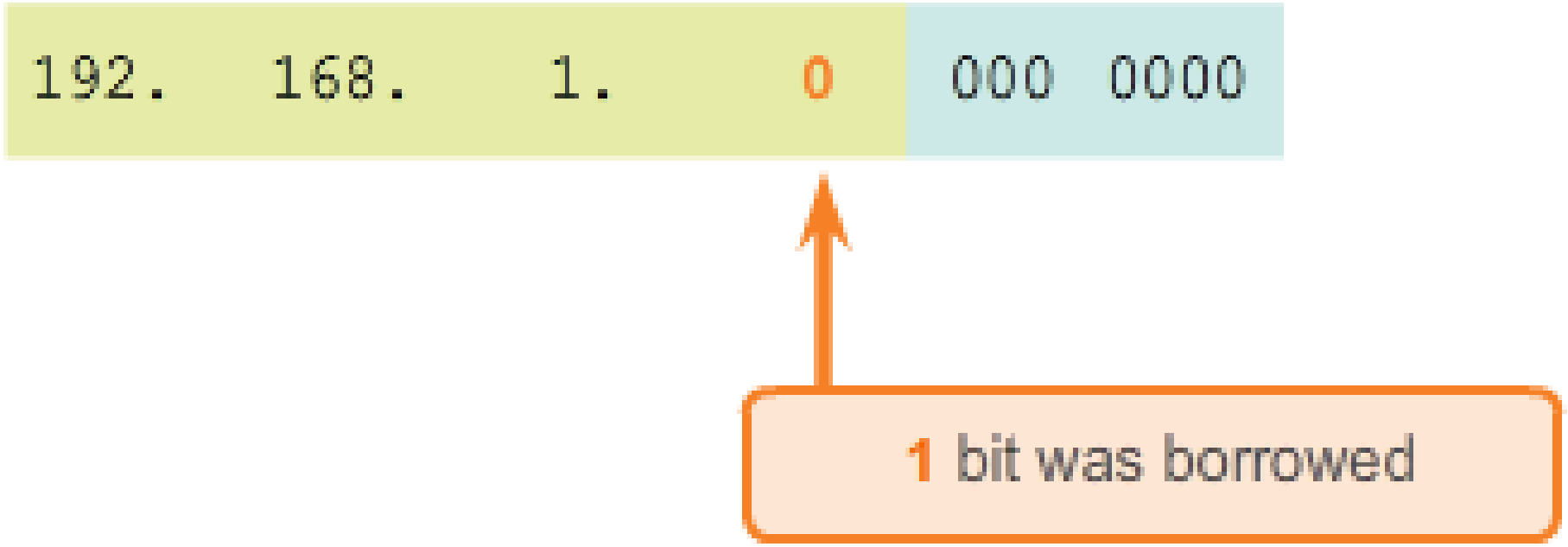

```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.1.1 255.255.255.128
R1(config-if)#exit
R1(config)#interface gigabitethernet 0/1
R1(config-if)#ip address 192.168.1.129 255.255.255.128
```

9.1.3.2 Subnets in Use



Calculate Number of Subnets

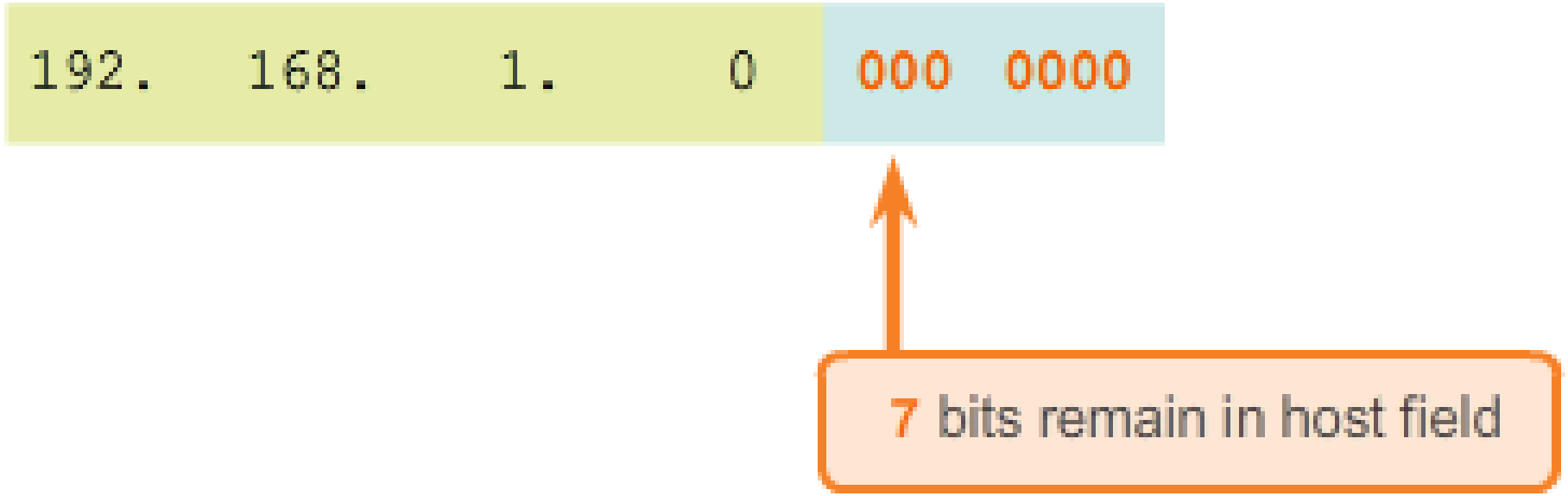
Subnets = 2^n
(where n = bits borrowed)



2^1 = 2 subnets

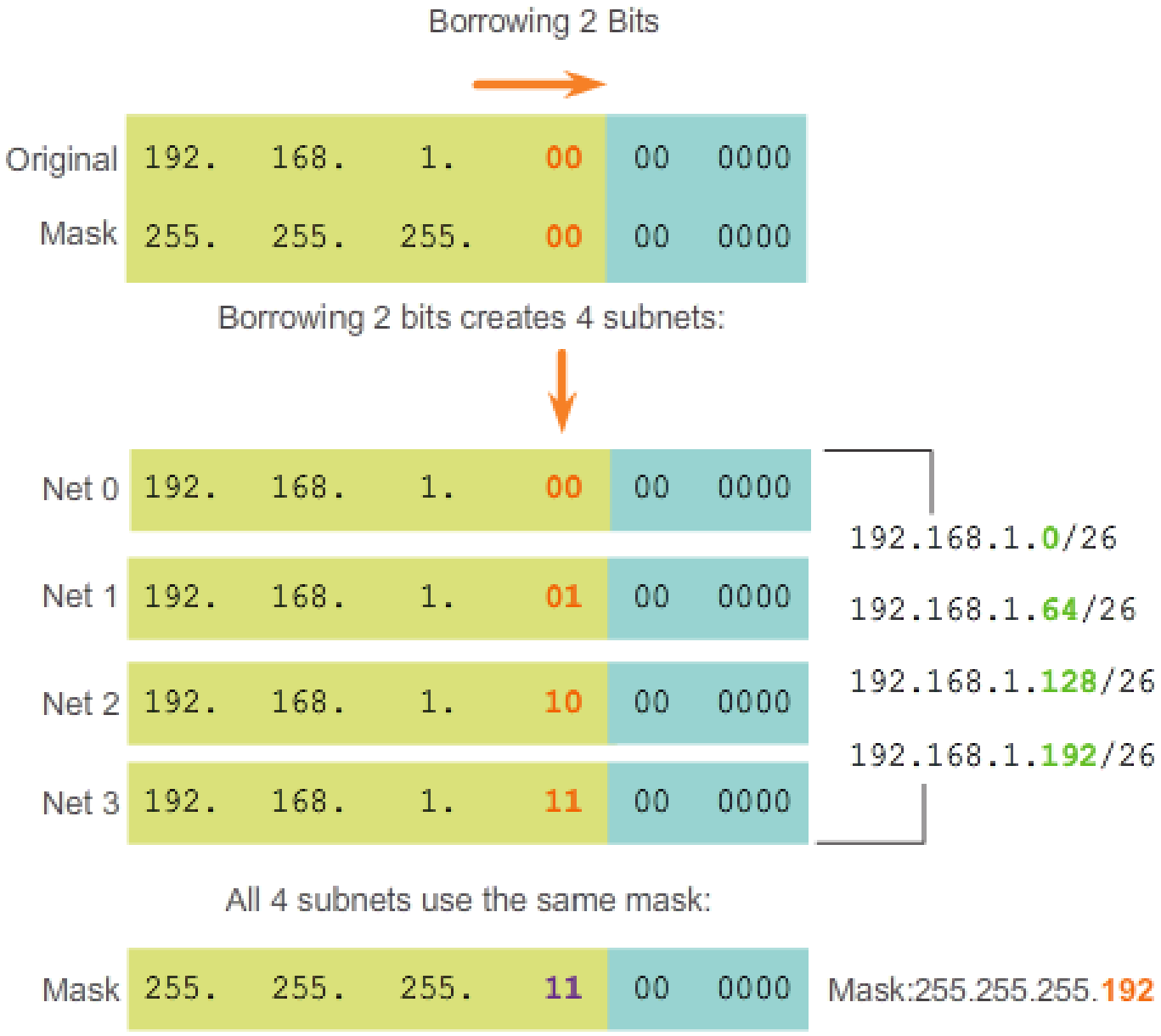
Calculate Number of Hosts

Hosts = 2^n
(where n = host bits remaining)



2^7 = 128 hosts per subnet
2^7 - 2 = 126 valid hosts per subnet

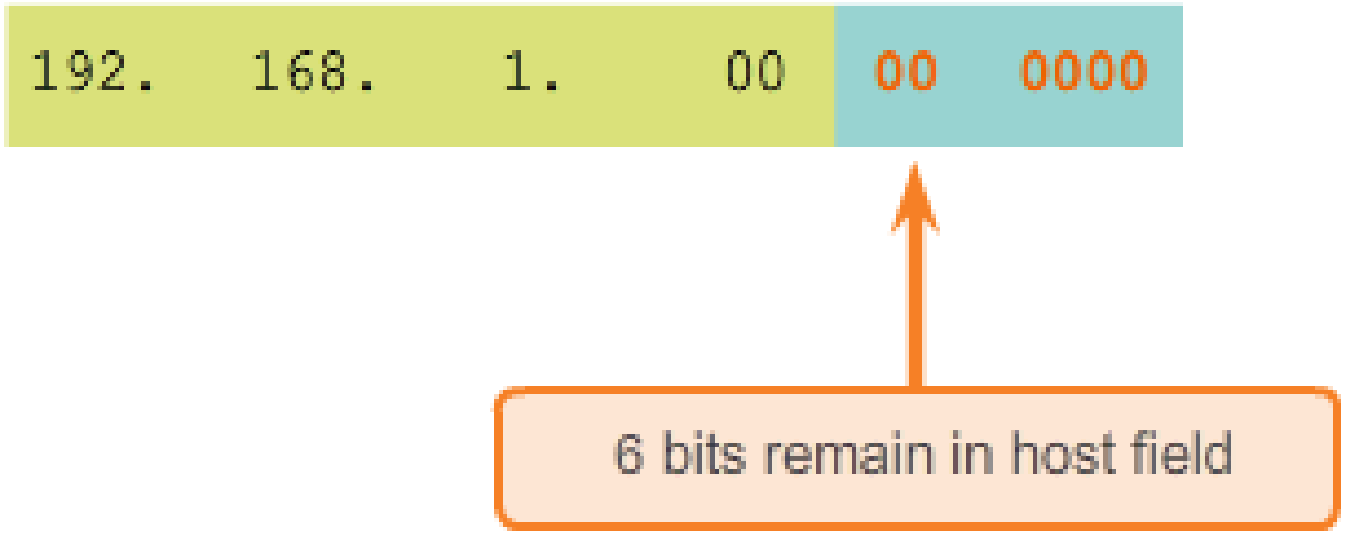
9.1.3.4 Creating 4 Subnets



9.1.3.4 Creating 4 Subnets

Calculate Number of Hosts

Hosts = 2^n
(where n = host bits remaining)



2^6 = 64 hosts per subnet
2^6 - 2 = 62 valid hosts per subnet

9.1.3.4 Creating 4 Subnets

Address Range for 192.168.1.0/26 Subnet

Network Address

192.	168.	1.	00	00	0000	= 192.168.1.0

First Host Address

192.	168.	1.	00	00	0001	= 192.168.1.1

Last Host Address

192.	168.	1.	00	11	1110	= 192.168.1.62

Broadcast Address

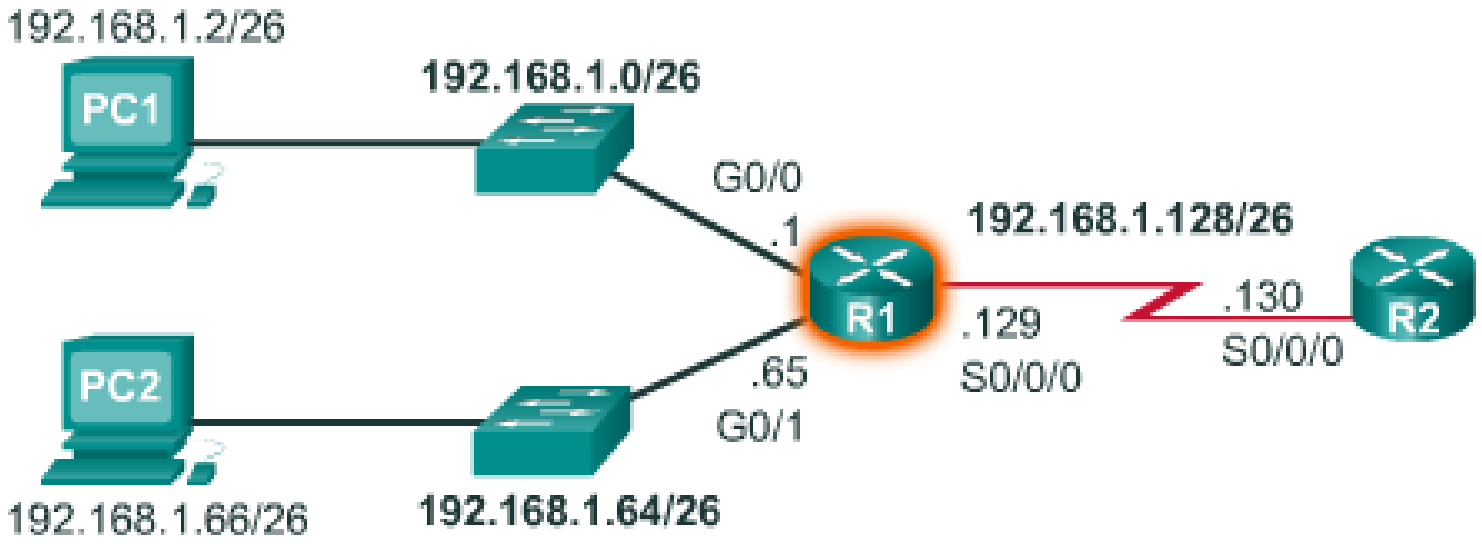
192.	168.	1.	00	11	1111	= 192.168.1.63

9.1.3.4 Creating 4 Subnets

Address Ranges Nets 0 - 2

Net 0	Network	192.	168.	1.	00	00	0000	192.168.1.0
	First	192.	168.	1.	00	00	0001	192.168.1.1
	Last	192.	168.	1.	00	11	1110	192.168.1.62
	Broadcast	192.	168.	1.	00	11	1111	192.168.1.63
Net 1	Network	192.	168.	1.	01	00	0000	192.168.1.64
	First	192.	168.	1.	01	00	0001	192.168.1.65
	Last	192.	168.	1.	01	11	1110	192.168.1.126
	Broadcast	192.	168.	1.	01	11	1111	192.168.1.127
Net 2	Network	192.	168.	1.	10	00	0000	192.168.1.128
	First	192.	168.	1.	10	00	0001	192.168.1.129
	Last	192.	168.	1.	10	11	1110	192.168.1.190
	Broadcast	192.	168.	1.	10	11	1111	192.168.1.191

9.1.3.4 Creating 4 Subnets

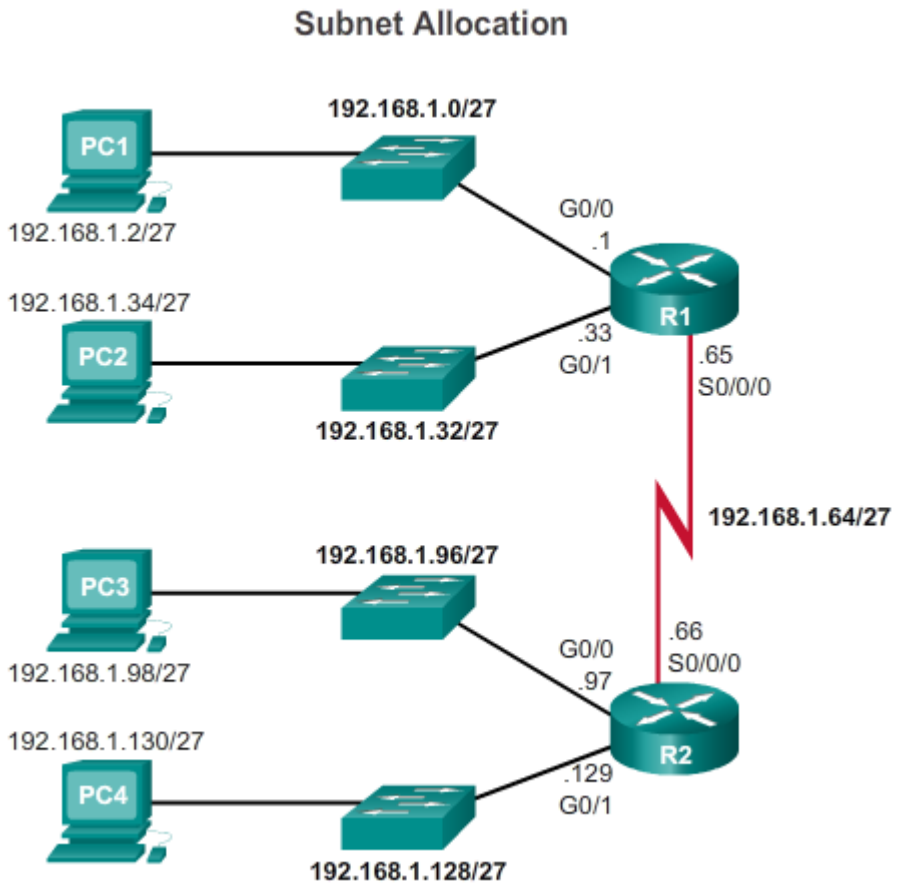



```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.1.1 255.255.255.192
R1(config-if)#exit
R1(config)#interface gigabitethernet 0/1
R1(config-if)#ip address 192.168.1.65 255.255.255.192
R1(config-if)#exit
R1(config)#interface serial 0/0/0
R1(config-if)#ip address 192.168.1.129 255.255.255.192
```

9.1.3.5 Creating 8 Subnets

Net 0	Network	192.	168.	1.	000	0	0000	192.168.1.0
	First	192.	168.	1.	000	0	0001	192.168.1.1
	Last	192.	168.	1.	000	1	1110	192.168.1.30
	Broadcast	192.	168.	1.	000	1	1111	192.168.1.31
Net 1	Network	192.	168.	1.	001	0	0000	192.168.1.32
	First	192.	168.	1.	001	0	0001	192.168.1.33
	Last	192.	168.	1.	001	1	1110	192.168.1.62
	Broadcast	192.	168.	1.	001	1	1111	192.168.1.63
Net 2	Network	192.	168.	1.	010	0	0000	192.168.1.64
	First	192.	168.	1.	010	0	0001	192.168.1.65
	Last	192.	168.	1.	010	1	1110	192.168.1.94
	Broadcast	192.	168.	1.	010	1	1111	192.168.1.95
Net 3	Network	192.	168.	1.	011	0	0000	192.168.1.96
	First	192.	168.	1.	011	0	0001	192.168.1.97
	Last	192.	168.	1.	011	1	1110	192.168.1.126
	Broadcast	192.	168.	1.	011	1	1111	192.168.1.127
Net 4	Network	192.	168.	1.	100	0	0000	192.168.1.128
	First	192.	168.	1.	100	0	0001	192.168.1.129
	Last	192.	168.	1.	100	1	1110	192.168.1.158
	Broadcast	192.	168.	1.	100	1	1111	192.168.1.159
Net 5	Network	192.	168.	1.	101	0	0000	192.168.1.160
	First	192.	168.	1.	101	0	0001	192.168.1.161
	Last	192.	168.	1.	101	1	1110	192.168.1.190
	Broadcast	192.	168.	1.	101	1	1111	192.168.1.191
Net 6	Network	192.	168.	1.	110	0	0000	192.168.1.192
	First	192.	168.	1.	110	0	0001	192.168.1.193
	Last	192.	168.	1.	110	1	1110	192.168.1.222
	Broadcast	192.	168.	1.	110	1	1111	192.168.1.223
Net 7	Network	192.	168.	1.	111	0	0000	192.168.1.224
	First	192.	168.	1.	111	0	0001	192.168.1.225
	Last	192.	168.	1.	111	1	1110	192.168.1.254
	Broadcast	192.	168.	1.	111	1	1111	192.168.1.255

9.1.3.5 Creating 8 Subnets



Interface Address Configuration

R1

```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.1.1 255.255.255.224
R1(config-if)#exit
R1(config)#interface gigabitethernet 0/1
R1(config-if)#ip address 192.168.1.33 255.255.255.224
R1(config-if)#exit
R1(config)#interface serial 0/0/0
R1(config-if)#ip address 192.168.1.65 255.255.255.224
```

R2

```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.1.97 255.255.255.224
R1(config-if)#exit
R1(config)#interface gigabitethernet 0/1
R1(config-if)#ip address 192.168.1.129 255.255.255.224
R1(config-if)#exit
R1(config)#interface serial 0/0/0
R1(config-if)#ip address 192.168.1.66 255.255.255.224
```

9.1.3.6 Activity - Determining the Network Address - Basic

Host Address	192	168	190	112
Subnet Mask	255	255	255	192
Host Address in binary	11000000	10101000	10111110	01110000
Subnet Mask in binary	11111111	11111111	11111111	11000000
Network Address in binary	**11000000**	**10101000**	**10111110**	**01000000**
Network Address in decimal	**192**	**168**	**190**	**64**

9.1.3.7 Activity - Calculate the Number of Hosts - Basic

Network Address	192	168	150	221
Subnet Mask	255	255	255	240
Network Address in binary	11000000	10101000	10010110	11011101
Subnet Mask in binary	11111111	11111111	11111111	11110000
Number of Valid Hosts	14			

9.1.3.8 Activity - Determining the Valid Addresses for Hosts - Basics

Network Address in decimal	192	168	101	192
Subnet Mask in decimal	255	255	255	240
Network address in binary	11000000	10101000	01100101	11000000
Subnet Mask in binary	11111111	11111111	11111111	11110000
First Usable Host IP Address in decimal	**192**	**168**	**101**	**193**
Last Usable Host IP Address in decimal	**192**	**168**	**101**	**206**
Broadcast Address in decimal	**192**	**168**	**101**	**207**
Next Network Address in decimal	**192**	**168**	**101**	**208**

9.1.3.9 Activity - Calculate the Subnet Mask

Subnet Mask	255	255	255	192
Subnet Mask in binary	11111111	11111111	11111111	11000000
Prefix notation			/26	

Calculating Class B Subnets

Thanks for your attention!!