

Chapter 8:

Subnetting IP networks

Introduction to Networks v5.1



Section 8.1:

Subnetting an IPv4 Network

Upon completion of this section, you should be able to:

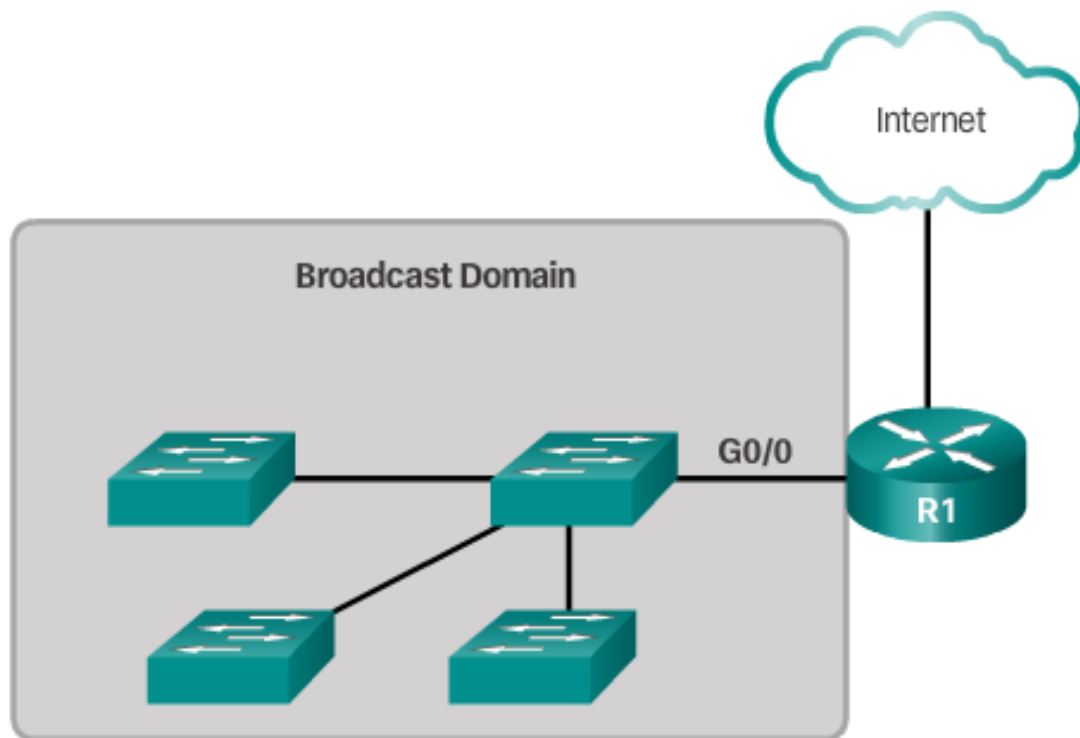
- Explain how subnetting segments a network to enable better communication.
- Explain how to calculate IPv4 subnets for a /24 prefix.
- Explain how to calculate IPv4 subnets for a /16 and /8 prefix.
- Given a set of requirements for subnetting, implement an IPv4 addressing scheme.
- Explain how to create a flexible addressing scheme using variable length subnet masking (VLSM).

Topic 8.1.1: Network Segmentation



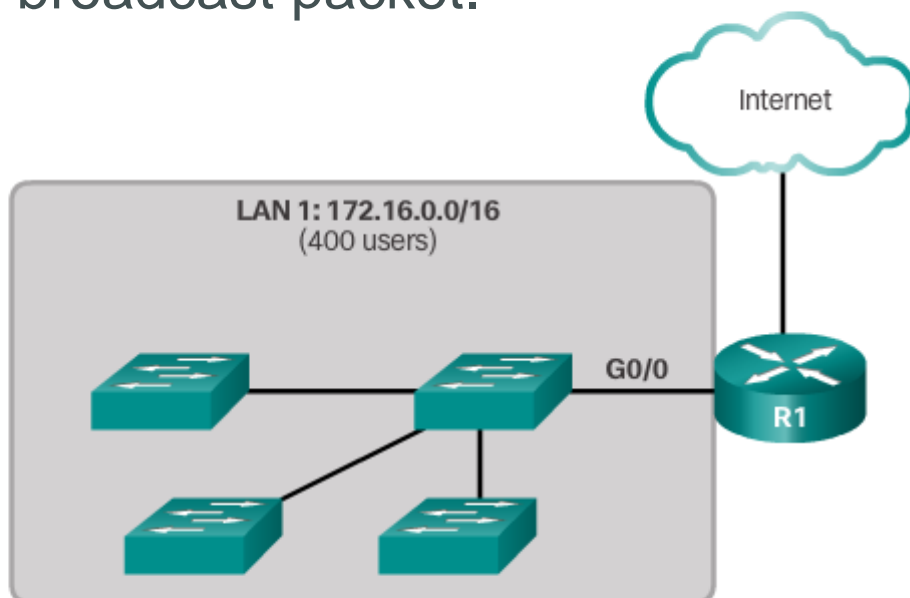
Broadcast Domains

Each router interface connects a *broadcast domain* and broadcasts are only propagated within its specific broadcast domain.



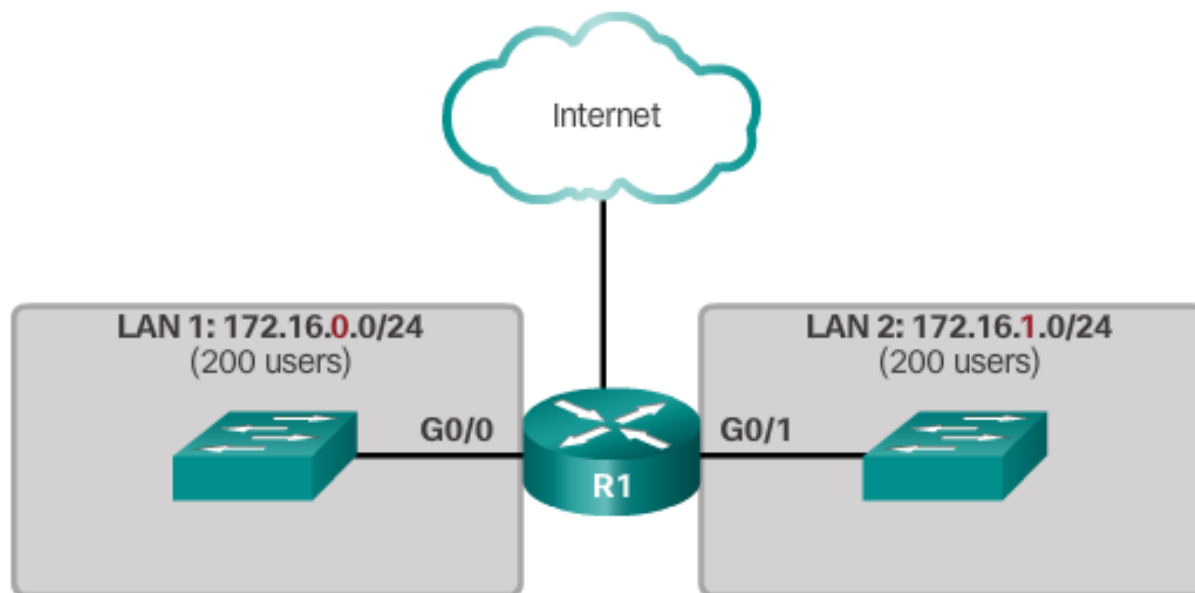
Problems with Large Broadcast Domains

- Slow network operations due to the significant amount of broadcast traffic.
- Slow device operations because a device must accept and process each broadcast packet.



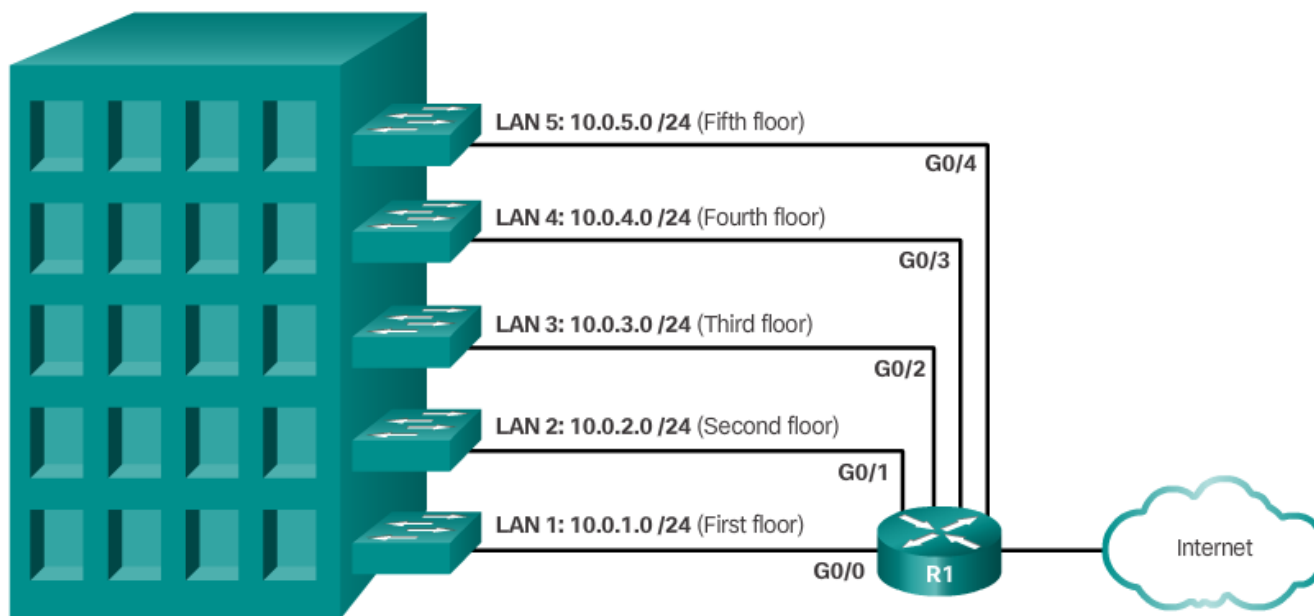
Problems with Large Broadcast Domains (cont.)

- Solution -reduce the size of the network to create smaller broadcast domains in a process called *subnetting*.
- These smaller network spaces are called *subnets*.



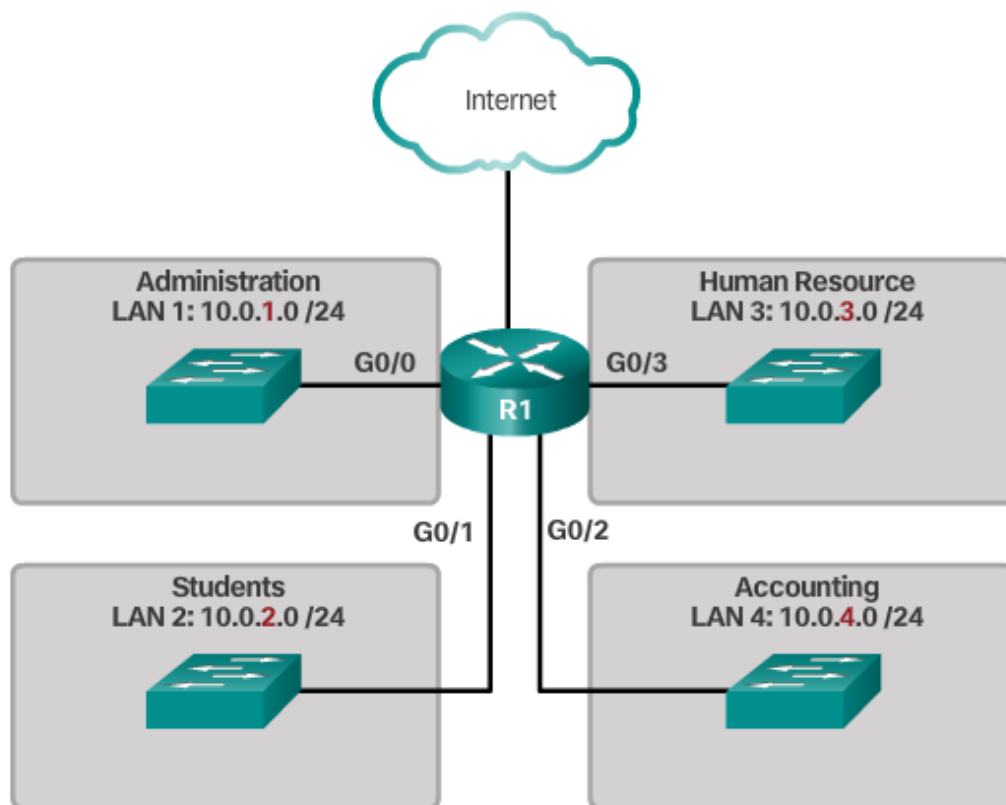
Reasons for Subnetting

Network administrators can group devices and services into subnets that are determined by: Location



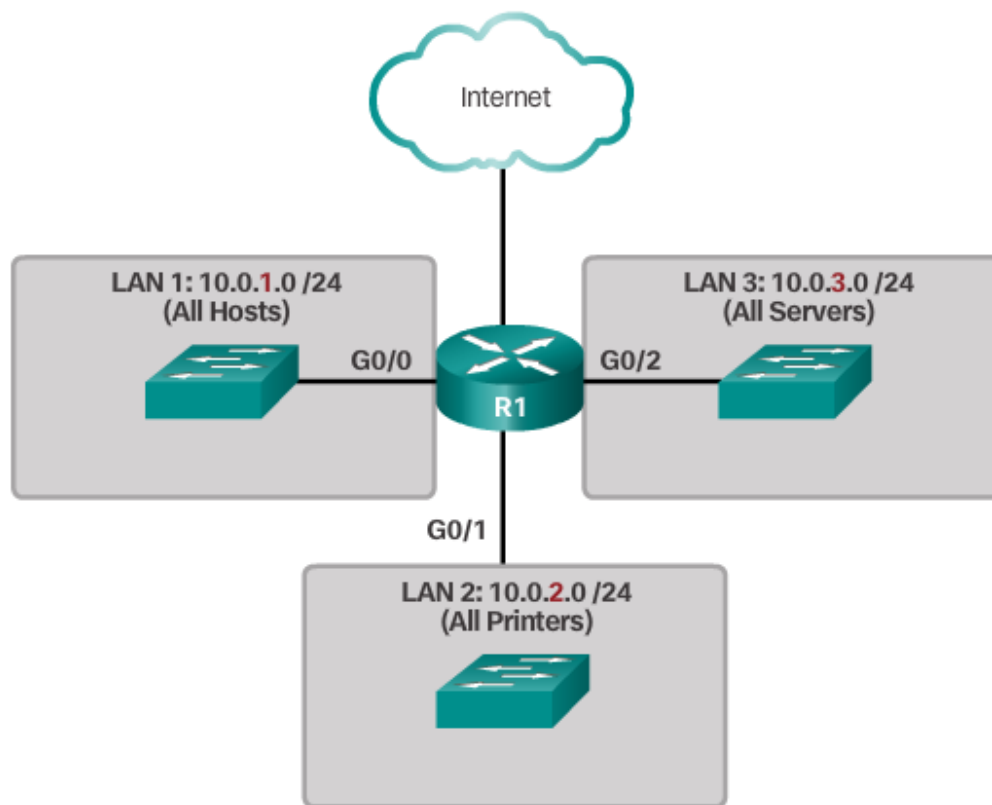
Reasons for Subnetting (cont.)

Network administrators can group devices and services into subnets that are determined by: Organizational unit.



Reasons for Subnetting (cont.)

Network administrators can group devices and services into subnets that are determined by: Device type.



Octet Boundaries

Subnetting Networks on the Octet Boundary

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of hosts
/8	255.0.0.0	nnnnnnnn . hhhhhhhh. hhhhhhhh. hhhhhhhh 11111111. 00000000. 00000000. 00000000	16,777,214
/16	255.255.0.0	nnnnnnnn . nnnnnnnn . hhhhhhhh. hhhhhhhh 11111111. 11111111. 00000000. 00000000	65,534
/24	255.255.255.0	nnnnnnnn . nnnnnnnn . nnnnnnnn . hhhhhhhh 11111111. 11111111. 11111111. 00000000	254

Subnetting on the Octet Boundary

Subnetting 10.x.0.0/16

Subnet Address (256 Possible Subnets)	Host Range (65,534 possible hosts per subnet)	Broadcast
<u>10.0.0.0/16</u>	<u>10.0.0.1</u> – <u>10.0.255.254</u>	<u>10.0.255.255</u>
<u>10.2.0.0/16</u>	<u>10.2.0.1</u> – <u>10.2.255.254</u>	<u>10.2.255.255</u>
<u>10.3.0.0/16</u>	<u>10.3.0.1</u> – <u>10.3.255.254</u>	<u>10.3.255.255</u>
<u>10.4.0.0/16</u>	<u>10.4.0.1</u> – <u>10.4.255.254</u>	<u>10.4.255.255</u>
<u>10.5.0.0/16</u>	<u>10.5.0.1</u> – <u>10.5.255.254</u>	<u>10.5.255.255</u>
<u>10.6.0.0/16</u>	<u>10.6.0.1</u> – <u>10.6.255.254</u>	<u>10.6.255.255</u>
<u>10.7.0.0/16</u>	<u>10.7.0.1</u> – <u>10.7.255.254</u>	<u>10.7.255.255</u>
...
<u>10.255.0.0/16</u>	<u>10.255.0.1</u> – <u>10.255.255.254</u>	<u>10.255.255.255</u>

Subnetting 10.x.x.0/24

Subnet Address (65,536 Possible Subnets)	Host Range (254 possible hosts per subnet)	Broadcast
<u>10.0.0.0/24</u>	<u>10.0.0.1</u> – <u>10.0.0.254</u>	<u>10.0.0.255</u>
<u>10.0.1.0/24</u>	<u>10.0.1.1</u> – <u>10.0.1.254</u>	<u>10.0.1.255</u>
<u>10.0.2.0/24</u>	<u>10.0.2.1</u> – <u>10.0.2.254</u>	<u>10.0.2.255</u>
...
<u>10.0.255.0/24</u>	<u>10.0.255.1</u> – <u>10.0.255.254</u>	<u>10.0.255.255</u>
<u>10.1.0.0/24</u>	<u>10.1.0.1</u> – <u>10.1.0.254</u>	<u>10.1.0.255</u>
<u>10.1.1.0/24</u>	<u>10.1.1.1</u> – <u>10.1.1.254</u>	<u>10.1.1.255</u>
<u>10.1.2.0/24</u>	<u>10.1.2.1</u> – <u>10.1.2.254</u>	<u>10.1.2.255</u>
...
<u>10.100.0.0/24</u>	<u>10.100.0.1</u> – <u>10.100.0.254</u>	<u>10.100.0.255</u>
...
<u>10.255.255.0/24</u>	<u>10.255.255.1</u> – <u>10.255.255.254</u>	<u>10.255.255.255</u>

Classless Subnetting


- /25 – Borrowing 1 bit from the fourth octet creates 2 subnets supporting 126 hosts each.
- /26 – Borrowing 2 bits creates 4 subnets supporting 62 hosts each.
- /27 – Borrowing 3 bits creates 8 subnets supporting 30 hosts each.
- /28 – Borrowing 4 bits creates 16 subnets supporting 14 hosts each.
- /29 – Borrowing 5 bits creates 32 subnets supporting 6 hosts each.
- /30 – Borrowing 6 bits creates 64 subnets supporting 2 hosts each.

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of subnets	# of hosts
/25	255.255.255.128	nnnnnnnn . nnnnnnnn . nnnnnnnn . nhhhhhhh 11111111 . 11111111 . 11111111 . 10000000	2	126
/26	255.255.255.192	nnnnnnnn . nnnnnnnn . nnnnnnnn . nnhhhhhh 11111111 . 11111111 . 11111111 . 11000000	4	62
/27	255.255.255.224	nnnnnnnn . nnnnnnnn . nnnnnnnn . nnnhhhhh 11111111 . 11111111 . 11111111 . 11100000	8	30
/28	255.255.255.240	nnnnnnnn . nnnnnnnn . nnnnnnnn . nnnnhhhh 11111111 . 11111111 . 11111111 . 11110000	16	14
/29	255.255.255.248	nnnnnnnn . nnnnnnnn . nnnnnnnn . nnnnnhhh 11111111 . 11111111 . 11111111 . 11111000	32	6
/30	255.255.255.252	nnnnnnnn . nnnnnnnn . nnnnnnnn . nnnnnnhh 11111111 . 11111111 . 11111111 . 11111100	64	2

Classless Subnetting Example

192.168.1.0/25 Network

Borrow 1 bit from the host portion of the address.



Original	192 .	168 .	1 .	0	000	0000	1 Network
Mask	255 .	255 .	255 .	0	000	0000	

The borrowed bit value is **0** for the Net 0 address.

Net 0	192 .	168 .	1 .	0	000	0000	2 Subnets
Net 1	192 .	168 .	1 .	1	000	0000	

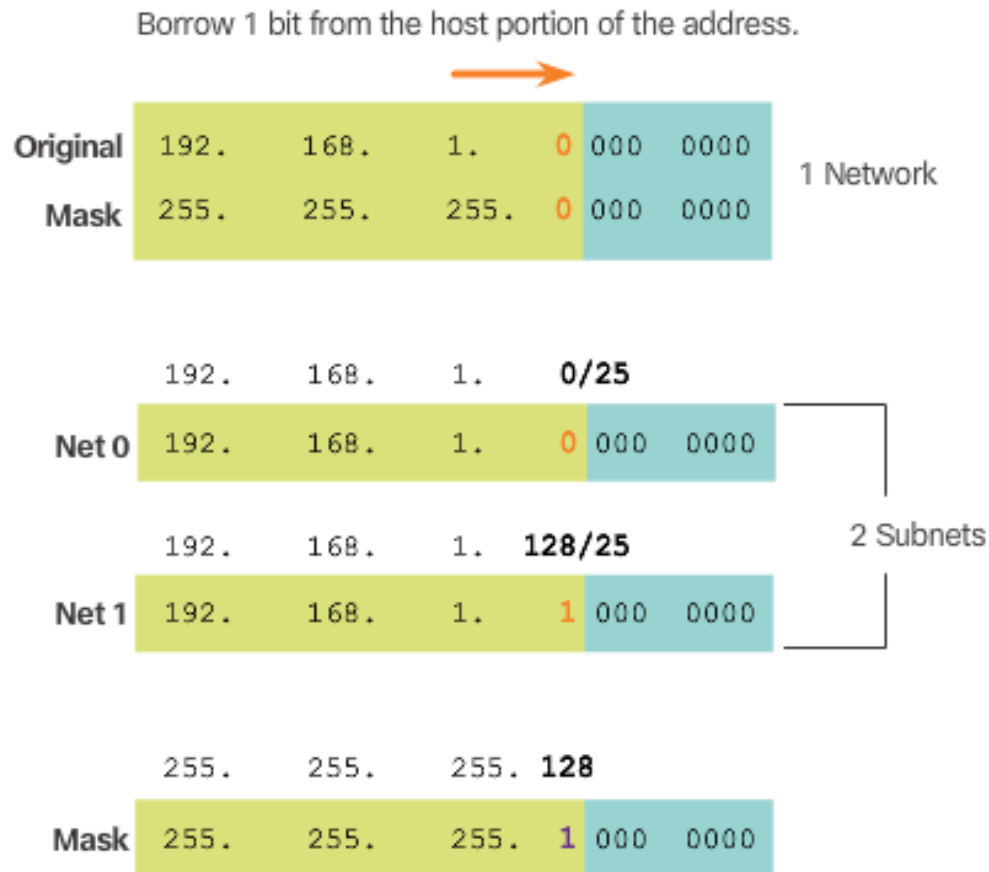
The borrowed bit value is **1** for the Net 1 address.

The new subnets have the **SAME** subnet mask.

Mask	255 .	255 .	255 .	1	000	0000
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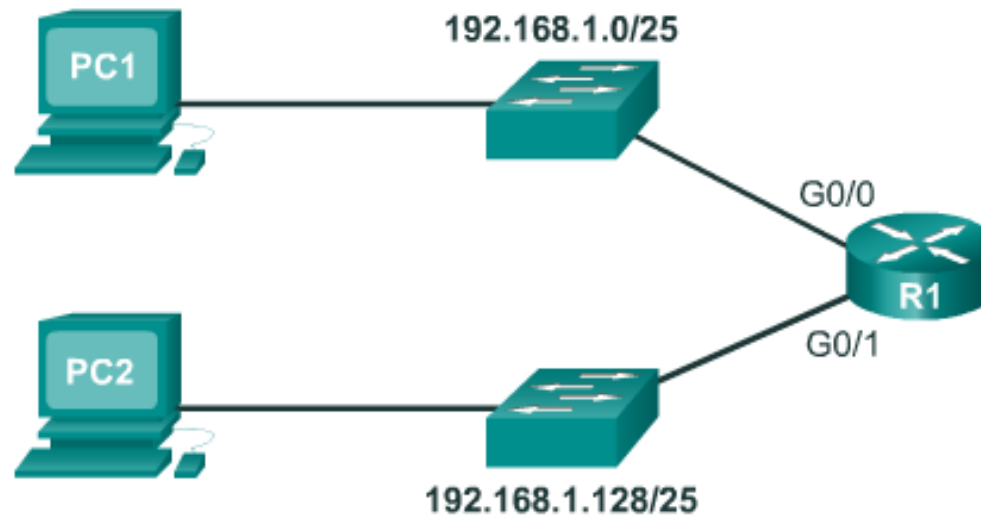
Classless Subnetting Example (cont.)

Dotted Decimal Addresses



Creating 2 Subnets

/25 Subnetting Topology



Creating 2 Subnets (cont.)

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

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

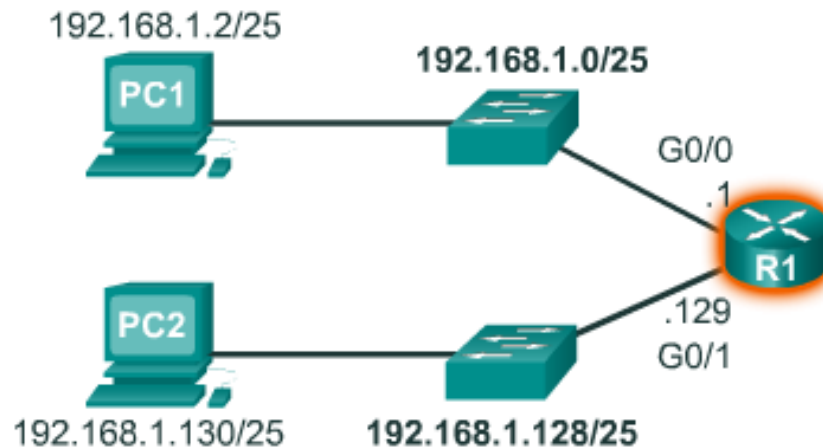
192. 168. 1. 1 111 1110 = 192.168.1.254

Broadcast Address

192. 168. 1. 1 111 1111 = 192.168.1.255

Creating 2 Subnets (cont.)

Configure R1 Gigabit Interfaces



```
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
```

Creating 2 Subnets (cont.)

Assign a Valid Host IP Address

The screenshot shows the 'Internet Protocol Version 4 (TCP/IPv4) Properties' dialog box with the 'General' tab selected. The dialog box contains instructions on how to obtain IP settings and two main configuration sections. In the first section, 'Obtain an IP address automatically' is unselected, and 'Use the following IP address:' is selected. Below this, the 'IP address' field is set to '192 . 168 . 1 . 130', the 'Subnet mask' is '255 . 255 . 255 . 128', and the 'Default gateway' is '192 . 168 . 1 . 129'. In the second section, 'Obtain DNS server address automatically' is unselected, and 'Use the following DNS server addresses' is selected. Below this, the 'Preferred DNS server' and 'Alternate DNS server' fields are both empty, showing only the dots for IP address format. At the bottom, there is a checkbox for 'Validate settings upon exit' which is unchecked, and an 'Advanced...' button. The 'OK' and 'Cancel' buttons are at the bottom right.

Internet Protocol Version 4 (TCP/IPv4) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

☐ Obtain an IP address automatically

☒ Use the following IP address:

IP address: 192 . 168 . 1 . 130

Subnet mask: 255 . 255 . 255 . 128

Default gateway: 192 . 168 . 1 . 129

☐ Obtain DNS server address automatically

☒ Use the following DNS server addresses

Preferred DNS server: . . .

Alternate DNS server: . . .

☐ Validate settings upon exit

Advanced...

OK Cancel

Subnetting Formulas

To calculate the number of subnets.

$$2^n$$

n = bits borrowed

192 . 168 . 1 . 0

nnnnnnnn . nnnnnnnn . nnnnnnnn . hhhhhhhh

Borrowing 1 bit:	$2^1 = 2$	←
Borrowing 2 bits:	$2^2 = 4$	←
Borrowing 3 bits:	$2^3 = 8$	←
Borrowing 4 bits:	$2^4 = 16$	←
Borrowing 5 bits:	$2^5 = 32$	←
Borrowing 6 bits:	$2^6 = 64$	←

Subnetting Formulas (cont.)

To calculate the number of hosts.

$$2^n - 2$$

n = the number of bits remaining in the host field

192. 168. 1. 0 000 0000



7 bits remain in host field

$$2^7 = 128 \text{ hosts per subnet}$$
$$2^7 - 2 = 126 \text{ valid hosts per subnet}$$