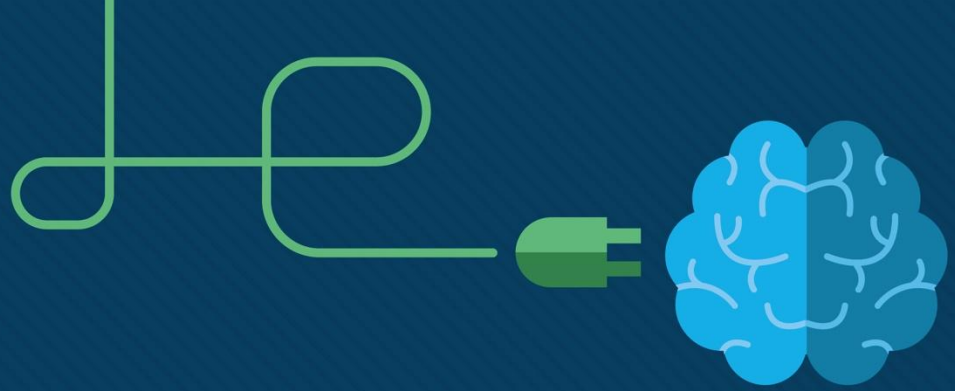


Module 1: IP Addressing & Subnetting.

BinhBT, UIT

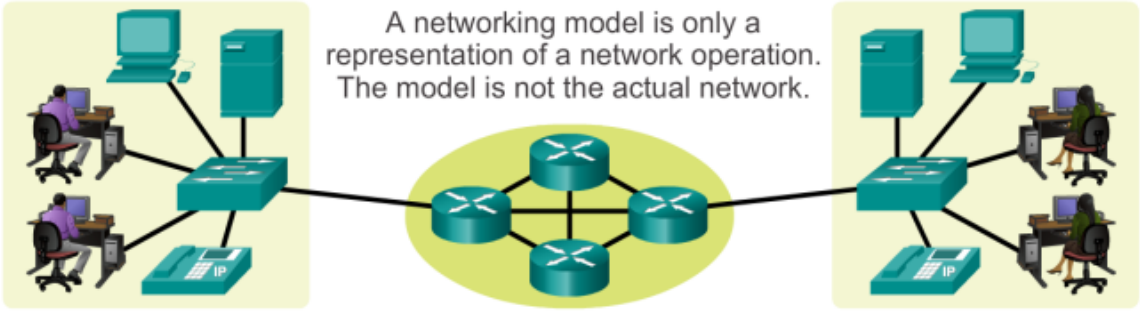
Module Objectives

Module Title: IP Addressing & Subnetting
Module Objective: Explain IPv4 and how to subnetting IP Address.

Topic Title	Topic Objective
IP Addressing verson 4	
Subnet Mask	
IP class	
IP Private and IP Public	
Subnetting IP Address	

1.0 Computer Network

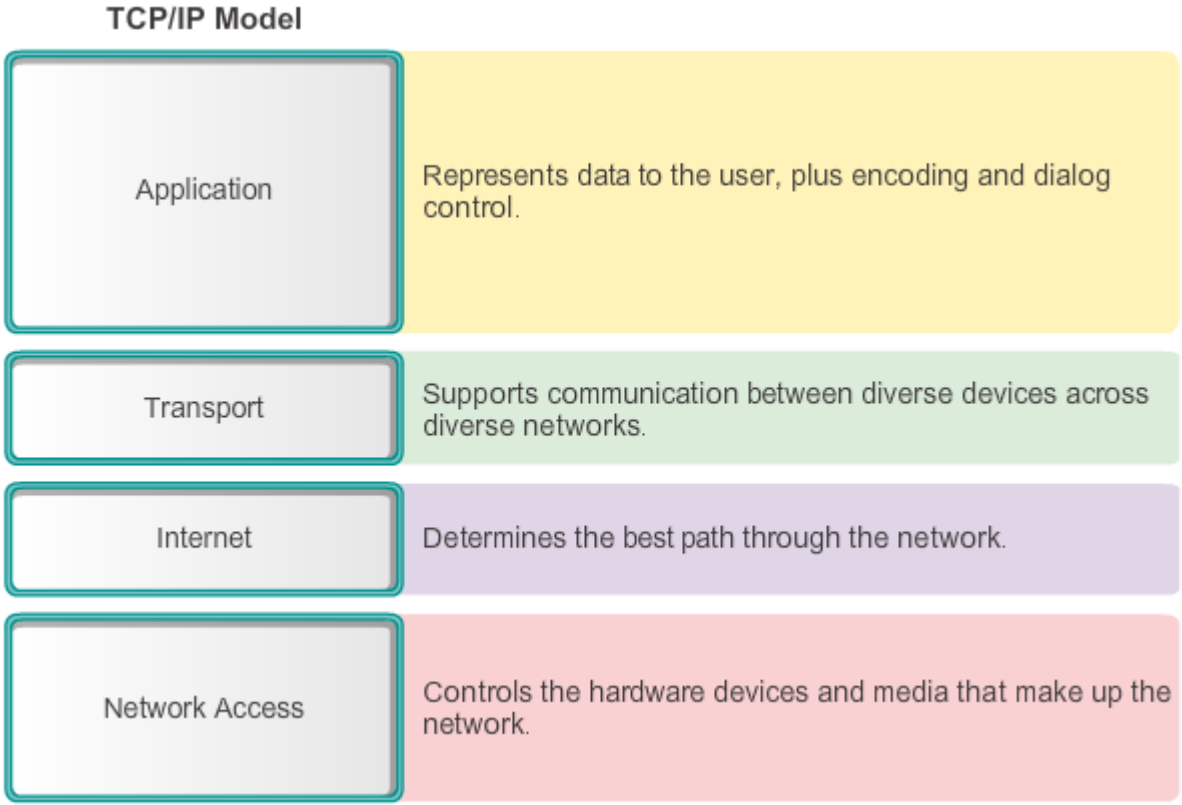
Benefits of Using a Layered Model



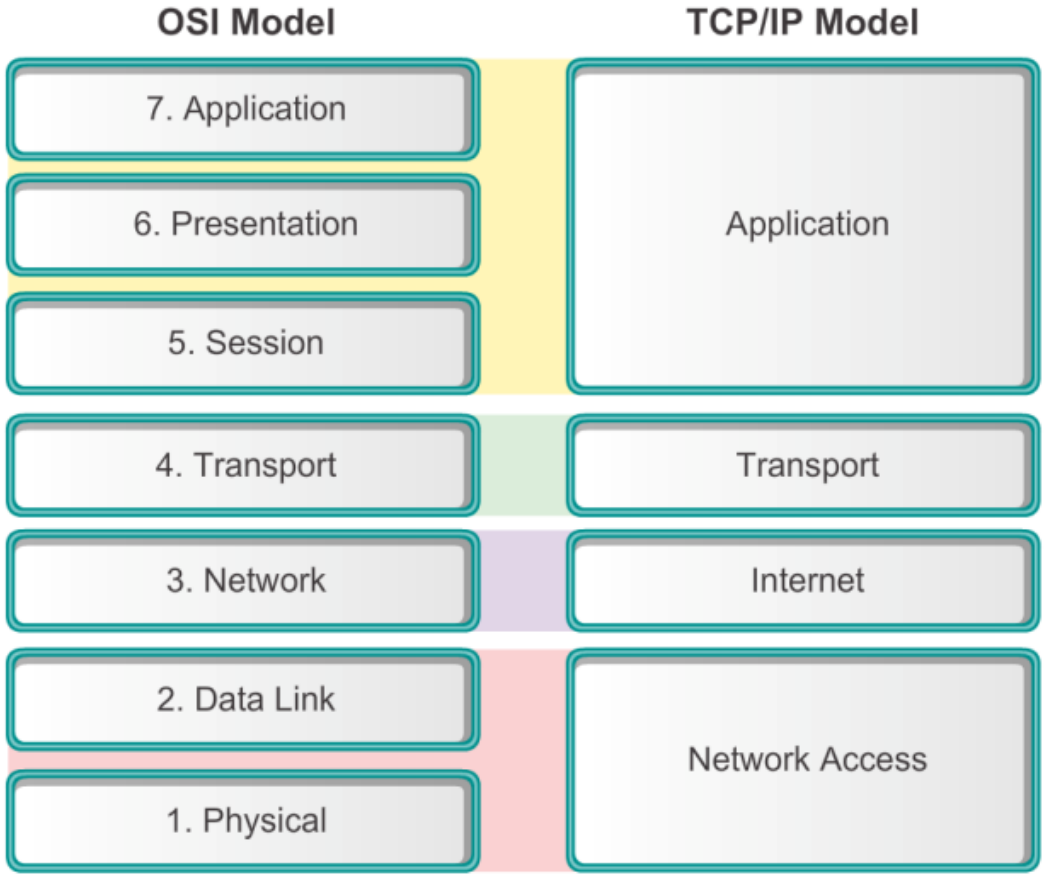
OSI Model	TCP/IP Protocol Suite	TCP/IP Model
Application	HTTP, DNS, DHCP, FTP	Application
Presentation		
Session		
Transport	TCP, UDP	Transport
Network	IPv4, IPv6, ICMPv4, ICMPv6	Internet
Data Link	PPP, Frame Relay, Ethernet	Network Access
Physical		

The OSI Reference Model

The TCP/IP Reference Model

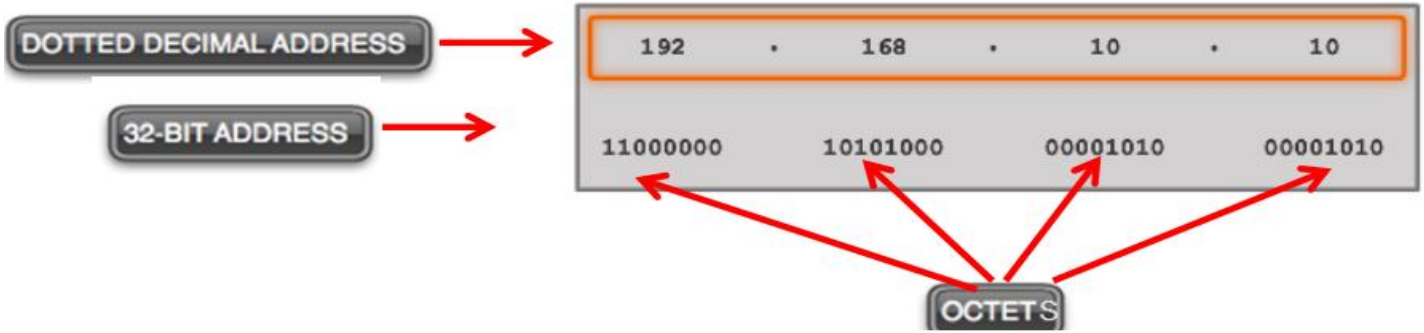


Comparing the OSI and TCP/IP Models



1.1 IPv4 Network Address

Binary Number System



Radix	2	2	2	2	2	2	2	2
Exponent	7	6	5	4	3	2	1	0
Octet Bit Values	128	64	32	16	8	4	2	1
Binary Address	1	1	0	0	0	0	0	0
Binary Bit Values	128	64	0	0	0	0	0	0

Add the binary bit values. 128 + 64 = 192

Converting a Binary Address to Decimal

Practice

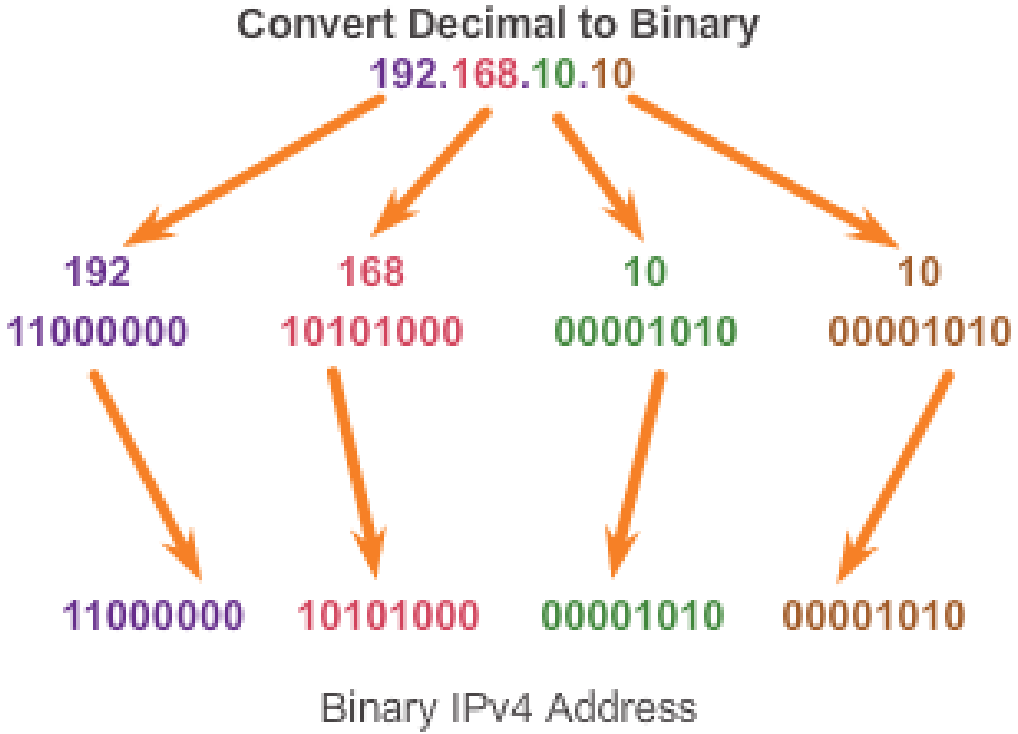
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	0	1	1	0	0	0	0

Answer = 176

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	1	1	1	1	1	1

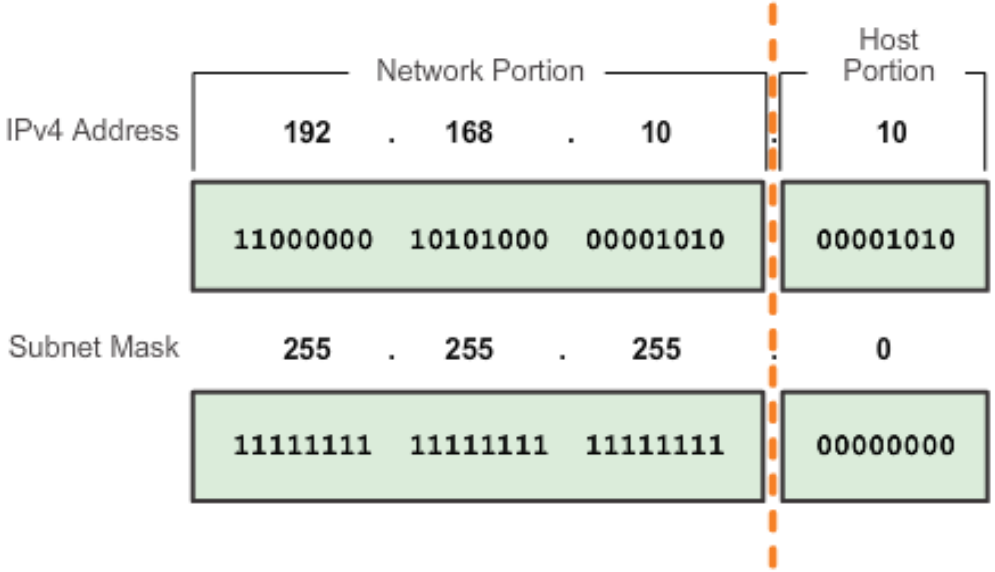
Answer = 255

Converting a Binary Address to Decimal



Network Portion and Host Portion of an IPv4 Address

- To define the network and host portions of an address, a devices use a separate 32-bit pattern called a subnet mask
- The subnet mask does not actually contain the network or host portion of an IPv4 address, it just says where to look for these portions in a given IPv4 address



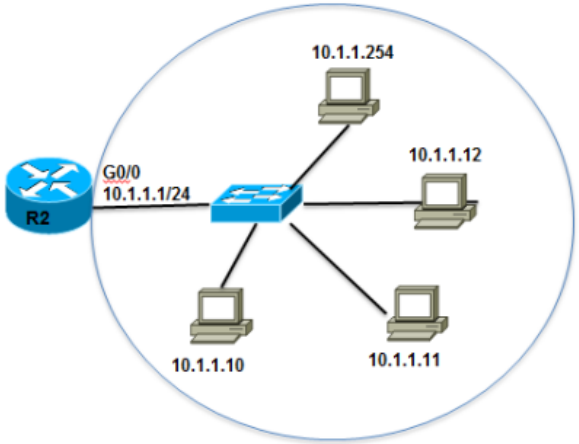
Network Portion and Host Portion of an IPv4 Address

	Dotted Decimal	Significant bits shown in binary
Network Address	**10.1.1.0/24**	**10.1.1.00000000**
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.254	10.1.1.11111110
Broadcast Address	10.1.1.255	10.1.1.11111111
Number of hosts: 2^8 – 2 = 254 hosts		

Network Address	**10.1.1.0/25**	**10.1.1.00000000**
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.126	10.1.1.01111110
Broadcast Address	10.1.1.127	10.1.1.01111111
Number of hosts: 2^7 – 2 = 126 hosts		

Network Address	**10.1.1.0/26**	**10.1.1.00000000**
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.62	10.1.1.00111110
Broadcast Address	10.1.1.63	10.1.1.00111111
Number of hosts: 2^6 – 2 = 62 hosts		

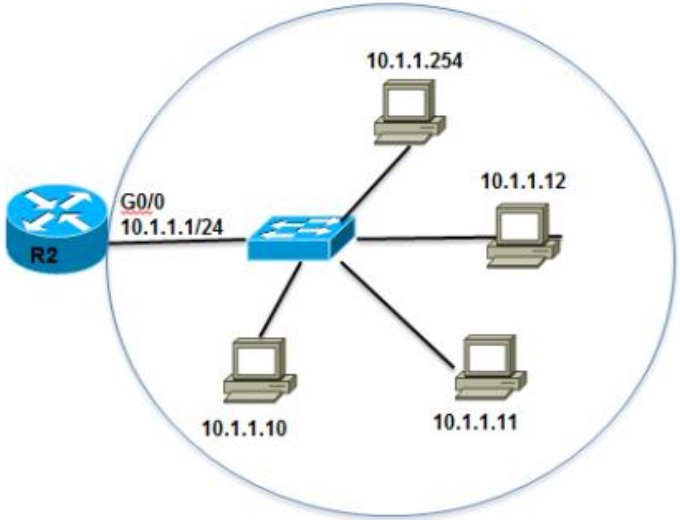
IPv4 Network. Host. and Broadcast Address



10.1.1.0/24

Network Portion			Host Portion	
10	1	1	0	
00001010	00000001	00000001	00000000	All 0s – NETWORK ADDRESS
10	1	1	10	
00001010	00000001	00000001	00001010	0s and 1s in host portion
10	1	1	255	
00001010	00000001	00000001	11111111	All 1s – BROADCAST ADDRESS

First Host and Last Host Addresses

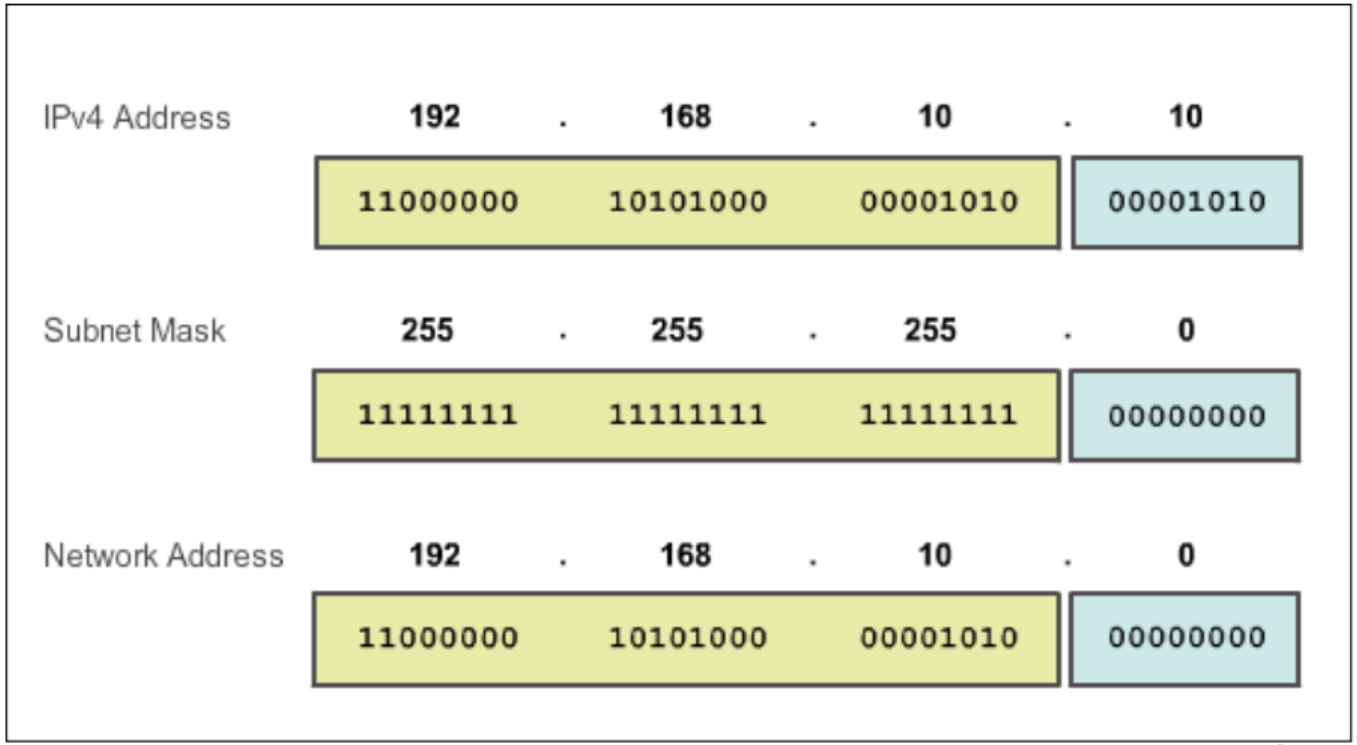


10.1.1.0/24

Network Portion			Host Portion	
10	1	1	1	FIRST HOST
00001010	00000001	00000001	00000001	All 0s and a 1 in the host portion
10	1	1	254	LAST HOST
00001010	00000001	00000001	11111110	All 1s and a 0 in the host portion

Bitwise AND Operation

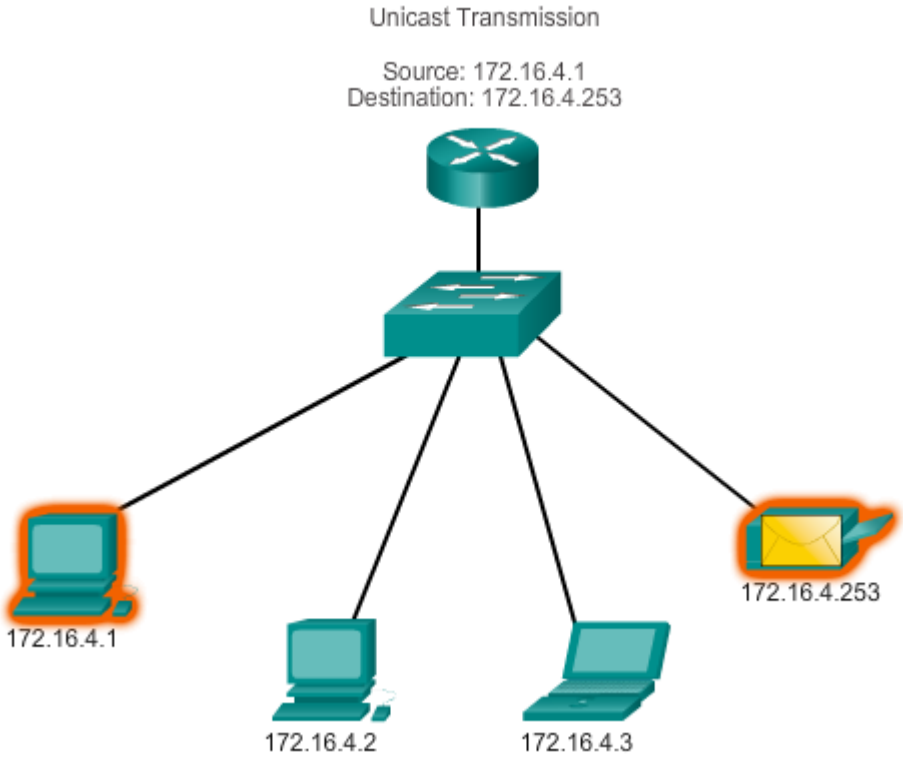
1 AND 1 = 1 1 AND 0 = 0 0 AND 1 = 0 0 AND 0 = 0



Unicast Transmission

In an IPv4 network, the hosts can communicate one of three different ways: **Unicast**, Broadcast, and Multicast

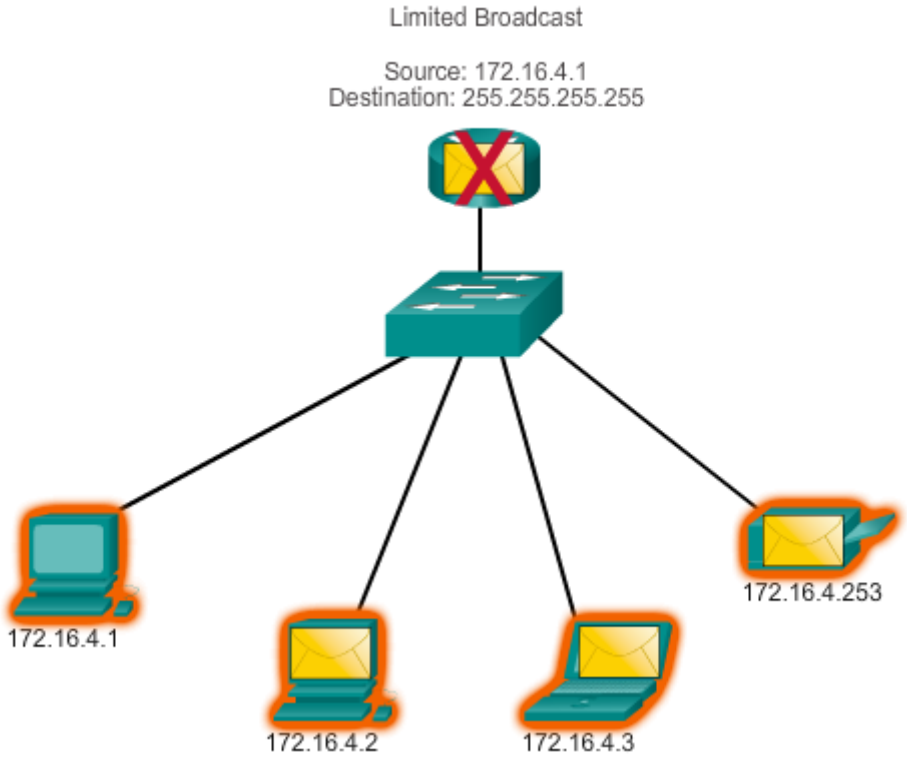
#1 Unicast – the process of sending a packet from one host to an individual host.



Broadcast Transmission

In an IPv4 network, the hosts can communicate one of three different ways: **Unicast**, Broadcast, and Multicast

#2 Broadcast – the process of sending a packet from one host to all hosts in the network.



Multicast Transmission

In an IPv4 network, the hosts can communicate one of three different ways: **Unicast**, Broadcast, and Multicast

#3 Multicast – The process of sending a packet from one host to a selected group of hosts, possibly in different networks.

Types of IPv4 Address

Classful Addressing

IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)	Number of possible networks and hosts per network
A	1-127**	00000000-01111111	N.H.H.H	255.0.0.0	128 nets (2^7) 16,777,214 hosts per net (2^24-2)
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0	16,384 nets (2^14) 65,534 hosts per net (2^16-2)
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0	2,097,150 nets (2^21) 254 hosts per net (2^8-2)
D	224-239	11100000-11101111	NA (multicast)		
E	240-255	11110000-11111111	NA (experimental)		

Classless Addressing

Classless Addressing

- Formal name is Classless Inter-Domain Routing (CIDR, pronounced
“cider
- Created a new set of standards that allowed service providers to allocate IPv4 addresses on any address bit boundary (prefix length) instead of only by a class A, B, or C address

Public and Private IPv4 Addresses

Private address blocks are:

- Hosts that do not require access to the Internet can use private addresses
- 10.0.0.0 to 10.255.255.255 (10.0.0.0/8)
- 172.16.0.0 to 172.31.255.255 (172.16.0.0/12)
- 192.168.0.0 to 192.168.255.255 (192.168.0.0/16)

1.2 Subnetting IP Networks

Reasons for Subnetting

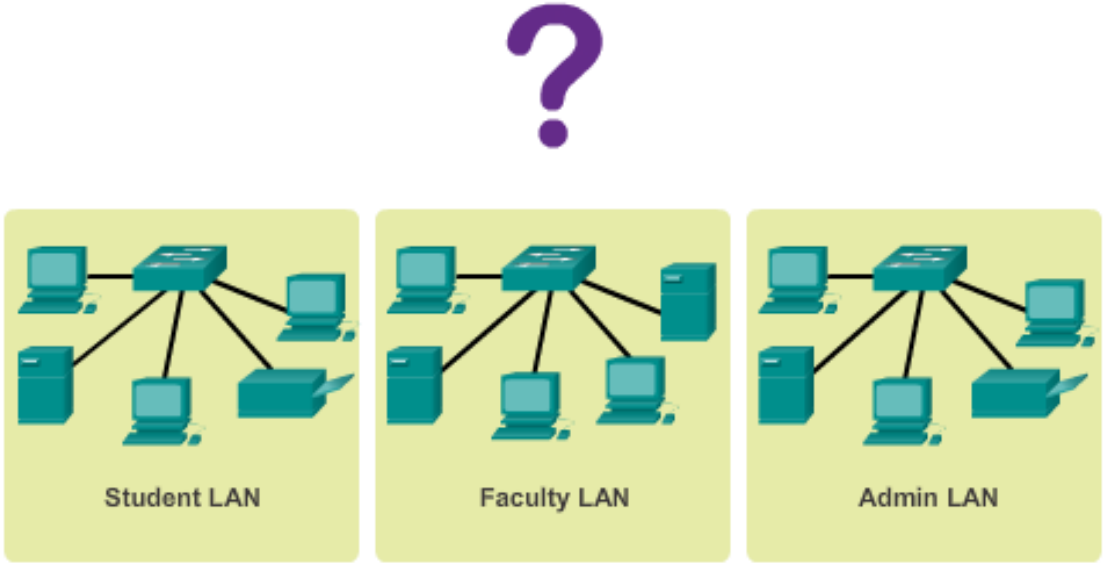
Subnetting is the process of segmenting a network into multiple smaller network spaces called subnetworks or subnets.

- Large networks must be segmented into smaller subnetworks, creating smaller groups of devices and services to:
  - Control traffic by containing broadcast traffic within each subnetwork.
  - Reduce overall network traffic and improve network performance.

Communication Between Subnets

- A router is necessary for devices on different networks and subnets to communicate.
- Each router interface must have an IPv4 host address that belongs to the network or subnet that the router interface is connected.
- Devices on a network and subnet use the router interface attached to their LAN as their default gateway.

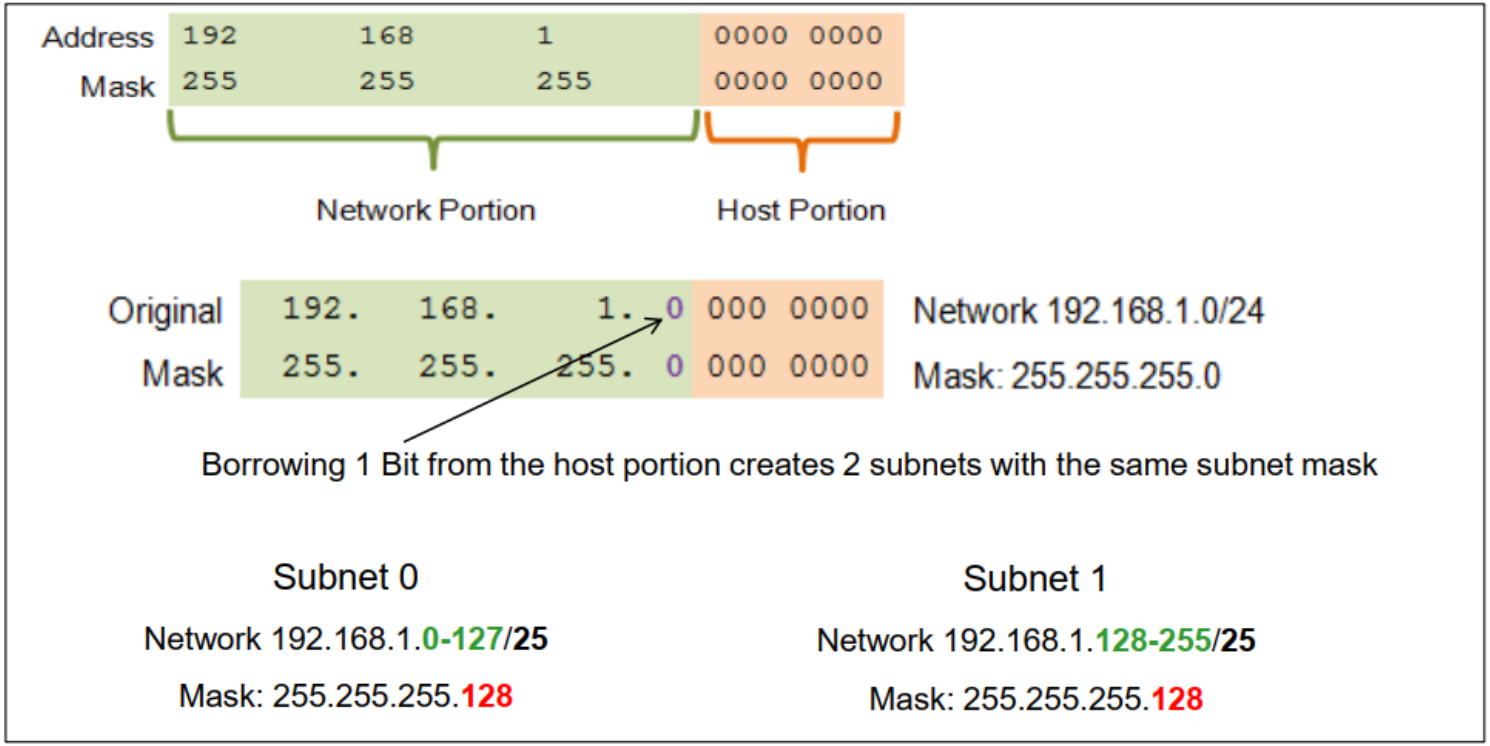
IP Subnetting is FUNdamental
The Plan



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

Basic Subnetting

- Borrowing Bits to Create Subnets
- Borrowing 1 bit 2_1 = 2 subnets

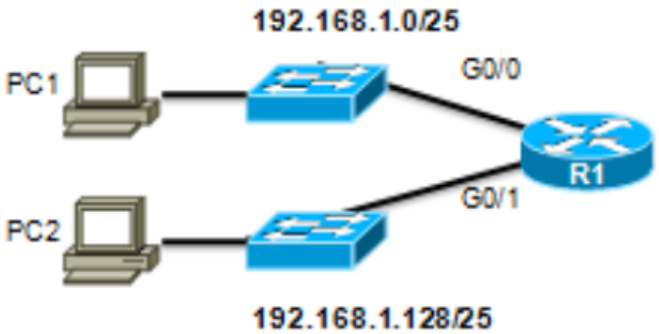


Subnets in Use

Subnets in Use

Subnet 0

Network 192.168.1.0-127/25



Subnet 1

Network 192.168.1.128-255/25

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

Subnetting Formulas

Calculate number of subnets

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

192. 168. 1. 0 000 0000

1 bit was borrowed

2^1 = 2 subnets

Calculate number of hosts

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

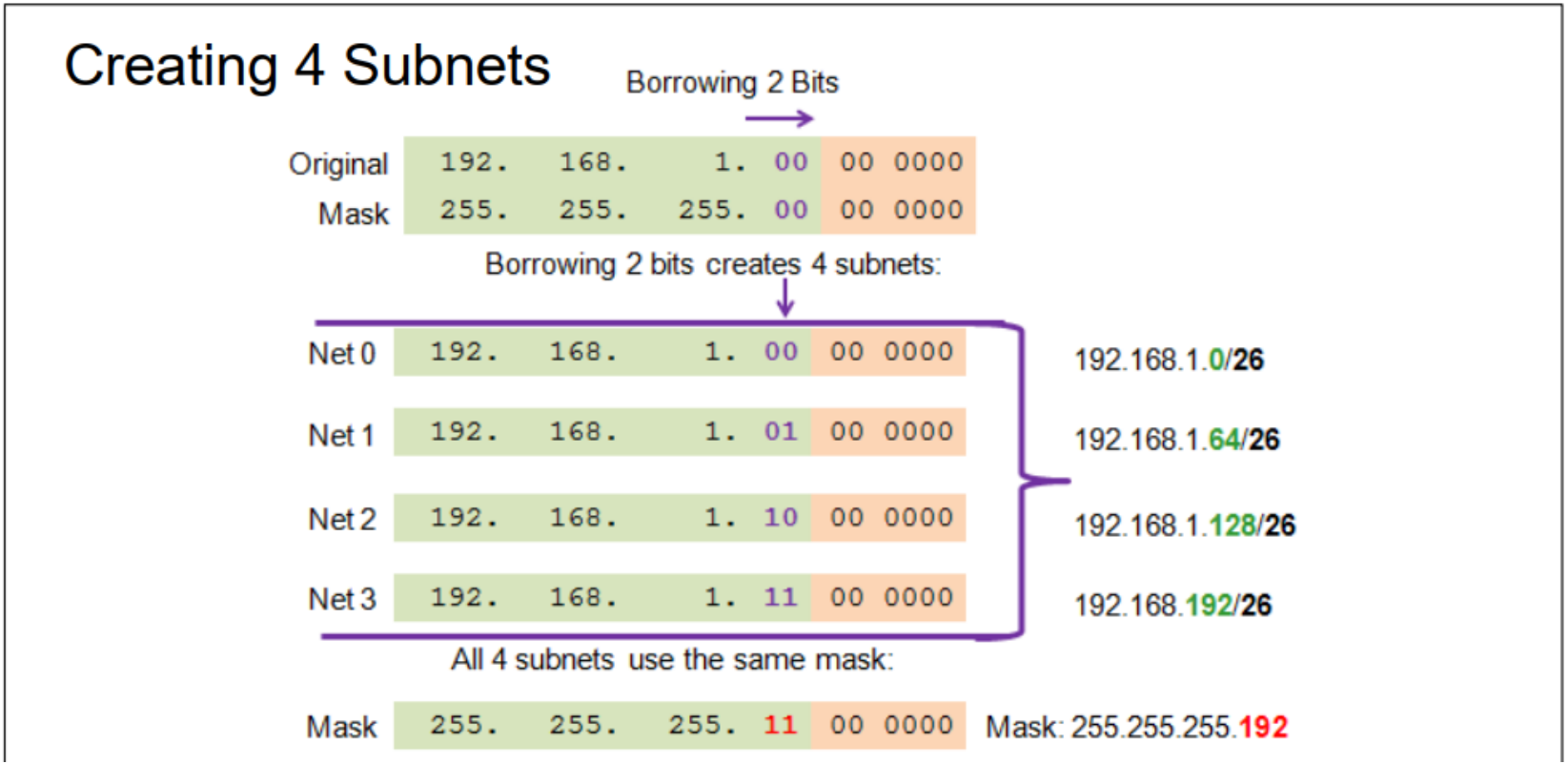
192. 168. 1. 0 000 0000

7 bits remain in host field

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

Creating 4 Subnets

Borrowing 2 bits to create 4 subnets. **2^2 = 4 subnets**



Creating 8 Subnets

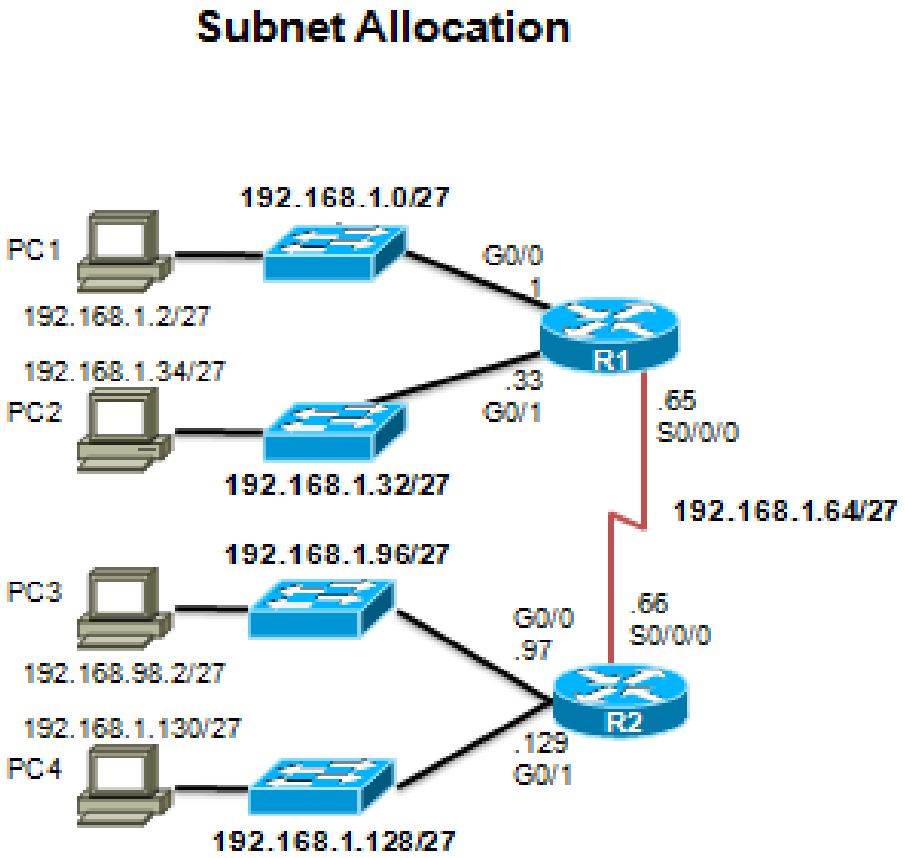
Borrowing 3 bits to **Create 8 Subnets**. $2^3 = 8$ subnets

Net 0	Network	192.	168.	1.	000	0 0000	192.168.1.1
	Fist	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
	Fist	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
	Fist	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.	010	0 0000	192.168.1.96
	Fist	192.	168.	1.	010	0 0001	192.168.1.97
	Last	192.	168.	1.	010	1 1110	192.168.1.126
	Broadcast	192.	168.	1.	010	1 1111	192.168.1.127

Creating 8 Subnets (cont.)

Net 4	Network	192.	168.	1.	100	0 0000	192.168.1.128
	Fist	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
	Fist	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
	Fist	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
	Fist	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

Creating 8 Subnets (cont.)



Subnetting Based on Host Requirements

Two considerations when planning subnets:

- Number of subnets required
- Number of host addresses required

Formula to determine number of usable hosts: 2^n-2

- 2^*n* (where *n* is the number of remaining host bits) is used to calculate the number of hosts.
- -2 (The subnetwork ID and broadcast address cannot be used on each subnet.)

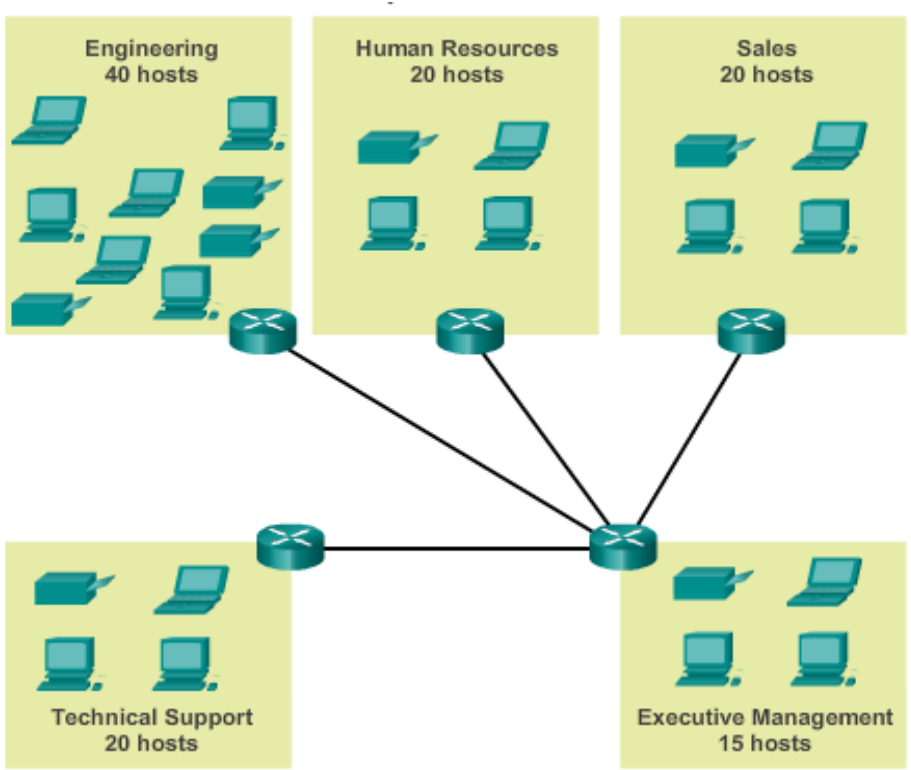
Subnetting Network-Based Requirements

Calculate the number of subnets:

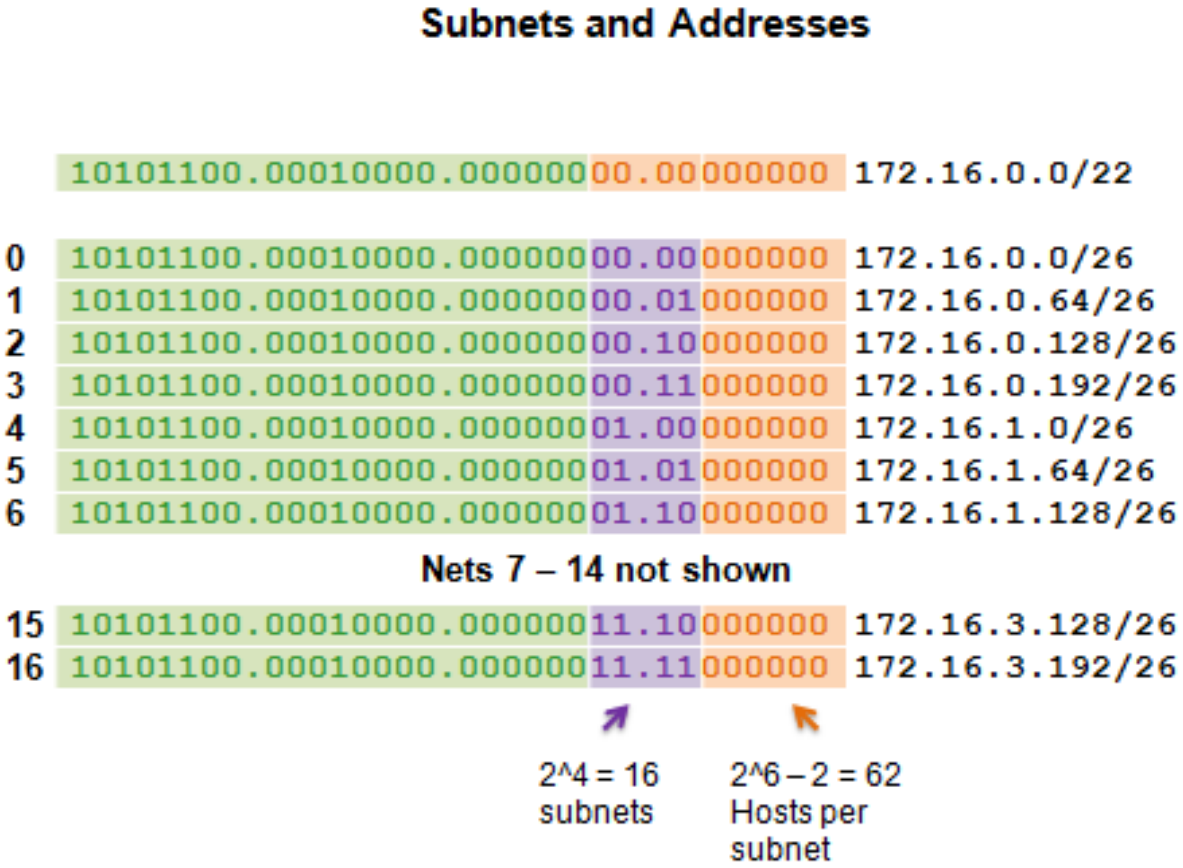
- **2^n** (where n is the number of bits borrowed)
- Subnet needed for each department.

Subnetting To Meet Network Requirements

- Balance the required number of subnets and hosts for the largest subnet.
- Design the addressing scheme to accommodate the maximum number of hosts for each subnet.
- Allow for growth in each subnet.

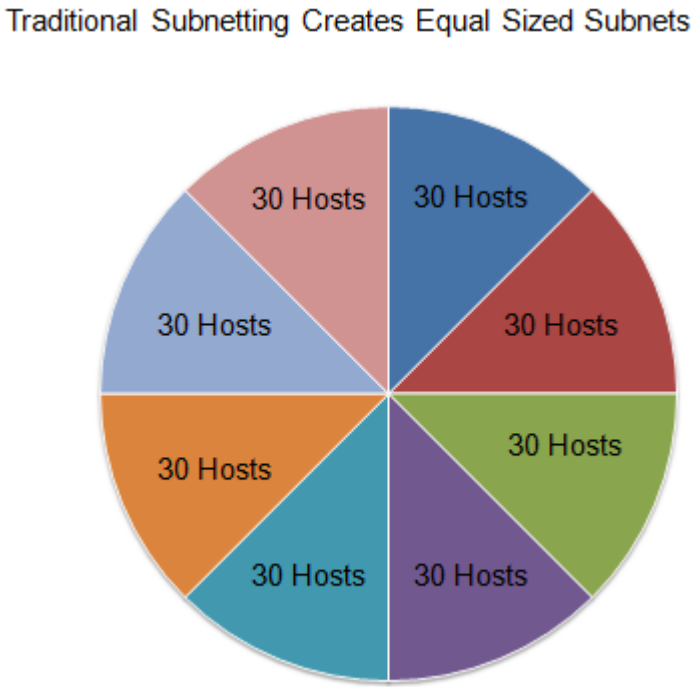


Subnetting To Meet Network Requirements



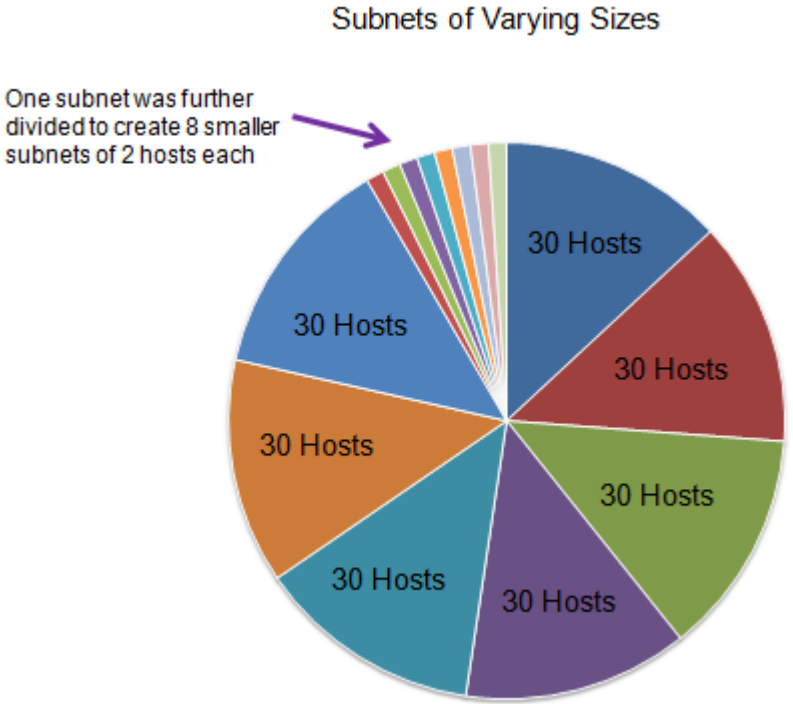
Traditional Subnetting Wastes Addresses

- Traditional subnetting – Uses the same number of addresses is allocated for each subnet.
- Subnets that require fewer addresses have unused (wasted) addresses; for example, WAN links only need two addresses.

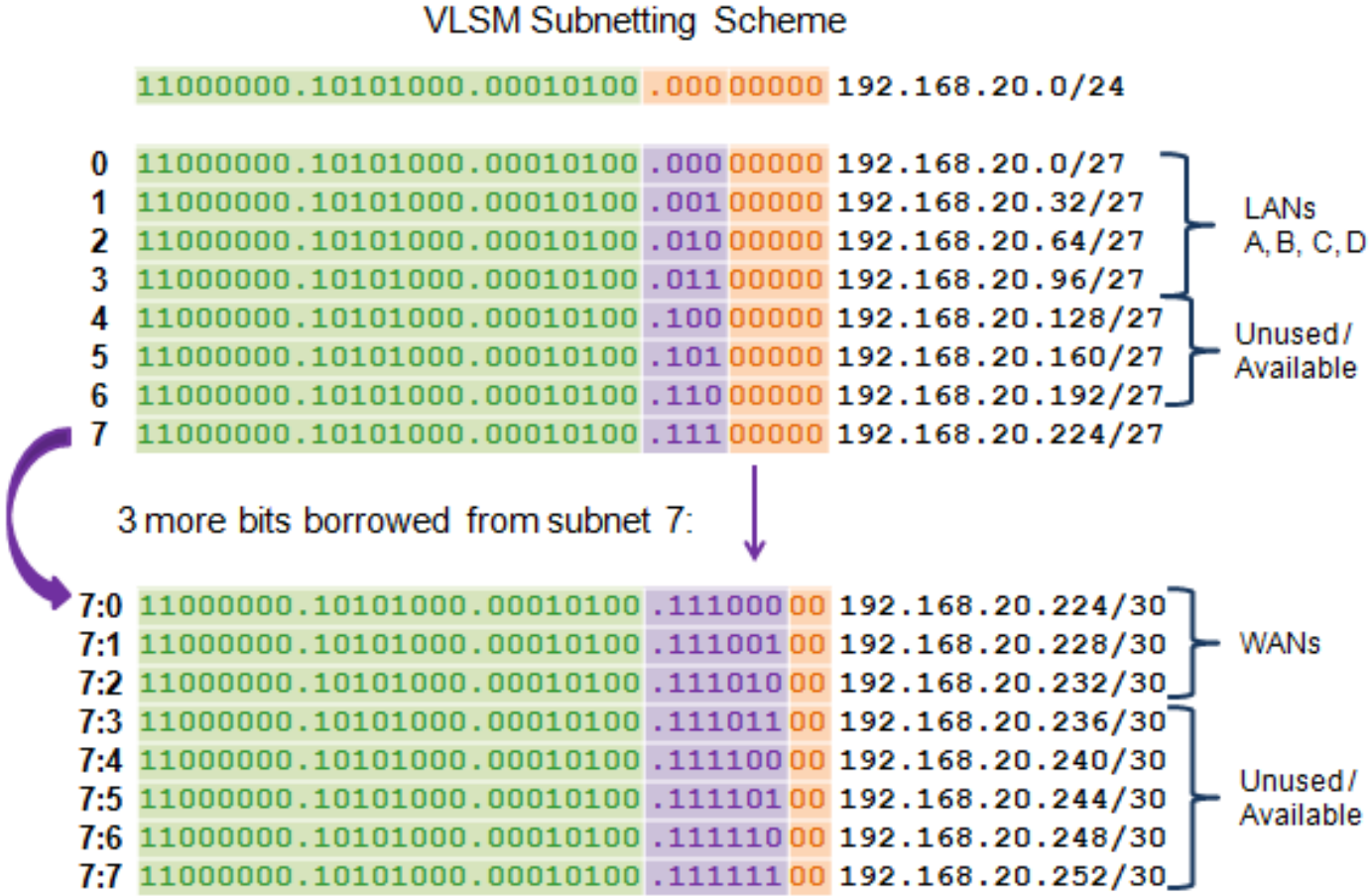


Variable Length Subnet Masks (VLSM)

- The variable-length subnet mask (VLSM) or subnetting a subnet provides more efficient use of addresses.
- VLSM allows a network space to be divided in unequal parts.
- Subnet mask varies, depending on how many bits have been borrowed for a particular subnet.
- Network is first subnetted, and then the subnets are resubnetted.

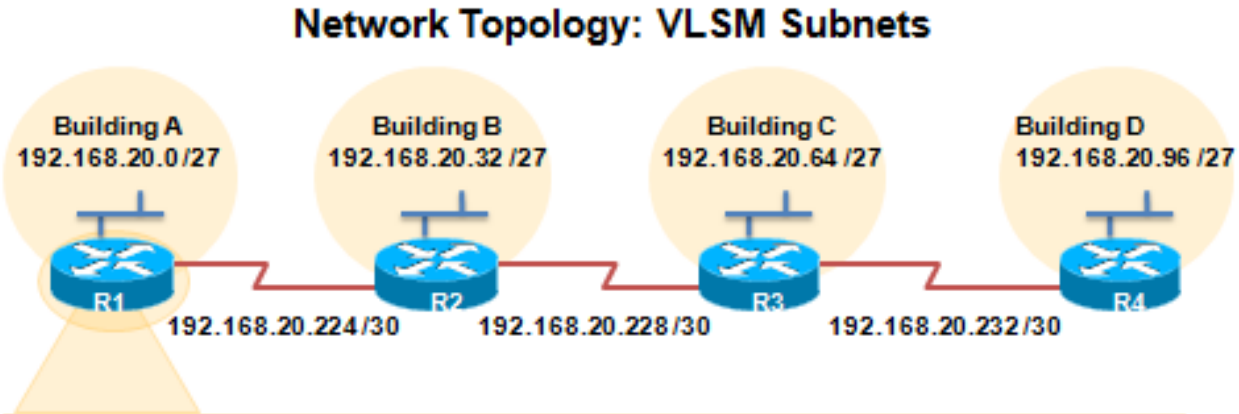


Basic VLSM


VLSM Subnetting Scheme
11000000.10101000.00010100.00000000 192.168.20.0/24
0 11000000.10101000.00010100.00000000 192.168.20.0/27
1 11000000.10101000.00010100.00100000 192.168.20.32/27
2 11000000.10101000.00010100.01000000 192.168.20.64/27
3 11000000.10101000.00010100.01100000 192.168.20.96/27
4 11000000.10101000.00010100.10000000 192.168.20.128/27
5 11000000.10101000.00010100.10100000 192.168.20.160/27
6 11000000.10101000.00010100.11000000 192.168.20.192/27
7 11000000.10101000.00010100.11100000 192.168.20.224/27
LANs A, B, C, D
Unused / Available
3 more bits borrowed from subnet 7:
7:0 11000000.10101000.00010100.11100000 192.168.20.224/30
7:1 11000000.10101000.00010100.11100100 192.168.20.228/30
7:2 11000000.10101000.00010100.11101000 192.168.20.232/30
7:3 11000000.10101000.00010100.11101100 192.168.20.236/30
7:4 11000000.10101000.00010100.11110000 192.168.20.240/30
7:5 11000000.10101000.00010100.11110100 192.168.20.244/30
7:6 11000000.10101000.00010100.11111000 192.168.20.248/30
7:7 11000000.10101000.00010100.11111100 192.168.20.252/30
WANs
Unused / Available

VLSM in Practice

- Using VLSM subnets, the LAN and WAN segments in example below can be addressed with minimum waste.
- Each LANs will be assigned a subnet with /27 mask.
- Each WAN link will be assigned a subnet with /30 mask.




```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.20.1 255.255.255.224
R1(config-if)#exit
R1(config)#interface serial 0/0/0
R1(config-if)#ip address 192.168.20.225 255.255.255.252
R1(config-if)#end
R1#
```

VLSM Chart

VLSM Subnetting of 192.168.20.0 /24

1

2

	/27 Network	Hosts
Bldg A	.0	.1 - .30
Bldg B	.32	.33 - .62
Bldg C	.64	.65 - .94
Bldg D	.96	.97 - .126
Unused	.128	.129 - .158
Unused	.160	.161 - .190
Unused	.192	.193 - .222
	.224	.225 - .254

	/30 Network	Hosts
WAN R1–R2	.224	.225 - .226
WAN R2–R3	.228	.229 - .230
WAN R3–R4	.232	.233 - .234
Unused	.236	.237 - .238
Unused	.240	.241 - .242
Unused	.244	.245 - .246
Unused	.248	.249 - .250
Unused	.252	.253 - .254

Summary

In this chapter, you learned that:

- IPv4 hosts can communicate one of three different ways: unicast, broadcast, and multicast.
- The private IPv4 address blocks are: 10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16.
- Subnetting is the process of segmenting a network, by dividing it into multiple smaller network spaces.
- Subnetting a subnet, or using VLSM, was designed to avoid wasting addresses.
- IPv6 address space is subnetted to support the hierarchical, logical design of the network.
- Size, location, use, and access requirements are all considerations in the address planning process.
- IP networks must be tested to verify connectivity and operational performance.