



Chapter 9: Subnetting IP Networks



Introduction to Networks

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9.1 Subnetting an IPv4 Network



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Network Segmentation

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

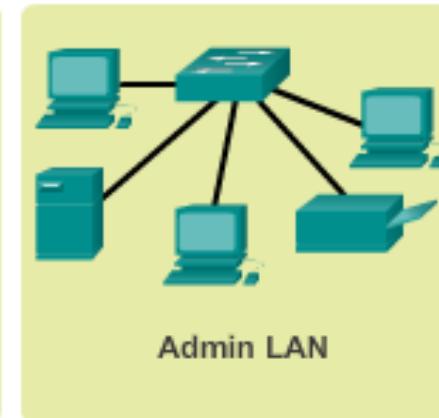
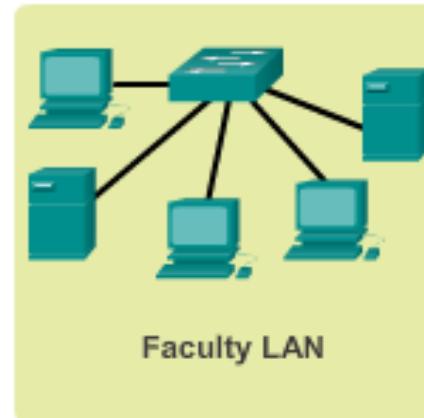
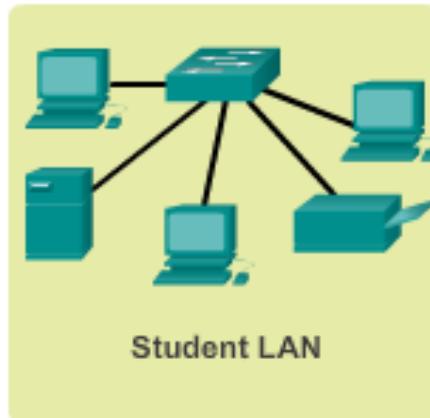
- A router is necessary for devices on different networks and subnets to communicate.
- Each router interface must have an IPv4 host address that belongs to the network or subnet that the router interface is connected.
- Devices on a network and subnet use the router interface attached to their LAN as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



IP Subnetting is FUNdamental

The Plan

Planning the Network



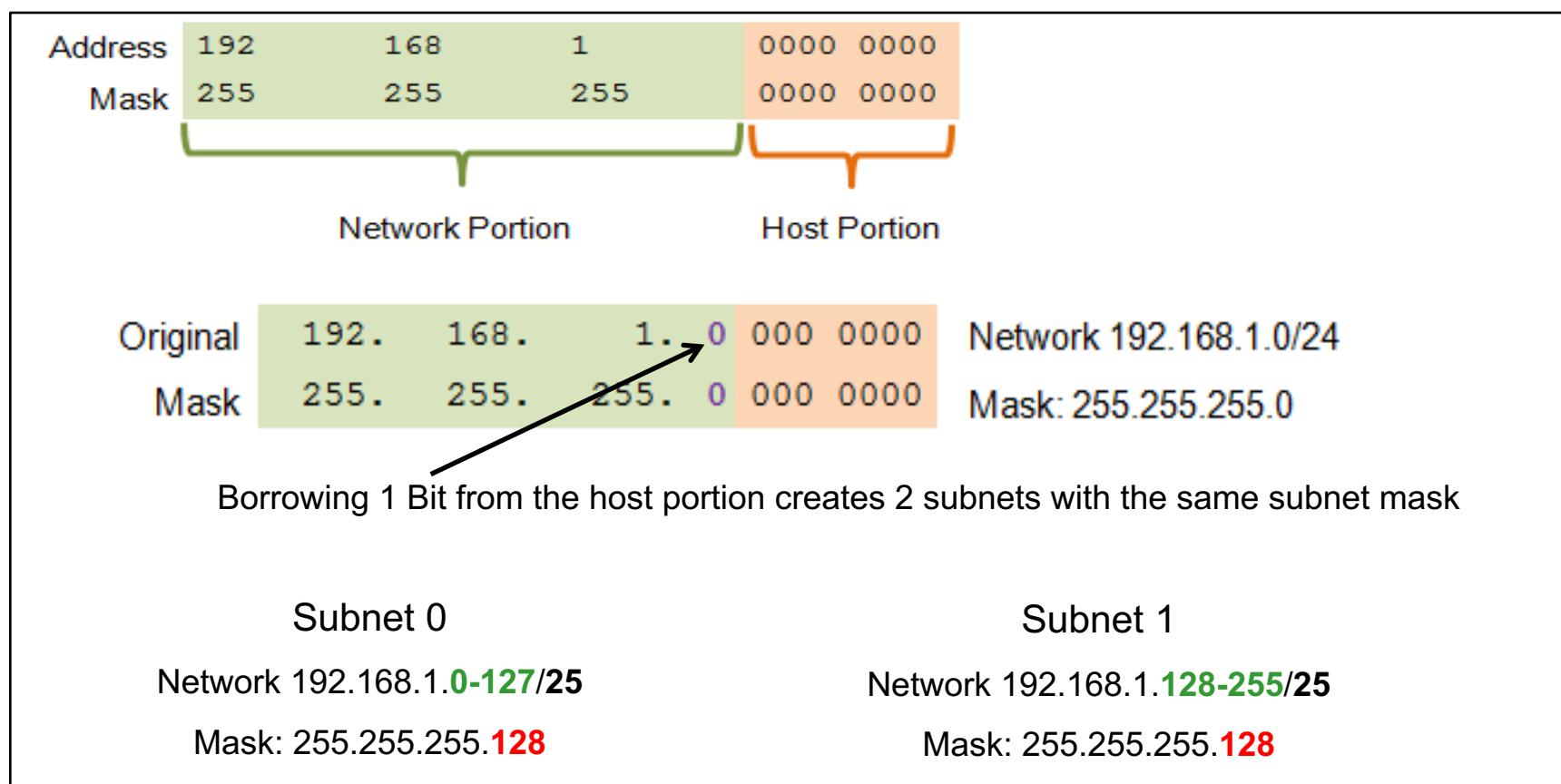
Planning requires decisions on each subnet in terms of size, the number of hosts per subnet, and how host addresses will be assigned.



Subnetting an IPv4 Network

Basic Subnetting

- Borrowing Bits to Create Subnets
- Borrowing 1 bit $2^1 = 2$ subnets





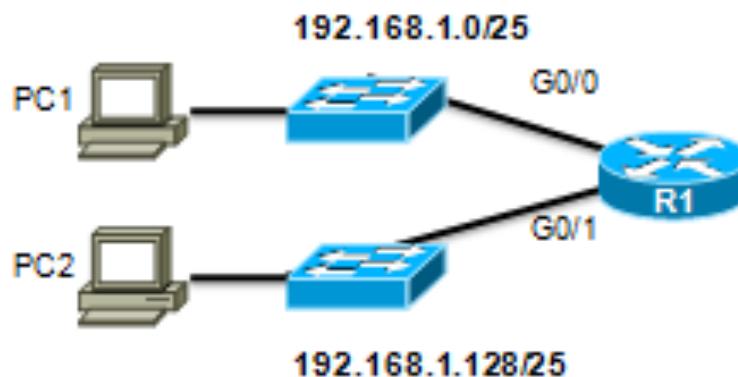
Subnetting an IPv4 Network

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 an IPv4 Network

Subnetting Formulas

$\text{Subnets} = 2^n$
(where n = bits borrowed)

Calculate number of subnets

192. 168. 1. 0 000 0000

↑
1 bit was borrowed

$$2^1 = 2 \text{ subnets}$$

$\text{Hosts} = 2^n$
(where n = host bits remaining)

Calculate number of hosts

192. 168. 1. 0 000 0000

↑
7 bits remain in host field

$$\begin{aligned} 2^7 &= 128 \text{ addresses per subnet} \\ 2^7 - 2 &= 126 \text{ valid hosts per subnet} \end{aligned}$$

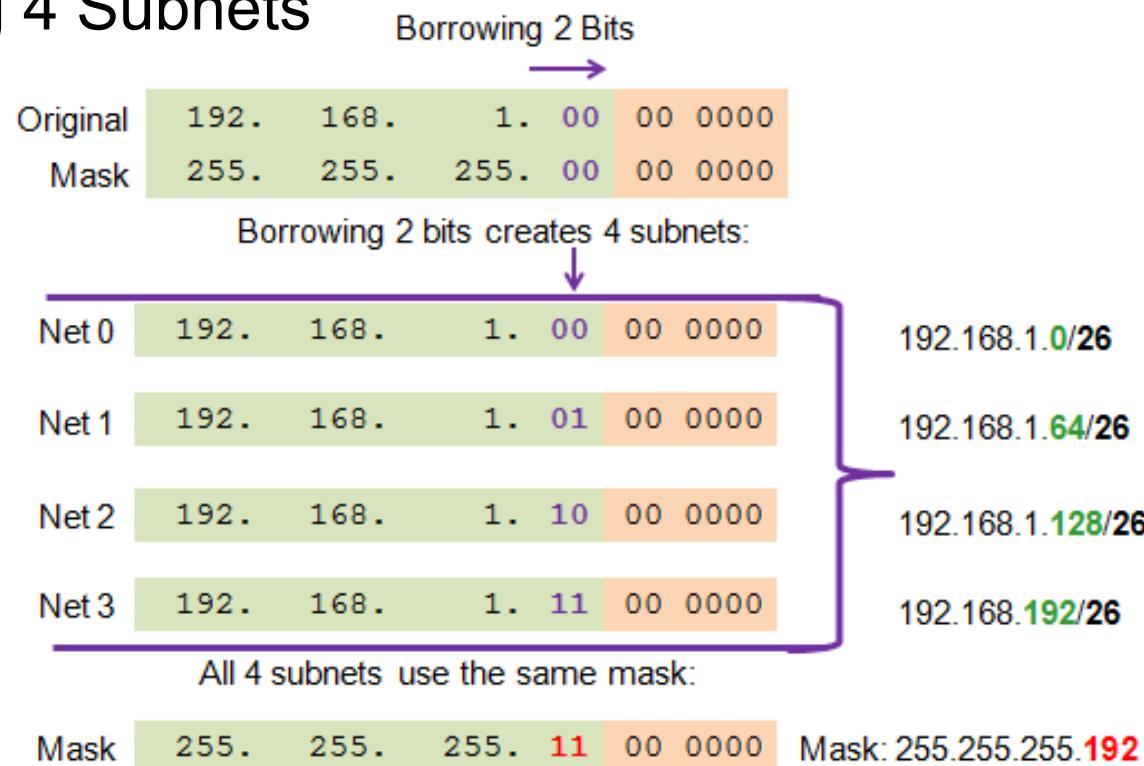


Subnetting an IPv4 Network

Creating 4 Subnets

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

Creating 4 Subnets





Subnetting an IPv4 Network

Creating Eight Subnets

Borrowing 3 bits to Create 8 Subnets. $2^3 = 8$ 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.	010	0 0000	192.168.1.96
	First	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



Subnetting an IPv4 Network

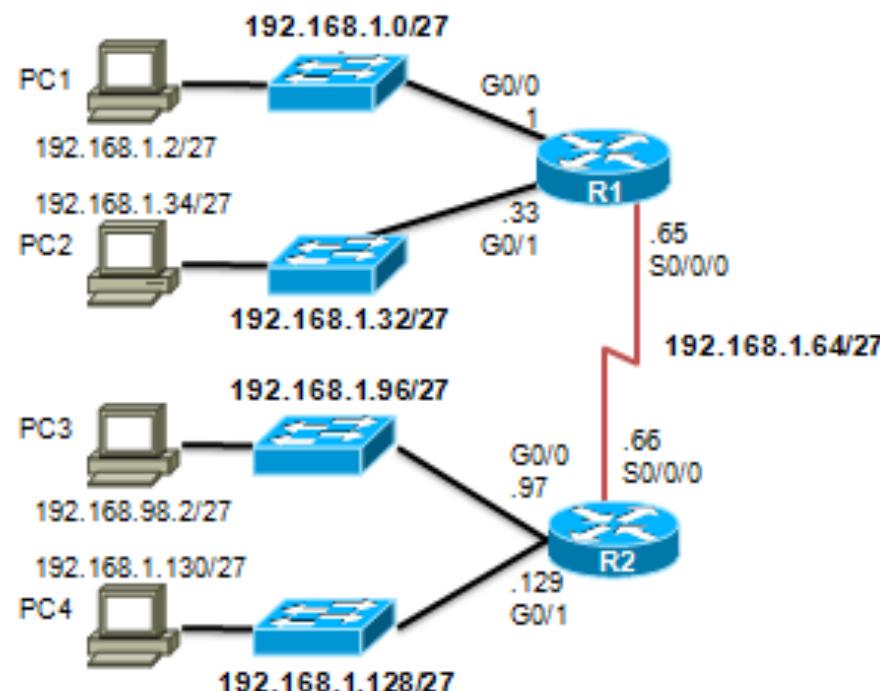
Creating Eight Subnets (Cont.)

	Network	192.	168.	1.	100	0 0000	192.168.1.128
Net 4	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
	Network	192.	168.	1.	101	0 0000	192.168.1.160
Net 5	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
	Network	192.	168.	1.	110	0 0000	192.168.1.192
Net 6	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
	Network	192.	168.	1.	111	0 0000	192.168.1.224
Net 7	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



Subnetting an IPv4 Network Creating Eight Subnets (Cont.)

Subnet Allocation





Determining the Subnet Mask

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.)

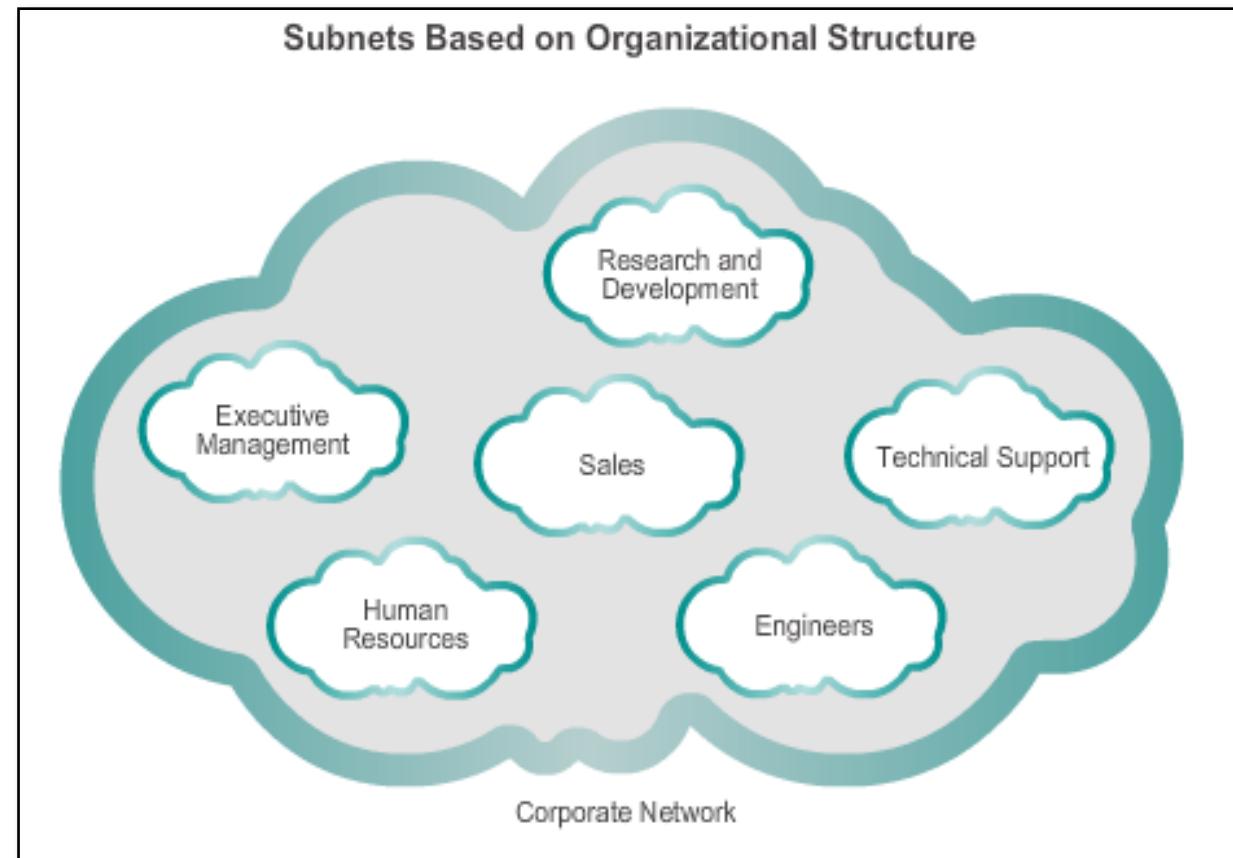


Determining the Subnet Mask

Subnetting Network-Based Requirements

Calculate the number of subnets:

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

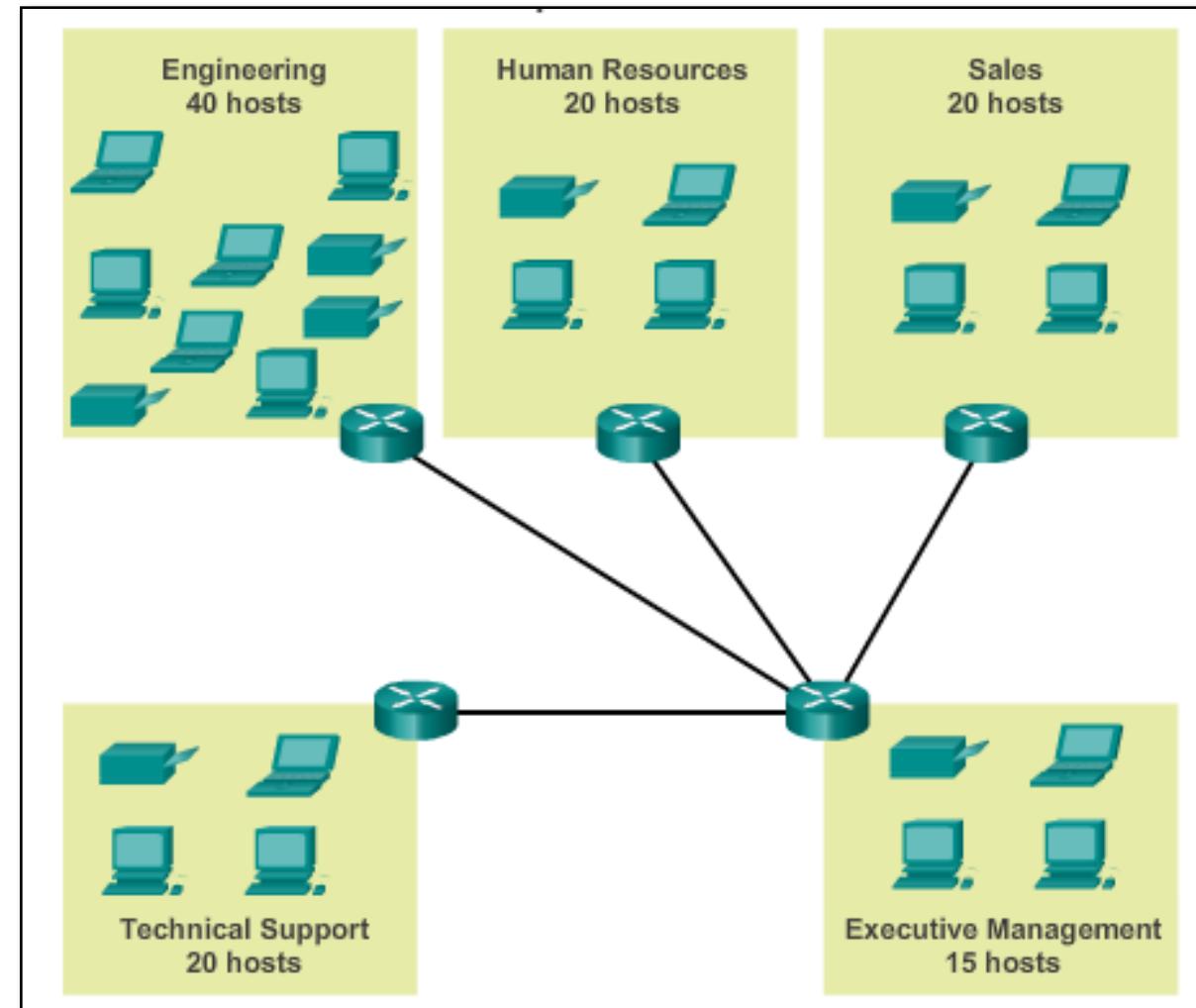




Determining the Subnet Mask

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.





Determining the Subnet Mask

Subnetting To Meet Network Requirements

Subnets and Addresses

	10101100.00010000.00000000.00.00000000	172.16.0.0/22
0	10101100.00010000.00000000.00.00000000	172.16.0.0/26
1	10101100.00010000.00000000.00.01000000	172.16.0.64/26
2	10101100.00010000.00000000.00.10000000	172.16.0.128/26
3	10101100.00010000.00000000.00.11000000	172.16.0.192/26
4	10101100.00010000.00000000.01.00000000	172.16.1.0/26
5	10101100.00010000.00000000.01.01000000	172.16.1.64/26
6	10101100.00010000.00000000.01.10000000	172.16.1.128/26
Nets 7 – 14 not shown		
15	10101100.00010000.00000000.11.10000000	172.16.3.128/26
16	10101100.00010000.00000000.11.11000000	172.16.3.192/26



$2^4 = 16$
subnets



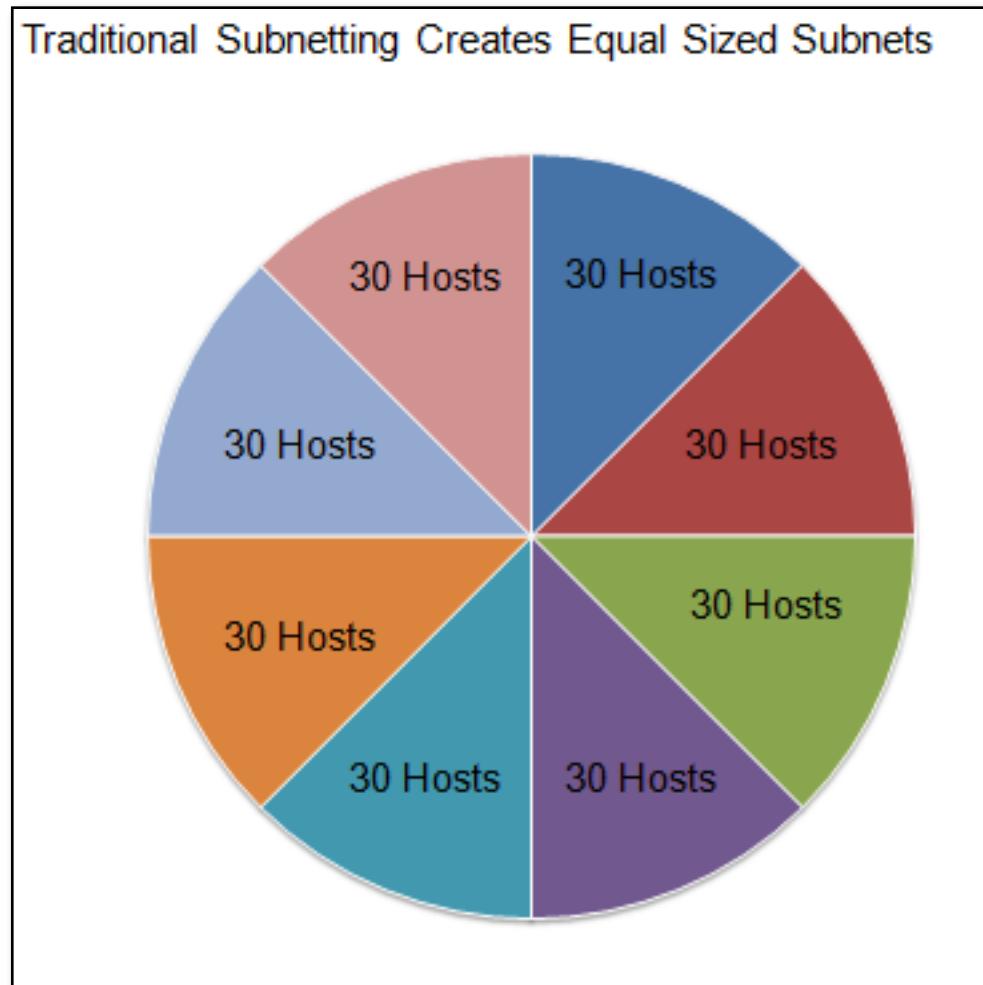
$2^6 - 2 = 62$
Hosts per
subnet



Benefits of Variable Length Subnet Masking

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.

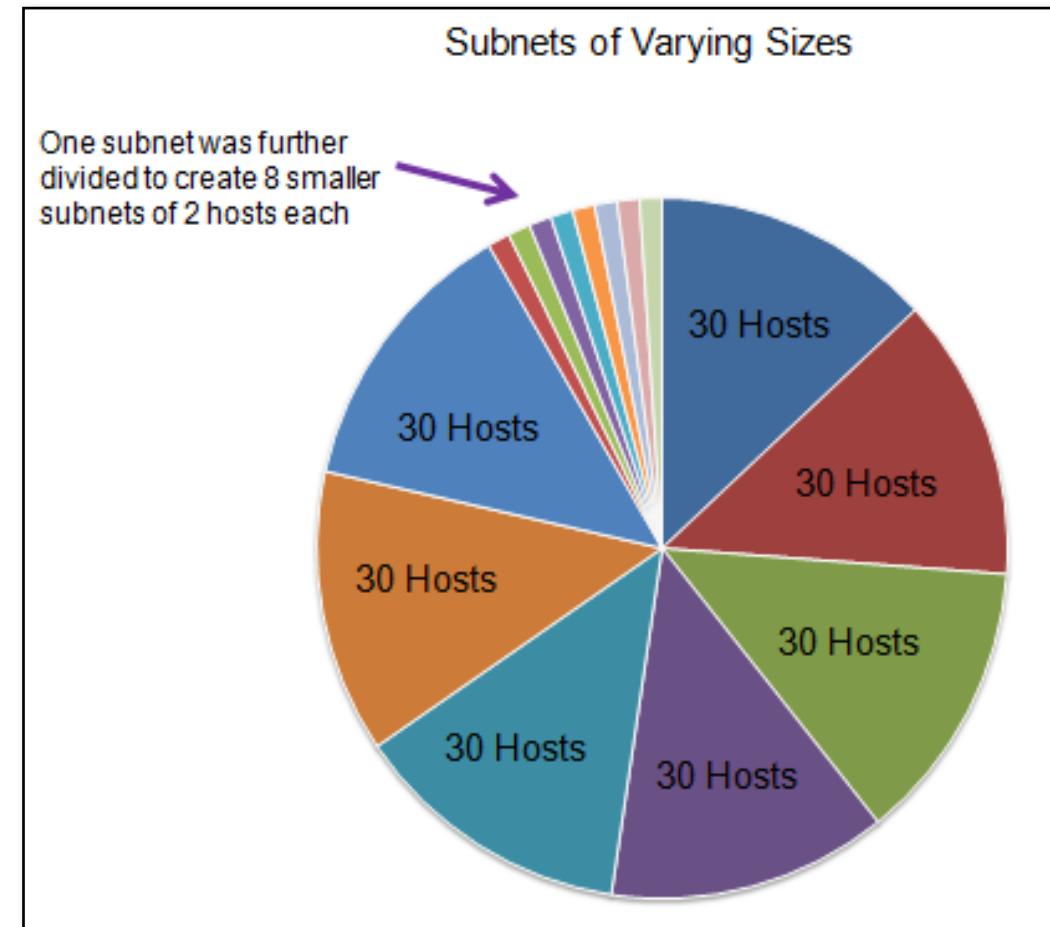




Benefits of Variable Length Subnet Masking

Variable Length Subnet Masks (VLSM)

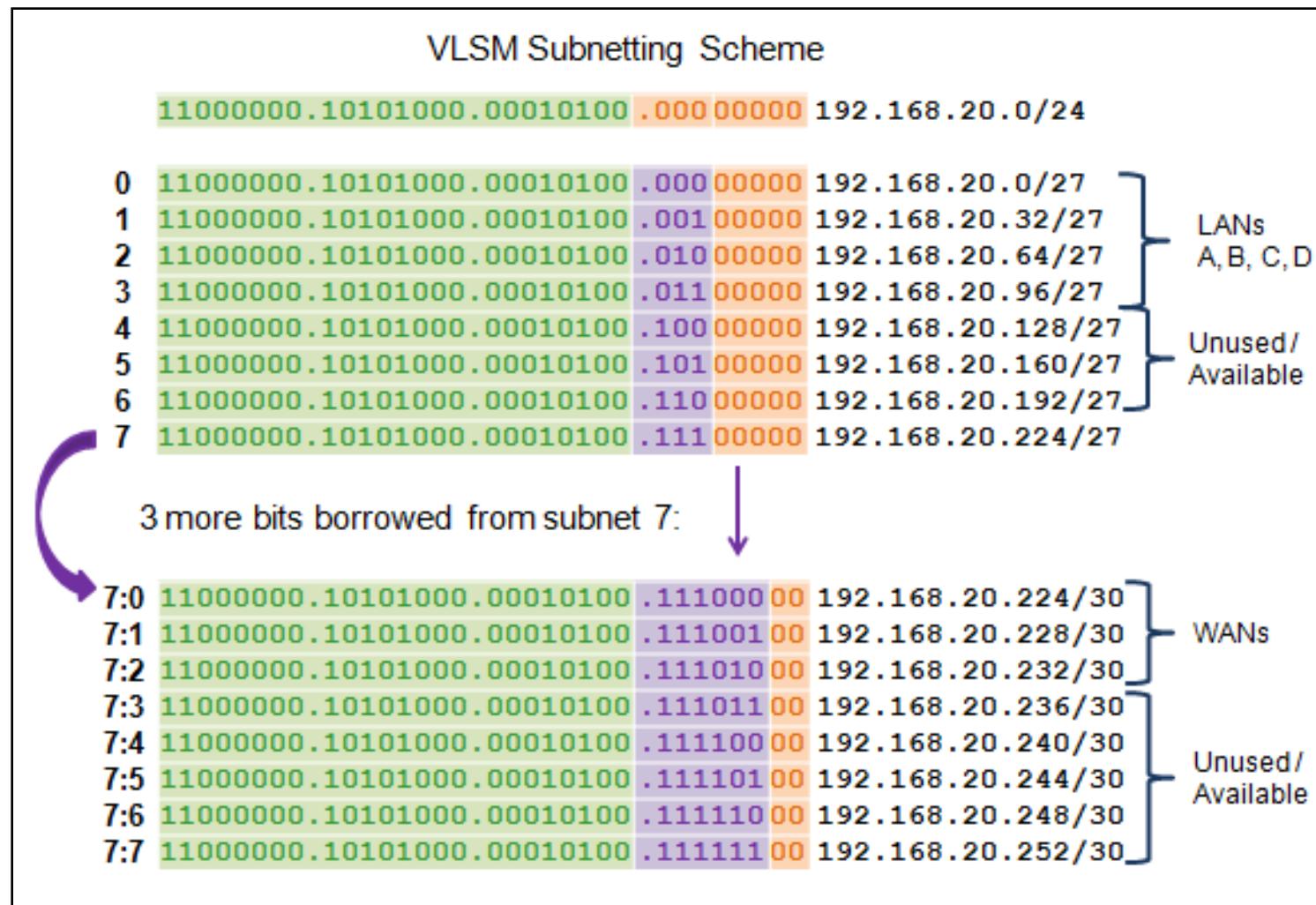
- The variable-length subnet mask (VLSM) or subnetting a subnet provides more efficient use of addresses.
- VLSM allows a network space to be divided in unequal parts.
- Subnet mask varies, depending on how many bits have been borrowed for a particular subnet.
- Network is first subnetted, and then the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





Benefits of Variable Length Subnet Masking

Basic VLSM

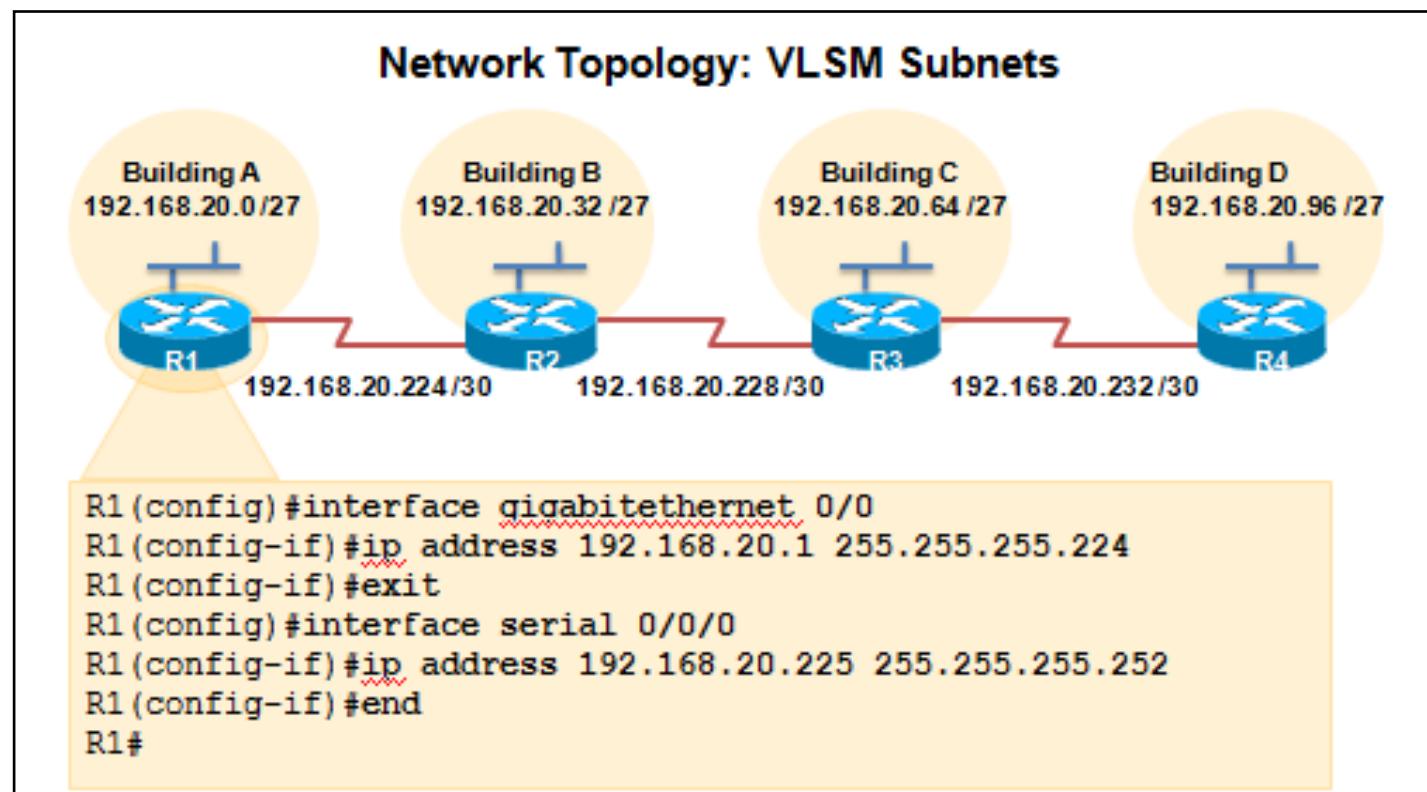




Benefits of Variable Length Subnet Masking

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.





Benefits of Variable Length Subnet Masking

VLSM Chart

VLSM Subnetting of 192.168.20.0 /24

	/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

9.2 Addressing Schemes





Structured Design

Planning to Address the Network

Allocation of network addresses should be planned and documented for the purposes of:

- Preventing duplication of addresses
- Providing and controlling access
- Monitoring security and performance

Client addresses – Usually dynamically assigned using the Dynamic Host Configuration Protocol (DHCP).

Sample
Network
Addressing
Plan

Network: 192.168.1.0/24		
Use	First	Last
Host Devices	.1	.229
Servers	.230	.239
Printers	.240	.249
Intermediary Devices	.250	.253
Gateway (router LAN interface)	.254	

