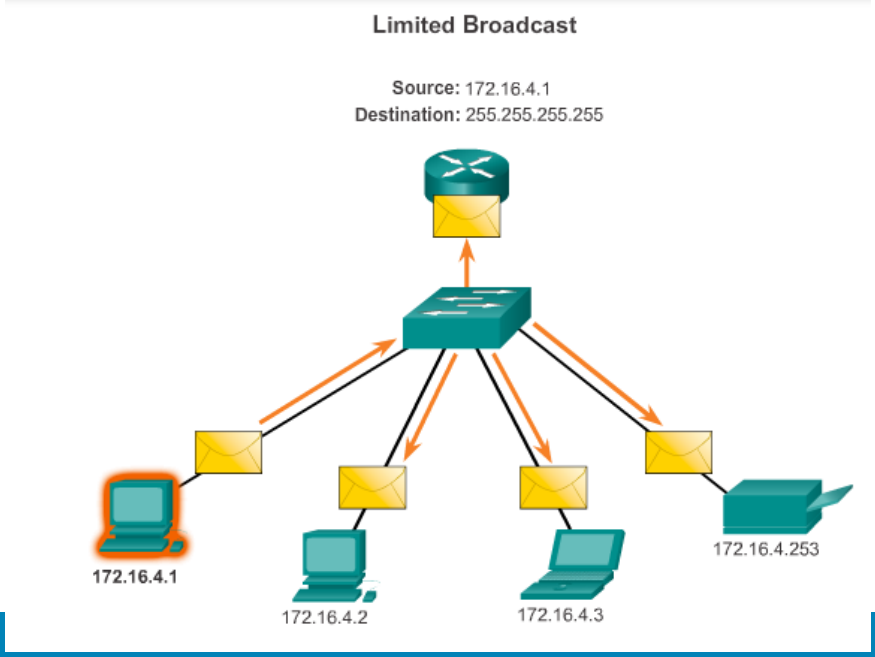
Network Segmentation

Reasons for Subnetting

Large networks need to be segmented into smaller sub-networks, creating smaller groups of devices and services in order to:

- Control traffic by containing broadcast traffic within subnetwork
- Reduce overall network traffic and improve network performance

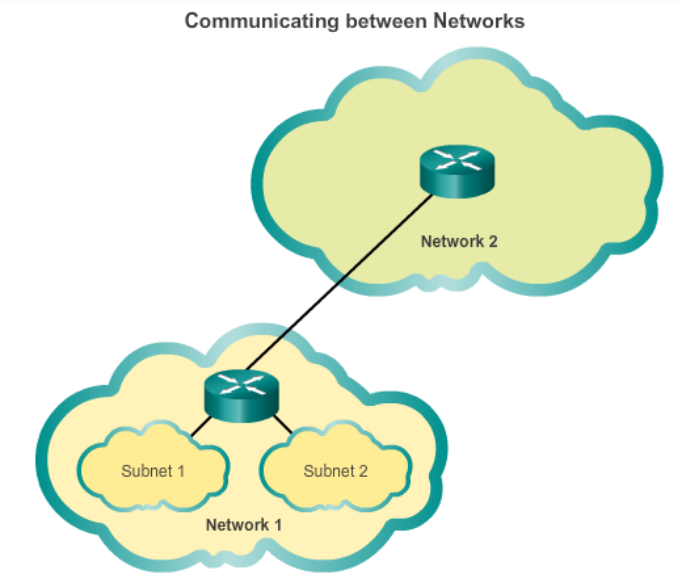
Subnetting - process of segmenting a network into multiple smaller network spaces called subnetworks or **Subnets.**



Reasons for Subnetting

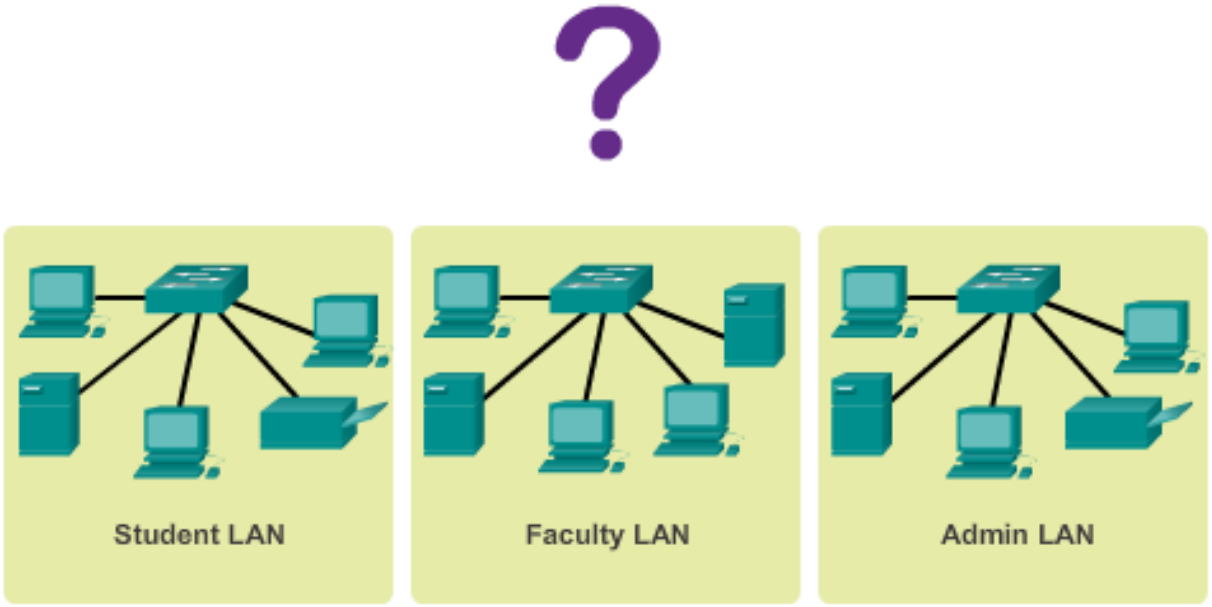
Communication Between Subnets

- 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 to.
- Devices on a network and subnet use the router interface attached to their LAN as their default gateway.



Subnetting an IPv4 Network

IP Subnetting is FUNdamental

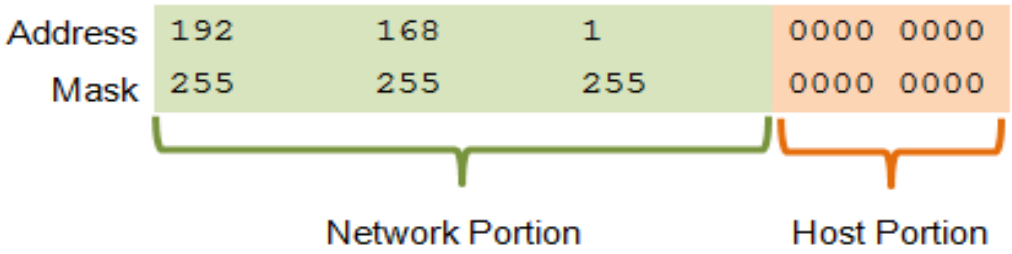


Planning requires decisions on each subnet in terms of size, the number of hosts per subnet, and how host addresses will be assigned.

Subnetting an IPv4 Network

Basic Subnetting

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



Original	192.	168.	1.	0 000 0000	Network 192.168.1.0/24
Mask	255.	255.	255.	0 000 0000	Mask: 255.255.255.0

Borrowing 1 Bit from the host portion creates 2 subnets with the same subnet mask

Subnet 0

Network 192.168.1.**0-127**/**25**

Mask: 255.255.255.**128**

Subnet 1

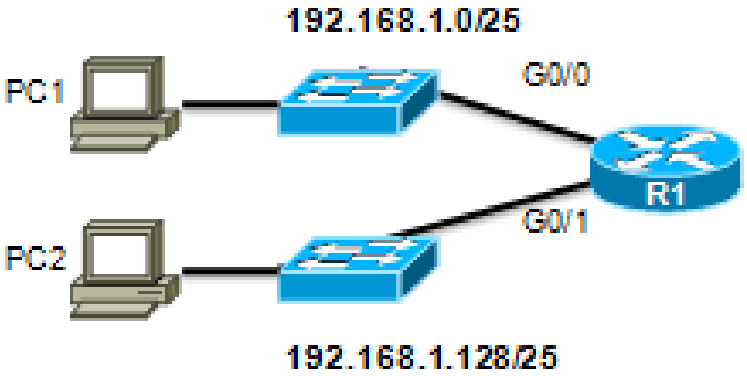
Network 192.168.1.**128-255**/**25**

Mask: 255.255.255.**128**

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)

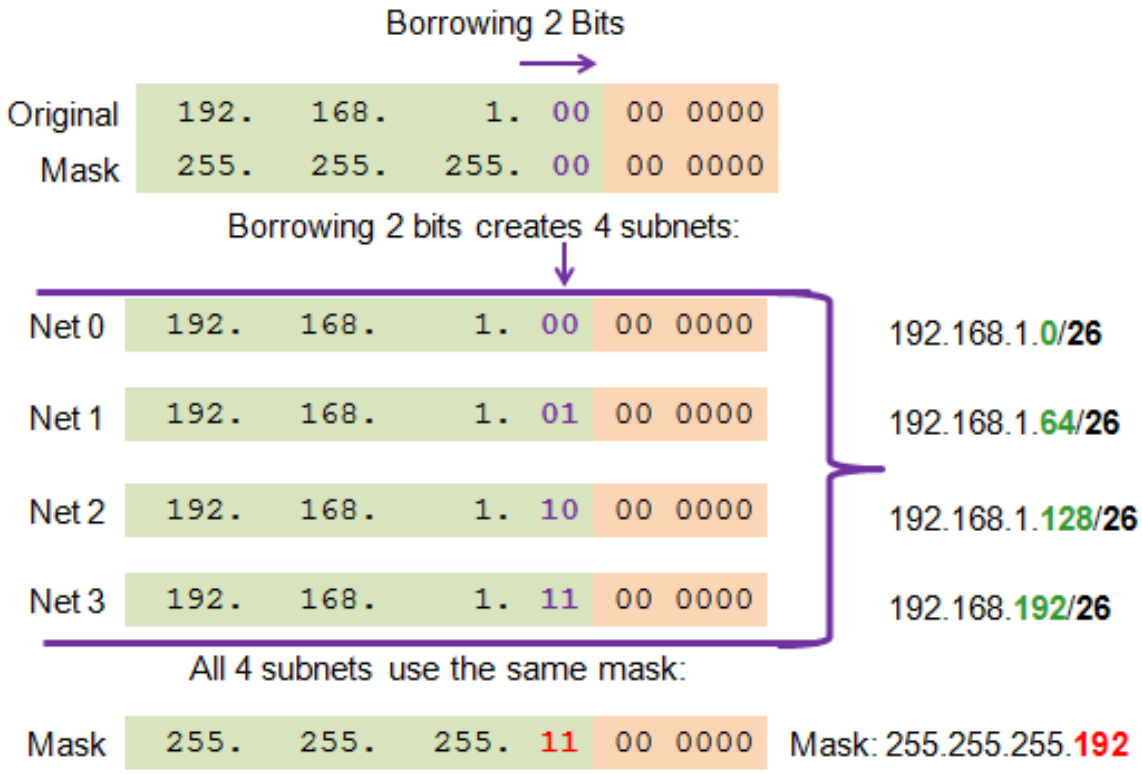
192. 168. 1. 0 000 0000

7 bits remain in host field

2^7 = 128 hosts per subnet

Creating 4 Subnets

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



Creating 8 Subnets

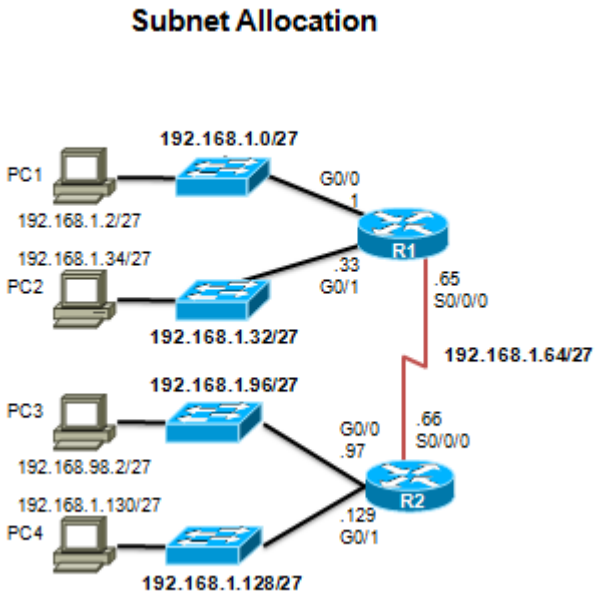
- Borrowing 3 bits to Create 8 Subnets. **$2^3 = 8$ subnets**

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

Subnetting an IPv4 Network

Creating 8 Subnets(continued)

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



Subnetting Based on Host Requirements

There are two considerations when planning subnets:

- Number of Subnets required
- Number of Host addresses required
- Formula to determine number of useable hosts

2^n-2

2^n (where n is the number the number of host bits remaining) is used to calculate the number of hosts

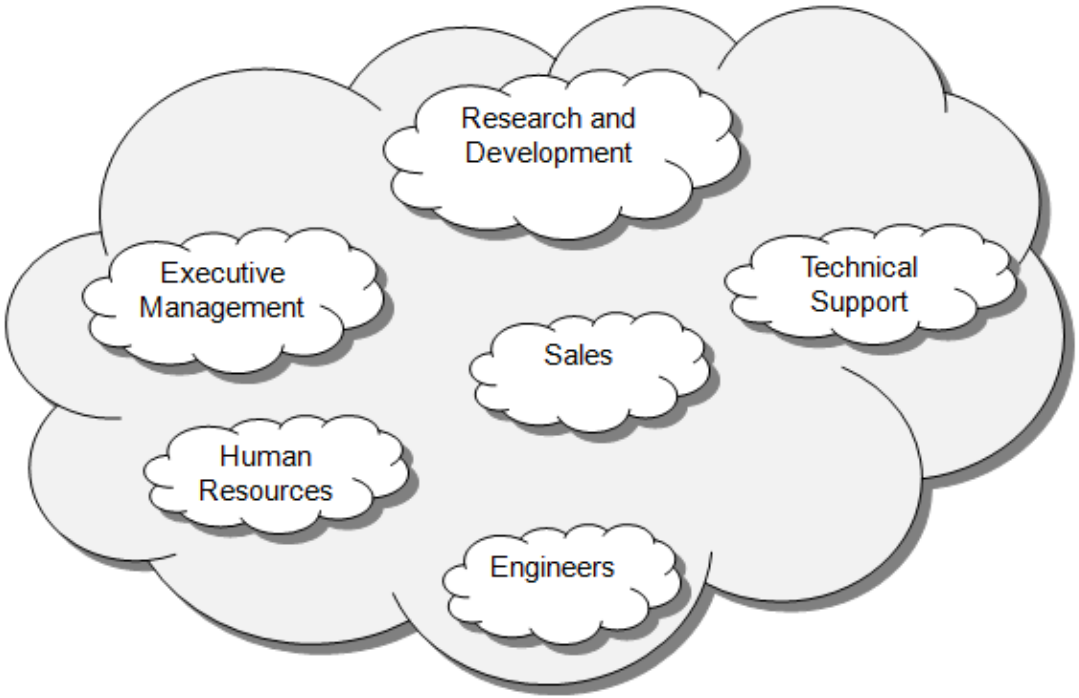
-2 Subnetwork ID and broadcast address cannot be used on each subnet

Determining the Subnet Mask

Subnetting Network-Based Requirements

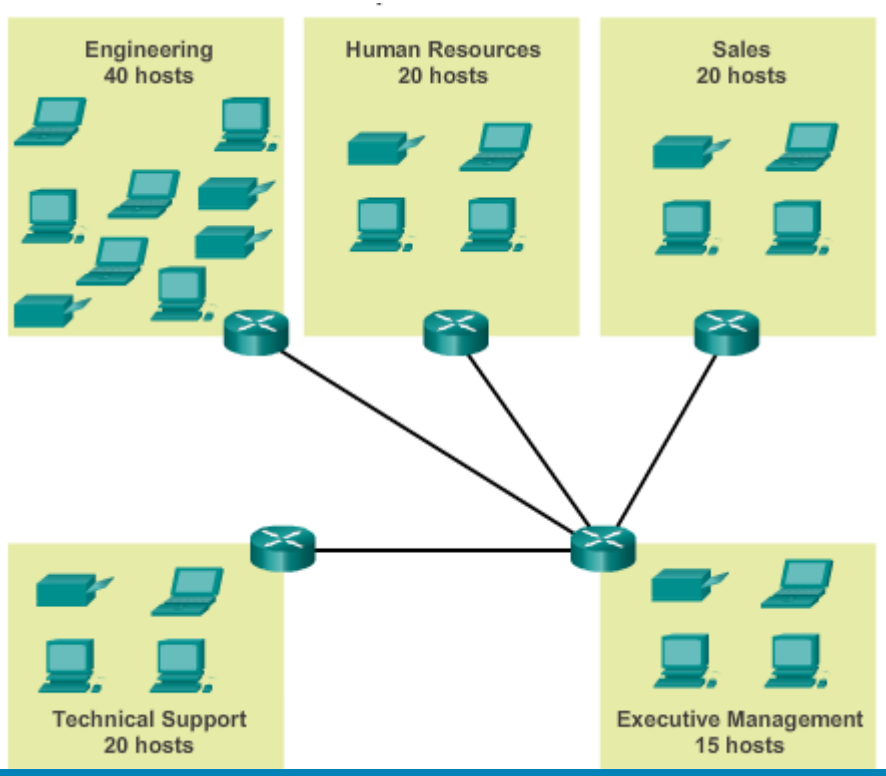
Calculate number of subnets

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



Subnetting To Meet Network Requirements

- It is important to balance the number of subnets needed and the number of hosts required 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 (cont)

Subnets and Addresses

	10101100.00010000.000000**00.00**000000	172.16.0.0/22
0	10101100.00010000.000000**00.00**000000	172.16.0.0/26
1	10101100.00010000.000000**00.01**000000	172.16.0.64/26
2	10101100.00010000.000000**00.10**000000	172.16.0.128/26
3	10101100.00010000.000000**00.11**000000	172.16.0.192/26
4	10101100.00010000.000000**01.00**000000	172.16.1.0/26
5	10101100.00010000.000000**01.01**000000	172.16.1.64/26
6	10101100.00010000.000000**01.10**000000	172.16.1.128/26
	Nets 7 – 14 not shown	
15	10101100.00010000.000000**11.10**000000	172.16.3.128/26
16	10101100.00010000.000000**11.11**000000	172.16.3.192/26

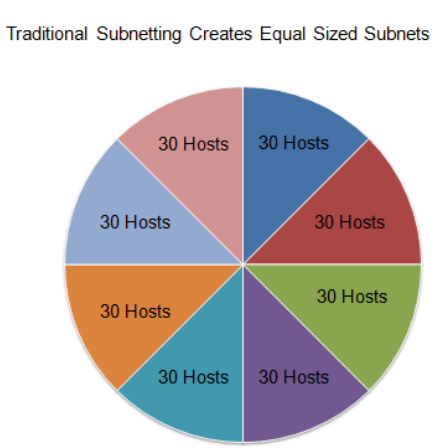
2^4 = 16 subnets

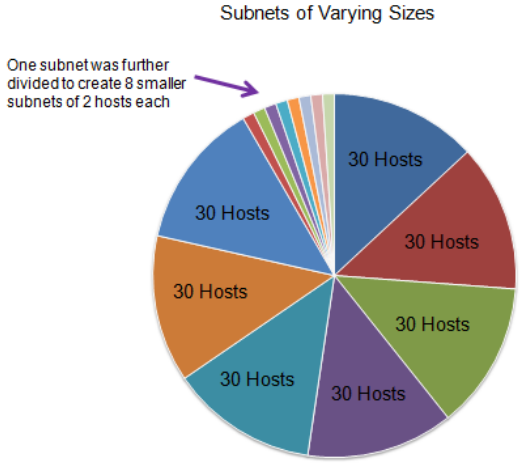
2^6 – 2 = 62 Hosts per subnet

Benefits of Variable Length Subnet Masking

Traditional Subnetting Wastes Addresses

- Traditional subnetting - same number of addresses is allocated for each subnet.
- Subnets that require fewer addresses have unused (wasted) addresses. For example, WAN links only need 2 addresses.
- Variable Length Subnet Mask (VLSM) or subnetting a subnet provides more efficient use of addresses.



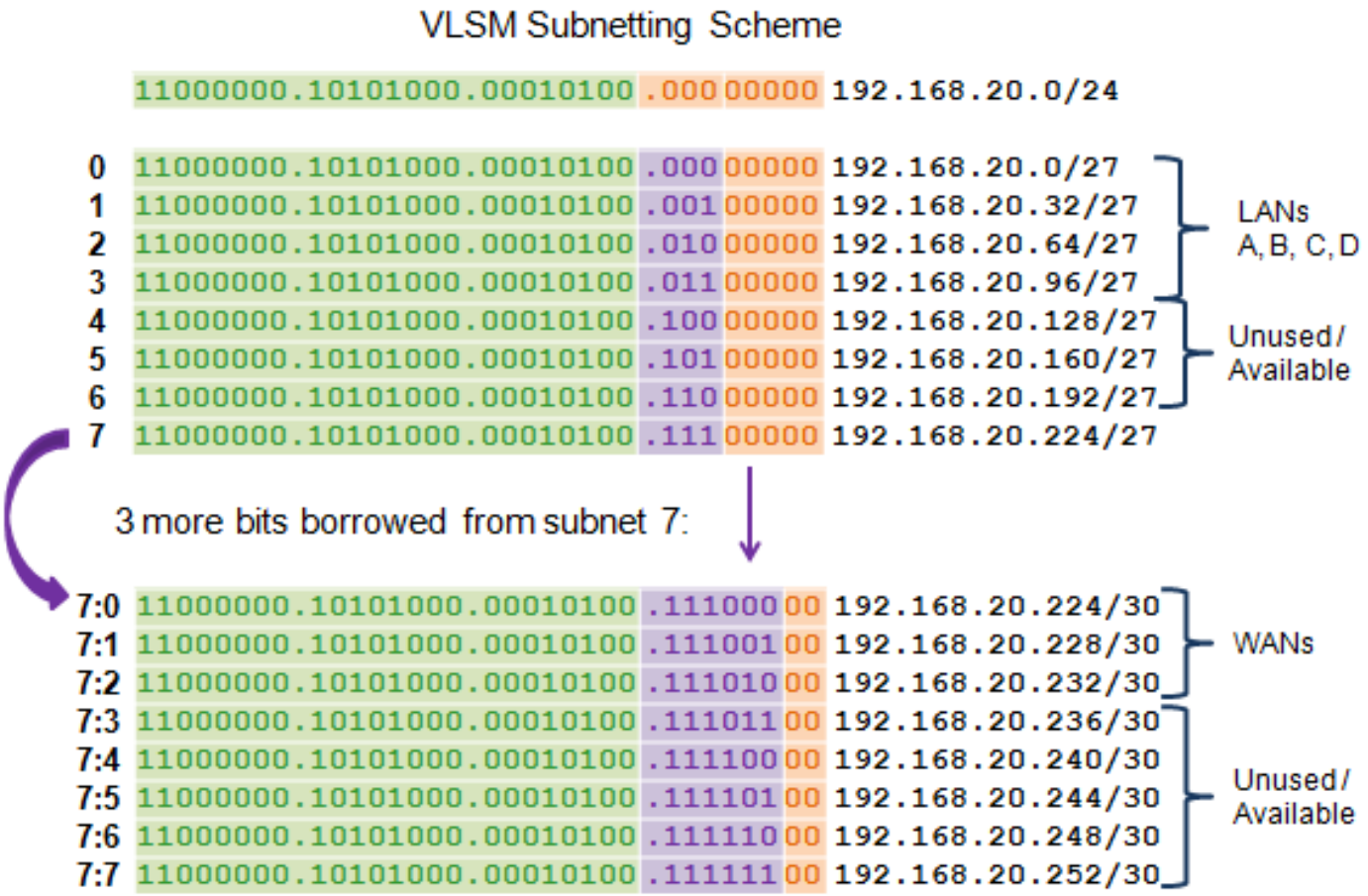


Variable Length Subnet Masks (VLSM)

- VLSM allows a network space to be divided in unequal parts.
- Subnet mask will vary depending on how many bits have been borrowed for a particular subnet.
- Network is first subnetted, and then the subnets are subnetted again.
- Process repeated as necessary to create subnets of various sizes.

Benefits of Variable Length Subnet Masking

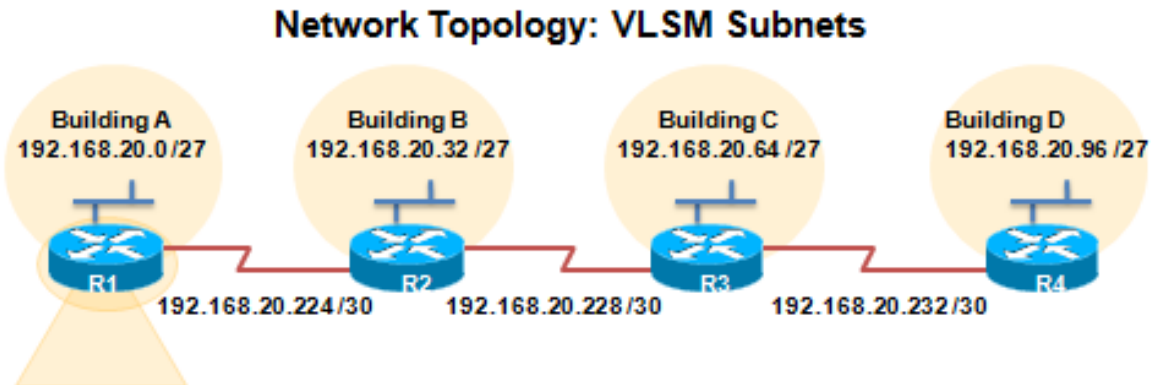
Basic VLSM



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.




```
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#
```

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

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

Addresses for Clients - usually dynamically assigned using Dynamic Host Configuration Protocol (DHCP)

Sample Network Addressing Plan

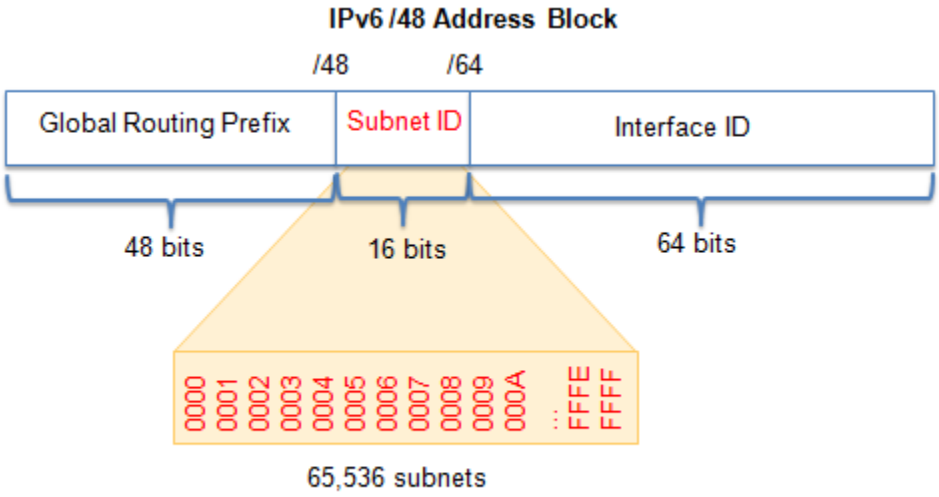
Network: 192.168.1.0/24

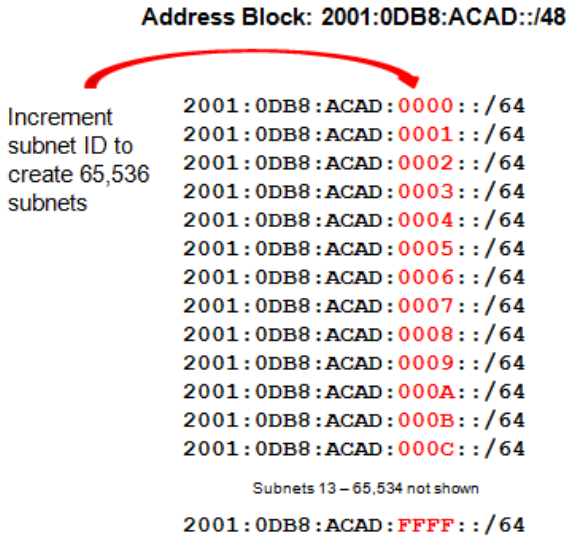
Use	First	Last
Host Devices	.1	.229
Servers	.230	.239
Printers	.240	.249
Intermediary Devices	.250	.253
Gateway (router LAN interface)	.254	

Subnetting an IPv6 Network

Subnetting Using the Subnet ID

An IPv6 Network Space is subnetted to support hierarchical, logical design of the network





Subnetting an IPv6 Network

IPV6 Subnet Allocation

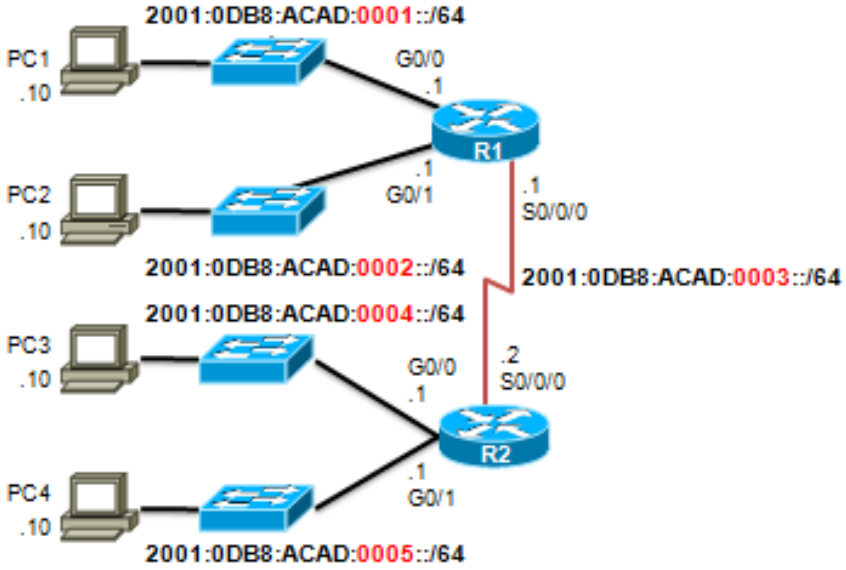
IPv6 Subnetting

Address Block: 2001:0DB8:ACAD::/48

2001:0DB8:ACAD:0000::/64
2001:0DB8:ACAD:0001::/64
2001:0DB8:ACAD:0002::/64
2001:0DB8:ACAD:0003::/64
2001:0DB8:ACAD:0004::/64
2001:0DB8:ACAD:0005::/64
2001:0DB8:ACAD:0006::/64
2001:0DB8:ACAD:0007::/64
2001:0DB8:ACAD:0008::/64
⋮
2001:0DB8:ACAD:FFFF::/64

5 subnets allocated from 65,536 available subnets

IPv6 Subnet Allocation



Subnetting into the Interface ID

IPv6 bits can be borrowed from the interface ID to create additional IPv6 subnets