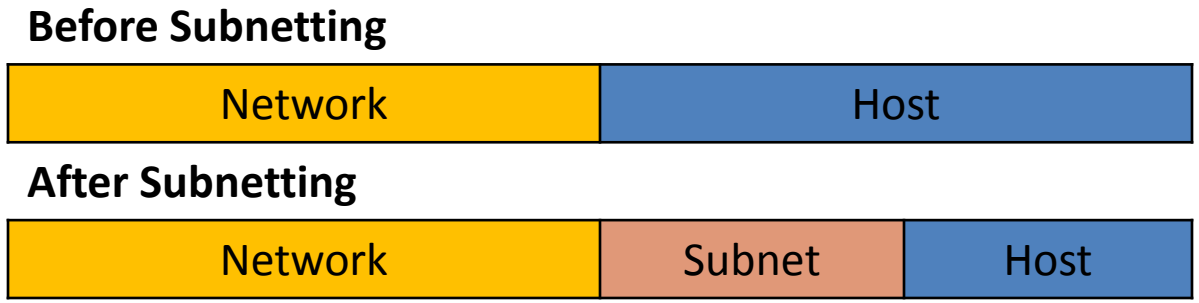
IPv4 Subnetting

TELECOMMUNICATIONS AND NETWORKING

Why Subnet?



1. A way of breaking networks into smaller more manageable pieces
2. More efficiently use IP addresses
3. Reduces the amount of wasted space
4. Reduce the size of a broadcast domains
5. Better bandwidth utilization

Subnetting

Network	Network	Network	Host	
8 Bits	8 Bits	8 Bits	8 Bits	
$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$	$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$	$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$	$2^7\ 2^6\ 2^5$	$2^4\ 2^3\ 2^2\ 2^1\ 2^0$
11000000 .	00000101 .	00100010 .	000	01011
			Subnet	Host

1. Subnet addresses include:
   - The Class A, Class B, or Class C network portion
   - A subnet field
   - A host field
2. Subnet field and the host field are created from the original host portion
3. Provides addressing flexibility
4. To create a subnet address:
   - Network administrator borrows bits from the original host portion
   - Designates them as the subnet field (gives up control)

What is a Subnet Mask?

Class B Default Subnet Mask
255.255.0.0

Class B Subnet Mask with
4 bits borrowed
255.255.240.0

1. Formal name: **Extended Network Prefix**
2. Tells the network devices which part of an address is the network field and which part is the host field
3. 32 bits long and 4 octets, just like an IP address
4. Bits are always borrowed from the left most available bit
5. Allowed numbers: 255, 254, 248, 240, 224, 192, 128, 0
6. Step to determine the subnet mask:
   - Express the subnetwork IP address in binary form
   - Replace the network and subnet portion of the address with all 1s
   - Replace the host portion of the address with all 0s
   - Convert the binary expression back to dotted-decimal notation

Allowed Numbers	
0-	0
1-	128
2-	192
3-	224
4-	240
5-	248
6-	252
7-	254
8-	255

Subnet Mask

If you have a class C address:

1. How many bits are used without subnetting?

   24 or /24

2. What is the subnet mask?

   11111111.11111111.11111111.00000000 or 255.255.255.0

   N . N . N . H

3. If you borrowed 4 bits, how many are used?

   28 or /28

4. What is the subnet mask?

   11111111.11111111.11111111.11110000 or 255.255.255.240

Examples of Subnet Mask

What is the Subnet Mask for this IP address?

1. 194.78.112.6/28 → **255.255.255.240**
2. 117.23.8.3/10 → **255.192.0.0**
3. 156.132.64.12/20 → **255.255.240.0**
4. 208.150.112.16/30 → **255.255.255.252**
5. 91.118.125.2/16 → **255.255.0.0**

Useable Subnets and Host

MEMORIZE

1. Formula for calculating **USEABLE Subnets** (borrowed bits):

$$2^{b} = \text{useable subnets}$$

2. Formula for calculation **USEABLE Hosts** (unused bits):

$$2^{u} - 2 = \text{useable hosts}$$

Calculating Subnets and Hosts

Example: Class C network, borrowing 3 bits:

1. What is the subnet mask?

255.255.255.224

2. How many useable subnets?

$2^b = ?$ **$2^3 = 8$ useable subnets**

3. How many useable hosts per subnet?

$2^u - 2 = ?$ **2^5 (32) - 2 = 30 useable hosts**

Possible number of hosts

Boolean Operations

1. The term "operations" in mathematics refers to rules that define how one number combines with other numbers
2. Boolean operators for binary numbers:
   - **AND** is like multiplication
   - **OR** is like addition
   - **NOT** changes 1 to 0, and 0 to 1
   - **NAND** is the AND with a reversed outcome
   - **NOR** is the OR with a reversed outcome
3. In order to route a data packet, the router must first determine the destination network/subnet address by performing a logical **AND** using the destination host's IP address and the subnet mask
4. Result will be the network/subnet/wire address

ANDing

Find the network address for this class B IP:

1. 180.160.120.8/18

2. What the subnet mask? 255.255.192.0
3. Change IP to binary 10110100.10100000.01111000.00001000
4. Change SM to binary 11111111.11111111.11000000.00000000
5. AND function 10110100.10100000.01000000.00000000
6. Convert back to decimal
7. Network address 180.160.64.0

Classful Subnetting

THINGS YOU KNOW BY DEFAULT:

1. Class
2. Formulas
3. Default Mask

THINGS YOU MUST ALWAYS FIND OUT FIRST BEFORE FINDING YOUR IP'S:

1. Bits Borrowed
2. Number of subnets
3. Numbers of hosts
4. Subnet Mask
5. Increment (Possible number of hosts)

An IP address of 196.112.48.0 with the most hosts:

1. Bits Borrowed **1**
2. Subnet Mask **255.255.255.128**
3. Number of subnets **2^1 = 2 useable**
4. Numbers of hosts **2^7 (128) - 2 = 126 useable**
5. Increment **128**

An IP address of 196.112.48.0 with 2 bits borrowed would have:

1. Bits Borrowed — **2**
2. Subnet Mask — **255.255.255.192**
3. Number of subnets — **2^2 = 4 useable**
4. Numbers of hosts — **2^6 (64) - 2 = 62 useable**
5. Increment — **64**

An IP address of 196.112.48.0/27:

1. Bits Borrowed — **3**
2. Subnet Mask — **255.255.255.224**
3. Number of subnets — **2^3 = 8 useable**
4. Numbers of hosts — **2^5 (32) - 2 = 30 useable**
5. Increment — **32**

A class C address 196.112.48.12 with 4 bits borrowed would have:

1. Bits Borrowed — **4**
2. Subnet Mask — **255.255.255.240**
3. Number of subnets — **2^4 = 16 useable**
4. Numbers of hosts — **2^4 (16) - 2 = 14 useable**
5. Increment — **16**

An IP address of 196.112.48.0/29:

1. Bits Borrowed — **5**
2. Subnet Mask — **255.255.255.248**
3. Number of subnets — **2^5 = 32 useable**
4. Numbers of hosts — **2^3 (8) - 2 = 6 useable**
5. Increment — **8**

An IP address of 196.112.48.0 with the most subnets:

1. Bits Borrowed **6**
2. Subnet Mask **255.255.255.252**
3. Number of subnets **2^6 = 64 useable**
4. Numbers of hosts **2^2 (4) - 2 = 2 useable**
5. Increment **4**

Class C Subnetting Bits

Formula = N.N.N.H Default Slash = /24 Default Mask = 255.255.255.0

Bits Borrowed	1	2	3	4	5	6
Slash Notation	/25	/26	/27	/28	/29	/30
Subnet Mask	255.255.255.128	255.255.255.192	255.255.255.224	255.255.255.240	255.255.255.248	255.255.255.252
Number of subnets	2	4	8	16	32	64
Numbers of Usable hosts	126	62	30	14	6	2
Increment	128	64	32	16	8	4

Class C Subnetting Chart

196.112.48.0/26 **Class C N.N.N.H 255.255.255.0**

Subnet Number	Network Address	Useable Range	Broadcast Address
SN0	196.112.48.**0**	196.112.48.**1** – 196.112.48.**62**	196.112.48.**63**
SN1	196.112.48.**64**	196.112.48.**65** – 196.112.48.**126**	196.112.48.**127**
SN2	196.112.48.**128**	196.112.48.**129** – 196.112.48.**190**	196.112.48.**191**
SN3	196.112.48.**192**	196.112.48.**193** – 196.112.48.**254**	196.112.48.**255**
	256		

Subnetting Fundamentals

Class	Range	Formula	Default Mask
A	0-126	N.H.H.H	255.0.0.0
B	128-191	N.N.H.H	255.255.0.0
C	192-223	N.N.N.H	255.255.255.0

1. Determine the Class of each given
2. Determine how many bits you must borrow (if applicable).
3. Determine the usable number of subnets.
   $2^{(B)}$ = Usable Subnets
4. Determine how many possible number and usable number of hosts.
   $2^{(U)} - 2$ = Usable Hosts
5. Determine the Default Mask.
6. Determine the Subnet Mask.
7. Determine the increment. (Increment = Possible Number of Hosts)
8. Determine the network and broadcast address for each subnetwork.
9. Determine the usable range for each subnetwork.

Private Addresses

The following rages are available for private addressing:	
Class A	10.0.0.0 – 10.255.255.255
Class B	172.16.0.0 – 172.31.255.255
Class C	192.168.0.0 – 192.168.255.255

1. Found in each class
2. Preserve IP addresses used on the Internet
3. Not routable or useable on the Internet
4. Added security
5. Used by:
   - Hosts that use **network address translation** (NAT)
   - Proxy server to connect to a public network
   - Hosts that do not connect to the Internet at all

Automatic Private IP Addressing (APIPA)

1. Feature of modern operating systems
2. Automatically self-configures an IP address and subnet mask when a DHCP server isn't available
3. IP address range: 169.254.0.1 through 169.254.255.254
4. Configures a default class B subnet mask of 255.255.0.0
5. Used until a DHCP becomes available
6. APIPA cannot be routed over the Internet