

Networking with TCP/IP

Subnetting Mechanics

Default Class Network/Host Bits

Class A	Network	Host		
Octet	1	2	3	4

Class B	Network		Host	
Octet	1	2	3	4

Class C	Network			Host
Octet	1	2	3	4

Subnetting Basics

- To create subnets, some host bits are reassigned, or borrowed as network bits.
- Always start borrowing with the leftmost host bit, the one closest to the last network octet.
- Subnetting provides
 - Addressing flexibility
 - Broadcast containment (smaller Broadcast domains)
 - Low level LAN security

Class C example

- Write out the binary for the following address, borrowing 3 bits for subnets:

192.168.10.0

Use **black** = network; **red** = sN; **green** = host

Class address first

11000000.10101000.00001010.00000000

11000000.10101000.00001010.00000000

Class B example

- Write out the binary for the following address, borrowing 5 bits for subnets:

147.10.0.0

Class address first

10010011.00001010. 00000000.00000000

10010011.00001010.00000000.00000000

Class A example

- Write out the binary for the following address, borrowing 12 bits for subnets:

28.0.0.0

Class address first

00011100. 00000000. 00000000.00000000

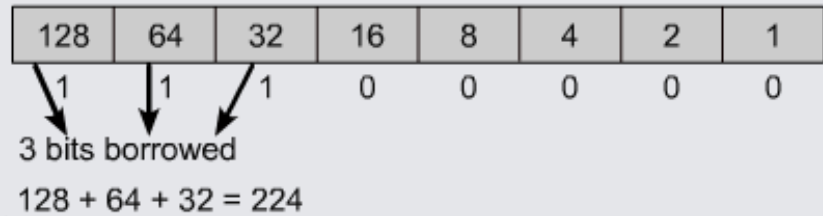
11000000.00000000.00000000.00000000

Subnet Mask

- The subnet mask gives the router the information required to determine in which network and subnet a particular host resides.
- The subnet mask is created by using binary ones in the network and subnet bits, and zeros in the host bits.

Subnet Mask

224 in the fourth octet represents the total place value of the bits borrowed.



- Class A = 255.0.0.0
- Class B = 255.255.0.0
- Class C = 255.255.255.0
- If three bits were borrowed, the mask for a Class C address would be 255.255.255.224 or 255.255.255.224/27
- The fourth octet, 224 = 11100000

Subnet Mask

- The /27 = the total network and subnet bits
 - For a Class C this means 3 bits are borrowed; $8+8+8+3$
 - For a Class B this means 11 bits are borrowed; $8+8+8+3$
 - For a Class A this means 19 bits are borrowed; $8+8+8+3$

Bits borrowed	1	2	3	4	5	6	7	8
Value	128	64	32	16	8	4	2	1

Slash format	/25	/26	/27	/28	/29	/30	N/A	N/A
Mask	128	192	224	240	248	252	254	255
Bits borrowed	1	2	3	4	5	6	7	8
Value	128	64	32	16	8	4	2	1

Subnet Mask

- To determine the number of bits to borrow:
 - Calculate how many hosts the largest subnet requires
 - Calculate the number of subnets needed

Slash format	/25	/26	/27	/28	/29	/30	N/A	N/A
Mask	128	192	224	240	248	252	254	255
Bits borrowed	1	2	3	4	5	6	7	8
Value	128	64	32	16	8	4	2	1
Total Subnets		4	8	16	32	64		
Usable Subnets		2	6	14	30	62		
Total Hosts		64	32	16	8	4		
Usable Hosts		62	30	14	6	2		

Usable Subnets

- Number of usable subnets = two to the power of the assigned subnet bits, or borrowed bits, minus two.
 - **$2^{\text{power of borrowed bits}} - 2 = \text{usable subnets}$**
 - **Borrow 3 bits: $2^3 - 2 = 6$ usable subnets**
 - **Borrow 4 bits: $2^4 - 2 = 14$ usable subnets**
 - **Borrow 5 bits: $2^5 - 2 = 30$ usable subnets**
 - **Borrow 6 bits: $2^6 - 2 = 62$ usable subnets**

Usable Hosts

- Number of usable hosts = two to the power of the bits remaining, minus two (reserved addresses for subnet id and subnet broadcast).
- **2 x power of remaining host bits - 2 = usable hosts**
 - **3 bits borrowed, leaves $2^5 - 2 = 30$ hosts**
 - **4 bits borrowed, leaves $2^4 - 2 = 14$ hosts**
 - **5 bits borrowed, leaves $2^3 - 2 = 6$ hosts**
 - **6 bits borrowed, leaves $2^2 - 2 = 2$ hosts**

Subnet Practice: Borrow 3 bits

Subnet #	Subnet ID	Host Range	Broadcast
0	192.168.4.0	.1-.31	192.168.4.31
1	192.168.4.32	.33-.62	192.168.4.63
2	192.168.4.64	.65-.94	192.168.4.95
3	192.168.4.96	.97-.126	192.168.4.127
4	192.168.4.128	.129-.158	192.168.4.159
5	192.168.4.160	.161-.190	192.168.4.191
6	192.168.4.192	.193-.222	192.168.4.223
7	192.168.4.224	.225-.254	192.168.4.255

When in doubt, do the binary!

Subnet Practice: Borrow 5 bits

Subnet #	Subnet ID	Host Range	Broadcast
0	192.168.26.0	.1-.6	192.168.26.7
1	192.168.26.8	.9-.14	192.168.26.15
2	192.168.26.16	.17-.22	192.168.26.23
3	192.168.26.24	.25-.30	192.168.26.31
4	192.168.26.32	.33-.38	192.168.26.39
5	192.168.26.40	.41-.46	192.168.26.47
6	192.168.26.48	.49-.54	192.168.26.55
7	192.168.26.56	.57-.62	192.168.26.63

When in doubt, do the binary!

ANDing to calculate the Subnet ID

- Routers use subnet masks to determine the home subnet for individual nodes. (ANDing)

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

Packet address	201.10.11.65	11001001.00001010.00001011.01000001
AND		
Mask	255.255.255.224	11111111.11111111.11111111.11100000
Subnetwork ID	201.10.11.64	11001001.00001010.00001011.01000000

Determining Subnet, Broadcast Address and Valid Host Range

Example:

Host: 172.16.10.33

Subnet Mask: 255.255.255.224

Is this a Class A, Class B or Class C address? **Class B**

Therefore how many bits make up the Network portion? **16**

How many bits are in the Subnet Mask?

11111111.11111111.11111111.11100000 = 27

How many bits are left for Host addresses? **5**

How many separate addresses in each subnet? **32**

Which address represents the whole subnet? **172.16.10.32**

Which address is used to broadcast to the subnet? **172.16.10.63**

Which addresses are left in the valid host range?

First Valid: 172.16.10.33

Last Valid: 172.16.10.62

Determining Subnet, Broadcast Address and Valid Host Range

Example 2:

Host: 192.168.100.25 Subnet Mask: 255.255.255.252

Is this a Class A, Class B or Class C address?

Therefore how many bits make up the Network portion?

How many bits are in the Subnet Mask?

How many bits are left for Host addresses?

How many separate addresses in each subnet?

Which address represents the whole subnet?

Which address is used to broadcast to the subnet?

Which addresses are left in the valid host range?