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

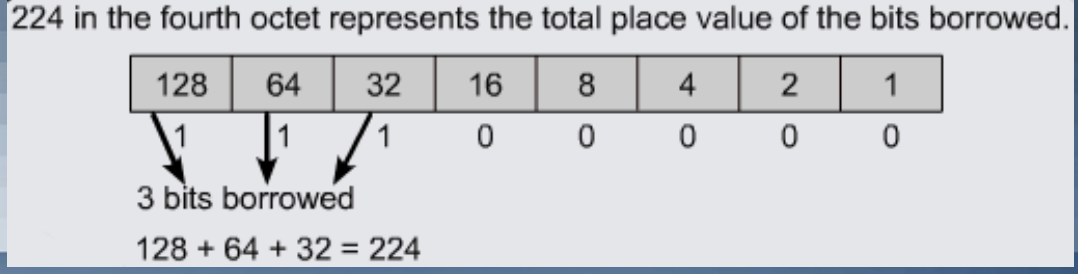
00011100. 00000000. 00000000.00000000

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



- 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 = 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? C

Therefore how many bits make up the Network portion? 30

How many bits are in the Subnet Mask? 30

How many bits are left for Host addresses? 2

How many separate addresses in each subnet? 2 usable

Which address represents the whole subnet? 192.168.100.24

Which address is used to broadcast to the subnet? 192.168.100.27

Which addresses are left in the valid host range? 192.168.100.26