Internet Fundamentals - Subnetting Prac 1

Part 1 - IP Addresses and Subnet Masks

An IPv4 address is a 32-bit number that consists of a portion to identify the network and then the individual host. A router uses a **subnet mask** to determine the network portion of an address. Like an IPv4 address, a subnet mask is a 32-bit number, but when in binary notation, it consists of a sequence of ones, followed by a sequence of zeroes, with no mixing. Subnet masks may be written in dotted decimal notation or in the more compact CIDR or slash notation, where in slash notation the number is how many ones are in the binary form of the mask. For example, 11111111.11111111.11111111.11000000 is 255.255.255.192 or /26.

	first octet	default subnet mask	number of usable host addresses
Class A	0 to 127	255.0.0.0 /8	16,777,214
Class B	128 to 191	255.255.0.0 /16	16,382
Class C	192 to 223	255.255.255.0 /24	254

Given a subnet mask and an IP address, the router will **AND** the bits together to work out the network address.

	dotted decimal	binary
IP address	200.172.138.222	11001000.10101100.10001010.11011110
Subnet mask	255.255.255.0 (/24)	Network. Network. Network. Host 11111111.11111111.11111111.00000000
Subnet address	200.172.138.0	11001000.10101100.10001010.00000000

What if the subnet mask is 255.255.255.224 (/27) instead?

IP address	200.172.138.222	11001000.10101100.10001010.11011110 Network. Network. Network. Host
Subnet mask	255.255.255.224 (/27)	11111111.11111111.11111111.11100000
Subnet address	200.172.138.192	11001000.10101100.10001010.11000000

Task 1

Complete the following tables.

A)		
IP address	200.172.138.101	11001000.10101100.10001010.01100101
Subnet mask	255.255.255.224 (/27)	11111111.11111111.11111111.11100000
Subnet address	200.172.138.96.	11001000.10101100.10001010.01100000
B)		
IP address	200.172.138.62	11001000.10101100.10001010. 00111110
Subnet mask	255.255.255.240 (/28)	11111111.11111111.11111111.11110000
Subnet address	200.172.138.48	11001000.10101100.10001010.00110000
C)		
IP address	200.172.138.233	11001000.10101100.10001010.11101001
Subnet mask	255.255.255.248 (/29)	11111111.11111111.11111111.11111000
Subnet address	200.172.138.235	11001000.10101100.10001010.11101000
D)		
IP address	200.172.138.233	11001000.10101100.10001010.11101001
Subnet mask	255.255.255.252 (/30)	11111111.11111111.11111111.11111100
Subnet address	200.172.138.232	11001000.10101100.10001010.11101000
E)		
IP address	155.155.155.179	10011011.10011011.10011011.10110011
Subnet mask	255.255.128.0 (/17)	11111111.11111111.11000000.00000000
Subnet address	155.155.155.0	10011011.10011011.10011011.00000000
F)		
IP address	155.155.155.179	10011011.10011011.10011011.10110011
Subnet mask	255.255.192.0 (/18)	11111111.11111111.11000000.00000000
Subnet address	155.155.155.0	10011011.10011011.10011011.00000000
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G)		
IP address	155.155.155.179	10011011.10011011.10011011.10110011
Subnet mask	255.255.224.0 (/19)	11111111.11111111.11100000.00000000
Subnet address	155.155.128.0	10011011.10011011.10000000.00000000

Part 2 - Subnetting a Class C block

Given a class A, B, or C network we can reassign (or “borrow”) host bits as subnet bits. Suppose we have N network bits, and borrow S bits to create subnets, this leaves $H = 32 – N – S$ bits for hosts. ($N + S + H$ must always equal 32.)

For example, if we have a class C network 200.200.200.0/24. $N = 24$. If we borrow 3 bits for subnets, $S = 3$ and $H = 5$.

Given numbers S and H, we can determine the size of the subnets we’ve created, and how many there are. Two addresses are usually reserved in a subnet, the subnet address, where all the host bits are 0, and the broadcast address, where all the host bits are 1.

Value	**Formula**	**Example**
Size (total addresses)	2^H	$2^5 = 32$
Total usable addresses	$2^H – 2$	$2^5 – 2 = 30$
Number of subnets	2^S	$2^3 = 8$

Suppose we have a building with four departments, and want to therefore create four subnets. We have the 200.200.200.0/24 block to split up. We need to choose S so that we get four: $2^S = 4$, so $S = 2$. We know that $N = 24$, because we started with a /24 network. Therefore $H = 32 – 24 – 2 = 6$, and hence each subnet consists of $2^6 = 64$ addresses, of which 62 are usable. We’ve borrowed 2 bits from hosts, so the subnet mask for our subnets is /26 (24 + 2) or 255.255.255.192 (note that 256 – 64 = 192).

Subnet		Subnet address		Broadcast address	
Bits	#	200.200.200.SSHHHHHH	200.200.200.x	200.200.200.SSHHHHHH	200.200.200.x
00	#0	200.200.200.00000000	200.200.200.0	200.200.200.00111111	200.200.200.63
01	#1	200.200.200.01000000	200.200.200.64	200.200.200.01111111	200.200.200.127
10	#2	200.200.200.10000000	200.200.200.128	200.200.200.10111111	200.200.200.191
11	#3	200.200.200.11000000	200.200.200.192	200.200.200.11111111	200.200.200.255

Is there an easier way than looking at the binary to work out the subnet and broadcast addresses? Yes, just use the subnet sizes. Subnet 0 starts at 200.200.200.0 and the subnet size is 64, so the next subnet begins at 200.200.200.64. The broadcast always precedes the subnet address of the next subnet, so subnet 0 has a broadcast address of 200.200.200.63. The usable addresses are all those between the subnet address and broadcast address, so these are 200.200.200.1 to 200.200.200.63.

Subnet	Subnet address	Usable host addresses	Broadcast address
#0	200.200.200.0	200.200.200.1-.62	200.200.200.63
#1	200.200.200.64	200.200.200.65-.126	200.200.200.127
#2	200.200.200.128	200.200.200.129-.190	200.200.200.191
#3	200.200.200.192	200.200.200.193-.254	200.200.200.255

Task 2

Suppose we need to create 16 subnets from the class C block 198.4.23.0/24. Determine the following values:

S	4
H	4
Size of subnets	16
Subnet mask - slash notation	/26
Subnet mask - octets	255.255.255.240

Now complete the following table:

Subnet	Subnet address	Usable host addresses	Broadcast address
#0	198.4.23.0	198.4.23.1-14	198.4.23.15
#1	198.4.23.16	198.4.23.17-30	198.4.23.31
#2	198.4.23.32	198.4.23.33-46	198.4.23.47
#3	198.4.23.48	198.4.23.49-62	198.4.23.63
#4	198.4.23.64	198.4.23.65-78	198.4.23.79
#5	198.4.23.80	198.4.23.81-94	198.4.23.95
#6	198.4.23.96	198.4.23.97-110	198.4.23.111
#7	198.4.23.112	198.4.23.113-126	198.4.23.127
#8	198.4.23.128	198.4.23.129-142	198.4.23.143
#9	198.4.23.144	198.4.23.145-158	198.4.23.159
#10	198.4.23.160	198.4.23.161-174	198.4.23.175
#11	198.4.23.176	198.4.23.177-190	198.4.23.191
#12	198.4.23.192	198.4.23.193-206	198.4.23.207
#13	198.4.23.208	198.4.23.209-222	198.4.23.223
#14	198.4.23.224	198.4.23.225-238	198.4.23.239
#15	198.4.23.240	198.4.23.241-254	198.4.23.255

Part 3 - Subnetting a Class B block

Suppose we're an organisation with a class B block available, let's say 155.155.0.0/16. We have branches in multiple cities, and want to split this address space into subnets to allocate to separate branches. We want each branch to have enough addresses for 2000 hosts. How should we subnet in this case?

A subnet size can only be a power of 2, so we need to find the next largest power of two: $2^{11} = 2048$. This means we need to leave 11 host bits ($H = 11$). We start with a class B block, so $N = 16$, and we know $N + S + H = 32$, so a little bit of algebra gives us $S = 5$, so we're borrowing 5 bits for subnetting. In slash notation, our subnet mask will be /21 (16 + 5), which in octet notation is 11111111.11111111.11111000.00000000 = 255.255.248.0.

This creates 32 (2^5) subnets as follows:

Subnet		Subnet address	
Bits	#	155.155.SSSSSHHH.HHHHHHHH	155.155.x.y
00000	#0	155.155.00000000.00000000	155.155.0.0
00001	#1	155.155.00001000.00000000	155.155.8.0
00010	#2	155.155.00010000.00000000	155.155.16.0
...	...	...	...
11111	#31	155.155.11111000.00000000	155.155.248.0

When working out subnetting for subnets of size more than 256, it can be simpler to think in terms of the number of class C blocks. Notice that 2048 = 8 × 256, so each of our subnets is equivalent 8 class C blocks. The subnet mask is 255.255.248.0, and 248 = 256 – 8. Each of our subnets begins at an address where the third octet is a multiple of 8.

Task 3

Consider the scenario above, but suppose we need to accommodate 3000 hosts per subnet.

A. What subnet size do we need? What are *S* and *H* in this case?
   At least 2(11)-2048, therefore, S=11 and H=21

B. How many subnets of this size can we create in the class B block?
   32
C. What is the subnet mask?
   255.255.248.0
D. Complete the table below to show the details for the first three of the subnets:

Subnet		Subnet address	
Bits	#	155.155.SSSSHHHH,HHHHHHH	155.155.x.y
	#0	155.155.00000000.00000000	155.155.0.0
	#1	155.155.00010000,00000000	155.155.16.0
	#2	155.155,00100000,00000000	155.155.32.0