Lab Handout 4: Subnet Calculations

IPv4 Address

- a 32-bit address which identifies a **host** in a **network**
- originally, **network identifie**r is represented by the first octet (8 bits) of the IP address which allows the creation of 256 networks
- hosts with the same network identifier can directly interact with one another while those that belong to different networks must use a router in order to do so
- originally, **host identifier** or rest field is represented by the remaining three octets of the IP address
- IP address space is limited to $\mathbf{2^{32} = 4,294,967,296}$ addresses which obviously cannot represent all the nodes present today
- IPv4 exhaustion address exhaustion occurred on February 3, 2011

How does a subnet mask work?

- A subnet mask works like a filter, helping to route traffic inside a subnet.
- For example, when a binary mask is laid over an IP address also translated into binary, a 1 over a number tells the router to look at the number beneath, and a 0 says to ignore the number.
- The subnet mask tells a router which bits to pay attention to when calculating the network ID portion of an IP address.
- By default, the subnet mask for a Class C IP address class is set to 255.255.255.0
- the first 3 octets (24 bits) in an IP address are used to identify the network ID, and
- the last octet (8 bits) are dedicated to the host ID
- To get to 255, all of the 8 bits must be set to 1, each one representing a number in decimal (1 + 2 + 4 + 8 + 16 + 32 + 64 + 128 = 255).
- When you include the number zero that makes 256 possible values.

Subnet Mask 255.255.255.0				
	24 bits for Network ID			8 bits for Host ID
Decimal	255	255	255	0
Binary	11111111	11111111	11111111	00000000

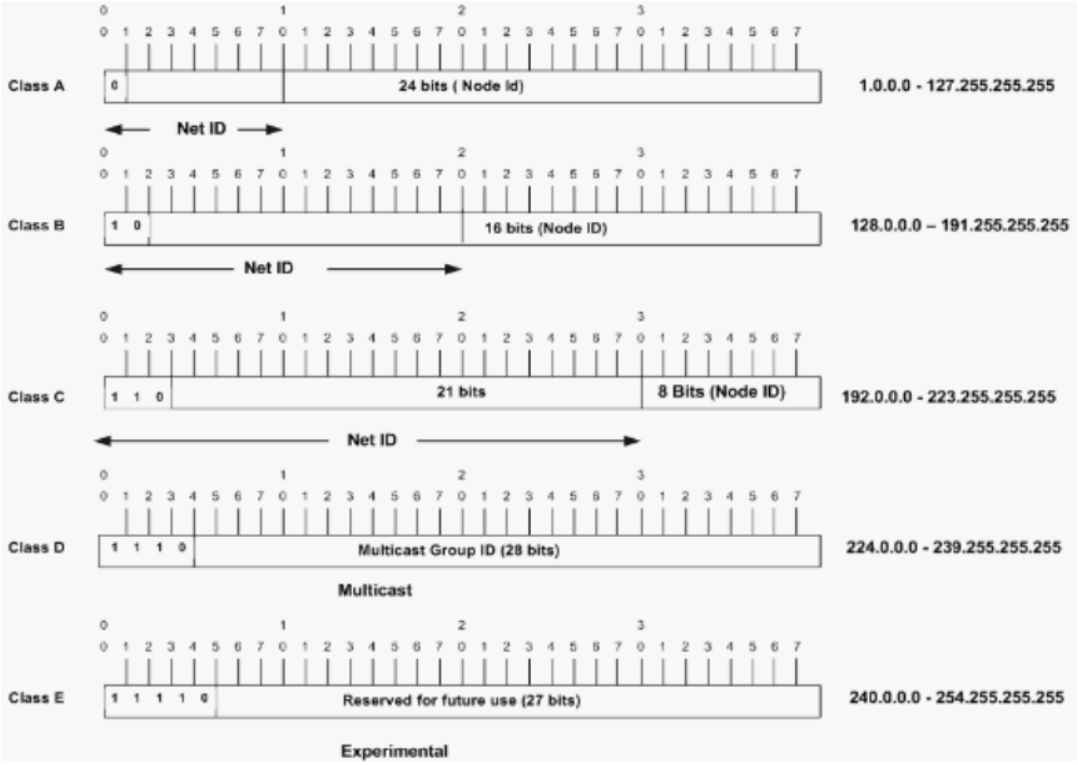
- But if we had a subnet mask of 255.255.255.192, that would mean there are only 6 bits available to us (we get 192 because the bits representing 128 and 64 are masked out).
- Because 63 is the highest decimal value that can be represented with 6 binary bits (1 + 2 + 4 + 8 + 16 + 32), when you add the zero, that makes 64 possible values.

Subnet Mask 255.255.255.0				
	24 bits for Network ID			8 bits for Host ID
Decimal	255	255	255	192
Binary	11111111	11111111	11111111	11000000

Solutions for IPv4 exhaustion

1. Classful Networking

- address spaces are divided into several classes: Class A, B, C, D, and E



2. Classless Inter-Domain Routing (CIDR)

- simplified method of representing a subnet mask
- identifies the number of binary bits set to 1 in a subnet mask, preceded by a slash
- dynamic **subnet mask**

Example: **10.0.3.25/24**

- the **network part** of the IP address is the first 24 bits of the address while the remaining bits or rest field will be the **host ID**.

3. Private Networks

- intended for use within organizations and can never be routed on the internet unless used with
  Network Address Translation (NAT)

Name	Address range	Number of addresses	*Classful* description	Largest CIDR block
24-bit block	10.0.0.0–10.255.255.255	16 777 216	Single Class A	10.0.0.0/8
20-bit block	172.16.0.0–172.31.255.255	1 048 576	Contiguous range of 16 Class B blocks	172.16.0.0/12
16-bit block	192.168.0.0–192.168.255.255	65 536	Contiguous range of 256 Class C blocks	192.168.0.0/16

How to Compute

To be able to compute for the total number of subnetworks that will be created and the maximum number of hosts per subnetwork, we use the following simple formula:

UNKNOWN	*FORMULA*	*REMARKS*
Subnetworks	2^N	where **N** is the number of bits borrowed from host portion of the IP address
Hosts	$2^H - 2$	where **H** is the number of bits remaining to represent a host in the subnetwork

The "-2" Rule of Subnetting

1. **For Network Address or Subnet Address**
   - The smallest address in a network or subnet, which is used to identify the network or subnet itself
   - The all-zeroes rest field was established as the standard network address for networks

2. **For Broadcast Address**
   - A broadcast address identifies ALL hosts on a particular network.
   - A packet sent to the broadcast address will be received and processed by every device on that network.
   - The all-ones rest field was established as the standard broadcast address for networks that support broadcast.

Example:
You have been given an IP Address **10.20.4.13/29** and been asked to find out its subnet address and broadcast address.

Step 1: Find Subnet Number. Subtract Prefix Number from /32

32-29=3

Calculate Subnet Mask: 8 Bits – 3 Bits = 5 Bits(Network Bits Turned On)
Note: 8 Bits are required for each octet.

Subnet Mask = 255.255.255.248

Step 2: Find Subnet Size

2n = Subnet Size**
2**3 = Subnet Sizes for each subnet.
2*2*2 = 8

Note: 8 is the block size for the subnet so for example, the increments will now be 0 8 16 32 40 and so on!

Step 3: Find Broadcast Address
Subnet Size – 1
(2n) – 1 = Broadcast Address**
(2**3) – 1 = (8-1) = 7

Step 4: Locate IP Address Subnet
Identify Subnet Block for IP Address:
Where in each increment is the address 10.20.4.**13**/29 located ***0 8 16 32 40***?

13 falls between *8 and 16* and therefore the address is in the valid host range of the subnet 10.20.4.8/29

Step 5: Calculate Valid Hosts | How to calculate number of hosts in the subnet
2n – 2 = Valid Host Range**
2**3 – 2 = (8-2) = 6

Subnet Address: 10.20.4.8/29
Min Host Address: 10.20.4.9/29
Max Host Address: 10.20.4.14/29
Broadcast Address: 10.20.4.15/29

Variable Length Subnets Mask Table

Prefix size	Network mask	Usable hosts per subnet
/1	128.0.0.0	2,147,483,646
/2	192.0.0.0	1,073,741,822
/3	224.0.0.0	536,870,910
/4	240.0.0.0	268,435,454
/5	248.0.0.0	134,217,726
/6	252.0.0.0	67,108,862

/7	254.0.0.0	33,554,430
Class A		
/8	255.0.0.0	16,777,214
/9	255.128.0.0	8,388,606
/10	255.192.0.0	4,194,302
/11	255.224.0.0	2,097,150
/12	255.240.0.0	1,048,574
/13	255.248.0.0	524,286
/14	255.252.0.0	262,142
/15	255.254.0.0	131,070
Class B		
/16	255.255.0.0	65,534
/17	255.255.128.0	32,766
/18	255.255.192.0	16,382
/19	255.255.224.0	8,190
/20	255.255.240.0	4,094
/21	255.255.248.0	2,046
/22	255.255.252.0	1,022
/23	255.255.254.0	510
Class C		

/24	255.255.255.0	254
/25	255.255.255.128	126
/26	255.255.255.192	62
/27	255.255.255.224	30
/28	255.255.255.240	14
/29	255.255.255.248	6
/30	255.255.255.252	2
/31	255.255.255.254	0
/32	255.255.255.255	0

References:

[1] Balchunas, A. IPv4 Addressing and Subnetting v.1.33. 2012
[2]IP Addressing and Subnetting for New Users. 26 September 2005.
[3] How to Calculate a Subnet Mask. https://community.spiceworks.com/networking/articles/2491-how-to-calculate-a-subnet-mask
[4] How to Calculate Subnet Mask from IP Address Step by Step. https://www.expertnetworkconsultant.com/expert-approach-in-successfully-networking-devices/how-to-calculate-subnet-mask-from-ip-address-step-by-step/