Week2: **Assignment 2:-Subnetting Exercises**

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Introduction

Complete the given subnetting exercises. First, you could start by watching the subnetting series from practical Networking YouTube channel, click here

For this Assignment I started with the last Part because that is what I had grasped very well

1. For each of the following IP addresses, carry out fixed length subnetting(FLSM) by applying the given subnet mask and utilizing additional masking bits borrowed from the default subnet mask. Determine the number of possible subnets per the given network ID **but only** state the **first three subnets,** where possible. Consider the zero subnet in each of the below network IDs as your first possible subnet.

Additionally, in every subnet, determine the; number of hosts, network address/ID, first and last usable IP and the broadcast address

a) 192.168.10.0/25
b) 192.168.10.0/28
c) 10.0.0.0/30
d) 10.0.0.0/16
e) 172.16.0.0/30
f) 172.16.0.0/17

A fixed-length subnet mask (FLSM) refers to a type of enterprise or provider networking where a block of IP addresses is divided into multiple subnets of equal length, i.e. an equal number of IP addresses. FLSM streamlines packet routing within the subnets of a proprietary network.

While solving this problems- we have a subnetting cheat-sheet that helps us. First we need to draw the sheet in 3 simple steps:

i. Start with 1 and double until you reach 128(right to left)-(**GROUP SIZE)**
ii. Subtract the top row from 256-**(SUBNET MASK)**
iii. Then you write the CIDR notation from right to left(from /32)**-(CIDR)**

Step i	128	64	32	16	8	4	2	1
Step ii	(256-128)	(256-64)	(256-32)	(256-16)	(256-8)	(256-4)	(256-2)	(256-1)
	128	192	224	240	248	252	254	255
Step iii	/25	/26	/27	/28	/29	/30	/31	/32

The 3 rows above make up the subnetting cheat-sheet

a) 192.168.10.0/25

- The /25 suffix describes how many bits are used for the network mask, the remaining bits are reserved for the host address.
- Subnet mask: /25 (which means 25 bits are allocated for the network portion)

❖ We use the given CIDR/mask(25) to find the column on the cheat sheet

128	**Group size**	**2^(32-25) = 2^7= 128 Subnets**
(256-128) 128	**Subnet mask**	
/25	**CIDR**	

❖ **We start at ".0" in relevant octet and increase by group size until you PASS target IP**

192.168.10.0/25
.0
.128

Network ID(First IP of each subnet) is 192.168.10.0
First Host Address(IP after the network ID) 192.168.10.1
Next Network(Network ID of the next subnet) is 192.168.10.128
Broadcast Address(Last IP address in each subnet) is 192.168.10.127
Last Host Address(IP Address before Broadcast Address) 192.168.10.126

Network ID(first IP of each subnet)	**192.168.10.0**
First Host IP Address (IP Address after Network ID)	**192.168.10.0 +1= 192.168.10.1**
Next Network	**192.168.10.128**
Broadcast Address	**192.168.10.128-1= 192.168.10.127**
Last Host IP Address	**192.168.10.127-1 = 192.168.10.126**
CIDR/subnet mask	**255.255.255.128**
Usable number of IP addresses **192.168.10.1 to 192.168.10.126**	**(32-25)=7, (subtract 2 for network and broadcast addresses) 2^7 - 2 = 126**

Network range: 192.168.10.0 to 192.168.10.127

b) 192.168.10.0/28

❖ We use the given CIDR/mask(28) to find the column on the cheat sheet

16	**Group size**	**2^(32-28) = 2^4= 16 Subnets**
(256-16) 240	**Subnet mask**	**255.255.255.240**
/28	**CIDR**	

❖ **We start at ".0" in relevant octet and increase by group size until you PASS target IP**

192.168.10.0/28
.0
.16

Network ID (First IP of each subnet) is 192.168.10.0
First Host Address (IP after the network ID) 192.168.10.1
Next Network (Network ID of the next subnet) is 192.168.10.16
Broadcast address (Last IP address in each subnet) is 192.168.10.

Last Host Address (IP Address before Broadcast Address) 192.168.10.14

Network ID(first IP of each subnet)	**192.168.10.0**
First Host IP Address (IP Address after Network ID)	**192.168.10.0 +1= 192.168.10.1**
Next Network	**192.168.10.16**
Broadcast Address(Next network -1)	**192.168.10.16-1= 192.168.10.15**
Last Host IP Address(Broadcast -1)	**192.168.10.15-1 = 192.168.10.14**
CIDR/subnet mask	**255.255.255.240**
Usable number of IP addresses **192.168.10.1 to 192.168.10.14**	**(32-28)=4, (subtract 2 for network and broadcast addresses) 2^4 - 2 = 14**

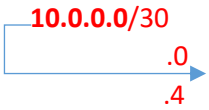
Network range: 192.168.10.0 to 192.168.10.15

c) 10.0.0.0/30

- We use the given CIDR/mask(30) to find the column on the cheat sheet

4	**Group size**	**2^(32-30) = 2^2= 4 Subnets**
(256-4) 252	**Subnet mask**	**255.255.255.252**
/30	**CIDR**	

- **We start at ".0" in relevant octet and increase by group size until you PASS target IP**



Network ID (First IP of each subnet) is 10.0.0.0
First Host Address (IP after the network ID) 10.0.0.1
Next Network (Network ID of the next subnet) is 10.0.0.4
Broadcast Address (Last IP address in each subnet) is 10.0.0.3
Last Host Address (IP Address before Broadcast Address) 10.0.0.2

Network ID(first IP of each subnet)	**10.0.0.0**
First Host IP Address (IP Address after Network ID)	**10.0.0.0+1 = 10.0.0.1**
Next Network	**10.0.0.4**
Broadcast Address(Next network -1)	**10.0.0.4-1= 10.0.0.3**
Last Host IP Address(Broadcast -1)	**10.0.0.3-1 = 10.0.0.2**
CIDR/subnet mask	**255.255.255.252**
Usable number of IP addresses **10.0.0.1 and 10.0.0.2**	**(32-30)=2, (subtract 2 for network and broadcast addresses) 2^2 - 2 = 2**

Network range: 10.0.0.0 to 10.0.0.3

2 addresses are reserved for network and broadcast, leaving 2 addresses for hosts.

d) 10.0.0.0/16

This one is a bit different because in our cheat sheet we don't have (CIDR/mask (16) **But we can still solve it using another formula (32-16) =16**

- **The subnet mask is a 32-bit value that consists of a series of contiguous '1's followed by a series of contiguous '0's. For the given CIDR notation /16, it means the first 16 bits of the 32-bit subnet mask are set to '1', indicating the network portion of the IP address. The remaining 16 bits are set to '0', indicating the host portion of the IP address.**
- **We represent this in binary and then convert it to dotted decimal notation (subnet mask):**
- **Binary Representation:**

  The first 16 bits are '1's, and the remaining 16 bits are '0's:
  11111111.11111111.00000000.00000000

  - **Convert to Dotted Decimal Notation (Subnet Mask): Convert Each Octet to Decimal:**

For the given subnet mask 11111111.11111111.00000000.00000000: Start from the left and convert each set of 8 bits to its decimal representation.			
11111111	**.11111111**	**.00000000**	**.00000000**
(2^7*1+2^6*1+2^5*1+2^4*1+2^3*1+2^2*1+2^1*1+2^0*1)	**(2^7*1+2^6*1+2^5*1+2^4*1+2^3*1+2^2*1+2^1*1+2^0*1)**	**(2^7*0+2^6*0…**	**(2^7*0+2^6*0…**
255	**255**	**0**	**0**
Therefore, the subnet mask corresponding to CIDR notation /16 is 255.255.0.0 in dotted decimal notation.			

- We use the given CIDR/mask(16) to find the column on the cheat sheet

65536	**Group size**	**2^(32-16) = 2^16= 65536 Subnets**
	Subnet mask	**255.255.0.0**
/16	**CIDR**	

Network ID (or Subnet Address):

- Network ID = IP Address & Subnet Mask
- 10.0.0.0 (IP address) AND 255.255.0.0 (Subnet mask)
- Applying the bitwise AND operation:

00001010.00000000.00000000.00000000 (10.0.0.0 - IP address)

11111111.11111111.00000000.00000000 (255.255.0.0 - Subnet mask)

00001010.00000000.00000000.00000000 (Network ID)

Convert the Network ID into Decimal Notation

0	0	0	0	1	0	1	0

(2^7)*0	(2^6) *0	(2^5) *0	(2^4) *0	(2^3) *1	(2^2) *0	(2^1) *1	(2^0) *0
Summation of the above gives us: 8+2=10							

Network ID= 10.0.0.0

Broadcast address

- Broadcast address is the highest address in the subnet.
- Broadcast address = Network ID OR (NOT Subnet Mask)
- Applying the bitwise NOT operation to the subnet mask(Inverse of the subnet)

11111111.11111111.00000000.00000000=255.255.0.0

- In a bitwise NOT operation, each '1' becomes '0', and each '0' becomes '1'.

NOT 255.255.0.0 = 00000000.00000000.11111111.11111111
Network ID (10.0.0.0)
OR
00000000.00000000.11111111.11111111 (Bitwise OR)

10.0.255.255 (Broadcast Address)

Network ID (First IP of each subnet) is 10.0.0.0
First Host Address (IP after the network ID) 10.0.0.1
Broadcast Address (Last IP address in each subnet) is 10.0.255.255
Last Host Address (IP Address before Broadcast Address) 10.0.255.254

Next Network (Network ID of the next subnet) after 10.0.0.0/16

We Convert the Network IP to Binary (10.0.0.0) - (already did it earlier, but repeating for clarity):

10.0.0.0 In binary = 00001010.00000000.00000000.00000000

Identify the 17th Bit:

The 17th bit (from left to right) is the first bit of the host portion since the first 16 bits are for the network.

Flip the 17th Bit:

Change the 17th bit to its opposite value.

Flipping the 17th bit:

00001010.00000000.00000000.00000000

↓

00001010.00000001.00000000.00000000

Convert Back to Decimal:

Convert the binary back to decimal.

00001010.00000001.00000000.00000000 in decimal = 10.1.0.0

Therefore, the Network ID of the next subnet after 10.0.0.0/16 is 10.1.0.0/16.

Network ID(first IP of each subnet)	**10.0.0.0**
First Host IP Address (IP Address after Network ID)	**10.0.0.0+1 = 10.0.0.1**
Next Network	**10.1.0.0**
Broadcast Address(Next network -1)	**10.1.0.0-1=** 10.0.255.255
Last Host IP Address(Broadcast -1)	**10.0. 255.255-1 = 10.0.255.254**
CIDR/subnet mask	**255.255.0.0**
Usable number of IP addresses **10.0.0.1 and 10.0.255.254**	**(32-16)=16, (subtract 2 for network and broadcast addresses) 2^16 - 2 =65536-2 = 65534**

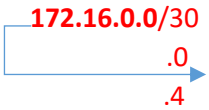
2 addresses are reserved for network and broadcast

e) 172.16.0.0/30

❖ We use the given CIDR/mask(30) to find the column on the cheat sheet

4	**Group size**	**2^(32-30) = 2^2= 4 Subnets**
(256-4) 252	**Subnet mask**	**255.255.255.252**
/30	**CIDR**	

❖ **We start at ".0" in relevant octet and increase by group size until you PASS target IP**



Network ID (First IP of each subnet) is 172.16.0.0
First Host Address (IP after the network ID) 172.16.0.1
Next Network (Network ID of the next subnet) is 172.16.0.4
Broadcast Address (Last IP address in each subnet) is 172.16.0.3
Last Host Address (IP Address before Broadcast Address) 172.16.0.2

Network ID(first IP of each subnet)	**172.16.0.0**
First Host IP Address (IP Address after Network ID)	**172.16.0.0+1 = 172.16.0.1**
Next Network(IP address after our target IP)	**172.16.0.4**
Broadcast Address(Next network -1)	**172.16.0.4-1= 172.16.0.3**
Last Host IP Address(Broadcast -1)	**172.16.0.3-1 = 172.16.0.2**
CIDR/subnet mask	**255.255.255.252**
Usable number of IP addresses **172.16.1.1 and 172.16.0.2**	**(32-30)=2, (subtract 2 for network and broadcast addresses) 2^2 - 2 = 2**

Network range: 172.16.0.0 to 172.16.0.3

Two addresses are reserved for network and broadcast, leaving two addresses for hosts.

f) 172.16.0.0/17

- **The subnet mask is a 32-bit value that consists of a series of contiguous '1's followed by a series of contiguous '0's. For the given CIDR notation /17, it means the first 17 bits of the 32-bit subnet mask are set to '1', indicating the network portion of the IP address. The remaining 15 bits are set to '0', indicating the host portion of the IP address.**
- **We represent this in binary and then convert it to dotted decimal notation (subnet mask):**
- **Binary Representation:**

  The first 17 bits are '1's, and the remaining 15 bits are '0's:
  11111111.11111111.10000000.00000000

  - **Convert to Dotted Decimal Notation (Subnet Mask): Convert Each Octet to Decimal:**

For the given subnet mask 11111111.11111111.10000000.00000000: Start from the left and convert each set of 8 bits to its decimal representation.			
11111111	**.11111111**	**.10000000**	**.00000000**
(2^7*1+2^6*1+2^5*1+2^4*1+2^3*1+2^2*1+2^1*1+2^0*1)	**(2^7*1+2^6*1+2^5*1+2^4*1+2^3*1+2^2*1+2^1*1+2^0*1)**	**(2^7*1+2^6*0…**	**(2^7*0+2^6*0…**
255	**255**	**128**	**0**
Therefore, the subnet mask corresponding to CIDR notation /17 is 255.255.128.0 in dotted decimal notation.			

- We use the given CIDR/mask(16) to find the column on the cheat sheet

32768	**Group size**	**2^(32-17) = 2^15=32768 Subnets**
	Subnet mask	**255.255.128.0**
/17	**CIDR**	

172.16.0.0 to Binary

172	(decimal) =	10101100	(binary)
16	(decimal) =	00010000	(binary)
0	(decimal) =	00000000	(binary)
0	(decimal) =	00000000	(binary)

Network ID (or Subnet Address):

- Network ID = IP Address & Subnet Mask
- **172.16.0.0** (IP address) AND **255.255.128.0 (**Subnet mask)
- Applying the bitwise AND operation:

10101100.00010000.00000000.00000000 (**172.16.0.0**- IP address)

11111111.11111111.10000000.00000000 (**255.255.128.0** - Subnet mask)

10101100.00010000.00000000.00000000 (Network ID)

Convert the Network ID into Decimal Notation

1	0	1	0	1	1	0	0
(2^7)*1	(2^6) *0	(2^5) *1	(2^4) *0	(2^3) *1	(2^2) *1	(2^1) *0	(2^0) *0
0	0	0	1	0	0	0	0
(2^7)*	(2^6) *0	(2^5) *1	(2^4) *0	(2^3) *1	(2^2) *1	(2^1) *0	(2^0) *0
Summation of the above gives us: 172.16.0.0							

Network ID= **172.16.0.0**

Broadcast address

- Broadcast address is the highest address in the subnet.
- Broadcast address = Network ID OR (NOT Subnet Mask)
- Applying the bitwise NOT operation to the subnet mask(Inverse of the subnet)\
  11111111.11111111.10000000.00000000 (**255.255.128.0** - Subnet mask
  Inverse of the above will be:
  00000000.00000000.01111111.11111111

  - Perform Bitwise OR Operation with the Network ID:
  - Network ID (172.16.0.0) in Binary: 10101100.00010000.00000000.00000000
  - Inverted Subnet Mask in Binary: 00000000.00000000.01111111.11111111

    10101100.00010000.01111111.11111111

  Convert the Result to Decimal:

10101100	(2^7)*1 +(2^6)*0+(2^5)*1+(2^4)*0+(2^3)*1+(2^2)*1+(2^1)*0+(2^0)*0	172
00010000	(2^7)*0 +(2^6)*0+(2^5)*1+(2^4)*0+(2^3)*0+(2^2)*0+(2^1)*0+(2^0)*0	16
01111111	(2^7)*0 +(2^6)*1+(2^5)*1+(2^4)*1+(2^3)*1+(2^2)*1+(2^1)*1+(2^0)*1	127
11111111	(2^7)*1 +(2^6)*1+(2^5)*1+(2^4)*1+(2^3)*1+(2^2)*1+(2^1)*1+(2^0)*1	255

  Broadcast Address: 172.16.127.255
  Therefore, the broadcast address for the network 172.16.0.0/17 with subnet mask 255.255.128.0 is 172.16.127.255. This confirms the correct broadcast address using the given formula. Thank you for your patience.

Network ID (First IP of each subnet) is 172.16.0.0
First Host Address (IP after the network ID) 172.16.0.1
Broadcast Address (Last IP address in each subnet) is 172.16.127.255
Last Host Address (IP Address before Broadcast Address) 172.16.127.254

Next Network (Network ID of the next subnet) after 172.16.0.0/17

- **We Convert the Network IP to Binary(172.16.0.0)- (already did it earlier, but repeating for clarity):**

- Network ID (172.16.0.0) in Binary= 10101100.00010000.00000000.00000000
- **Identify the 17th Bit:**
  10101100.00010000.00000000.00000000 (**172.16.0.0**- IP address)
- **The 17th bit (from left to right) is the first bit of the host portion since the first 16 bits are for the network.**
- **Flip the 17th Bit: Change the 17th bit to its opposite value.**

10101100.00010000.00000000.00000000

↓

10101100.00010000.10000000.00000000

- **Convert Back to Decimal:**

10101100.00010000.10000000.00000000 in decimal = 172.16.128.0

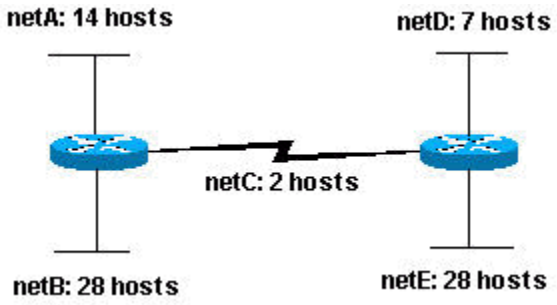
Therefore, the Network ID of the next subnet after 10.0.0.0/16 is 172.16.128.0

Network ID(first IP of each subnet)	**172.16.0.0**
First Host IP Address (IP Address after Network ID)	**172.16.0.0+1 = 172.16.0.1**
Next Network	**172.16.128.0**
Broadcast Address(Next network -1)	172.16.127.255
Last Host IP Address(Broadcast -1)	172.16.127.254
CIDR/subnet mask	**255.255.128.0**
Usable number of IP addresses	**(32-17)=15 (subtract 2 for network and broadcast addresses) 2^(32-17) = 2^15=32768 Subnets**

2 addresses are reserved for network and broadcast

2. A company has been allocated a Class C network **192.168.5.0/24.** The physical network should be divided into 5 subnets, which will be interconnected by routers as shown in the figure below. Class C custom subnets need to be designed. Derive the subnets that would meet the requirements shown outlining the:

- Network Address(network ID)
- First and last usable IP addresses
- Broadcast address(broadcast ID)
- Hosts per subnet



In the above Class C network **192.168.5.0/24 :**

Step 1: Determine the number of bits to borrow from the host portion of the IP address.

To create 5 subnets with different numbers of hosts, we need to borrow a different number of bits from the host portion of the IP address for each subnet. We can use the following table to determine the number of bits to borrow for each subnet**: Number of bits borrowed = log2(number of hosts)**

subnet	Number of hosts	Number of bits to borrow
A	14	4
B	28	3
C	2	6
D	7	5
E	28	3

Step 2: Calculate the subnet masks.

To calculate the subnet mask for each subnet, we can use the following formula:

Subnet mask = 255 - (number of bits borrowed)

The following table shows the subnet masks for each subnet:

subnet	Number of bits to borrow	Subnet Mask
netA	4	255.255.255.240
netB	3	255.255.255.224
netC	6	255.255.255. 192
netD	5	255.255.255. 248
netE	3	255.255.255.224

Step 3: Calculate the network addresses.

To calculate the network address for each subnet, we can simply OR the subnet mask with the first IP address in the network range. The following table shows the network addresses for each subnet:

Subnet	Subnet Mask	Network address
netA	255.255.255.240	192.168.5.0
netB	255.255.255.224	192.168.5.32
netC	255.255.255. 192	192.168.5.64
netD	255.255.255. 248	192.168.5.96
netE	255.255.255.224	192.168.5.128

netA (4 bits borrowed):

- Subnet Mask: 255.255.255.240
- Subnet Mask (Binary): 11111111.11111111.11111111.11110000
- Number of subnets = 2^4 = 16
- Subnet size = 2^(32 - 28) = 16 addresses per subnet
- Network Addresses:
- netA1: 192.168.5.0 (First Subnet)
- netA2: 192.168.5.16
- netA3: 192.168.5.32

netB (3 bits borrowed):

- Subnet Mask: 255.255.255.224
- Subnet Mask (Binary): 11111111.11111111.11111111.11100000
- Number of subnets = 2^3 = 8
- Subnet size = 2^(32 - 25) = 32 addresses per subnet
- Network Addresses:
- netB1: 192.168.5.0 (First Subnet)
- netB2: 192.168.5.32
- netB3: 192.168.5.64

netC (6 bits borrowed):

- Subnet Mask: 255.255.255.192
- Subnet Mask (Binary): 11111111.11111111.11111111.11000000
- Number of subnets = 2^6 = 64
- Subnet size = 2^(32 - 26) = 64 addresses per subnet
- Network Addresses:
- netC1: 192.168.5.0 (First Subnet)
- netC2: 192.168.5.64
- netC3: 192.168.5.128

netD (5 bits borrowed):

- Subnet Mask: 255.255.255.248
- Subnet Mask (Binary): 11111111.11111111.11111111.11111000
- Number of subnets = 2^5 = 32
- Subnet size = 2^(32 - 27) = 32 addresses per subnet
- Network Addresses:
- netD1: 192.168.5.0 (First Subnet)
- netD2: 192.168.5.32
- netD3: 192.168.5.64

netE (3 bits borrowed):

- Subnet Mask: 255.255.255.224

- Subnet Mask (Binary): 11111111.11111111.11111111.11100000
- Number of subnets = 2^3 = 8
- Subnet size = 2^(32 - 29) = 8 addresses per subnet
- Network Addresses:
- netE1: 192.168.5.0 (First Subnet)
- netE2: 192.168.5.8
- netE3: 192.168.5.16

The network addresses for each subnet are calculated based on the number of bits borrowed and the respective subnet masks. These network addresses will be the starting addresses for each subnet.

Calculate the first and last usable IP addresses.

To calculate the first and last usable IP addresses for a subnet, we can simply subtract and add 1 to the network address, respectively. The following table shows the first and last usable IP addresses for each subnet:

Subnet	First usable IP address		Last usable IP address
netA	192.168.5.1		192.168.5.14
netB	192.168.5.33		192.168.5.60
netC	192.168.5.65		192.168.5.66
netD	192.168.5.97		192.168.5.103
netE	192.168.5.129		192.168.5.156

Calculate the broadcast addresses.

To calculate the broadcast address for a subnet, we can simply OR the subnet mask with the last IP address in the network range. The following table shows the broadcast addresses for each subnet:

Subnet	Broadcast address
netA	192.168.5.15
netB	192.168.5.61
netC	192.168.5.67
netD	192.168.5.104
netE	192.168.5.157