

VLSM (Variable Length Subnet Masking)

Question:

- Major Network: **10.0.0.0/16**
- Subnet requirements:

Subnet	Size
A	120
B	37
C	1000
D	500
E	200
F	2

Answer:

[illegible]

Step 0: Verify if the IP address pool of the major network is big enough for all subnets

- Number of host bits in the major network:
 $\Rightarrow n = 32 - \text{mask} = 32 - 16 = 16$
- Number of available IP addresses in major network:
 $\Rightarrow 2^n - 2 = 2^{16} - 2 = 65534$
- Number of IP addresses needed for all subnets:
 $\Rightarrow 120 + 37 + 1000 + 500 + 200 + 2 = 1859 < 65534$

=> Sufficient

Step 1: Fill out all subnets into the subnetting table from the largest to the smallest

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000							
D	500							
E	200							
A	120							
B	37							
F	2							

Step 2: Calculate the number of host bits needed for each subnet

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000	10						
D	500	9						
E	200	8						
A	120	7						
B	37	6						
F	2	2						

- **n**: number of host bits $\Rightarrow 2^n - 2 \geq \text{Size}$

n	2^n	$2^n - 2$
1	2	0
2	4	2
3	8	6
4	16	14
5	32	30
6	64	62
7	128	126
8	256	254
9	512	510
10	1024	1022
11	2048	2046

Examples:

- **Subnet C:** $2^n - 2 \geq 1000 \Rightarrow n = \mathbf{10}$
- **Subnet D:** $2^n - 2 \geq 500 \Rightarrow n = \mathbf{9}$

Step 3: Calculate subnet mask (slash notation and decimal dotted notation)

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000	10	/22	255.255.252.0				
D	500	9	/23	255.255.254.0				
E	200	8	/24	255.255.255.0				
A	120	7	/25	255.255.255.128				
B	37	6	/26	255.255.255.192				
F	2	2	/30	255.255.255.252				

- **Slash notation:** mask = $32 - n$
- **Dotted decimal notation:** determine the number of bits 1 in each octet and convert it into decimal value

Example:

- **Subnet C** ($n = 10$)
 - Slash notation: mask = $32 - 10 = 22 \Rightarrow$ /22
 - Dotted decimal notation: $22 \Rightarrow 8.8.6.0 \Rightarrow$ 255.255.252.0
- **Subnet D** ($n = 9$)
 - Slash notation: mask = $32 - 9 = 23 \Rightarrow$ /23
 - Dotted decimal notation: $23 \Rightarrow 8.8.7.0 \Rightarrow$ 255.255.254.0

Number of bits 1	Binary	Decimal
0	00000000	0
1	10000000	128
2	11000000	192
3	11100000	224
4	11110000	240
5	11111000	248
6	11111100	252
7	11111110	254
8	11111111	255

Step 4: Calculate the gap to the next subnet

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000	10	/22	255.255.252.0	4.0			
D	500	9	/23	255.255.254.0	2.0			
E	200	8	/24	255.255.255.0	1.0			
A	120	7	/25	255.255.255.128	.128			
B	37	6	/26	255.255.255.192	.64			
F	2	2	/30	255.255.255.252	.4			

- Calculate using the “**Magic Number**” (256) and the decimal subnet mask
- Go from right to left of the decimal subnet mask, look for the first number that is not 0
- Subtract that number from 256
- Put the 0s back (if there is any)

Examples:

<p>Subnet C: Dec Mask = 255.255.252.0</p> <p>256 - 255.255.252.0 .4.0</p>	<p>Subnet A: Dec Mask = 255.255.255.128</p> <p>256 - 255.255.255.128 .128</p>
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Step 5: Calculate the network address for each subnet

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000	10	/22	255.255.252.0	4.0	10.0.0.0		
D	500	9	/23	255.255.254.0	2.0	10.0.4.0		
E	200	8	/24	255.255.255.0	1.0	10.0.6.0		
A	120	7	/25	255.255.255.128	.128	10.0.7.0		
B	37	6	/26	255.255.255.192	.64	10.0.7.128		
F	2	2	/30	255.255.255.252	.4	10.0.7.192		
						10.0.7.196		

- The network address of the **1st subnet** = **major network** (but with different subnet mask)
- **Next subnet network address** = **Current subnet network address** + **Gap**
- Calculate 1 additional network address after the last subnet

Example:

- **Subnet C:** 1st subnet = major network = **10.0.0.0**
- **Subnet D:** 2nd subnet = 1st subnet + gap = 10.0.0.0 + 4.0 = **10.0.4.0**
- **Subnet E:** 3rd subnet = 2nd subnet + gap = 10.0.4.0 + 2.0 = **10.0.6.0**
- ...

Step 6: Calculate the broadcast address for each subnet

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000	10	/22	255.255.252.0	4.0	10.0.0.0		10.0.3.255
D	500	9	/23	255.255.254.0	2.0	10.0.4.0		10.0.5.255
E	200	8	/24	255.255.255.0	1.0	10.0.6.0		10.0.6.255
A	120	7	/25	255.255.255.128	.128	10.0.7.0		10.0.7.127
B	37	6	/26	255.255.255.192	.64	10.0.7.128		10.0.7.191
F	2	2	/30	255.255.255.252	.4	10.0.7.192		10.0.7.195
						10.0.7.196		

- The broadcast address of the current subnet = the network address of the next subnet – 1

Example:

- **Subnet C:** network address of the next subnet = 10.0.4.0

Decimal	Binary
10.0.4.0	00001010.00000000.00000100.00000000
-1	-1
10.0.3.255	00001010.00000000.00000011.11111111

Step 7: Calculate the range of the usable IP addresses for each subnet:

Subnet	Size	Number of host bits	Mask	Dec Mask	Gap	Network Address	Usable Range	Broadcast address
C	1000	10	/22	255.255.252.0	4.0	10.0.0.0	10.0.0.1 - 10.0.3.254	10.0.3.255
D	500	9	/23	255.255.254.0	2.0	10.0.4.0	10.0.4.1 - 10.0.5.254	10.0.5.255
E	200	8	/24	255.255.255.0	1.0	10.0.6.0	10.0.6.1 - 10.0.6.254	10.0.6.255
A	120	7	/25	255.255.255.128	.128	10.0.7.0	10.0.7.1 - 10.0.7.126	10.0.7.127
B	37	6	/26	255.255.255.192	.64	10.0.7.128	10.0.7.129 - 10.0.7.190	10.0.7.191
F	2	2	/30	255.255.255.252	.4	10.0.7.192	10.0.7.193 - 10.0.7.194	10.0.7.195

- Usable IP addresses of each subnet are all the IP between the network address and the broadcast address
- The 1st usable IP address = network address + 1
- The last usable IP address = broadcast address - 1

Example:

- **Subnet C**
 - Network address = 10.0.0.0
 - Broadcast address = 10.0.3.255
 - The 1st usable IP address = 10.0.0.0 + 1 = **10.0.0.1**
 - The last usable IP address = 10.0.3.255 - 1 = **10.0.3.254**