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172.16.1.0

01.0

1.0

VLSM
Variable-Length Subnet Mask

Workbook
Version 1.0

192.168

192.168.10.96

192.168.10.126

172.31.15.0

10.250.1.0

IP Address Classes

Class A	1 – 127	(Network 127 is reserved for loopback and internal testing)

Leading bit pattern   0   00000000.00000000.00000000.00000000
                                   Network .   Host   .   Host   .   Host

Class B	128 – 191	Leading bit pattern 10

10000000.00000000.00000000.00000000
Network .   Network .   Host   .   Host

Class C	192 – 223	Leading bit pattern 110

11000000.00000000.00000000.00000000
Network .   Network .   Network .   Host

Class D	224 – 239	(Reserved for multicast)
Class E	240 – 255	(Reserved for experimental, used for research)

Private Address Space

Class A	10.0.0.0 to 10.255.255.255
Class B	172.16.0.0 to 172.31.255.255
Class C	192.168.0.0 to 192.168.255.255

Default Subnet Masks

Class A	255.0.0.0
Class B	255.255.0.0
Class C	255.255.255.0

This workbook assumes you already have a background in subnetting. If you don't you may want to consider completing the IP Addressing and Subnetting Workbook.

Inside Cover

What is VLSM

Variable Length Subnet Masks allow you a much tighter control over your addressing scheme. If you use a class C address with a default subnet mask you end up with one subnet containing 256 addresses. By using VLSM you can adjust the number of subnets and number of addresses depending on the specific needs of your network. The same rules apply to a class A or B addresses.

VLSM is supported by Cisco, OSPF, Dual IS-IS, BGP-4, and EIGRP. You need to configure your router for Variable Length Subnet Masking by setting up one of these protocols. Then configure the subnet masks of the various interfaces in the IP address interface sub-command. To use supernet you must also configure IP classless routes.

The Box Method

The box method is the simplest way to visualize the breakdown of a range of addresses into smaller different sized subnets.
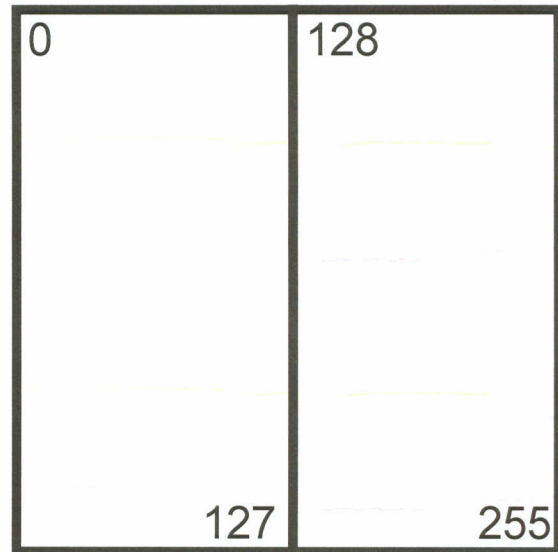
Start with a square. The whole square is a single subnet comprised of 256 addresses.

/24
255.255.255.0
256 Hosts
1 Subnet

```
0




                        255
```
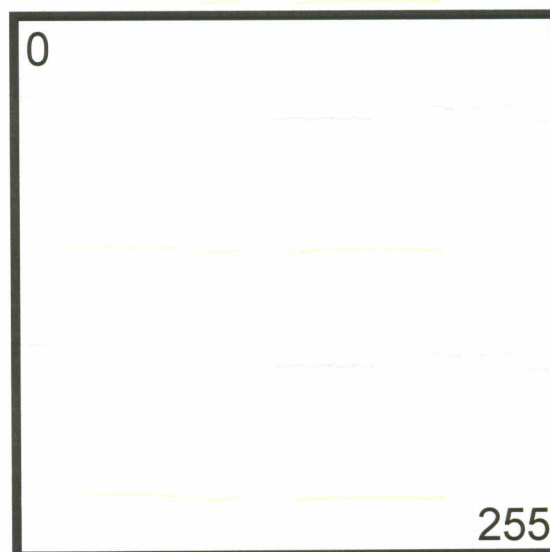
Split the box in half and you get two
subnets with 128 addresses,

0	128
127	255

/25
255.255.255.128
128 Hosts
2 Subnets

Divide the box into quarters and you
get four subnets with 64 addresses,

0	128
63	191
64	192
127	255

/26
255.255.255.192
64 Hosts
4 Subnets
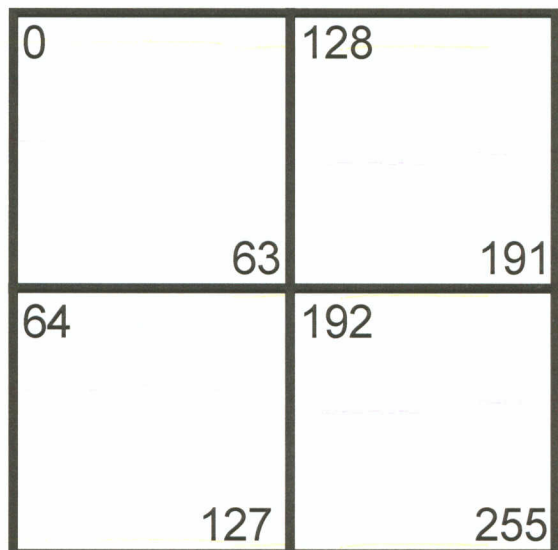
Split each individual square and you
get eight subnets with 32 addresses,

0	32	128	160
31	63	159	191
64	96	192	224
95	127	223	255

/27
255.255.255.224
32 Hosts
8 Subnets

2

Split the boxes in half again and you get sixteen subnets with sixteen addresses,

/28
255.255.255.240
16 Hosts
16 Subnets

0	32	128	160
15	47	143	175
16	48	144	176
31	63	159	191
64	96	192	224
79	111	207	239
80	112	208	240
95	127	223	255

The next split gives you thirty two subnets with eight addresses,

/29
255.255.255.248
8 Hosts
32 Subnets

0	8	32	40	128	136	160	168
7	15	39	47	135	143	167	175
16	24	48	56	144	152	176	184
23	31	55	63	151	159	183	191
64	72	96	104	192	200	224	232
71	79	103	111	199	207	321	239
80	88	112	120	208	216	240	248
87	95	119	127	215	223	247	255

The last split gives sixty four subnets with four addresses each,
You can use these squares in any combination to fit your addressing needs.

/30
255.255.255.252
4 Hosts
64 Subnets

0	8	32	40	128	136	160	168
3	11	35	43	131	139	163	171
4	12	36	44	132	140	164	172
7	15	39	47	135	143	167	175
16	24	48	56	144	152	176	184
19	27	51	59	147	155	179	187
20	28	52	60	148	156	180	188
23	31	55	63	151	159	183	191
64	72	96	104	192	200	224	232
67	75	99	107	195	203	227	235
68	76	100	108	196	204	228	236
71	79	103	111	199	207	321	239
80	88	112	120	208	216	240	248
83	91	115	123	211	219	243	251
84	92	116	124	212	220	244	252
87	95	119	127	215	223	247	255

VLSM Addressing

Problem 1

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This business will be using the class C address 220.10.10.0. Remember to start with your largest groups first.
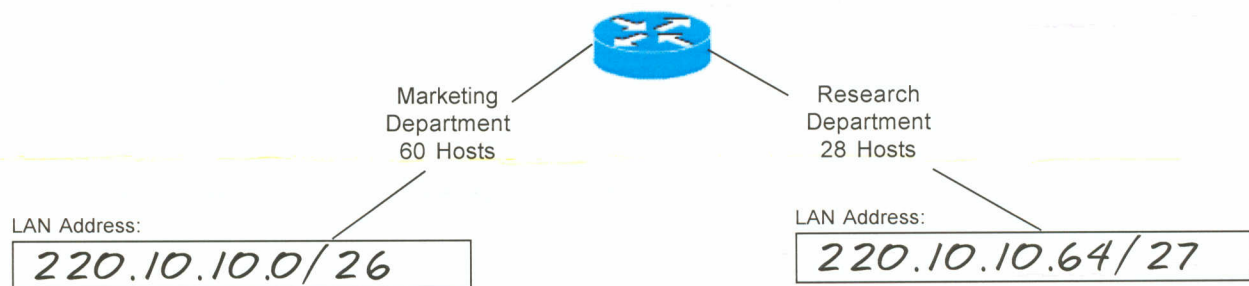
Marketing
Department
60 Hosts

Research
Department
28 Hosts

LAN Address:

220.10.10.0/26

LAN Address:

220.10.10.64/27

Color in the squares used with different shades to highlight each subnet.

0	128
63	
64 96	
95 127	255

4

VLSM Addressing

(Sample)

Problem 2

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 192.168.16.0. Remember to start with your largest groups first.

LAN Address:
Washington D.C.
120 Hosts

$$192.168.16.0/25$$

WAN Address #1:

$$192.168.16.224/30$$

WAN Address #2:

$$192.168.16.228/30$$

Baltimore
60 Hosts

Frederick
20 Hosts

LAN Address:

$$192.168.16.128/26$$

LAN Address:

$$192.168.16.192/27$$

Color in the squares used with different shades to highlight each sub-subnet.

VLSM Addressing

Problem 3

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 190.10.10.0. Remember to start with your largest groups first.
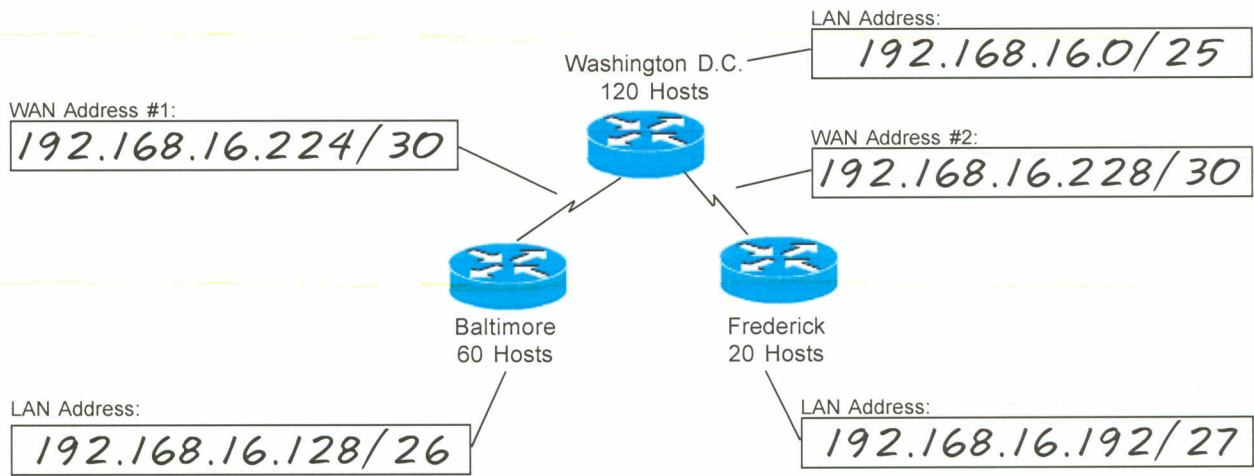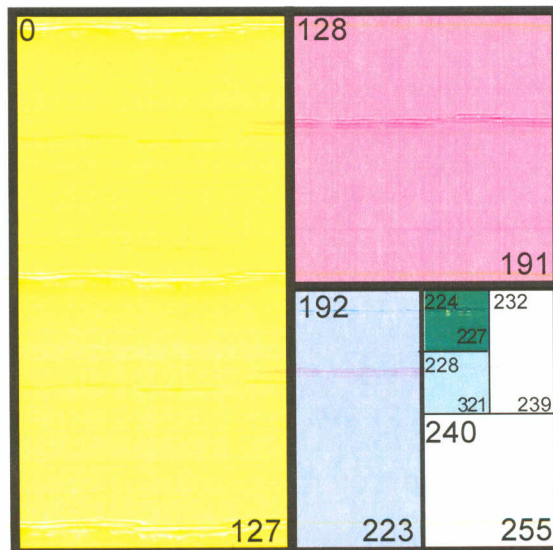
Dallas.
60 Hosts

LAN Address:
190.10.10.0/26

WAN Address #1:
190.10.10.96/30

Ft. Worth
25 Hosts

LAN Address:
190.10.10.64/27

Color in the squares used with different
shades to highlight each sub-subnet.

0	128
63	
64 96 104	
99	
100	
103 111	
112	
95 127	255

VLSM Addressing

Problem 4

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 220.108.38.0. Remember to start with your largest groups first.
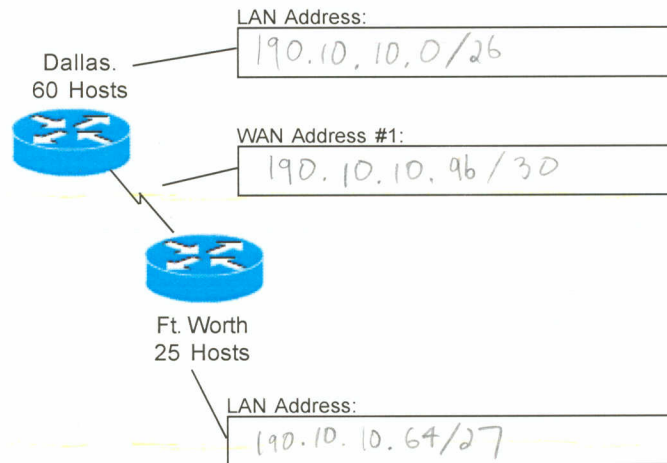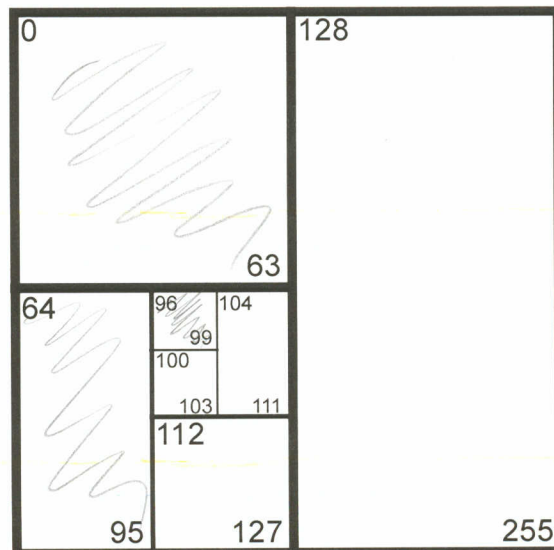
LAN Address:

220.108.38.192/27

Corpus Christi
25 Hosts

WAN Address #1:

220.108.38.224/30

WAN Address #2:

220.108.38.228/30

Houston
120 Hosts

Waco
50 Hosts

LAN Address:

220.108.38.0/25

LAN Address:

220.108.38.128/26

Color in the squares used with different shades to highlight each sub-subnet.

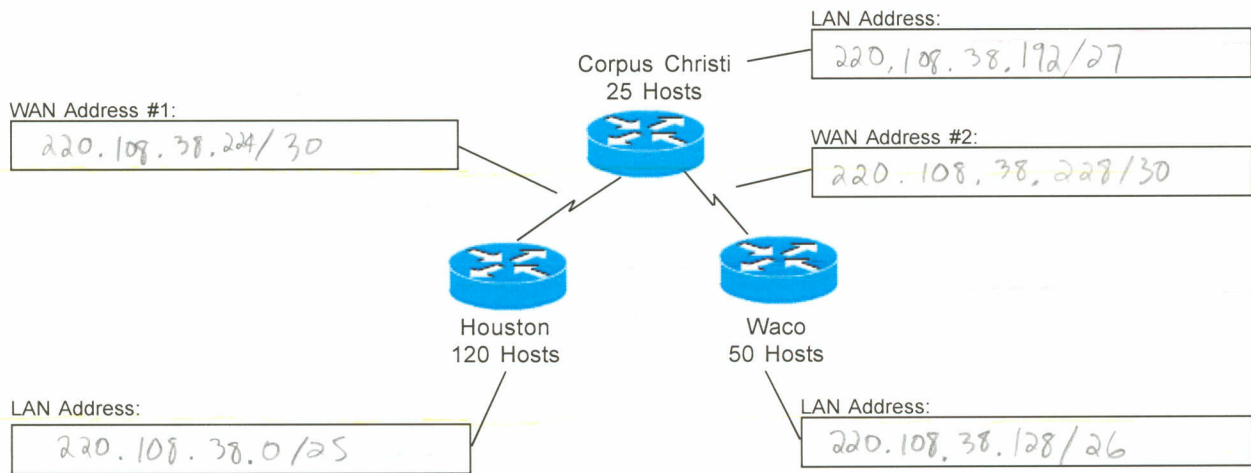| 0	8	32	40	128	136	160	168
3	11	35	43	131	139	163	171
4	12	36	44	132	140	164	172
7	15	39	47	135	143	167	175
16	24	48	56	144	152	176	184
19	27	51	59	147	155	179	187
20	28	52	60	148	156	180	188
23	31	55	63	151	159	183	191
64	72	96	104	192	200	224	232
67	75	99	107	195	203	227	235
68	76	100	108	196	204	228	236
71	79	103	111	199	207	321	239
80	88	112	120	208	216	240	248
83	91	115	123	211	219	243	251
84	92	116	124	212	220	244	252
87	95	119	127	215	223	247	255

VLSM Addressing

Problem 5

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 192.168.10.0. Remember to start with your largest groups first.
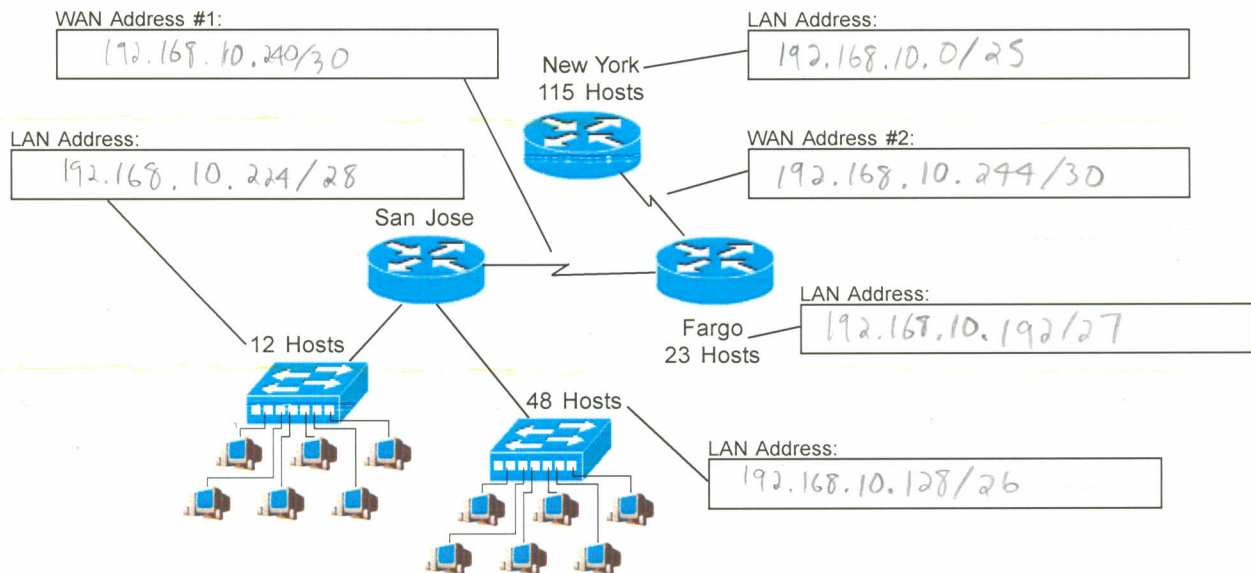
WAN Address #1:

192.168.10.240/30

New York
115 Hosts

LAN Address:

192.168.10.0/25

LAN Address:

192.168.10.224/28

San Jose

WAN Address #2:

192.168.10.244/30

12 Hosts

Fargo
23 Hosts

LAN Address:

192.168.10.192/27

48 Hosts

LAN Address:

192.168.10.128/26

Color in the squares used with different
shades to highlight each sub-subnet.

0	8	32	40	128	136	160	168
3	11	35	43	131	139	163	171
4	12	36	44	132	140	164	172
7	15	39	47	135	143	167	175
16	24	48	56	144	152	176	184
19	27	51	59	147	155	179	187
20	28	52	60	148	156	180	188
23	31	55	63	151	159	183	191
64	72	96	104	192	200	224	232
67	75	99	107	195	203	227	235
68	76	100	108	196	204	228	236
71	79	103	111	199	207	321	239
80	88	112	120	208	216	240	248
83	91	115	123	211	219	243	251
84	92	116	124	212	220	244	252
87	95	119	127	215	223	247	255

VLSM Addressing

Problem 6

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 222.10.150.0. Remember to start with your largest groups first.
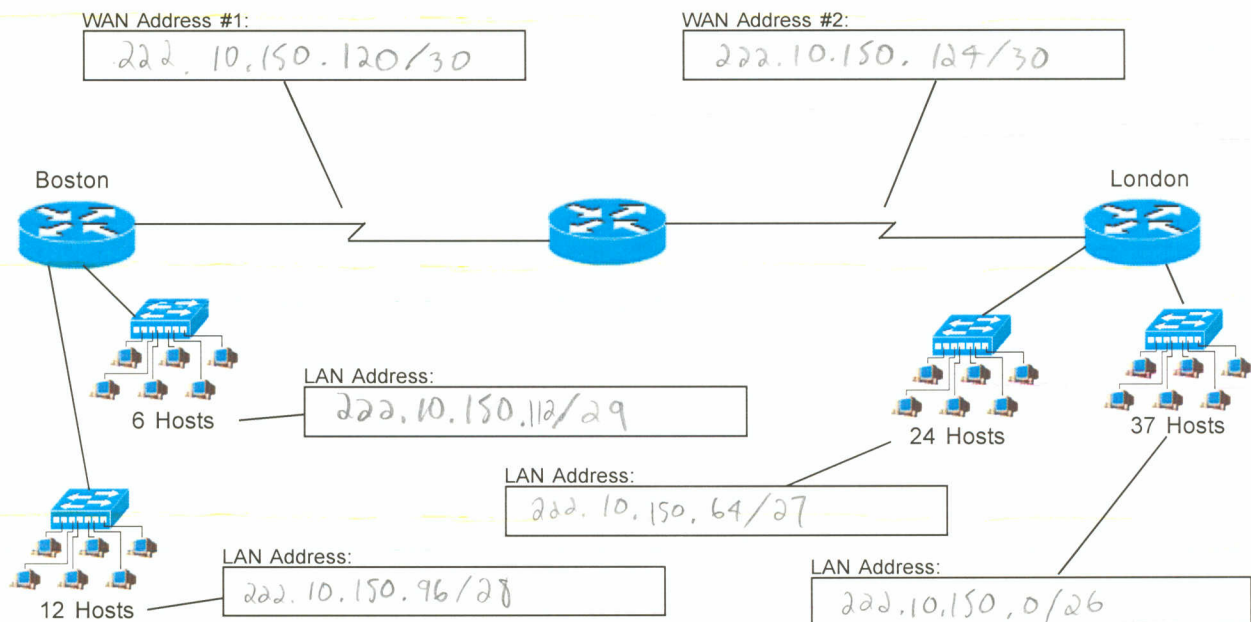
WAN Address #1:
222.10.150.120/30

WAN Address #2:
222.10.150.124/30

Boston

London

LAN Address:
222.10.150.112/29

6 Hosts

24 Hosts

37 Hosts

LAN Address:
222.10.150.64/27

LAN Address:
222.10.150.96/28

12 Hosts

LAN Address:
222.10.150.0/26

Draw the necessary lines and color in the used squares
with different shades to highlight each sub-subnet.

0	32	128	160
31	63	159	191
64	96	192	224
95	127	223	255

VLSM Addressing

Problem 7

    Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 200.150.70.0. Remember to start with your largest groups first.

LAN Address:

200.150.70.0/27

25 Hosts

Boston

LAN Address:

200.150.70.64/29

6 Hosts

LAN Address:

200.150.70.48/28

12 Hosts

14 Hosts

LAN Address:

200.150.70.32/28

Draw the necessary lines and color in the used squares
with different shades to highlight each sub-subnet.

0 63	128 191
64 127	192 255

VLSM Addressing

Problem 8

Using the network diagram and information given create an addressing scheme which utilizes variable-length subnet masks. Show the subnet address and subnet mask in the boxes below, color or shade the sub-subnets used in the box. This company will be using the class C address 192.168.24.0. Remember to start with your largest groups first.
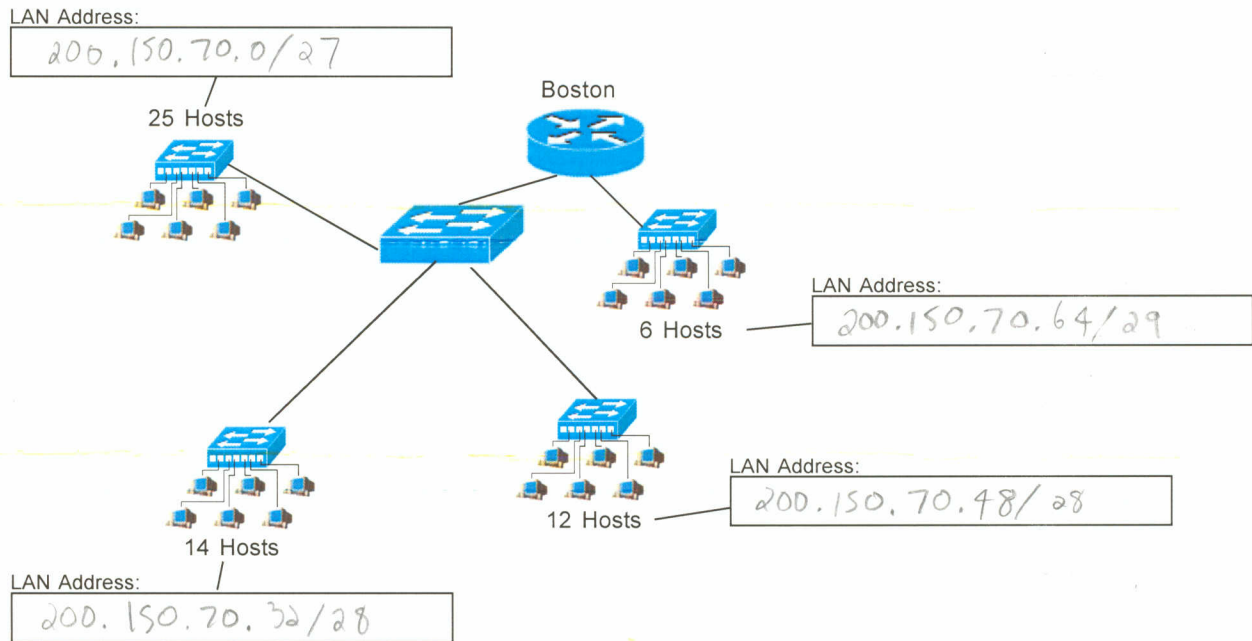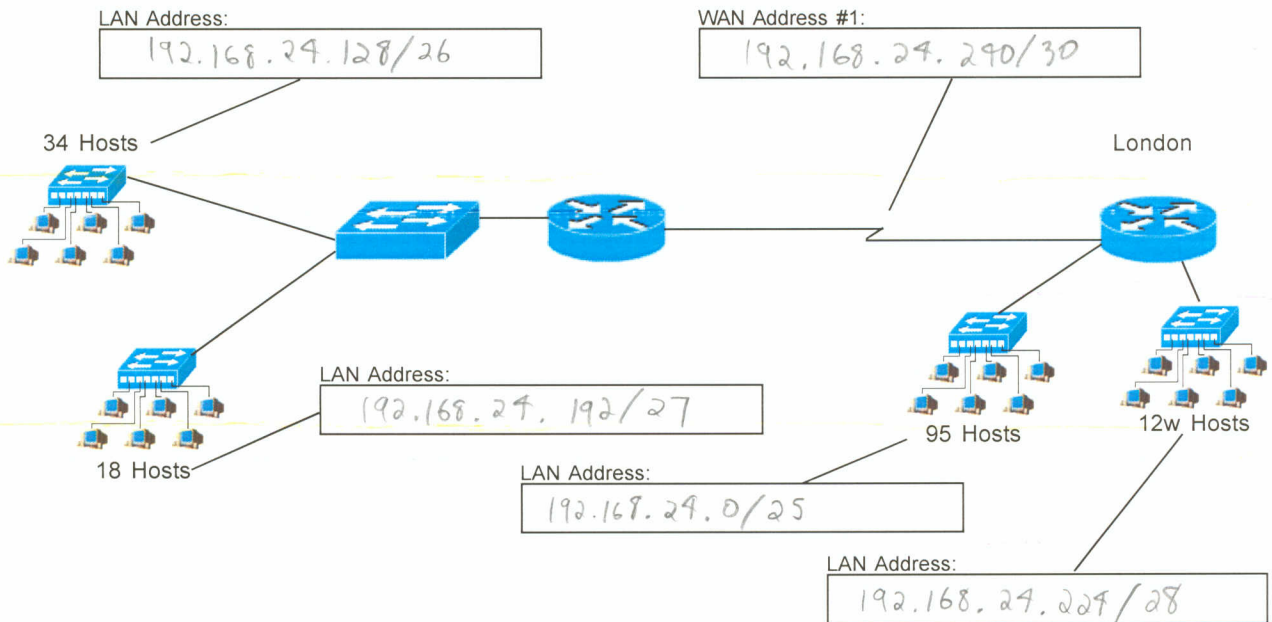
LAN Address:
192.168.24.128/26

WAN Address #1:
192.168.24.240/30

London

34 Hosts

LAN Address:
192.168.24.192/27

18 Hosts

LAN Address:
192.168.24.0/25

95 Hosts

12w Hosts

LAN Address:
192.168.24.224/28

Draw the necessary lines and color in the used squares
with different shades to highlight each sub-subnet.

0

255

VLSM Addressing

(Sample)

Problem 9

You are developing a school network with the class C address 192.168.2.0/24. There will be three computer labs with 30 computers each that need to be on different sub-subnets. Forty eight classrooms with one computer each that will comprise a single sub-subnet. The administrative office and guidance office contain a total of seven computers which will need to be grouped together. Plan for four more mini labs with six computers to each sub-subnetwork. Divide the network using variable length subnet masks. Complete the information required below. Remember to work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	192.168.2.0	/26	192.168.2.1	192.168.2.62	192.168.2.63
2	192.168.2.64	/27	192.168.2.65	192.168.2.94	192.168.2.95
3	192.168.2.96	/27	192.168.2.97	192.168.2.126	192.168.2.127
4	192.168.2.128	/27	192.168.2.129	192.168.2.158	192.168.2.159
5	192.168.2.160	/28	192.168.2.161	192.168.2.174	192.168.2.175
6	192.168.2.176	/29	192.168.2.177	192.168.2.182	192.168.2.183
7	192.168.2.184	/29	192.168.2.185	192.168.2.190	192.168.2.191
8	192.168.2.192	/29	192.168.2.193	192.168.2.198	192.168.2.199
9	192.168.2.200	/29	192.168.2.201	192.168.2.206	192.168.2.207
10					
11					
12					
13					
14					

VLSM Addressing

Problem 10

You are setting up a small business network with the class C address 220.55.80.0/24. The marketing division will need 12 computers. Research and development needs 27 computers. The reception area will need two computers. Management requires 19 computers. Divide the network using variable length subnet masks. Complete the information required below. Remember to work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	220.55.80.0	/27	220.55.80.1	220.55.80.30	220.55.80.31
2	220.55.80.32	/27	220.55.80.	220.55.80.62	220.55.80.63
3	220.55.80.64	/28	220.55.80.65	220.55.80.78	220.55.80.79
4	220.55.80.80	/30	220.55.80.81	220.55.80.82	220.55.80.83
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

VLSM Addressing

Problem 11

You are setting up a medium sized network with the class C address 222.37.34.0/24. Marketing needs 29 computers. Research and development needs 110 computers. Bookkeeping will use 12 computers. The reception area will need three computers. Management requires 60 computers. Divide the network using variable length subnet masks. Complete the information required below. Remember to work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	222.37.34.0	25	222.37.34.1	222.37.34.126	222.37.34.127
2	222.37.34.128	26	222.37.34.129	222.37.34.190	222.37.34.191
3	.192	27	.193	.222	.223
4	.224	28	.225	.238	.239
5	.240	29	.241	.246	.247
6					
7					
8					
9					
10					
11					
12					
13					
14					

VLSM Addressing

Problem 12

A shipping company needs to set up its network across several locations. The Denver office needs six computers. The Waco office needs 22 computers. The Fargo office will need five computers. The WAN links between all three locations need to be included in the solution. Using the IP address 192.168.10.0/24 divide the network using VLSM. Complete the information required below. Remember to work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	192.168.10.0	27	.1	.30	.31
2	.32	29	.33	.38	.39
3	.40	29	.41	.46	.47
4	.48	30	.49	.50	.51
5	.52	30	.53	.54	.55
6	.56	30	.57	.58	.59
7					
8					
9					
10					
11					
12					
13					
14					

VLSM Addressing

Problem 13

A new school is being built in the local school district. It will have three computer labs with 28 computers each. There will be 58 classrooms with 2 computers each that need to be on one sub-subnet. The office staff and administrators will need 7 computers. The guidance and attendance office will have 5 computers. Setup the remaining addressing into one sub-subnet for future expansion. The school has been given the address 223.145.75.0/24. Complete the information required below. Remember to work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	223.145.75.0	25	.1	.126	.127
2	.128	27	.129	.158	.159
3	.160	27	.161	.190	.191
4	.192	27	.193	.222	.223
5	.224	28	.225	.238	.239
6	.240	29	.241	.246	.247
7	.248	29	.249	.254	.255
8					
9					
10					
11					
12					
13					
14					

Left margin: 116, 28, 28, 28, 7, 5

VLSM Addressing

Problem 14

A local college is setting up a campus wide network. The technology wing will be on its own network address of 192.168.250.0/24. The office wing will include 15 computers. There are 2 labs of 20 computers each, 2 labs of 30 computers each and one lab of 35 computers. Complete the information required below. Remember to work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	192.168.250.0	26	.1	.62	.63
2	192.168.250.64	26	.65	.126	.127
3	.128	26	.129	.190	.191
4	.192	27	.193	.222	.223
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

VLSM Addressing

Problem 15

You are setting up a network for a company in four locations. Location A has 8 computers. Location B has 122 computers. Location C has 4 computers. Location D has 55 computers. There is a WAN connection between all four locations. Complete the information required below using the class C address 192.168.10.0. Remember to work from largest to smallest.

this is wrong

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	192.168.10.0	25	.1	.126	.127
2	.128	26	.129	.190	.191
3	.192	28	.193	.222	.223
4	.224	29	.225	.230	.231
5	.232	30	.233	.234	.235
6	.236	30	.237	.238	.239
7	.240	30	.241	.242	.243
8	.244	30	.245	.246	.247
9					
10					
11					
12					
13					
14					

122
55
8
4
v
w
w
w

VLSM Addressing

Problem 16

A college dormitory is being remolded. A new network is being installed. There are 50 dorm rooms with two drops each that will be on one sub-subnet. The offices will have 5 drops. The reception desk will have three drops. A small study hall will include 30 drops. Using the IP address 192.168.12.0/24 complete the information required below using VLSM. Work from largest to smallest.

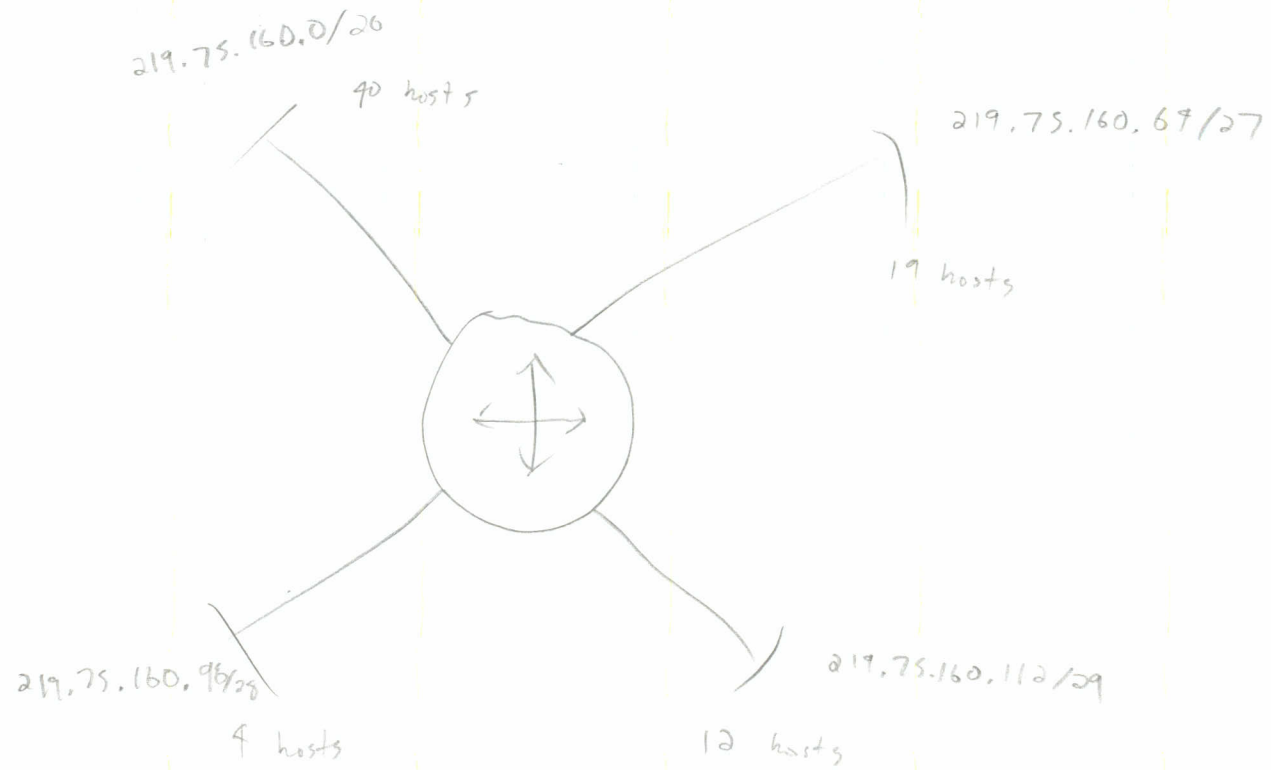| Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	192.168.12.0	25	.1	.126	.127
2	.128	27	.129	.158	.159
3	.160	29	.161	.166	.167
4	.168	29	.169	.174	.175
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

100

40

5

3

VLSM Addressing

Problem 17

You are setting up a business network with the class C address 219.75.160.0/24. The marketing division will need 19 computers. Research and development needs 40 computers. The reception area will need four computers. Management requires 12 computers. Divide the network using variable length subnet masks. On the opposite page draw a detailed map of this network. Include the sub-subnet IP addresses for each branch of the network with the subnet mask. One router with four ethernet ports will be used for this network.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	219.75.160.0	26	.1	.62	.63
2	.64	27	.65	.94	.95
3	.96	28	.97	.110	.111
4	.112	29	.113	.118	.119
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

Problem 17 - Detailed Map

219.75.160.0/26

40 hosts

219.75.160.64/27

19 hosts

219.75.160.96/29
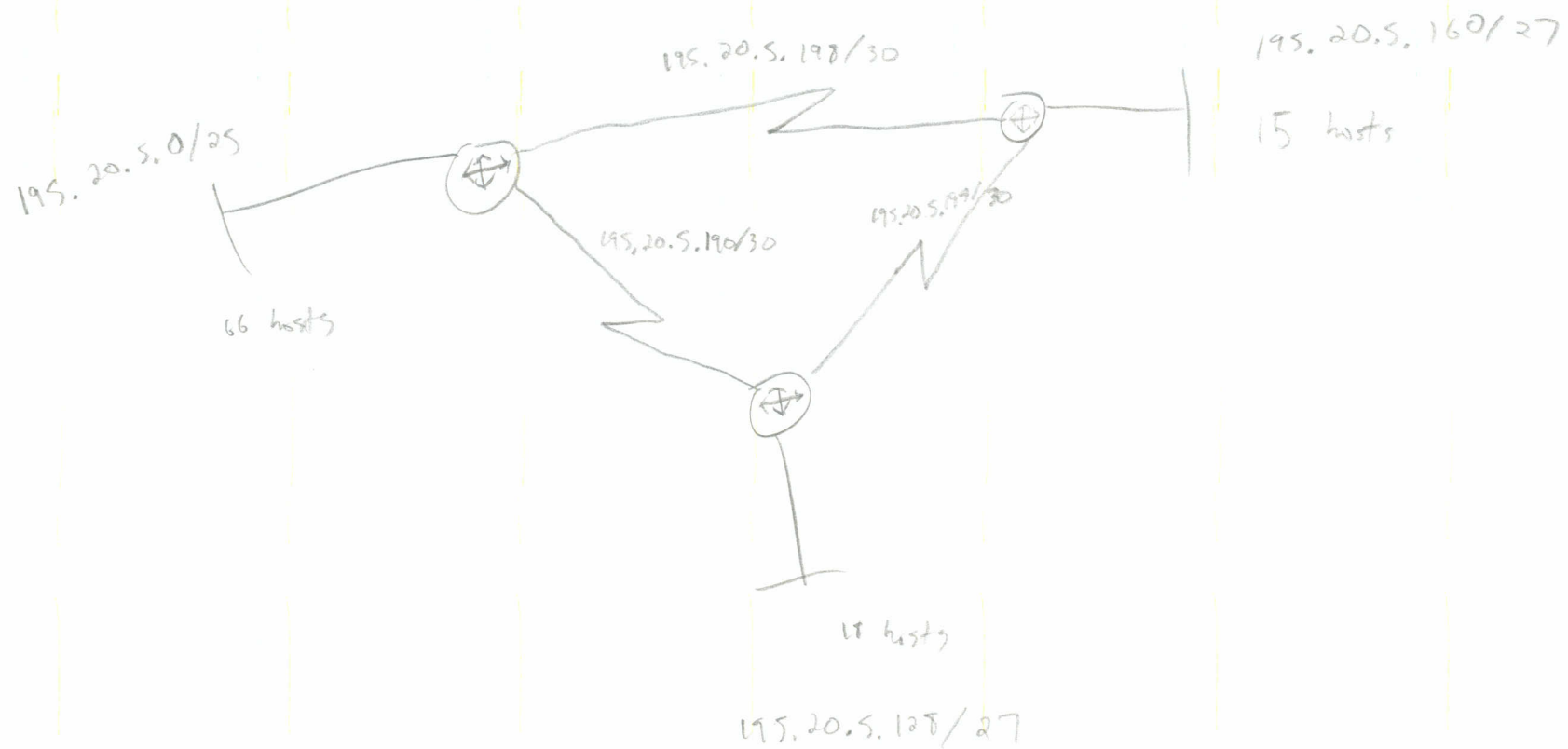
4 hosts

219.75.160.112/29

12 hosts

VLSM Addressing

Problem 18

A small company needs to set up its network across several locations. The New York branch office needs 15 computers. The San Jose office needs 66 computers. The Trinidad office will need 18 computers. The WAN links between all three locations need to be included. Using the IP address 195.20.5.0/24 divide the network using VLSM. On the opposite page draw a detailed map of this network. Include the sub-subnet IP addresses for each branch of the network with the subnet mask. Label the WAN links with the same information. Complete the information required below. Work from largest to smallest.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	195.20.5.0	25	.1	.126	.127
2	.128	27	.129	.158	.159
3	.160	27	.161	.188	.189
4	.190	30	.191	.192	.193
5	.194	30	.195	.196	.197
6	.198	30	.199	.200	.201
7					
8					
9					
10					
11					
12					
13					
14					

(margin notes left of table: 66, 18, 15, 2, 2, 2)

Problem 18 - Detailed Map

195. 20. 5. 198/30

195. 20. 5. 160/27

15 hosts

195. 20. 5. 0/25

195. 20. 5. 199/30

195. 20. 5. 190/30

66 hosts

18 hosts

195. 20. 5. 128/27

Class A Addressing Guide

# of Bits Borrowed	Subnet Mask	Total # of Subnets	Usable # of Subnets	Total # of Hosts	Usable # of Hosts
2	255.192.0.0	4	2	4,194,304	4,194,302
3	255.224.0.0	8	6	2,097,152	2,097,150
4	255.240.0.0	16	14	1,048,576	1,048,574
5	255.248.0.0	32	30	524,288	524,286
6	255.252.0.0	64	62	262,144	262,142
7	255.254.0.0	128	126	131,072	131,070
8	255.255.0.0	256	254	65,536	65,534
9	255.255.128.0	512	510	32,768	32,766
10	255.255.192.0	1,024	1,022	16,384	16,382
11	255.255.224.0	2,048	2,046	8,192	8,190
12	255.255.240.0	4,096	4,094	4,096	4,094
13	255.255.248.0	8,192	8,190	2,048	2,046
14	255.255.252.0	16,384	16,382	1,024	1,022
15	255.255.254.0	32,768	32,766	512	510
16	255.255.255.0	65,536	65,534	256	254
17	255.255.255.128	131,072	131,070	128	126
18	255.255.255.192	262,144	262,142	64	62
19	255.255.255.224	524,288	524,286	32	30
20	255.255.255.240	1,048,576	1,048,574	16	14
21	255.255.255.248	2,097,152	2,097,150	8	6
22	255.255.255.252	4,194,304	4,194,302	4	2

Class B Addressing Guide

# of Bits Borrowed	Subnet Mask	Total # of Subnets	Usable # of Subnets	Total # of Hosts	Usable # of Hosts
2	255.255.192.0	4	2	16,384	16,382
3	255.255.224.0	8	6	8,192	8,190
4	255.255.240.0	16	14	4,096	4,094
5	255.255.248.0	32	30	2,048	2,046
6	255.255.252.0	64	62	1,024	1,022
7	255.255.254.0	128	126	512	510
8	255.255.255.0	256	254	256	254
9	255.255.255.128	512	510	128	126
10	255.255.255.192	1,024	1,022	64	62
11	255.255.255.224	2,048	2,046	32	30
12	255.255.255.240	4,096	4,094	16	14
13	255.255.255.248	8,192	8,190	8	6
14	255.255.255.252	16,384	16,382	4	2

Class C Addressing Guide

# of Bits Borrowed	Subnet Mask	Total # of Subnets	Usable # of Subnets	Total # of Hosts	Usable # of Hosts
2	255.255.255.192	4	2	64	62
3	255.255.255.224	8	6	32	30
4	255.255.255.240	16	14	16	14
5	255.255.255.248	32	30	8	6
6	255.255.255.252	64	62	4	2

VLSM Chart 24-30 Bits

/24 255.255.255.0 256 Hosts	/25 255.255.255.128 128 Hosts	/26 255.255.255.192 64 Hosts	/27 255.255.255.224 32 Hosts	/28 255.255.255.240 16 Hosts	/29 255.255.255.248 8 Hosts	/30 255.255.255.252 4 Hosts
0-127	0-127	0-63	0-31	0-15	0-7	0-3
						4-7
					8-15	8-11
						12-15
				16-31	16-23	16-19
						20-23
					24-31	24-27
						28-31
			32-63	32-47	32-39	32-35
						36-39
					40-47	40-43
						44-47
				48-63	48-55	48-51
						52-55
					56-63	56-59
						60-63
		64-127	64-95	64-79	64-71	64-67
						68-71
					72-79	72-75
						76-79
				80-95	80-87	80-83
						84-87
					88-95	88-91
						92-95
			96-127	96-111	96-103	96-99
						100-103
					104-111	104-107
						108-111
				112-127	112-119	112-115
						116-119
					120-127	120-123
						124-127
	128-255	128-191	128-159	128-143	128-135	128-131
						132-135
					136-143	136-139
						140-143
				144-159	144-151	144-147
						148-151
					152-159	152-155
						156-159
			160-191	160-175	16-167	160-163
						164-167
					168-175	168-171
						172-175
				176-191	176-183	176-179
						180-183
					184-191	184-187
						188-191
		192-255	192-223	192-207	192-199	192-195
						196-199
					200-207	200-203
						204-207
				208-223	208-215	208-211
						212-215
					216-223	216-219
						220-223
			224-255	224-239	224-231	224-227
						228-231
					232-239	232-235
						236-239
				240-255	240-247	240-243
						244-247
					248-255	248-251
						252-255