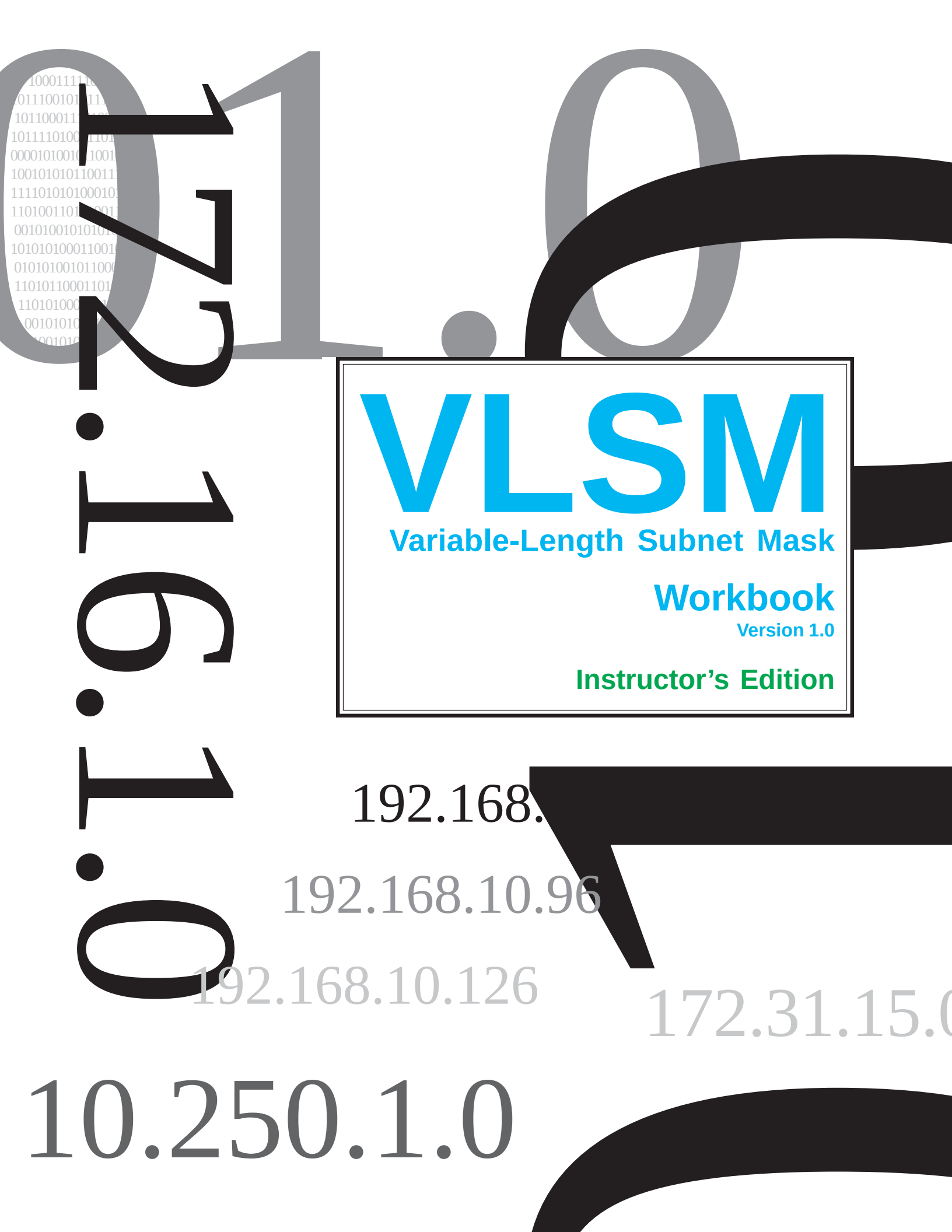

VLSM

Variable-Length Subnet Mask

Workbook

Version 1.0

Instructor's Edition

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.

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Frederick County Public Schools
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Special Thanks to Melvin Baker and Jim Dorsch
for taking the time to check this workbook for errors.

Instructors (and anyone else for that matter) please do not post the Instructors version on public websites. When you do this your giving everyone else worldwide the answers. Yes, students look for answers this way. It also discourages others; myself included, from posting high quality materials.

What is VLSM

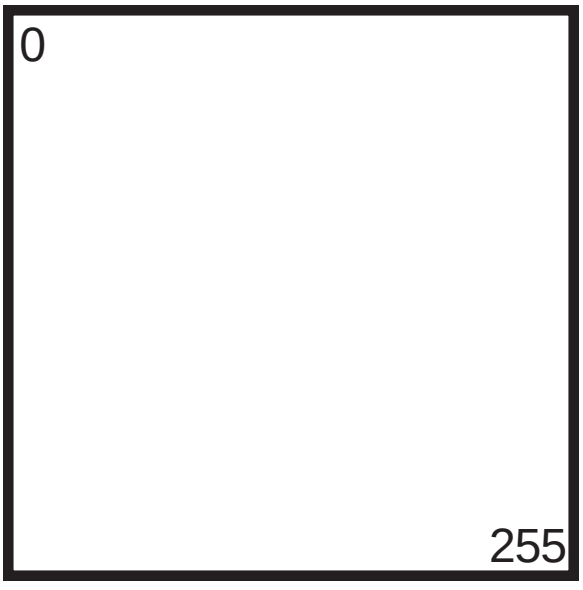
Variable Length Subnet Masks allow you a much tighter control over your addressing scheme. If you use a class C address with a default subnet mask you end up with one subnet containing 256 addresses. By using VLSM you can adjust the number of subnets and number of addresses depending on the specific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

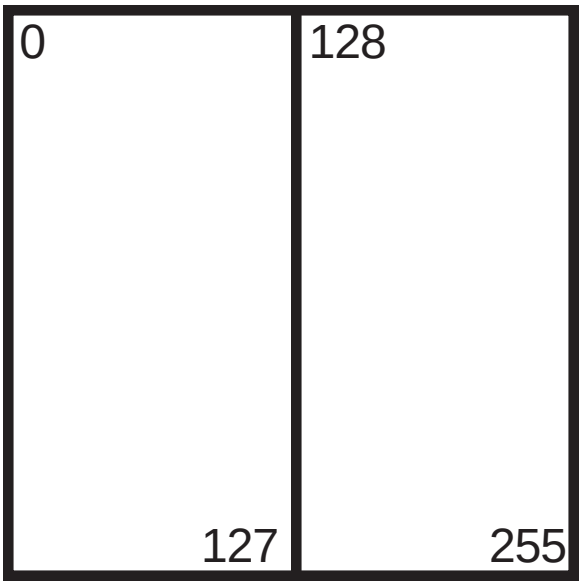
Start with a square. The whole square is a single subnet comprised of 256 addresses.



/24
255.255.255.0
256 Hosts
1 Subnet

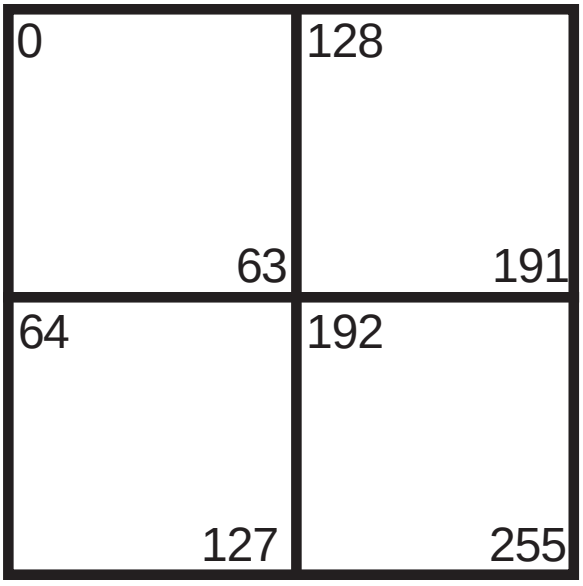
Split the box in half and you get two subnets with 128 addresses,

/25
255.255.255.128
128 Hosts
2 Subnets



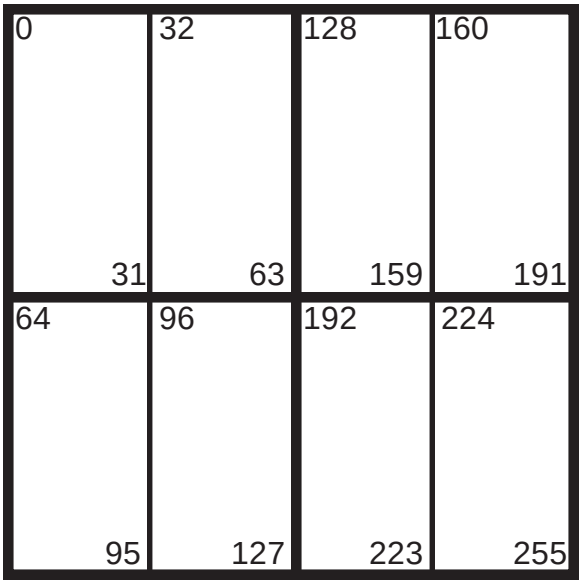
Divide the box into quarters and you get four subnets with 64 addresses,

/26
255.255.255.192
64 Hosts
4 Subnets



Split each individual square and you get eight subnets with 32 addresses,

/27
255.255.255.224
32 Hosts
8 Subnets



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

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

/28
255.255.255.240
16 Hosts
16 Subnets

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

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

/29
255.255.255.248
8 Hosts
32 Subnets

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

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

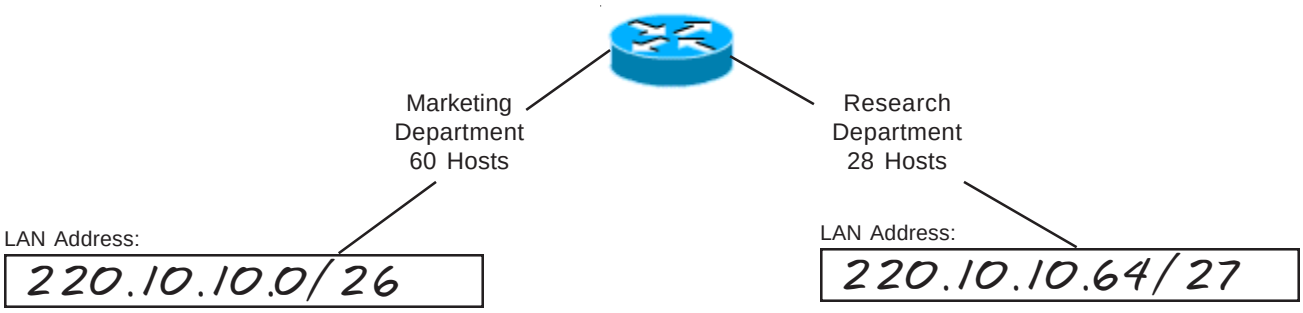
/30
255.255.255.252
4 Hosts
64 Subnets

VLSM Addressing

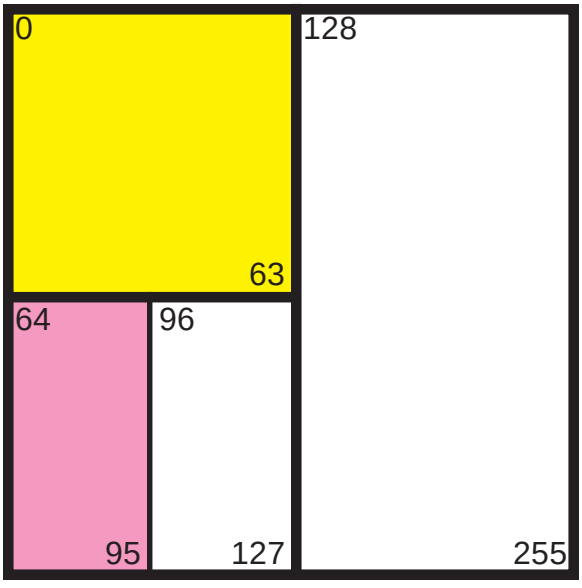
(Sample)

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.



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

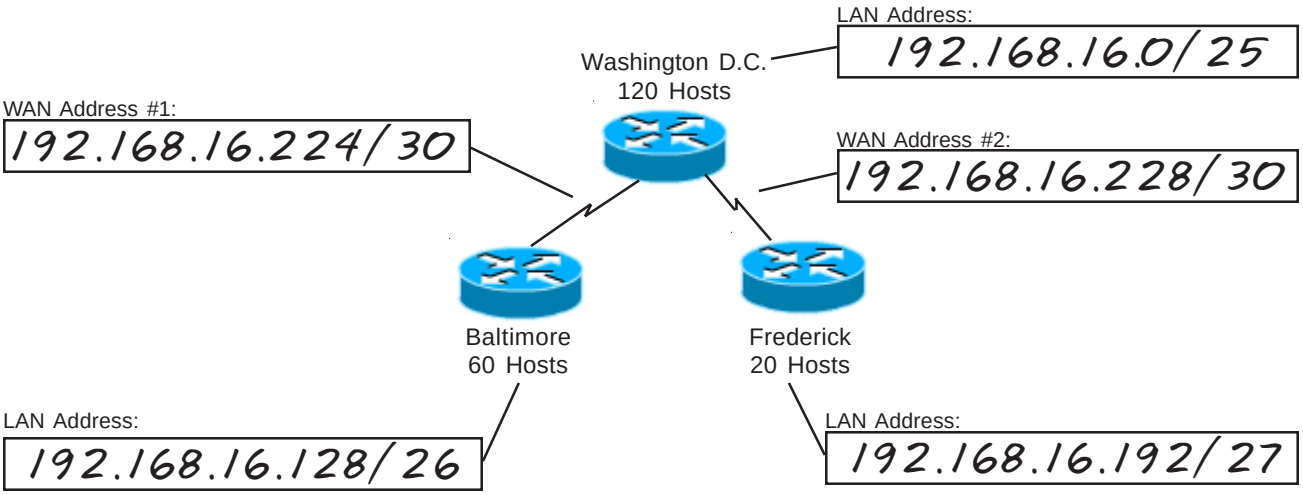


VLSM Addressing

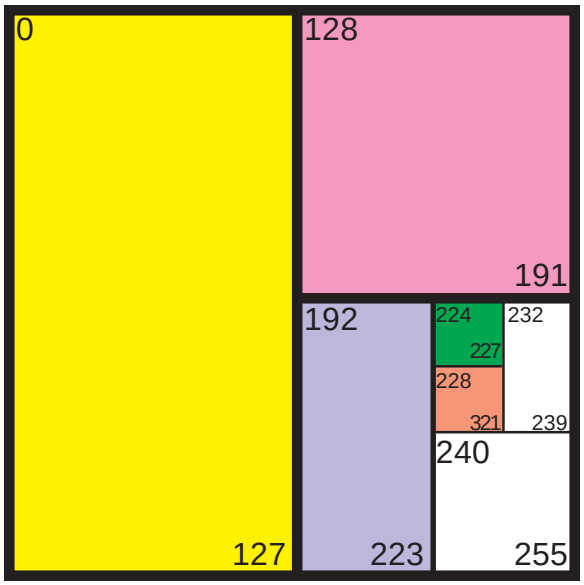
(Sample)

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.



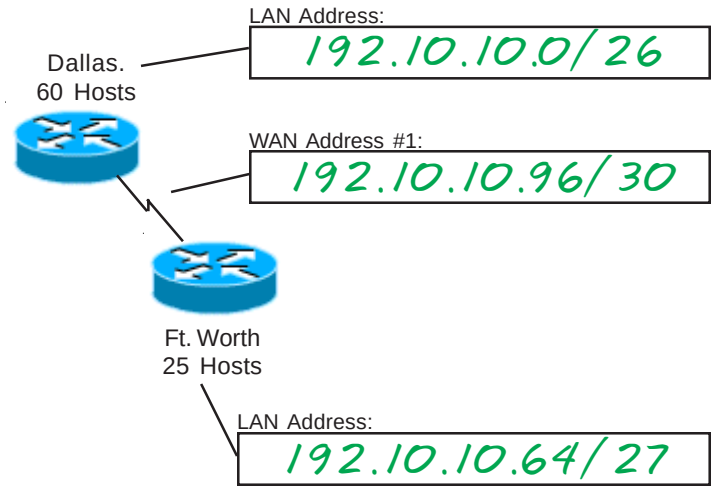
Color in the squares used with different shades to highlight each sub-subnet.



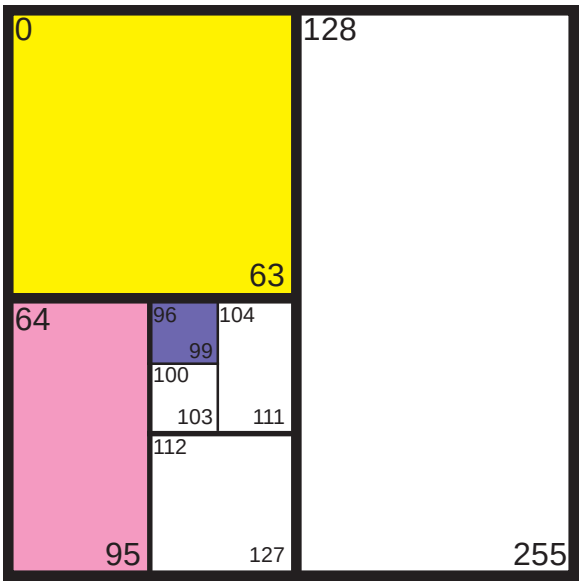
VLSM Addressing

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.



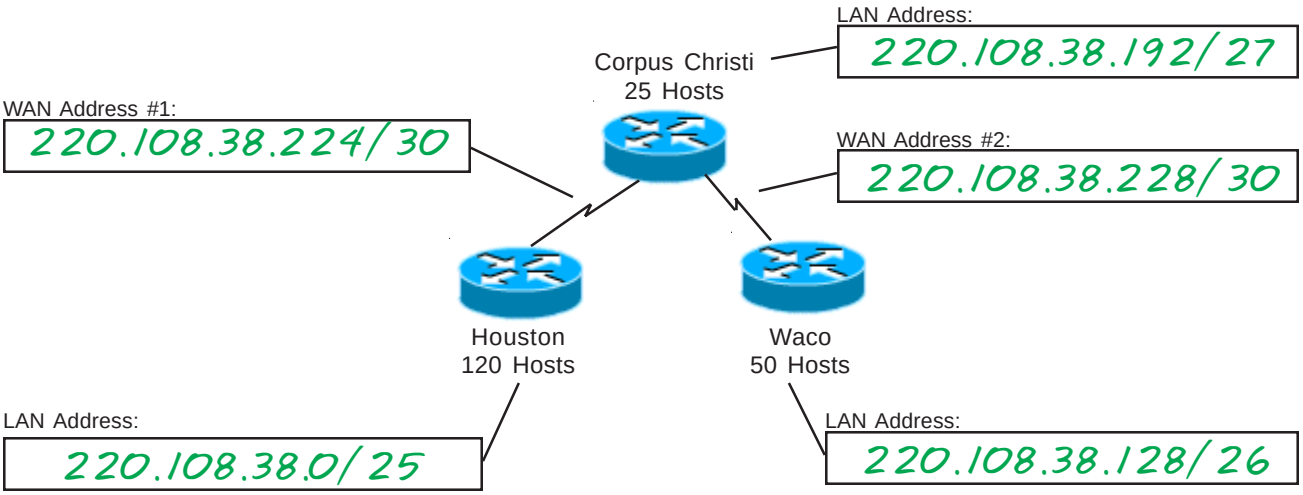
Color in the squares used with different shades to highlight each sub-subnet.



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.



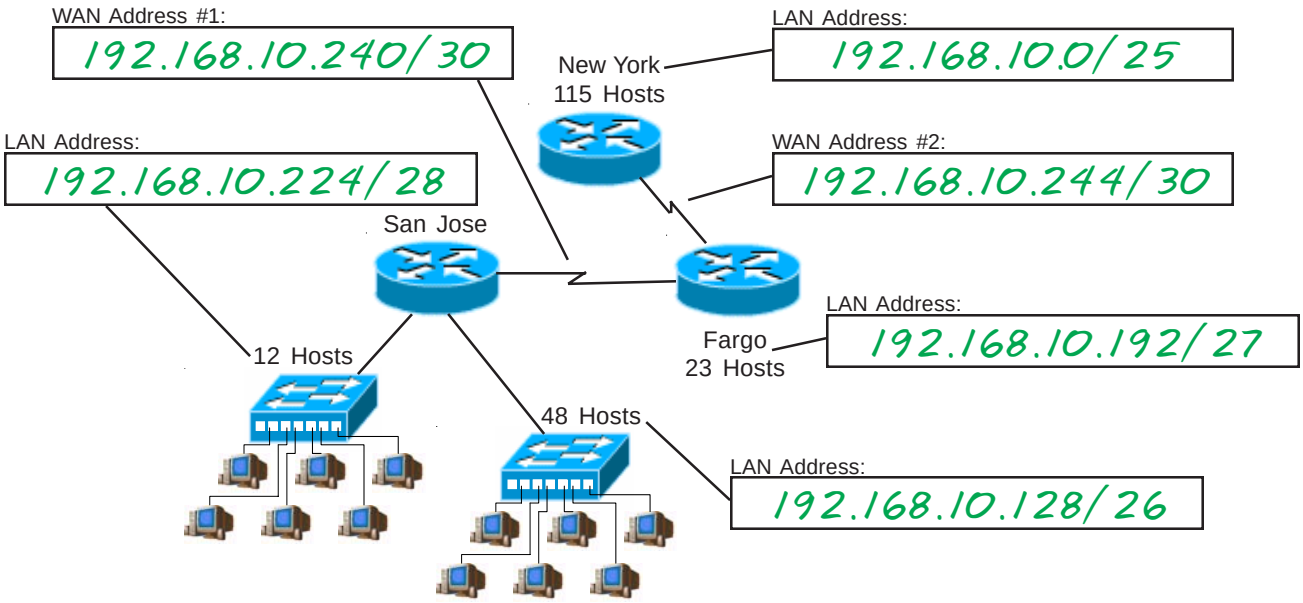
Color in the squares used with different shades to highlight each sub-subnet.

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

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.



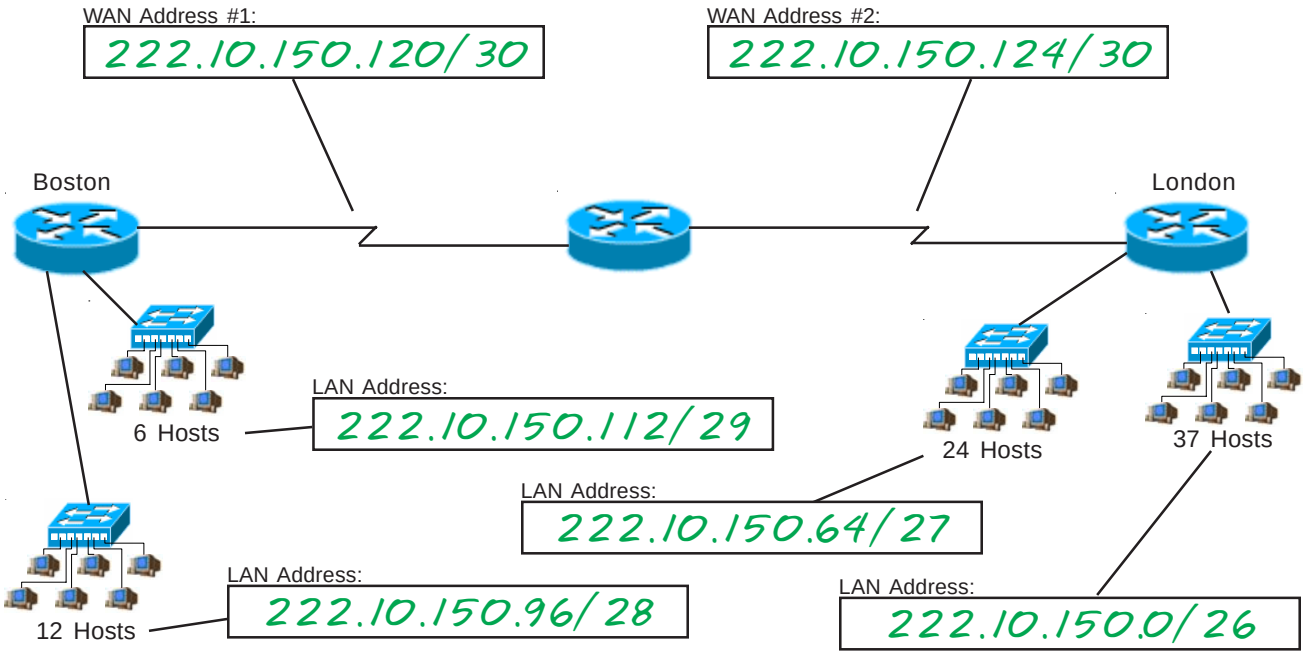
Color in the squares used with different shades to highlight each sub-subnet.

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

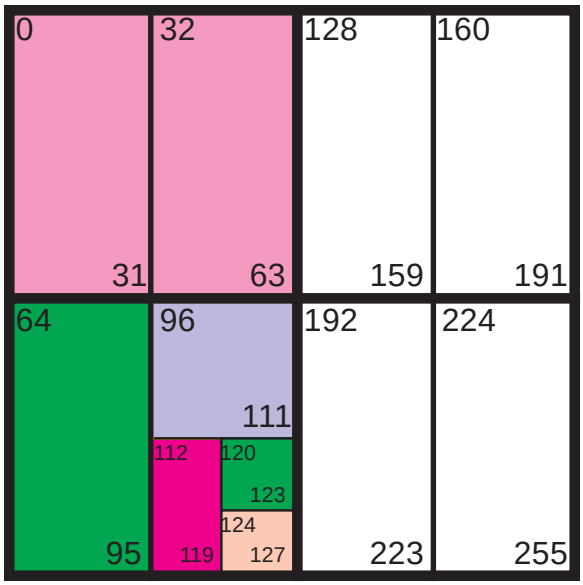
VLSM Addressing

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.



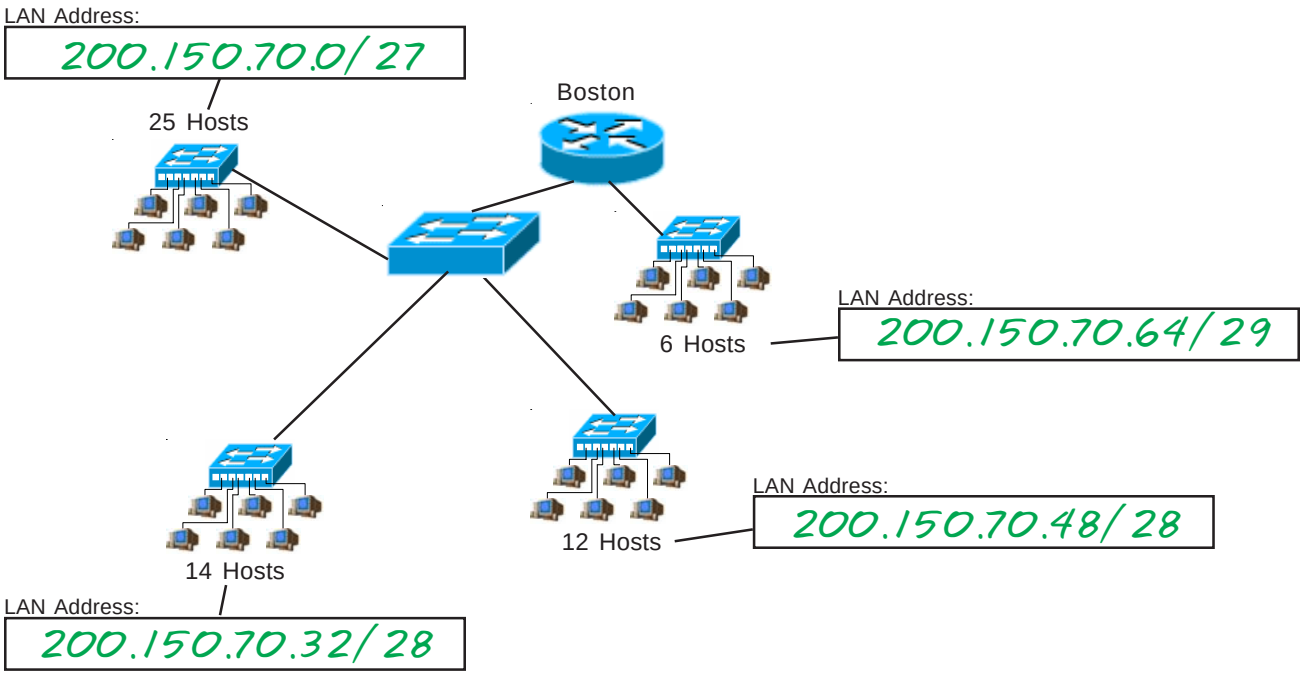
Draw the necessary lines and color in the used squares with different shades to highlight each sub-subnet.



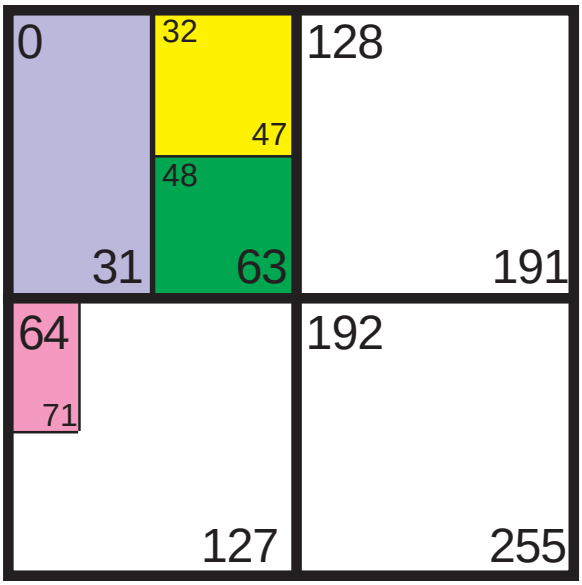
VLSM Addressing

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.



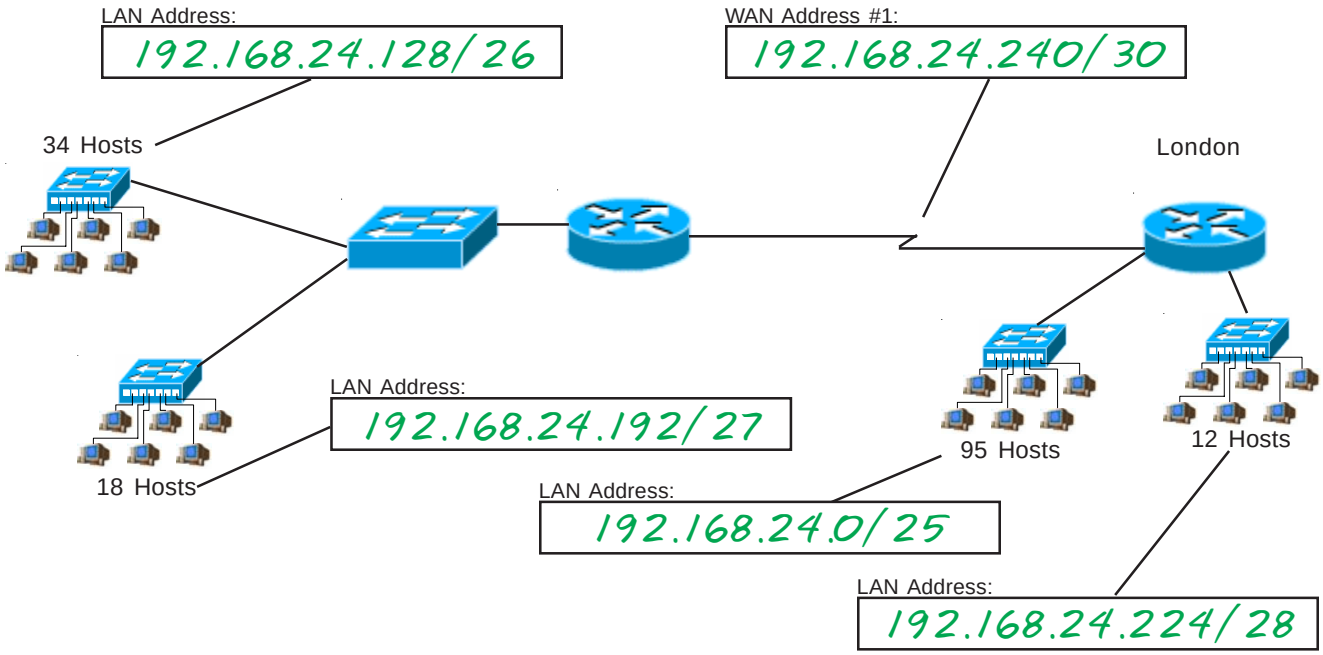
Draw the necessary lines and color in the used squares with different shades to highlight each sub-subnet.



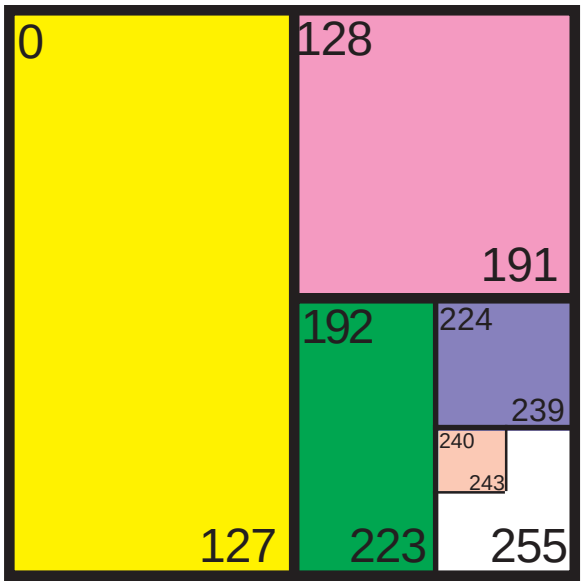
VLSM Addressing

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.



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



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

(Sample)

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	222.37.34.192	/27	222.37.34.193	222.37.34.222	222.37.34.223
4	222.37.34.224	/28	222.37.34.225	222.37.34.238	222.37.34.239
5	222.37.34.240	/29	222.37.34.241	222.37.34.246	222.37.34.247
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	192.168.10.1	192.168.10.30	192.168.10.31
2	192.168.10.32	/29	192.168.10.33	192.168.10.38	192.168.10.39
3	192.168.10.40	/29	192.168.10.41	192.168.10.46	192.168.10.47
4	192.168.10.48	/30	192.168.10.49	192.168.10.50	192.168.10.51
5	192.168.10.52	/30	192.168.10.53	192.168.10.54	192.168.10.55
6					
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	223.145.75.1	223.145.75.126	223.145.75.127
2	223.145.75.128	/27	223.145.75.129	223.145.75.158	223.145.75.159
3	223.145.75.160	/27	223.145.75.161	223.145.75.190	223.145.75.191
4	223.145.75.192	/27	223.145.75.193	223.145.75.222	223.145.75.223
5	223.145.75.224	/28	223.145.75.225	223.145.75.238	223.145.75.239
6	223.145.75.240	/29	223.145.75.241	223.145.75.246	223.145.75.247
7	223.145.75.248	/29	223.145.75.249	223.145.75.254	223.145.75.255
8					
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11					
12					
13					
14					

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	92.168.250.1	92.168.250.62	92.168.250.63
2	92.168.250.64	/27	92.168.250.65	92.168.250.94	92.168.250.95
3	92.168.250.96	/27	92.168.250.97	92.168.250.126	92.168.250.127
4	92.168.250.128	/27	92.168.250.129	92.168.250.158	92.168.250.159
5	92.168.250.160	/27	92.168.250.161	92.168.250.190	92.168.250.191
6	92.168.250.192	/27	92.168.250.193	92.168.250.222	92.168.250.223
7					
8					
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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.

Subnet	Subnet Address	Subnet Mask (/X)	First Usable Host	Last Usable Host	Broadcast Address
1	192.168.10.0	/25	192.168.10.1	192.168.10.126	192.168.10.127
2	192.168.10.128	/26	192.168.10.129	192.168.10.190	192.168.10.191
3	192.168.10.192	/28	192.168.10.193	192.168.10.206	192.168.10.207
4	192.168.10.208	/29	192.168.10.209	192.168.10.214	192.168.10.215
5	192.168.10.216	/30	192.168.10.217	192.168.10.218	192.168.10.219
6	192.168.10.220	/30	192.168.10.221	192.168.10.222	192.168.10.223
7	192.168.10.224	/30	192.168.10.225	192.168.10.226	192.168.10.227
8					
9					
10					
11					
12					
13					
14					

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	192.168.12.1	192.168.12.126	192.168.12.127
2	192.168.12.128	/27	192.168.12.129	192.168.12.158	192.168.12.159
3	192.168.12.160	/29	192.168.12.161	192.168.12.166	192.168.12.167
4	192.168.12.168	/29	192.168.12.169	192.168.12.174	192.168.12.175
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

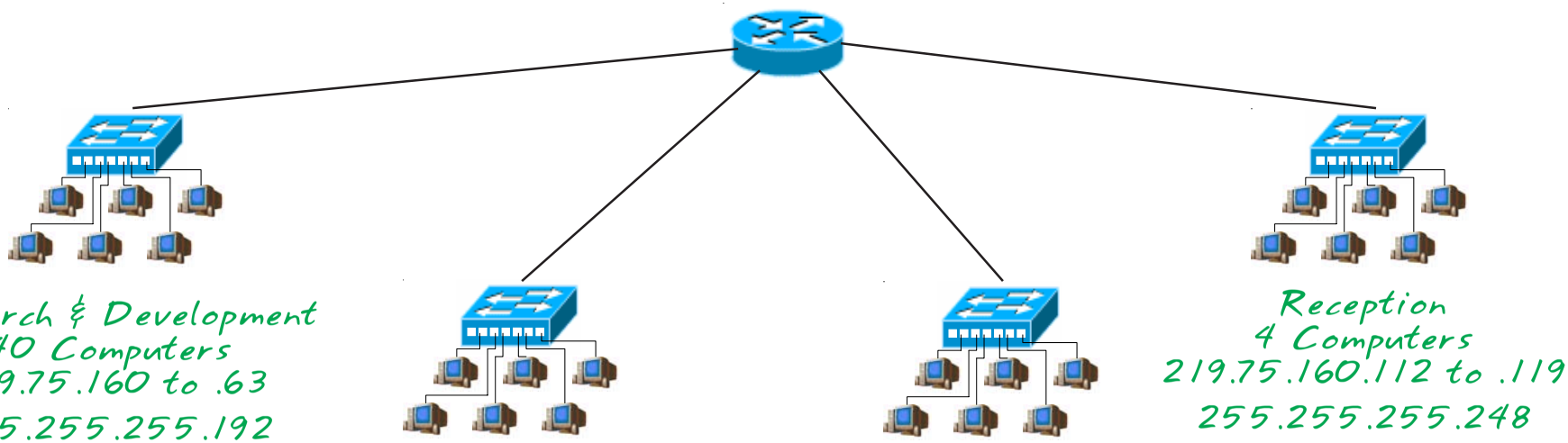
VLSM Addressing

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	219.75.160.1	219.75.160.62	219.75.160.63
2	219.75.160.64	/27	219.75.160.65	219.75.160.94	219.75.160.95
3	219.75.160.96	/28	219.75.160.97	219.75.160.110	219.75.160.111
4	219.75.160.112	/29	219.75.160.113	219.75.160.118	219.75.160.119
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

Problem 17 - Detailed Map



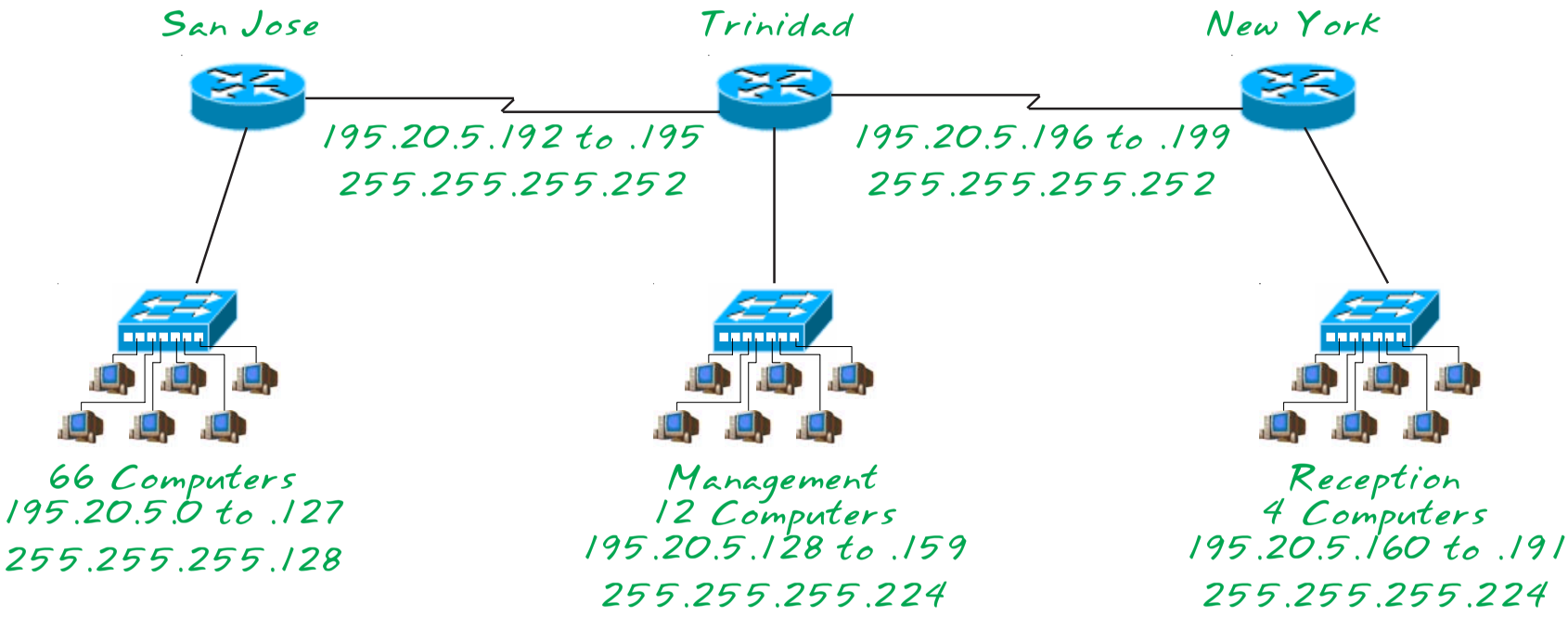
VLSM Addressing

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	195.20.5.1	195.20.5.126	195.20.5.127
2	195.20.5.128	/27	195.20.5.129	195.20.5.158	195.20.5.159
3	195.20.5.160	/27	195.20.5.161	195.20.5.190	195.20.5.191
4	195.20.5.192	/30	195.20.5.193	195.20.5.194	195.20.5.195
5	195.20.5.196	/30	195.20.5.197	195.20.5.198	195.20.5.199
6					
7					
8					
9					
10					
11					
12					
13					
14					

Problem 18 - Detailed Map



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