IP Address Classes

Class A  1 – 127  (Network 127 is reserved for loopback and internal testing)
Leading bit pattern  0  00000000.00000000.00000000.00000000

Class B  128 – 191  Leading bit pattern  10  10000000.00000000.00000000.00000000

Class C  192 – 223  Leading bit pattern  110  11000000.00000000.00000000.00000000

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.

Produced by: Robb Jones
jonesr@careertech.net
Frederick County Career & Technology Center
Cisco Networking Academy
Frederick County Public Schools
Frederick, Maryland, USA

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

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>128</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>127</td>
<td>255</td>
</tr>
</tbody>
</table>

/25
255.255.255.128
128 Hosts
2 Subnets

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

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>128</th>
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</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
<td>127</td>
<td>255</td>
</tr>
</tbody>
</table>

/26
255.255.255.192
64 Hosts
4 Subnets

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

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>32</th>
<th>128</th>
<th>160</th>
</tr>
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<td>159</td>
<td>191</td>
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<tr>
<td></td>
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<td>127</td>
<td>223</td>
<td>255</td>
</tr>
</tbody>
</table>

/27
255.255.255.224
32 Hosts
8 Subnets
Split the boxes in half again and you get sixteen subnets with sixteen addresses,

<table>
<thead>
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<th>160</th>
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<tbody>
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<tr>
<td>31</td>
<td>63</td>
<td>159</td>
<td>191</td>
</tr>
</tbody>
</table>

/28
255.255.255.240
16 Hosts
16 Subnets

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

<table>
<thead>
<tr>
<th>0</th>
<th>32</th>
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<th>128</th>
<th>136</th>
<th>160</th>
<th>168</th>
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<tr>
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<td>55</td>
<td>63</td>
<td>151</td>
<td>159</td>
<td>183</td>
</tr>
</tbody>
</table>

/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.

<table>
<thead>
<tr>
<th>0</th>
<th>32</th>
<th>40</th>
<th>128</th>
<th>136</th>
<th>160</th>
<th>168</th>
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<td>55</td>
<td>63</td>
<td>151</td>
<td>159</td>
<td>183</td>
</tr>
</tbody>
</table>

/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.

Marketing Department
60 Hosts
LAN Address:
220.10.10.0/26

Research Department
28 Hosts
LAN Address:
220.10.10.64/27

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.

**LAN Address:**
- 192.168.16.0/25
- 192.168.16.128/26
- 192.168.16.192/27

**WAN Address #1:**
- Washington D.C.
  - 120 Hosts
  - 192.168.16.0/25

**WAN Address #2:**
- Frederick
  - 20 Hosts
  - 192.168.16.224/30

**WAN Address #2:**
- Baltimore
  - 60 Hosts
  - 192.168.16.128/26

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

Ft. Worth 25 Hosts

LAN Address: 192.10.10.0/26
WAN Address #1: 192.10.10.96/30
LAN Address: 192.10.10.64/27

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.

<table>
<thead>
<tr>
<th>LAN Address:</th>
<th>220.108.38.0/25</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAN Address #1:</td>
<td>220.108.38.224/30</td>
</tr>
<tr>
<td>WAN Address #2:</td>
<td>220.108.38.228/30</td>
</tr>
<tr>
<td>LAN Address:</td>
<td>220.108.38.192/27</td>
</tr>
<tr>
<td>LAN Address:</td>
<td>220.108.38.128/26</td>
</tr>
<tr>
<td>LAN Address:</td>
<td>220.108.38.128/26</td>
</tr>
</tbody>
</table>

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

New York
115 Hosts

Fargo
23 Hosts

San Jose
12 Hosts

128 Hosts

LAN Address:

WAN Address #1:

192.168.10.240/30

LAN Address:

192.168.10.0/25

WAN Address #2:

192.168.10.244/30

LAN Address:

192.168.10.192/27

LAN Address:

192.168.10.128/26

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

LAN Address: 222.10.150.112/29

LAN Address: 222.10.150.96/28

LAN Address: 222.10.150.64/27

London

LAN Address: 222.10.150.0/26

24 Hosts

37 Hosts

6 Hosts

12 Hosts

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

LAN Address: 200.150.70.32/28

LAN Address: 200.150.70.64/29

LAN Address: 200.150.70.48/28

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.

**LAN Address:**
- 192.168.24.0/25
- 192.168.24.128/26
- 192.168.24.192/27
- 192.168.24.224/28

**WAN Address #1:**
- 192.168.24.240/30

**London**
- 95 Hosts
- 12 Hosts

**LAN Address:**
- 192.168.24.0/25

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

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>192.168.2.0</td>
<td>/26</td>
<td>192.168.2.1</td>
<td>192.168.2.62</td>
<td>192.168.2.63</td>
</tr>
<tr>
<td>2</td>
<td>192.168.2.64</td>
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<td>3</td>
<td>192.168.2.96</td>
<td>/27</td>
<td>192.168.2.97</td>
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<td>192.168.2.127</td>
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<td>192.168.2.129</td>
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<td>192.168.2.175</td>
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<tr>
<td>6</td>
<td>192.168.2.176</td>
<td>/29</td>
<td>192.168.2.177</td>
<td>192.168.2.182</td>
<td>192.168.2.183</td>
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<tr>
<td>7</td>
<td>192.168.2.184</td>
<td>/29</td>
<td>192.168.2.185</td>
<td>192.168.2.190</td>
<td>192.168.2.191</td>
</tr>
<tr>
<td>8</td>
<td>192.168.2.192</td>
<td>/29</td>
<td>192.168.2.193</td>
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</tbody>
</table>
**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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
## 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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
</tr>
</thead>
<tbody>
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<td>14</td>
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</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
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</tbody>
</table>
**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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
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</table>
**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.

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<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
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**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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
<th>Broadcast Address</th>
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</table>
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.

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</table>
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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
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Problem 17 - Detailed Map

Research & Development
40 Computers
219.75.160 to .63
255.255.255.192

Marketing
19 Computers
219.75.160.64 to .95
255.255.255.224

Management
12 Computers
219.75.160.96 to .111
255.255.255.240

Reception
4 Computers
219.75.160.112 to .119
255.255.255.248
## 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.

<table>
<thead>
<tr>
<th>Subnet</th>
<th>Subnet Address</th>
<th>Subnet Mask (/X)</th>
<th>First Usable Host</th>
<th>Last Usable Host</th>
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</table>
Problem 18 - Detailed Map

San Jose

66 Computers
195.20.5.0 to .127
255.255.255.128

Trinidad

Management
12 Computers
195.20.5.128 to .159
255.255.255.224

New York

Reception
4 Computers
195.20.5.160 to .161
255.255.255.224

195.20.5.192 to .195
255.255.255.252

195.20.5.196 to .199
255.255.255.252
### Class A Addressing Guide

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### Class B Addressing Guide

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### Class C Addressing Guide

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