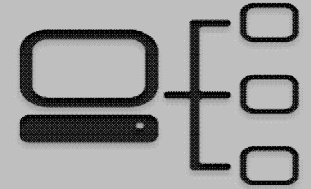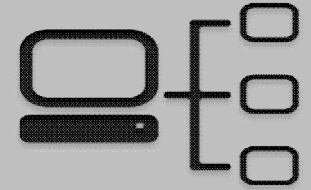# Why Subnet?

- Using default Class A, B and C subnets (called Classful IP Addressing) is inefficient:
  - Wastes unused IP Addresses (Public IP Addresses)

- Allows you to create multiple logical networks that exist within a single Class A, B, or C network.
  - break a major network down into multiple smaller sub-networks, i.e. subnets!

- Allows for more efficient routing via router summarization.

# Fixed Length Subnetting

- We will begin learning about fixed length subnetting, known as a fixed-length subnet mask (FLSM)

# Process of Subnetting
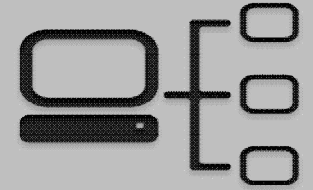
- We **borrow** host bits to create more **sub-networks (subnets)** from a Class A, B, or C network.

- When you borrow hosts bits:
  - You create additional sub-networks, i.e. subnets
  - You also decrease the amount of host IP addresses available to use

# How to Create Subnets
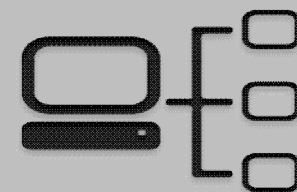
- Borrow bits from the host portion of an IP address
  - Each bit we borrow is equal to $2^1$ Subnets
    - Borrow 1 Bit = $2^1$ = 2
    - Borrow 2 Bits = $2^2$ = 4
    - Borrow 2 Bits = $2^3$ = 8
    - Etc.

# Creating Subnets Visualized
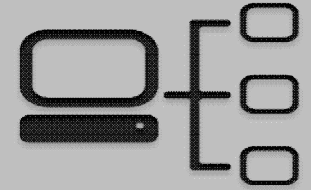
| Default Class C Network (8 Host Bits) |
|:---:|

2 Host Bits Borrowed = $2^2$ = Subnetted into 4 Subnets

| 1 | 2 | 3 | 4 |
|:---:|:---:|:---:|:---:|
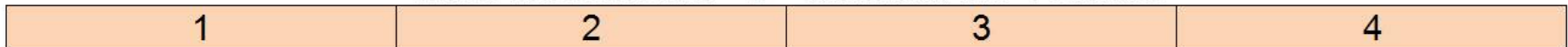
3 Host Bits Borrowed = $2^3$ = Subnetted into 8 Subnets

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|:---:|:---:|:---:|:---:|:---:|:---:|:---:|:---:|
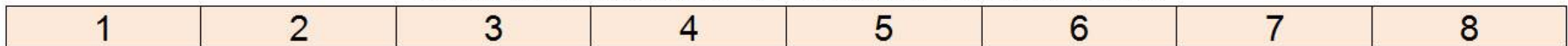
# Subnetting Questions
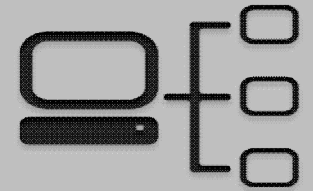
- To Create a Subnet, Answer the Following Questions:
  - How many subnets are needed?
  - How many hosts do you need per subnet?

# Class C Possible Subnets
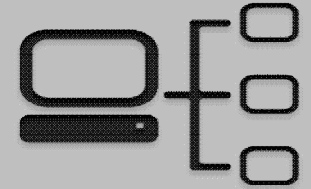
| Binary (N.N.N.H) | Decimal | CIDR | # Subnets ($2^x$) | Block Size ($2^y$) | # Hosts ($2^y$ - 2) |
|---|---|---|---|---|---|
| N.N.N.00000000 | 255.255.255.0 | /24 | $2^0 = 1$ | $2^8 = 256$ | $2^8 - 2 = 254$ |
| N.N.N.10000000 | 255.255.255.128 | /25 | $2^1 = 2$ | $2^7 = 128$ | $2^7 - 2 = 126$ |
| N.N.N.11000000 | 255.255.255.192 | /26 | $2^2 = 4$ | $2^6 = 64$ | $2^6 - 2 = 62$ |
| N.N.N.11100000 | 255.255.255.224 | /27 | $2^3 = 8$ | $2^5 = 32$ | $2^5 - 2 = 30$ |
| N.N.N.11110000 | 255.255.255.240 | /28 | $2^4 = 16$ | $2^4 = 16$ | $2^4 - 2 = 14$ |
| N.N.N.11111000 | 255.255.255.248 | /29 | $2^5 = 32$ | $2^3 = 8$ | $2^3 - 2 = 6$ |
| N.N.N.11111100 | 255.255.255.252 | /30 | $2^6 = 64$ | $2^2 = 4$ | $2^2 - 2 = 2$ |

# Class B Possible Sunets
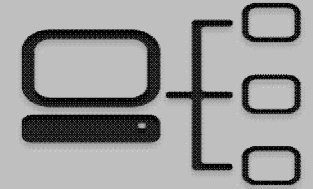
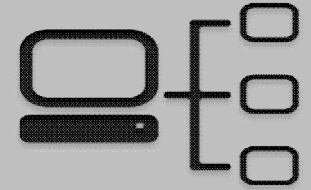| Binary (N.N.H.H) | Decimal | CIDR | # Subnets ($2^x$) | Block Size ($2^y$) | # Hosts ($2^y - 2$) |
|---|---|---|---|---|---|
| N.N.00000000.00000000 | 255.255.0.0 | /16 | $2^0 = 1$ | $2^{16} = 65,536$ | $2^{16} - 2 = 65,534$ |
| N.N.10000000.00000000 | 255.255.128.0 | /17 | $2^1 = 2$ | $2^{15} = 32,768$ | $2^{15} - 2 = 32,766$ |
| N.N.11000000.00000000 | 255.255.192.0 | /18 | $2^2 = 4$ | $2^{14} = 16,384$ | $2^{14} - 2 = 1,.382$ |
| N.N.11100000.00000000 | 255.255.224.0 | /19 | $2^3 = 8$ | $2^{13} = 8,192$ | $2^{13} - 2 = 8,190$ |
| N.N.11110000.00000000 | 255.255.240.0 | /20 | $2^4 = 16$ | $2^{12} = 4,096$ | $2^{12} - 2 = 4,094$ |
| N.N.11111000.00000000 | 255.255.248.0 | /21 | $2^5 = 32$ | $2^{11} = 2,048$ | $2^{11} - 2 = 2,046$ |
| N.N.11111100.00000000 | 255.255.252.0 | /22 | $2^6 = 64$ | $2^{10} = 1,024$ | $2^{10} - 2 = 1,022$ |
| N.N.11111110.00000000 | 255.255.254.0 | /23 | $2^7 = 128$ | $2^9 = 512$ | $2^9 - 2 = 510$ |
| N.N.11111111.00000000 | 255.255.255.0 | /24 | $2^8 = 256$ | $2^8 = 256$ | $2^8 - 2 = 254$ |
| N.N.11111111.10000000 | 255.255.255.128 | /25 | $2^9 = 512$ | $2^7 = 128$ | $2^7 - 2 = 126$ |
| N.N.11111111.11000000 | 255.255.255.192 | /26 | $2^{10} = 1,024$ | $2^6 = 64$ | $2^6 - 2 = 62$ |
| N.N.11111111.11100000 | 255.255.255.224 | /27 | $2^{11} = 2,048$ | $2^5 = 32$ | $2^5 - 2 = 30$ |
| N.N.11111111.11110000 | 255.255.255.240 | /28 | $2^{12} = 4,096$ | $2^4 = 16$ | $2^4 - 2 = 14$ |
| N.N.11111111.11111000 | 255.255.255.248 | /29 | $2^{13} = 8,192$ | $2^3 = 8$ | $2^3 - 2 = 6$ |
| N.N.11111111.11111100 | 255.255.255.252 | /30 | $2^{14} = 16,384$ | $2^2 = 4$ | $2^2 - 2 = 2$ |

# Class A Possible Subnets
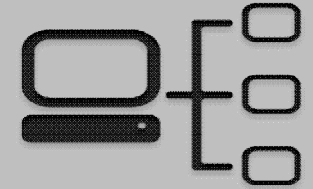
| Binary (N.H.H.H) | Decimal | CIDR | # Subnets $(2^x)$ | Block Size $(2^y)$ | # Hosts $(2^y - 2)$ |
|---|---|---|---|---|---|
| N.00000000.00000000.00000000 | 255.0.0.0 | /8 | $2^0 = 1$ | $2^{22} = 16,777,216$ | $2^{22} - 2 = 16,777,214$ |
| N.10000000.00000000.00000000 | 255.128.0.0 | /9 | $2^1 = 2$ | $2^{23} = 8,388,608$ | $2^{23} - 2 = 8,388,606$ |
| N.11000000.00000000.00000000 | 255.192.0.0 | /10 | $2^2 = 4$ | $2^{22} = 4,194,304$ | $2^{22} - 2 = 4,194,302$ |
| N.11100000.00000000.00000000 | 255.224.0.0 | /11 | $2^3 = 8$ | $2^{21} = 2,097,152$ | $2^{21} - 2 = 2,097,150$ |
| N.11110000.00000000.00000000 | 255.240.0.0 | /12 | $2^4 = 16$ | $2^{20} = 1,048,576$ | $2^{20} - 2 = 1,048,574$ |
| N.11111000.00000000.00000000 | 255.248.0.0 | /13 | $2^5 = 32$ | $2^{19} = 524,288$ | $2^{19} - 2 = 524,286$ |
| N.11111100.00000000.00000000 | 255.252.0.0 | /14 | $2^6 = 64$ | $2^{18} = 262,144$ | $2^{18} - 2 = 262,142$ |
| N.11111110.00000000.00000000 | 255.254.0.0 | /15 | $2^7 = 128$ | $2^{17} = 131,072$ | $2^{17} - 2 = 131,070$ |
| N.11111111.00000000.00000000 | 255.255.0.0 | /16 | $2^8 = 256$ | $2^{16} = 65,536$ | $2^{16} - 2 = 65,534$ |
| N.11111111.10000000.00000000 | 255.255.128.0 | /17 | $2^9 = 512$ | $2^{15} = 32,768$ | $2^{15} - 2 = 32,766$ |
| N.11111111.11000000.00000000 | 255.255.192.0 | /18 | $2^{10} = 1,024$ | $2^{14} = 16,384$ | $2^{14} - 2 = 1,.382$ |
| N.11111111.11100000.00000000 | 255.255.224.0 | /19 | $2^{11} = 2,048$ | $2^{13} = 8,192$ | $2^{13} - 2 = 8,190$ |
| N.11111111.11110000.00000000 | 255.255.240.0 | /20 | $2^{12} = 4,096$ | $2^{12} = 4,096$ | $2^{12} - 2 = 4,094$ |
| N.11111111.11111000.00000000 | 255.255.248.0 | /21 | $2^{13} = 8,192$ | $2^{11} = 2,048$ | $2^{11} - 2 = 2,046$ |
| N.11111111.11111100.00000000 | 255.255.252.0 | /22 | $2^{14} = 16,384$ | $2^{10} = 1,024$ | $2^{10} - 2 = 1,022$ |
| N.11111111.11111110.00000000 | 255.255.254.0 | /23 | $2^{15} = 32,768$ | $2^9 = 512$ | $2^9 - 2 = 510$ |
| N.11111111.11111111.00000000 | 255.255.255.0 | /24 | $2^{16} = 65,536$ | $2^8 = 256$ | $2^8 - 2 = 254$ |
| N.11111111.11111111.10000000 | 255.255.255.128 | /25 | $2^{17} = 131,072$ | $2^7 = 128$ | $2^7 - 2 = 126$ |
| N.11111111.11111111.11000000 | 255.255.255.192 | /26 | $2^{18} = 262,144$ | $2^6 = 64$ | $2^6 - 2 = 62$ |
| N.11111111.11111111.11100000 | 255.255.255.224 | /27 | $2^{19} = 524,288$ | $2^5 = 32$ | $2^5 - 2 = 30$ |
| N.11111111.11111111.11110000 | 255.255.255.240 | /28 | $2^{20} = 1,048,576$ | $2^4 = 16$ | $2^4 - 2 = 14$ |
| N.11111111.11111111.11111000 | 255.255.255.248 | /29 | $2^{21} = 2,097,152$ | $2^3 = 8$ | $2^3 - 2 = 6$ |
| N.11111111.11111111.11111100 | 255.255.255.252 | /30 | $2^{22} = 4,194,304$ | $2^2 = 4$ | $2^2 - 2 = 2$ |

# Subnet Calculation Table ($2^h$)

| Host Bits Borrowed | $2^x$ | Number of Subnets Created |
|---|---|---|
| 1 | $2^1$ | 2 |
| 2 | $2^2$ | 4 |
| 3 | $2^3$ | 8 |
| 4 | $2^4$ | 16 |
| 5 | $2^5$ | 32 |
| 6 | $2^6$ | 64 |
| 7 | $2^7$ | 128 |
| 8 | $2^8$ | 256 |
| 9 | $2^9$ | 512 |
| 10 | $2^{10}$ | 1,024 |
| 11 | $2^{11}$ | 2,048 |
| 12 | $2^{12}$ | 4,096 |

# Subnet Hosts & Addresses Calculation Table ($2^h$)
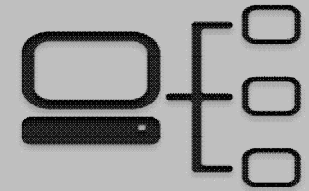
| Host Bits Left | $2^h$ | Hosts / Subnet ($2^h - 2$) | Addresses / Subnet ($2^h$) |
|---|---|---|---|
| ~~1~~ | ~~$2^1$~~ | ~~0~~ | ~~2~~ |
| 2 | $2^2$ | 2 | 4 |
| 3 | $2^3$ | 6 | 8 |
| 4 | $2^4$ | 14 | 16 |
| 5 | $2^5$ | 30 | 32 |
| 6 | $2^6$ | 62 | 64 |
| 7 | $2^7$ | 126 | 128 |
| 8 | $2^8$ | 254 | 256 |
| 9 | $2^9$ | 510 | 512 |
| 10 | $2^{10}$ | 1,022 | 1,024 |
| 11 | $2^{11}$ | 2,046 | 2,048 |
| 12 | $2^{12}$ | 4,094 | 4,096 |