Why Subnet?

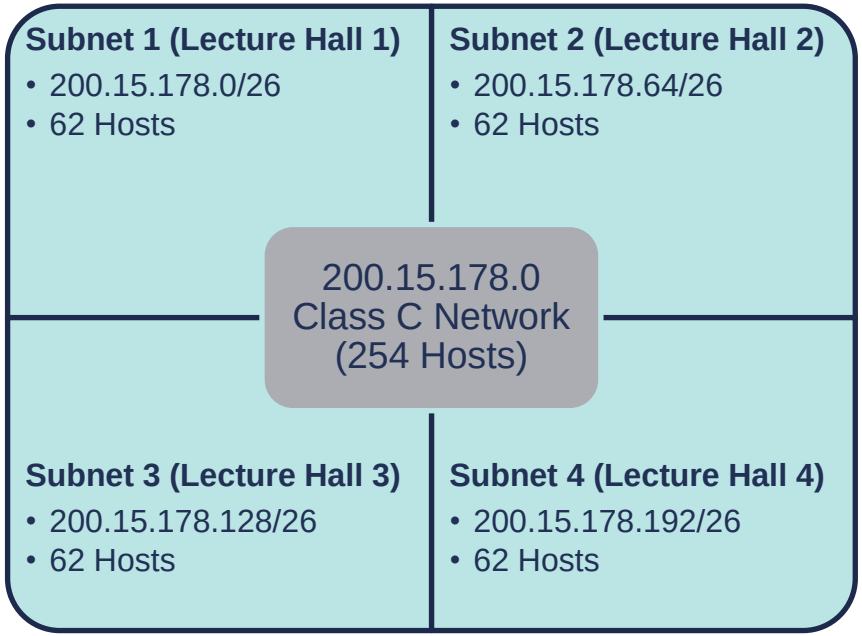
- Using default Class A, B and C subnets (called Classful IP Addressing) is inefficient:
  - Wastes unused IP Addresses (Public IP Addresses)
- Allows you to create multiple logical networks that exist within a single Class A, B, or C network.
  - Breaks up larger networks into multiple smaller sub-networks, which are called subnets
- Allows for more efficient routing via router summarization.
- Increased network security!

Fixed Length Subnetting

- We will be learning about fixed-length subnetting, known as a fixed-length subnet mask (FLSM).
- There is also variable-length subnetting (VLSM), which is beyond the scope of this beginner's course.

Class C Subnetting Example

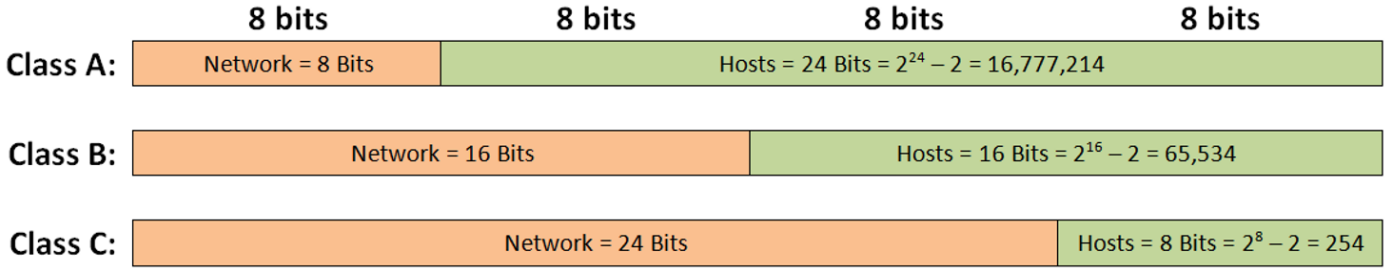
- You're the network administrator for the Computer Science department at a university.
- You're setting up four new lecture halls that must have their own 60-person wireless network.
- You've been assigned the 200.15.178.0 Class C Network by the university, that supports 254 hosts per network by default.
- How do you break up this one Class C network into 4 smaller networks that support 60 host IP addresses per network?
- You subnet it.
- Subnetting allows your to breakup a larger network into smaller networks (subnets).



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 Host Bit = $2^1 = 2$
    - Borrow 2 Host Bits = $2^2 = 4$
    - Borrow 3 Host Bits = $2^3 = 8$
    - Borrow 4 Host Bits = $2^4 = 16$
    - Etc.

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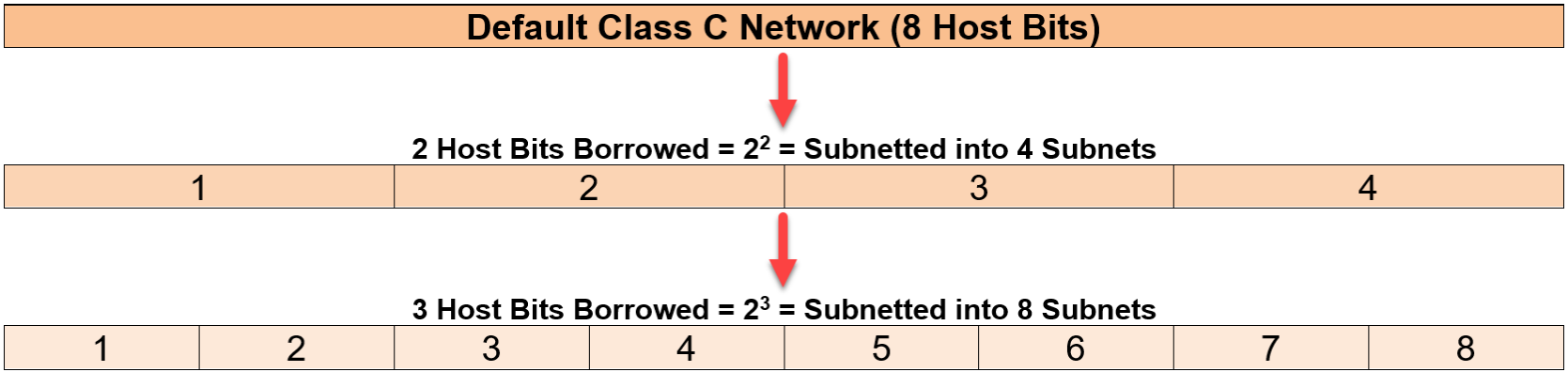
Creating Subnets Visualized



Subnetting Questions

- To Create a Subnet, Answer the Following Questions:
  - How many subnets are needed?
  - How many hosts do you need per subnet?

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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	$2^6 = 64$	$2^2 = 4$	$2^2 – 2 = 2$

Number of Subnets (2^x)

- X = number of host bits we borrow to create subnets

Block Size (2^y)

- Y = number of remaining host bits left that are used for the subnet IP addresses

Hosts per Subnet ($2^y – 2$)

- There are two addresses per network (or subnet) that we cannot use to assign to hosts on that network:
    - **Network Address**: This is the address used to uniquely identify the network (or subnet).
    - **Broadcast Address**: Address reserved for broadcast communication on the network.

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Class B Possible Subnets

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	$2^2 = 4$	$2^{14} = 16{,}384$	$2^{14} – 2 = 16{,}382$
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	$2^{14} = 16{,}384$	$2^2 = 4$	$2^2 – 2 = 2$

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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	$2^{10} = 1{,}024$	$2^{14} = 16{,}384$	$2^{14} - 2 = 16{,}382$
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	$2^{22} = 4{,}194{,}304$	$2^2 = 4$	$2^2 - 2 = 2$

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Subnet Calculation Table (2^x)

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
Etc.…		

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Subnet Hosts & Addresses Calculation Table (2^y)

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