

Table of Contents

- ▶ What is Subnetting, Why do it?
- Subnet Masks and CIDR Notation
- Analyzing Subnet Sizing
- Architecting Subnets
- Default Gateways





2

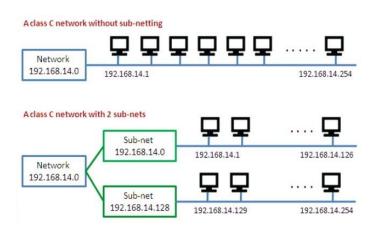
What is Subnetting, Why do it?



Subnetting Basics



 The process of taking an extensive network and splitting into smaller networks is known as subnetting



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4

Why Use Subnetting

- Improved network performance
 - Streamlined / reduced network traffic
- Simplified Management
 - o Easier to identify and isolate network problems
- Facilitates global networks
 - o Connecting multiple smaller networks creates efficiencies
- Improves security
 - Isolated networks ("blast radius")
 - Reduces changes of unauthorized network hopping



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Subnet Mask & CIDR Notation



IP Addresses



- 4-byte / 32-bit numerical address to identify a host
- This is for IPV4 (vs. IPV6)
- Each octet usually represented by a decimal number
 - o e.g. **192.168.1.35**
- For subnetting, must switch between binary & decimal



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Class A, B, C Private Networks



- A network is defined by a range of IP addresses
- There are 3 classes of network address
- Within each class, there is a subset of private or non-routable addresses

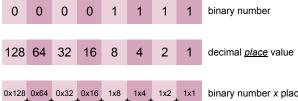
Class	First Byte	<u>Private</u> IF (from	Example IP		
Α	0-126*	10.0.0.0	10.255.255.255	10.1.0.5	
В	128-191	172.16.0.0	172.31.255.255	172.16.10.3	
С	192-223	192.168.0.0	192.168.255.255	192.168.1.2	

(*) the 127 IP range is a loopback (e.g. 127.0.0.1)



Binary to Decimal Conversion





binary number x place value

resulting decimal value

Notice:

- Just add the decimal place values to get the decimal result
 - o e.g. **15=1+2+4+8**
- Sum of n lowest bits is one less than the (n+1) decimal value
 - o e.g. **15 = 16-1**

so....

00001111 (binary) = 15 (decimal)



Binary Conversion Practice



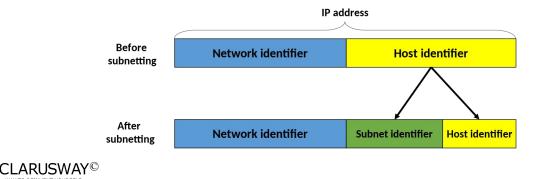


$$= 2 + 1 = 3$$

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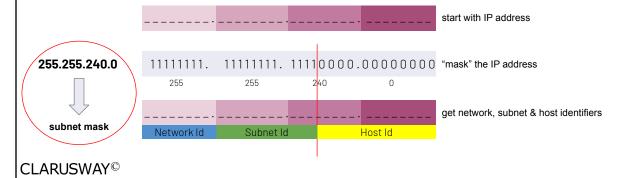
- IPv4 address is divided into network ID and host ID by using octets
- In subnetting we can borrow some bits from host ID to use as subnetwork



Subnet Mask



- 4-byte / 32-bit value
- Identifies the network and subnet portions of an IP address
- Series of consecutive ones and zeros in binary
- Number of zeros in the mask dictate the max hosts

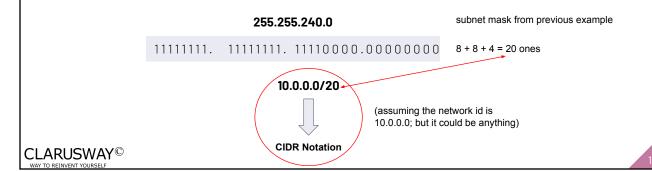


12





- Classless Inter-Domain Routing (CIDR)
- An alternate way to define the size of the network
- Use the "/" notation after the network ID
- Easy: count the number of ones in the subnet mask



Revisit Class A, B, C Private Networks



Class	First Byte	<u>Private</u> IP (from	•	Largest Network (Subnet Mask)	Largest Network (CIDR Notation)	
А	0-126	10.0.0.0	10.255.255.255	255.0.0.0	10.0.0.0/8	
В	128-191	172.16.0.0	172.31.255.255	255.240.0.0	172.16.0.0/12	
С	192-223	192.168.0.0	192.168.255.255	255.255.0.0	192.168.0.0/16	



14



Computing IPs and Hosts



Calculate Hosts from Binary Mask



How many hosts can a network with this subnet mask have?

11111111. 11111111. 11111111. 00000000

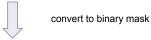
- Number of zeros dictate the maximum hosts
- 8 zeros \Rightarrow 2⁸ = 256 (max possibilities)
- Networks* reserve 2 addresses
 - o First network ID
 - Last broadcast
- Answer: 256-2 = 254

Calculate Hosts from Subnet Mask



How many hosts can a network with this subnet mask have?

255.255.255.0



11111111. 11111111. 11111111. 00000000

- 8 zeros, again
- Same as previous example
- Answer: 254 hosts



1

Calculate Hosts from CIDR Notation



How many hosts can a network with this subnet mask have?

10.0.0.0/24

- "/24" tells us there are 24 "1"s
- Every mask has 32 bits
- So there are 32-24 = 8 "0"s
- Same as previous example
- Answer: 254 hosts



Formula: Hosts from CIDR Notation



x.x.x.x/n

Hosts =
$$2^{(32-n)} - 2$$



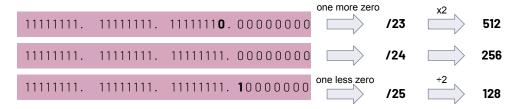
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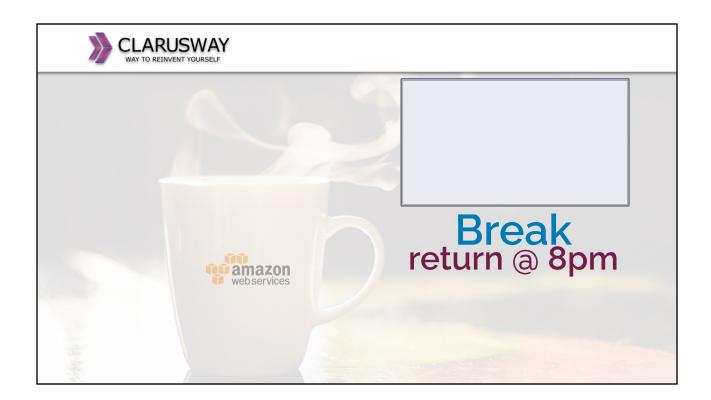
Table: Hosts from CIDR Notation

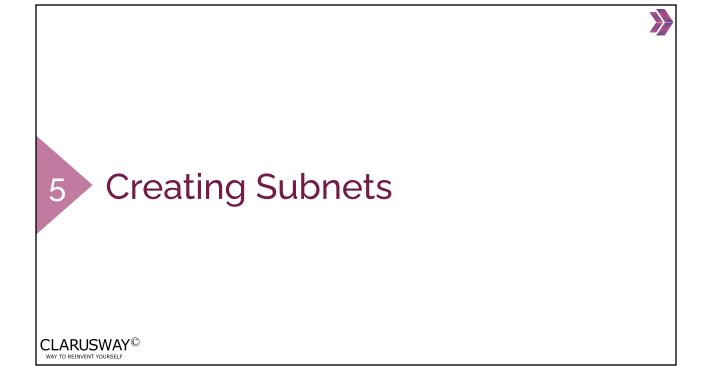


Size	/16	/17	/18	/19	/20	/21	/22	/23	/24	/25	/26	/27	/28
IPs	65536	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16
IPs (K)	64K	32K	16K	8K	4K	2K	1K	512	256	128	64	32	16
Hosts	(subtract 2)												

- As you decrease "/" value by 1, double number of IPs
- Tip: remember /24, /16 then go up/down from there









Subnetting IPv4 Address:

- A Class A. B. or C TCP/IP network can be further divided, or subnetted, by a system administrator
- For example, you have 150 hosts on three networks that are connected by a router
- You are allocated a **Class C** address:

192.168.123 Network ID Host ID

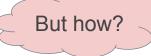
You can use from 192.168.123 .1 to | 192.168.123 (Just remember that the first and last address in any network or subnet cannot be assigned to any individual host, so you cannot use 192.168.123.0 and 192.168.123.255) CLARUSWAY®

Subnetting Basics



Subnetting IPv4 Address:

- With the allocated Class C IP address we can map 254 hosts on one network
- But our 150 hosts are located on **three** separate networks
- Instead of requesting more address blocks for each network, we can divide our block into three subnets



Subnetting IPv4 Address:

- Remember we can create subnets by borrowing bits from Host ID
- How many bits to "borrow"?



21

How Many Bits? 1bit 2 numbers (networks) 2 bits 4 numbers (networks) 3 bits 8 numbers (networks)



Subnetting IPv4 Address:

- Remember we can create subnets by borrowing bits from Host ID
- We need 3 subnets in total, so if we borrow 1 bit we will get 2 subnets which is not enough
- So we need more bits, if we borrow 2 bits we will get 4 subnets and our subnet mask will be:



Subnetting Basics



Subnetting IPv4 Address:

- Since we borrowed 2 bits, there are only 6 bits left for Host ID which makes 2⁶ 2 = 62 hosts (first and last numbers are reserved)
- Our company has 3 networks and 50 hosts on each network
- We have **4 subnets**, and **62 host IDs** for each subnet (that means 1 subnet with 62 host IDs will be reserved for future use)



Subnetting IPv4 Address:

- Using subnet mask 255.255.255.192, our 192.168.123.0 network will become 4 networks:
 - o 192.168.123.0 111111111111111111111111100 000000

 - 192.168.123.128 1111111111111111111111111111 0000000
 - 0 192.168.123.192 11111111111111111111111111 000000
- Valid host addresses will be:

 192.168.123.1-62
 192.168.123.129-190

 192.168.123.65-126
 192.168.123.193-254

(Remember, again, that binary host addresses with all 1s or all 0s are reserved, so you cannot use addresses with the last octet of 0, 63, 64, 127, 128, 191, 192, and 255)

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20

Creating Equal Subnets



- Address Space : 192.168.0.0/24
- Num. Subnets : 6

Why 3? \Rightarrow This gives us 2^3 or 8 subnets. Will have 2 left over

This leaves us 5 bits for the host.

- ⇒ Total IPs = 2^5 = 32
- ⇒ Total hosts = 32 -2 = 30 per subnet

Creating Subnets

Network ID

Address Space: 192.168.0.0/24

IP Address: 11000000.10101000.0000000.00000000

```
192.168.0.0
Subnet o
                :11000000.10101000.00000000.<u>000</u>00000
Subnet 1
                : 11000000.10101000.00000000.<u>001</u>00000
                                                             192.168.0.32
Subnet 2
                :11000000.10101000.00000000.<u>010</u>00000
                                                             192.168.0.64
Subnet 3
                : 11000000.10101000.00000000.<u>011</u>00000
                                                             192.168.0.96
Subnet 4
                :11000000.10101000.00000000.<u>100</u>00000
                                                             192.168.0.128
Subnet 5
                : 11000000.10101000.00000000.<u>101</u>00000
                                                             192.168.0.160
Subnet 6
                : 11000000.10101000.00000000.11000000
                                                             192.168.0.192
Subnet 7
                :11000000.10101000.00000000.<u>111</u>00000
                                                             192.168.0.224
```



3

Subnet Calculators



- Many online calculators. Examples:
 - https://www.site24x7.com/tools/ipv4-subnetcalculator.html
 - https://www.tunnelsup.com/subnet-calculator/
 - https://community.spiceworks.com/tools/subnet-calc/



Default Gateway



Default Gateway

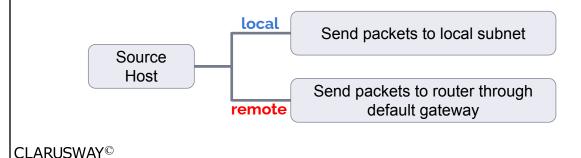


- If a host needs to communicate with a host on another network, it will communicate through a router
- A router specified on a host is called default gateway
- So how does TCP/IP knows if the destination host is on the same network or not?

Default Gateway Routing



When a host wants to communicate with another device, it performs a comparison process using the defined subnet mask with the destination IP address and its own IP address



Default Gateway - Local Network



Source host :192.168.123.72 Subnet mask 255.255.255.192 Destination host 192.168.123.109

Source IP :11000000.10101000.01111011.01001000 Logical Subnet mask : 11111111.1111111.1111111.11000000 AND Network ID 11000000.10101000.01111011.01000000(192.168.123.64)

Destination IP: 11000000.10101000.01111011.01101101

Logical AND

11000000.10101000.01111011.01000000 192.168.123.64)

Network ID

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Same result! Two hosts are on the same network.

Default Gateway - Remote Network

Source host :192.168.123.46 Subnet mask 255.255.255.192

Destination host 192.168.123.202

Source IP :11000000.10101000.01111011.00101110 Logical Subnet mask: 11111111.1111111.1111111.11000000 AND

Network ID 11000000.10101000.01111011.00000000 (192.168.123.0)

Destination IP: 11000000.10101000.01111011.11001010

Subnet mask: 11111111.1111111.1111111.11000000

Network ID **11000000.10101000.01111011.11000000** (192.168.123.192)

AND

Logical

Not the same! Two hosts are on different networks.

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