

Subnetting IPv4 and IPv6

Advanced Networking: Routing & Switching 1 – Chapter 9

Why subnetting?

- Using smaller networks we optimize address space
- Network segmentation, communication between subnetworks need routing
- Limiting broadcast
- Increased security

Note: A subnet is equivalent to a network and these terms can be used interchangeably. Most networks are a subnet of some larger address block.

Subnetting = borrowing bits

Decimal ← | → Binary

Original	192.	168.	1.	0	000	0000	Network: 192.168.1.0/24
Mask	255.	255.	255.	0	000	0000	Mask: 255.255.255.0

Borrowing 1 bit creates 2 subnets with the same mask.



Net 0	192.	168.	1.	0	000	0000	Network: 192.168.1.0/25
Mask	255.	255.	255.	1	000	0000	Mask: 255.255.255.128
Net 1	192.	168.	1.	1	000	0000	Network: 192.168.1.128/25
Mask	255.	255.	255.	1	000	0000	Mask: 255.255.255.128

2 subnets

Network Address

192. 168. 1. 0 000 0000 = 192.168.1.0

First Host Address

192. 168. 1. 0 000 0001 = 192.168.1.1

Last Host Address

192. 168. 1. 0 111 1110 = 192.168.1.126

Broadcast Address

192. 168. 1. 0 111 1111 = 192.168.1.127

192.168.1.0/25



Network Address

192. 168. 1. 1 000 0000 = 192.168.1.128

First Host Address

192. 168. 1. 1 000 0001 = 192.168.1.129

Last Host Address

192. 168. 1. 1 111 1110 = 192.168.1.254

192.168.1.128/25



Broadcast Address

192. 168. 1. 1 111 1111 = 192.168.1.255

Number of Subnets and Hosts

- Calculating Subnets
 - Use this formula to calculate the number of subnets:
 - 2^n (where n = the number of bits borrowed)
 - In the previous 192.168.1.0/25 example, the calculation looks like this:
 - $2^1 = 2$ subnets
- Calculating Hosts per subnetwork
 - Use this formula to calculate the number of hosts per network:
 - $2^n - 2$ (where n = the number of bits remaining in the host field)
 - In the previous 192.168.1.0/25 example, the calculation looks like this:
 - $2^7 - 2 = 126$ per subnetwork

Subnetting example

Borrowing 2 Bits



Original	192.	168.	1.	00	00	0000
Mask	255.	255.	255.	00	00	0000

Borrowing 2 bits creates 4 subnets:



Net 0	192.	168.	1.	00	00	0000	192.168.1.0/26
Net 1	192.	168.	1.	01	00	0000	192.168.1.64/26
Net 2	192.	168.	1.	10	00	0000	192.168.1.128/26
Net 3	192.	168.	1.	11	00	0000	192.168.1.192/26

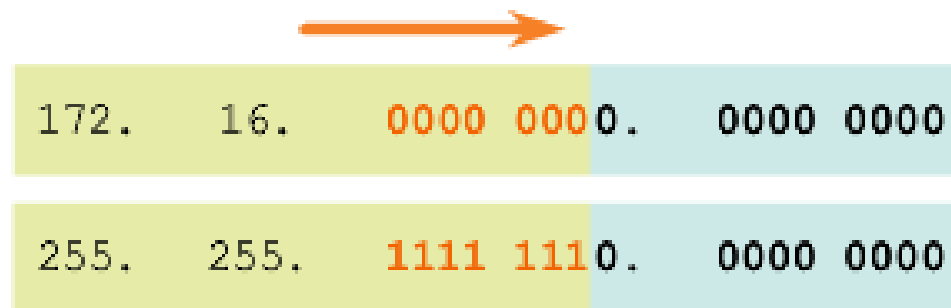
All 4 subnets use the same mask:

Mask	255.	255.	255.	11	00	0000	Mask:255.255.255.192
------	------	------	------	----	----	------	----------------------

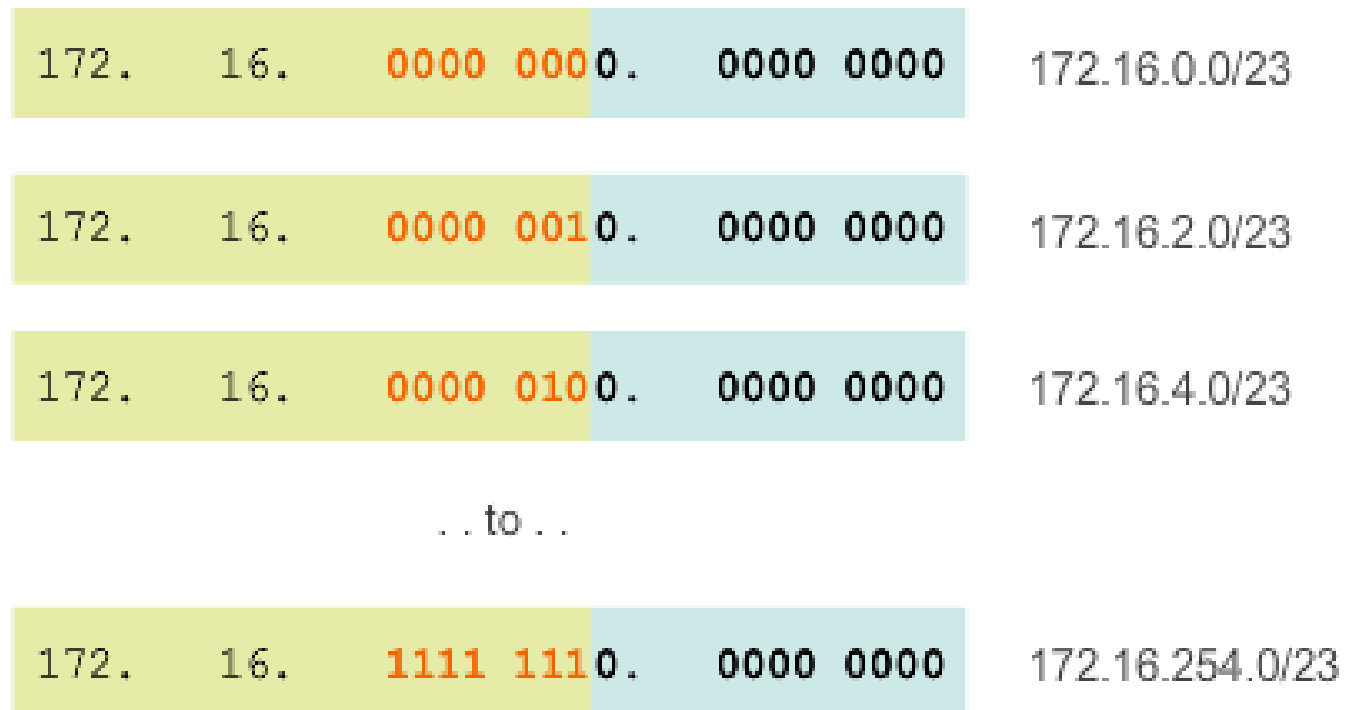
Exercise

- Calculate **network address**, **broadcast address** and **subnet mask** for:
 - 192.168.120.99/28
 - 192.168.120.99/29
 - 100.100.100.100/25
 - 100.100.100.150/30
 - 10.0.1.230/26
 - 10.0.1.230/27

Borrowing bits from 3rd octet



Borrowing 7 bits creates 128 subnets



Variable Length Subnet Masks (VLSM)

- VLSM subnetting is similar to traditional subnetting in that bits are borrowed to create subnets.
- The formulas to calculate the number of hosts per subnet and the number of subnets created still apply.
- The difference is that subnetting is not a single pass activity.
- With VLSM, the network is first subnetted, and then the subnets are subnetted again.
 - This process can be repeated multiple times to create subnets of various sizes.

VLSM Exercise

- Take the 192.168.1.0/24 and:
 - Subnet it /27
 - Take the third subnet and subnet it /29
 - For the second sub-subnetwork print
 - Network address
 - First host address
 - Last host address
 - Broadcast address

VLSM Exercise: solution

- Take the 192.168.1.0/24 and:
 - Subnet it /27:
 - 192.168.1.0/27
 - 192.168.1.32/27
 - 192.168.1.64/27
 - ...(*4 more subnets*)
 - 192.168.1.224/27
 - Take the third subnet and subnet it /29
 - 192.168.1.64/29
 - 192.168.1.72/29
 - 192.168.1.80/29
 - 192.168.1.88/29
 - For the second sub-subnetwork print
 - Network address: 192.168.1.64
 - First host address: 192.168.1.65
 - Last host address: 192.168.1.70
 - Broadcast address: 192.168.1.71
 - Subnet mask: 255.255.255.248

Planning to Address the Network

- There are three primary considerations when planning address allocation.
 - **Preventing Duplication of Addresses** - Without the proper planning and documentation, an address could be assigned to more than one host, resulting in access issues for both hosts.
 - **Providing and Controlling Access** - Some hosts, such as servers, provide resources to internal hosts as well as to external hosts. If the address is randomly assigned and not well documented, controlling access is more difficult.
 - **Monitoring Security and Performance** - As part of the monitoring process, network traffic is examined for addresses that are generating or receiving excessive packets. If there is proper planning and documentation of the network addressing, problematic network devices can be easily found.

Classifying addresses

- Addressing should consider host requirements:
 - Addresses for Clients (DHCP)
 - Addresses for Servers and Peripherals
 - Addresses for Hosts that are Accessible from Internet
 - Addresses for Network (Intermediary) Devices
 - Address for the Gateway (Routers and Firewalls)

IPv6 Subnetting

- An IPv6 address space is not subnetted to conserve addresses; rather, **it is subnetted to support hierarchical, logical design of the network.**
- While IPv4 subnetting is about *managing address scarcity*, IPv6 subnetting is about ***building an addressing hierarchy*** based on the number of routers and the networks they support.
- An **IPv6 address block with a /48 prefix** has **16 bits for subnet ID.**
 - Subnetting using the 16 bit subnet ID yields a possible **65,536 /64 subnets** and does not require borrowing any bits from the interface ID, or host portion of the address.

IPv6 Subnet example

Address Block: 2001:0DB8:ACAD::/48

5 subnets allocated
from 65,536
available subnets

2001:0DB8:ACAD:0000::/64
2001:0DB8:ACAD:0001::/64
2001:0DB8:ACAD:0002::/64
2001:0DB8:ACAD:0003::/64
2001:0DB8:ACAD:0004::/64
2001:0DB8:ACAD:0005::/64
2001:0DB8:ACAD:0006::/64
2001:0DB8:ACAD:0007::/64
2001:0DB8:ACAD:0008::/64
⋮
2001:0DB8:ACAD:FFFF::/64

```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ipv6 address 2001:db8:acad:1::1/64
R1(config-if)#exit
R1(config)#interface gigabitethernet 0/1
R1(config-if)#ipv6 address 2001:db8:acad:2::1/64
R1(config-if)#exit
R1(config)#interface serial 0/0/0
R1(config-if)#ipv6 address 2001:db8:acad:3::1/64
R1(config-if)#end
R1#
```

IPv6 Subnetting considerations

- Subnetting with IPv6 is not drastically different than subnetting with IPv4, we just need to keep a few things in mind:
 - Each character in an IPv6 address represents 4 bits (a **nibble**).
 - Since 0xF is 1111 in binary, it's easy to fall back into an IPv4 habit and forget that 0x11 is actually 0001 0001 in binary.
- **The leading practice is to receive at least a /48 prefix from an ISP.** This leaves you with **2⁸⁰ bits to manipulate**. More bits than the entire IPv4 address space!
- According to ***RFC4291*** the current **recommended smallest prefix is a /64.**
 - **You can assign a /64 to a point-to-point link and *not feel guilty*.**
 - The only exception to this is the recommendation from ARIN to use a /128 on loopback addresses.
- This gives us **one block of hex digits, or 16-bits, to use for subnetting.** One block might not sound like much, but 16-bits is half of the entire IPv4 address space.

End of lesson