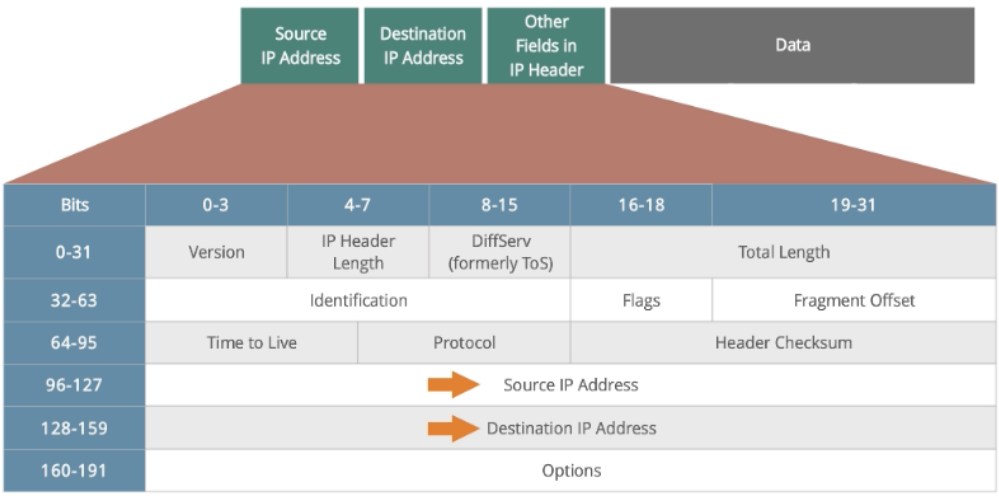
- Layer 3 : Network Layer : IP - Addressing
- Most common Layer 3 protocol
- Transmits data from a source network device to a destination network device.
- Performs other services such as fragmentation and reassembly of data.

- IPv4 vs IPv6
  - next generation protocol
  - size?

- Transport Layer → Network Layer

How IP Works?



Click each field to learn about its function.

- An IPv4 address in dotted decimal format

↳ Because IP adeless do not clearly seperate network bits & IP adeless bits.

→ Network mask is added : (32 bits)
(Address mask, Subnet mask)
↳ identifies network portion.

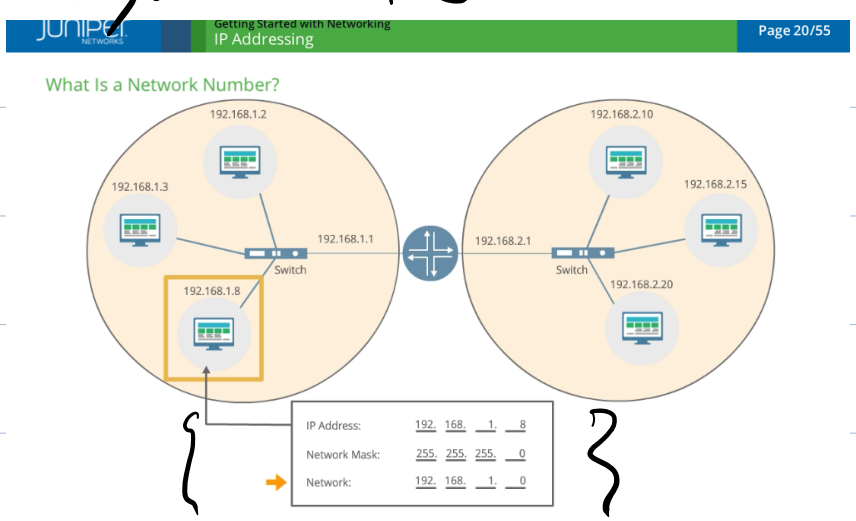
* MAC and IPv6 addresses use hexadecimal numbers

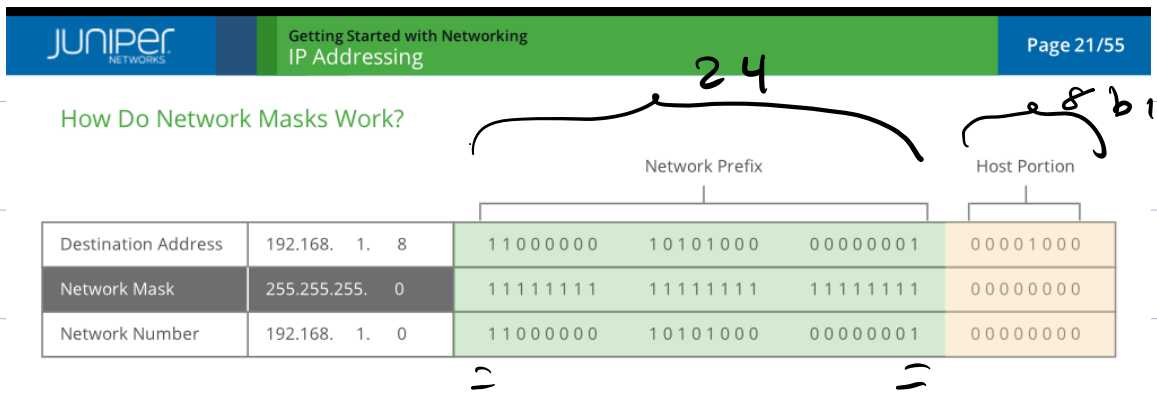
* A broadcast MAC address: ffff.ffff.ffff } 48 bits set to 1

* Network Number:

To define network number, a device uses a network mask @es: 255.255.255.0

The bits turned on in network mask to designate the network number





* Where we have a 1 & 1 = 1

1 & 0 = 0.

* CIDR Notation:

[Classless Inter-Domain Routing]

→ 192.168.1.8/24

↓ ↳ Number of bits

IP address in Network Prefix.

→ We can also use CIDR notation to identify a range of addresses.

eg

192.168.1.0/24 identifies the range starting at 192.168.1.0 and continuing through 192.168.1.255.

Classful and Classless Routing and CIDR Notation

Class	Natural Mask	First Octet	First Bits of First Octet
Class A	255.0.0.0	0–127	0
Class B	255.255.0.0	128–191	10
Class C	255.255.255.0	192–223	110

Class A

Network Number	10. 0. 0. 0	00001010	00000000	00000000	00000000

Class B

Network Number	172. 16. 0. 0	10101100	00010000	00000000	00000000

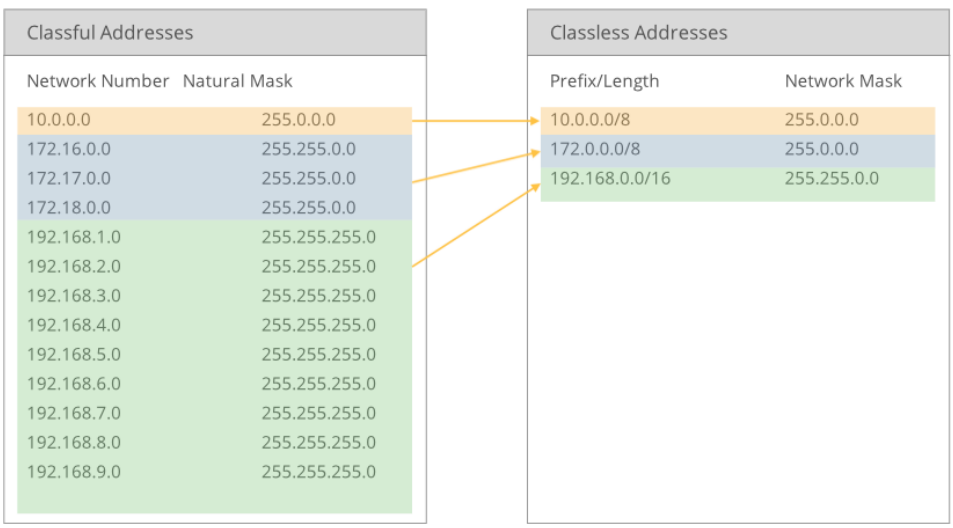
Class C

Network Number	192. 168. 1. 0	11000000	10101000	00000001	00000000

solution

Classful and Classless Routing and CIDR Notation

To reduce the size of routing tables, CIDR provides a way to summarize many "classful" network numbers into a single routing table entry.



IP Subnetting: means taking a single network number and splitting it into smaller networks -or subnets- which is short for sub-networks.

Creating IP Subnets

Assigned Address Range: 192.168.3.0/24
Prefix Length: 24 bits
Network Mask: 255.255.255.0

Decimal	192	168	3	0
Binary	11000000	10101000	00000011	00000000
Network Mask	11111111	11111111	11111111	00000000

Network Prefix
24 bits

Host Portion
8 bits

New Prefix Length: 27 bits
New Subnet Mask: 255.255.255.224

Decimal	192	168	3	0
Binary	11000000	10101000	00000011	000 00000
Network Mask	11111111	11111111	11111111	111 00000

Host Portion
5 bits

More network bits means fewer hosts per network. More host bits means more hosts with fewer networks.

- Calculating Number of Network & Hosts

Calculating the Number of Networks and Hosts

Minimum Prefix Length: 24 bits
New Prefix Length: 28 bits

Decimal	192	168	3	0
Binary	11000000	10101000	00000011	0000 0000
Network Mask	11111111	11111111	11111111	1111 0000

Subnet Portion: 4 bits ↔ Host Portion: 4 bits

Subnet Portion: 4 bits — Host Portion: 4 bits

128's	64's	32's	16's	8's	4's	2's	1's
1	1	1	1	0	0	0	0

Using 4 bits for the network provides 2^4 or **16 networks**.
Valid Subnets: 0000 through 1111

Using 4 bits for the host provides $2^4 - 2$ or **14 host addresses**.
Valid Hosts: 0001 through 1110
(0000 and 1111 are reserved)

Network Prefix on Octet Boundary

First Subnet:

Network Prefix Does Not Falls on an Octet Boundary

Binary	11000000	10101000	00000011	000 00000
Decimal	192	168	3	0

First host in this subnet:

Binary	11000000	10101000	00000011	000 00001
Decimal	192	168	3	1

Second Subnet:

Binary	11000000	10101000	00000011	001 00000
Decimal	192	168	3	32

First host in this subnet:

Binary	11000000	10101000	00000011	001 00001
Decimal	192	168	3	33

Example :

2 PC want to communicate.

PC1 : 192.168.3.60

PC2 : 192.168.3.66

① Check if are on the same network

Source PC:

IP Address	192.168.3.60	11000000	10101000	00000011	00111100
Subnet Mask	255.255.255.224	11111111	11111111	11111111	11100000
Subnet	192.168.3.32	11000000	10101000	00000011	00100000

Destination PC:

IP Address	192.168.3.66	11000000	10101000	00000011	01000010
Subnet Mask	255.255.255.224	11111111	11111111	11111111	11100000
Subnet	192.168.3.64	11000000	10101000	00000011	01000000

→ 2 devices are not on the same network ∴ need a router to communicate.

* Subnet mask.: decimal equivalent of last octet

Loopback Interface

- A device uses the loopback interface to send a message back to itself → used for network testing

(127.0.0.1 – 127.255.255.255)

Multicast IP Addresses

- Devices use multicast IP addresses to send the same data to specific group of devices.

(224.0.0.0 – 239.255.255.255)

---

* Page 40/55 | (Data Flow between
* Page 41/55 | PC in different network)

---

* Routers use static routes and dynamic routing protocols such as OSPF or IS-IS to learn about remote networks and build their routing tables.

* Longest Match Routing *

- Challenges Faced by Packets

Packet contains:

- Source IP Address
- Destination IP Address
- Other Fields in IP Header.
- Data.

→ What is the maximum packet size that can be supported?

- Maximum Transmission Unit (MTU)

The fixed upper limit on the size of a packet that can be sent in a single frame.

eg

MTU

Ethernet v2 → 1500

802.11 → 2272

⋮ ⋮

→ what happens when a router receives a packet with a larger MTU?

→ IP Fragmentation.

JUNIPER NETWORKS

Getting Started with Networking
IP Addressing

IP Fragmentation

One packet ...

Source IP Address	Destination IP Address	Other Fields in IP Header	Data 1400 bytes

... is split into 3 packets that will fit within the next network's 620 MTU.

Source IP Address	Destination IP Address	Other Fields in IP Header	Data 600 bytes
Source IP Address	Destination IP Address	Other Fields in IP Header	Data 600 bytes
Source IP Address	Destination IP Address	Other Fields in IP Header	Data 200 bytes

IPv4 vs IPv6

IPv4 versus IPv6

IP Version 5 (IPv5), "Internet Stream Protocol", never made it past experimental stages.

IP Version 4 (IPv4)

172.16.32.17

192.168.10.1

207.17.137.229

- Currently the most commonly used protocol.
- The 32-bit address allows for 2^{32} (about 4.3 billion) unique addresses.
- The number of available IPv4 IP addresses has almost been exhausted!

IP Version 6 (IPv6)

2001:db8:31:1:20a:95ff:fef5:246e

2001:0db8:85a3:08d3:1319:8a2e:0370:7348

3ffe:1900:4545:3:200:f8ff:fe21:67cf

- The next-generation protocol.
- The 128-bit address allows for 2^{128} (about 3.4×10^{38}) unique addresses.
- The larger address size means we won't exhaust the supply of addresses for many years to come.

Advantages of IPv6

Advantages of IPv6

IP Version 6 (IPv6)

- The next-generation protocol.
- The 128-bit address allows for 2^{128} (about 3.4×10^{38}) unique addresses.
- The larger address size means we won't exhaust the supply of addresses for many years to come.

Additional Benefits

- Eliminates the need for Network Address Translation (NAT) because of the huge number of IP addresses available.
- Reduces administrative overhead. Hosts can use stateless address autoconfiguration or DHCPv6 to assign an IP address to themselves.
- Supports greater levels of security.
- Makes processing more efficient in several ways.

- IPv6 Header [40 bytes in total].

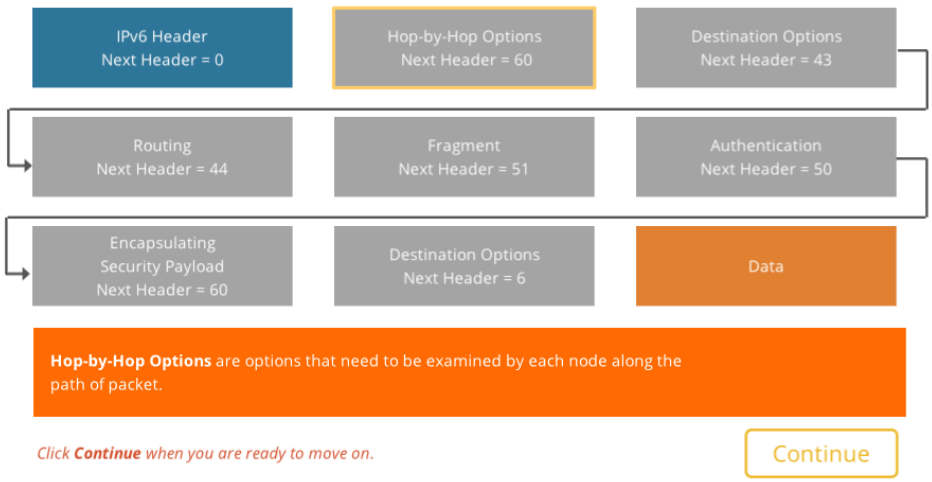
IPv4 Header versus IPv6 Header

IPv4		IPv6
IP Header Length	Specifies actual length of header, since length of options field can vary.	Removed; IP Header Length is always 40 bytes.
Header Checksum	Used for error correction for just the IP header.	Removed to simplify processing; Instead, error checking takes place at Layer 4.
Identification	Used together with the Flags and Fragment Offset fields, is used to uniquely identify fragments of an original IP datagram.	Removed; in IPv6, routers do not fragment IPv6 packets; hosts are responsible for this.
Flags	Used to control or identify fragments.	
Fragment Offset	Specifies the offset of a particular fragment relative to the beginning of the original datagram.	
Protocol	Specifies the number of the Layer 4 protocol used in the data portion of the packet.	Replaced with the Next Header field.

IPv4 Header versus IPv6 Header

IPv6 Extensions

Click any of the extension headers to learn more about its function.



Hop-by-Hop Options are options that need to be examined by each node along the path of packet.

*Click **Continue** when you are ready to move on.*

Continue

IPv6 Addressing

IPv6 Addressing

Key requirements outlined in RFC 5952:

- Leading zeros must be suppressed.
- The use of the symbol "::" must be used to its maximum capability.
- The characters "a", "b", "c", "d", "e", and "f", must be represented in lowercase.
- The symbol "::" must not be used to shorten just one 16-bit field.
- When an alternative choice exists in the placement of a "::", the longest run of consecutive 16-bit 0 fields must be shortened.
- When the length of the consecutive 16-bit 0 fields are equal, the first sequence of zero bits must be shortened.

This format should be followed by people and systems when representing IPv6 addresses as text, but systems should be able to accept and handle any legitimate IPv6 format.

- 192.168.254.110/24

Network Prefix
24 bits.

Host portion
(8 bits)

- 2bfc:0000:0000:0000:0217:cbff:fe8c:5c85/64

Global Routing Prefix

Subnet ID

Interface ID
(64 bits)

Network Prefix.
64 bits

- IPv6 Subnetting
↳ Create a subnet by changing the mask size.
* Global Routing Prefix does not change.

Summery

Summary

At this point, we now know how IPv4 and IPv6 addressing and subnet masking work. We learned about the different fields in an IP header, and we've seen how an IP datagram travels from a source device to a destination device using Ethernet as our Layer 2 networking technology.