

Network Layer: Internet Protocol, Version 6 (IPv6)

Lecture 13 | CSE421 – Computer Networks

Department of Computer Science and Engineering
School of Data & Science

IPv6

- Initial motivation:
 - 32-bit address space soon to be completely allocated.
- Additional motivation:
 - Simpler header format helps speed processing/forwarding
 - header changes to facilitate QoS

Reasons for using IPv6

- Address Availability:

- **IPv4:** 4 octets - 32 bits

- 2^{32} or 4,294,467,295 IP Addresses.

- **IPv6:** 16 octets - 128 bits

- 3.4×10^{38} or

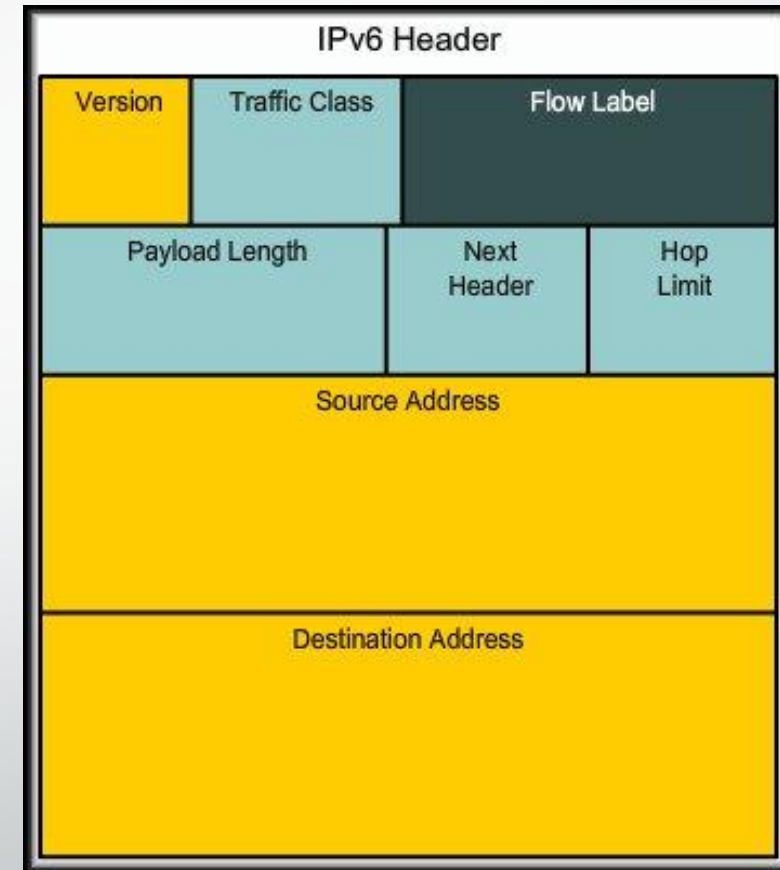
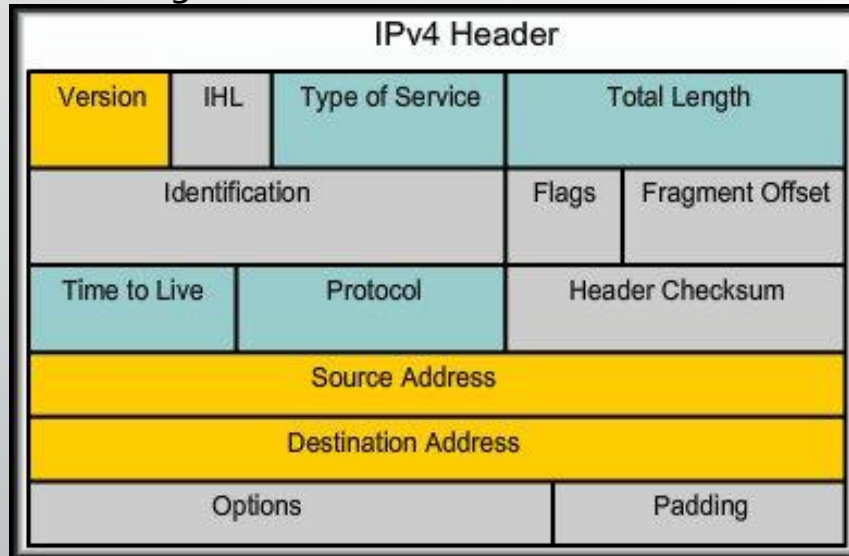
- 340,282,366,920,938,463,463,374,607,431,768,211,456

- (340 undecillion) IP Addresses.

- *Every atom of every person on Earth* could be assigned 7 unique addresses with some to spare (assuming 7×10^{27} atoms per human x 6.5 Billion).

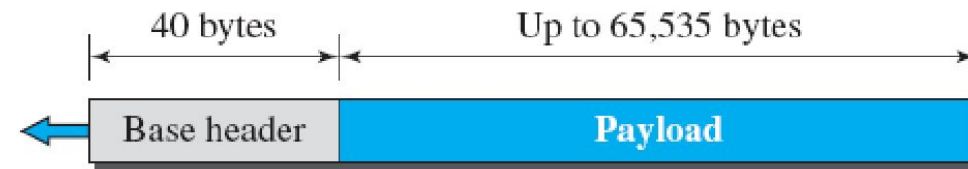
Reasons for Using IPv6

- IPv6 Features:
 - fixed-length 40 byte header
 - no fragmentation allowed



IPv6 Datagram

40 Octets, 8 fields

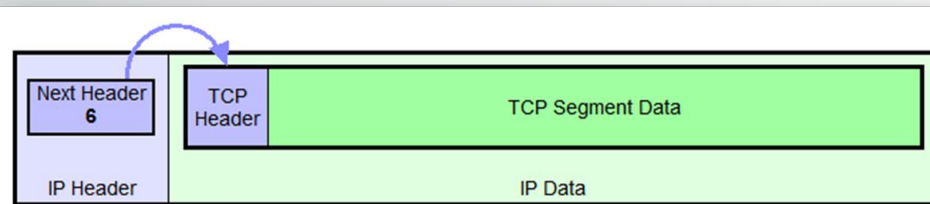
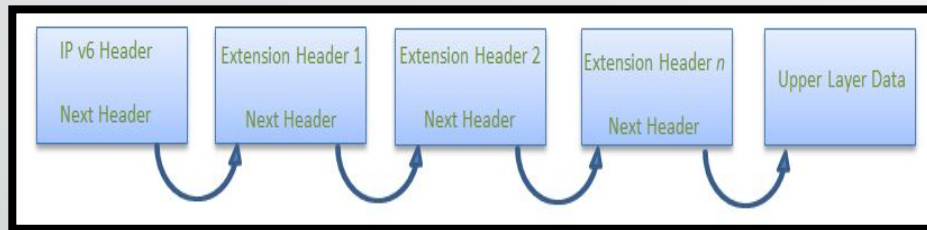


a. IPv6 packet

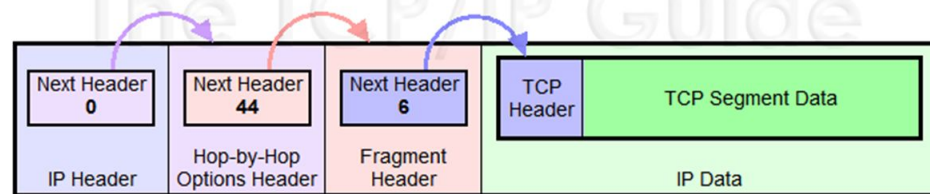
0	4	12	16	24	31
Version	Traffic class	Flow label			
Payload length			Next header	Hop limit	
Source address (128 bits = 16 bytes)					
Destination address (128 bits = 16 bytes)					

b. Base header

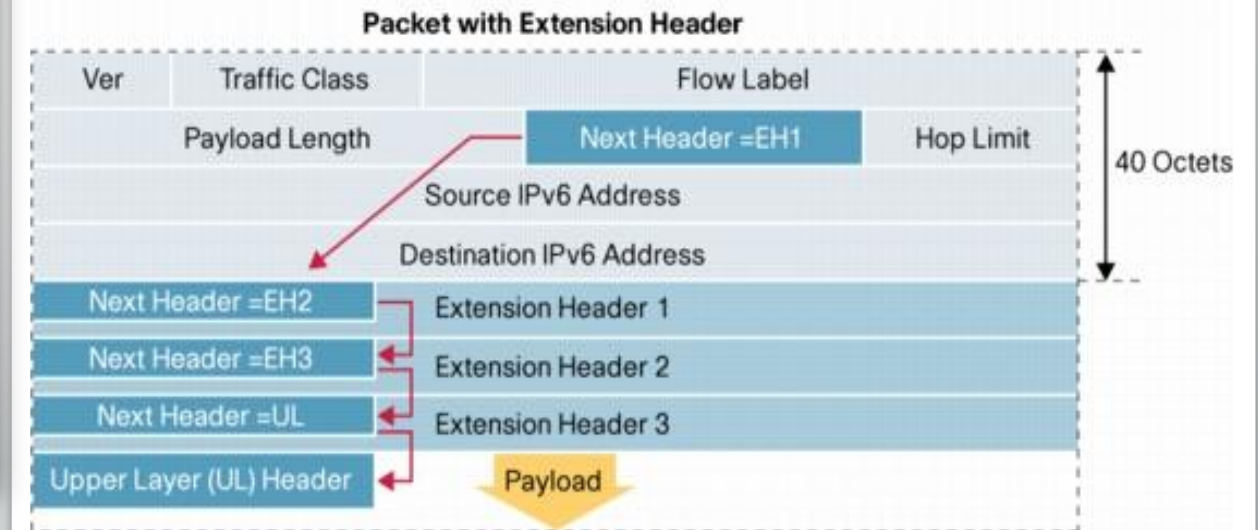
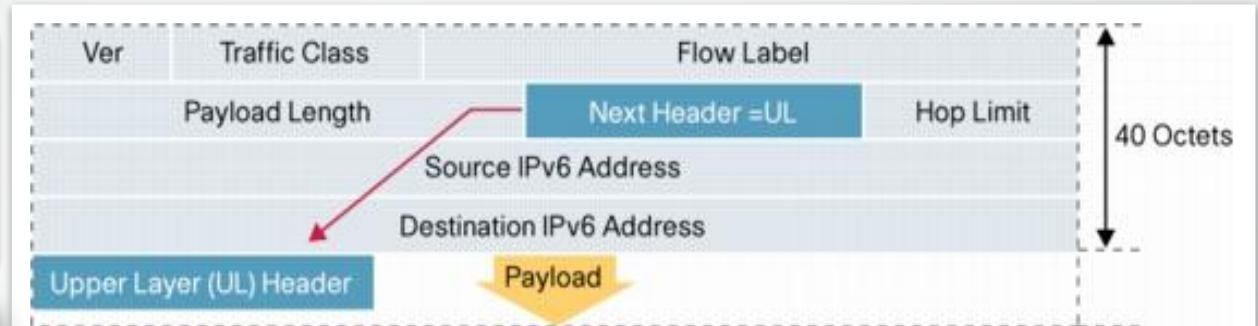
Extension Headers



IPv6 Datagram With No Extension Headers Carrying TCP Segment

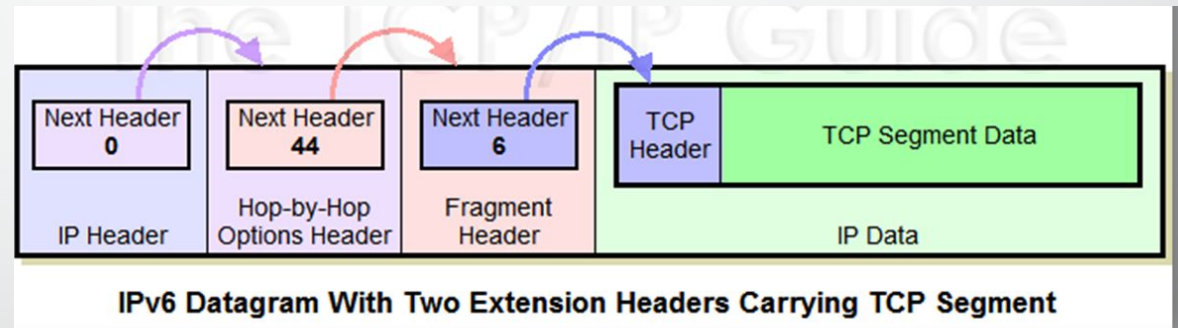


IPv6 Datagram With Two Extension Headers Carrying TCP Segment

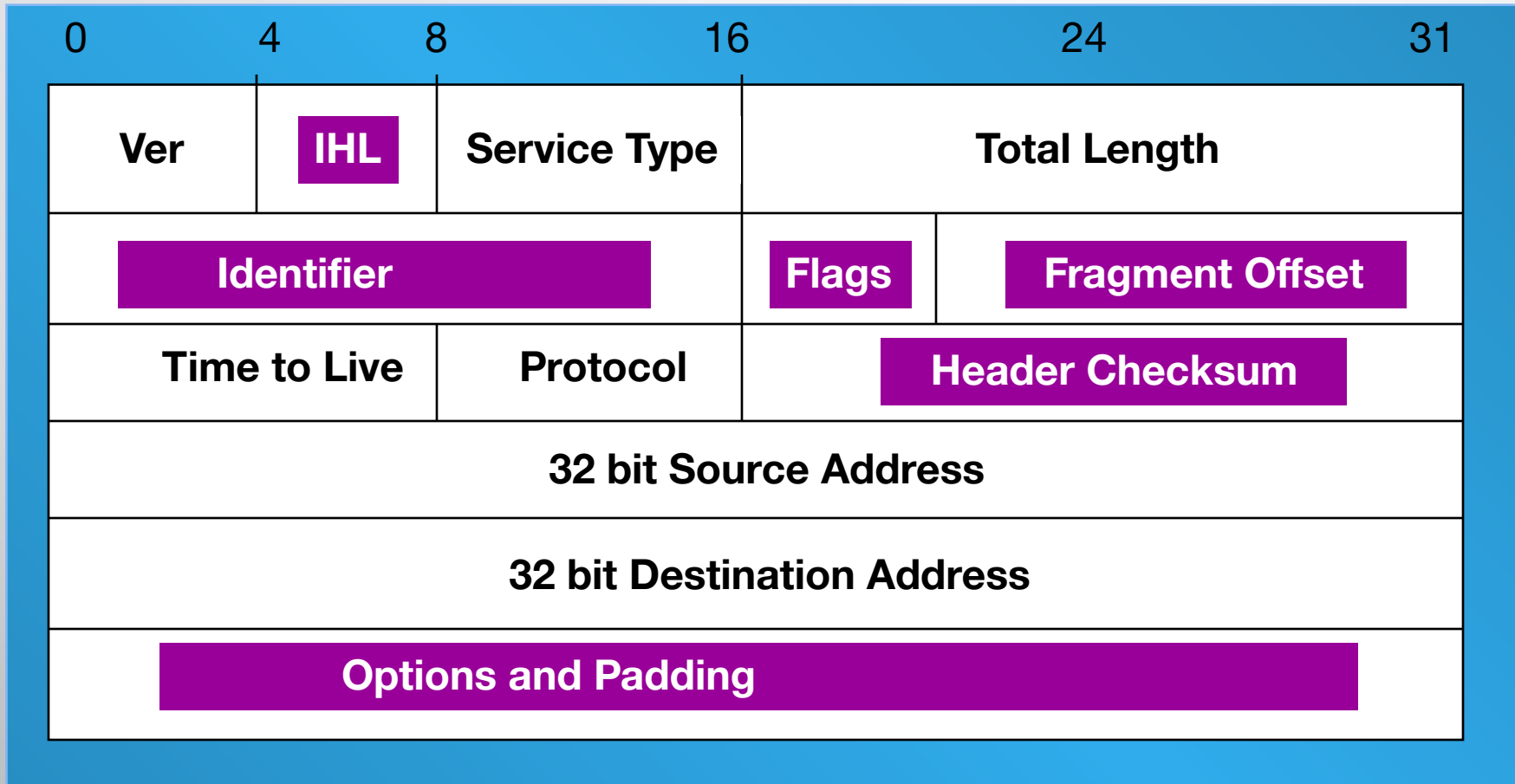


Extension Headers

- Basic header simplified for ease of processing
- Additional information carried in extension headers
 - Hop-by-hop options
 - Routing header
 - Fragment header
 - Destination options header
 - Authentication header (AH)
 - Encrypted security payload (ESP) header
- Next Header field says what type of header follows
 - E.g. Fragment Header, TCP, ICMP, etc.



The IPv4 Header



shaded fields are absent from IPv6 header

Header Changes between IPv4 and IPv6

- Revised
 - Time to Live (Hop Limit)
 - Addresses increased from 32 bits to 128 bits
 - Protocol (Next Header)
 - Precedence & TOS (Traffic Class)
- Extended
 - Flow Label field added (Recommended read: Page 676 of Forouzan's Book)

IPv6 Address

- 128 bits
- given below is a 128 bit IPv6 address represented in binary format and

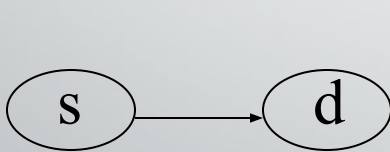
```
0010000000000001 0000000000000000 0011001000111000 110111111100001  
0000000001100011 0000000000000000 0000000000000000 111111011111011
```

```
2001:0000:3238:DFE1:0063:0000:0000:FEFB
```

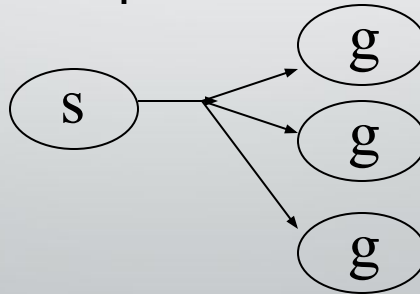
Called **string notation**

Types of IPv6 addresses

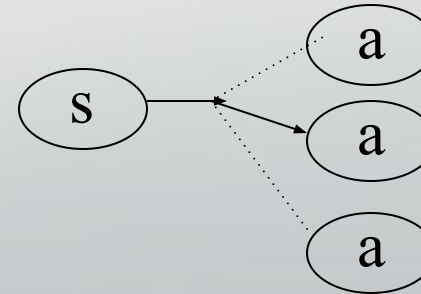
- **unicast**
 - communicate specified 1 computer
- **multicast**
 - communicate group of computers
- **anycast**
 - send group address that can receive multiple computers, but receive 1 computer



unicast



multicast



anycast

Types of IPv6 addresses

- Unlike IPv4, there is no broadcast address.
- There is an “all nodes multicast” which serves the same purpose.

Unicast Global Addresses

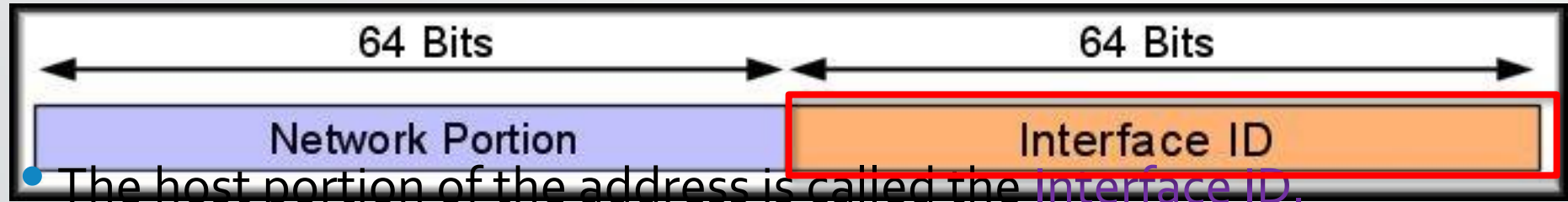
- These are assigned by the IANA and used on **public networks**.
- They are equivalent to IPv4 global (sometimes called public) addresses.
- Typically they start at 2000::/3

Unicast addresses

- A **unicast address** is an address that identifies a **single device**.
- Types of Unicast Addresses:

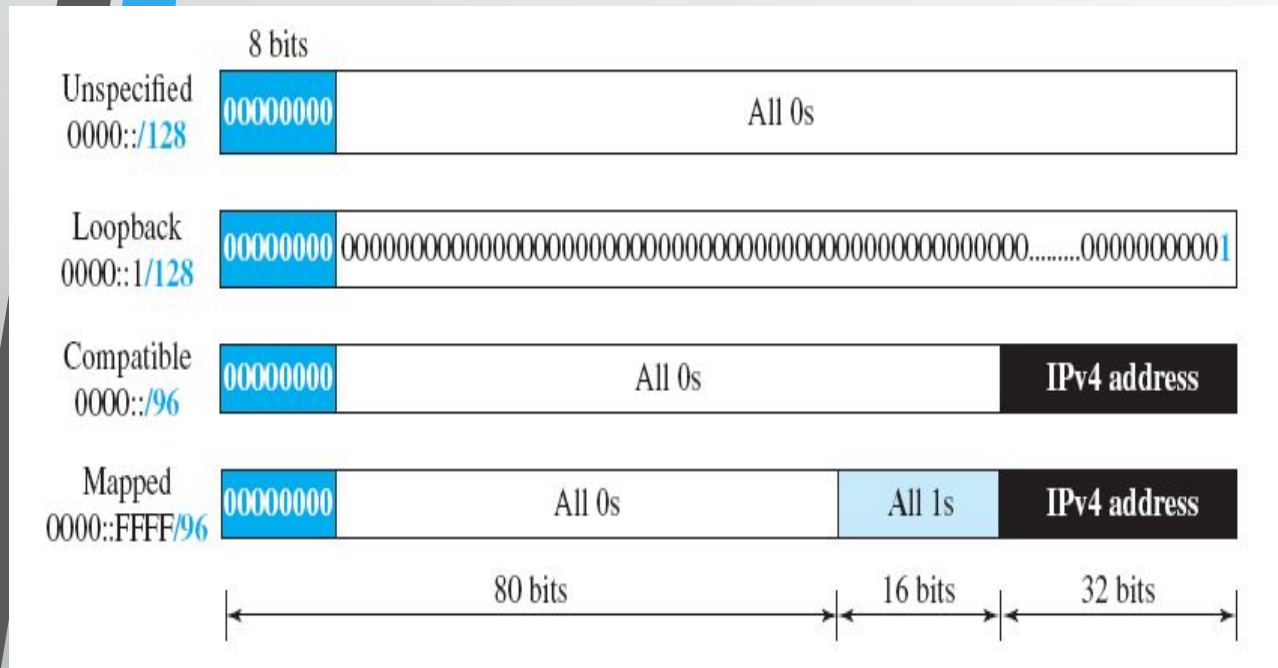
<i>Block prefix</i>	<i>CIDR</i>	<i>Block assignment</i>	<i>Fraction</i>
0000 0000	0000::/8	Special addresses	1/256
001	2000::/3	Global unicast	1/8
1111 110	FC00::/7	Unique local unicast	1/128
1111 1110 10	FE80::/10	Link local addresses	1/1024
1111 1111	FF00::/8	Multicast addresses	1/256

Unicast Global Addresses



- Can contain:
 - The interface's **48-bit** MAC Address.
 - An identifier derived from the EUI-64 Address (more later).
 - A manually configured address.

Special Addresses



- **Unspecified Address:**

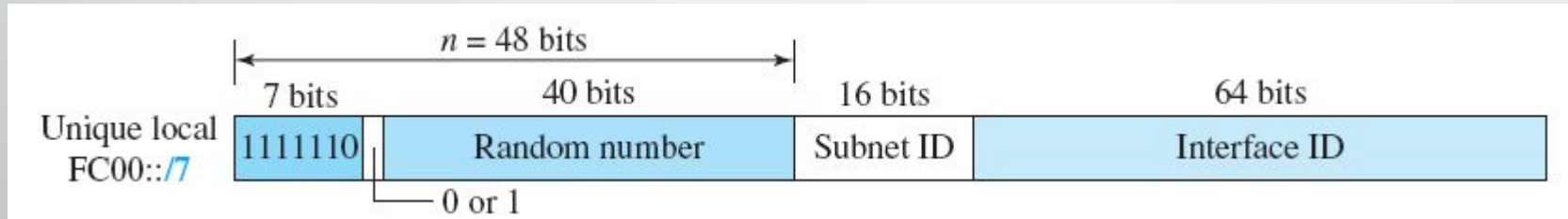
- ::/128
- In a host, it refers to the host itself, and is used when a device does not know its own address
- For addressing purposes within a software..

- **Loopback Address**

- ::1/128
- loopback (same as 127.0.0.1 in many IPv4 implementations)
- In IPv6 there is just one address, not a¹⁶ whole block, for this function.

Unique Local Unicast Address

- FC00::/7
- Globally unique,
- But it should be used in local communication.



Link Local Unicast Address

- FE80::/10

- These addresses refer **only to a particular physical network**.
- **Routers do not forward** datagrams using link-local addresses.
- They are only for **local communication** on a particular physical **network segment**.
 - Automatic address configuration.
 - Neighbor discovery.

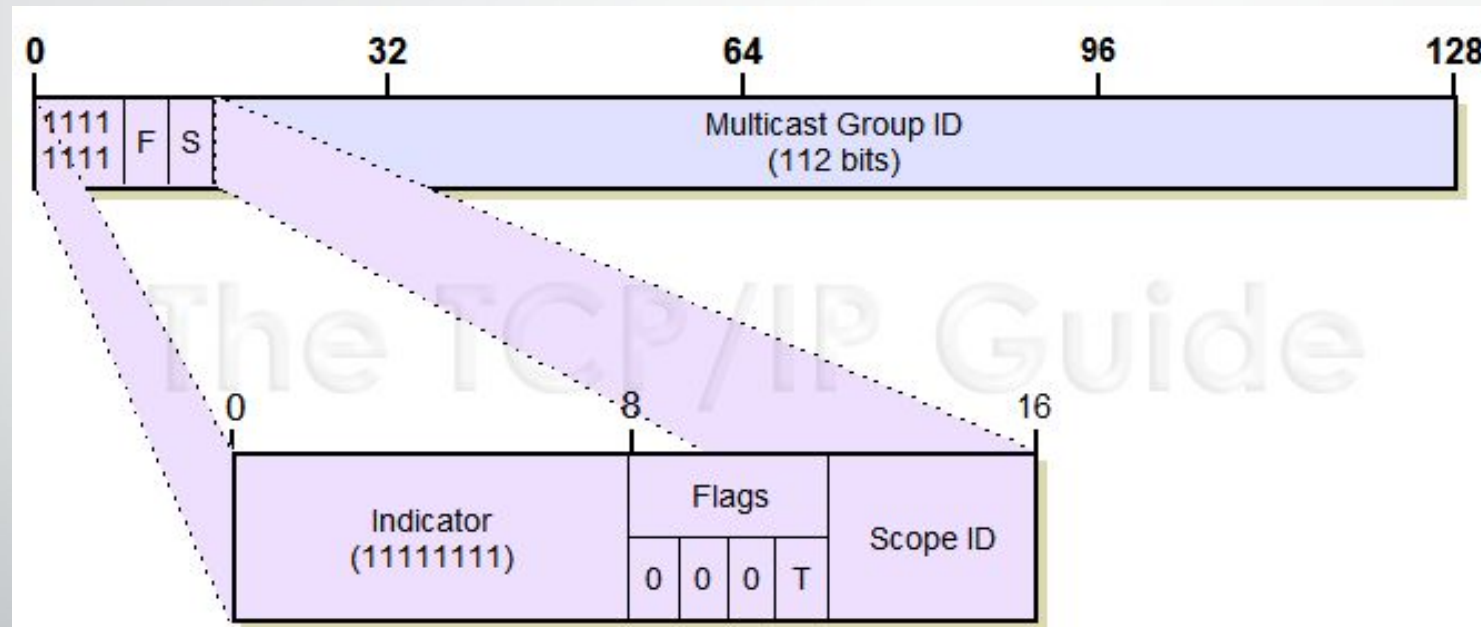
	10 bits	38 bits	16 bits	64 bits
Link local FE80::/10	1111111010	All 0s	All 0s	Interface ID

Scope of IPv6 Unicast Addresses



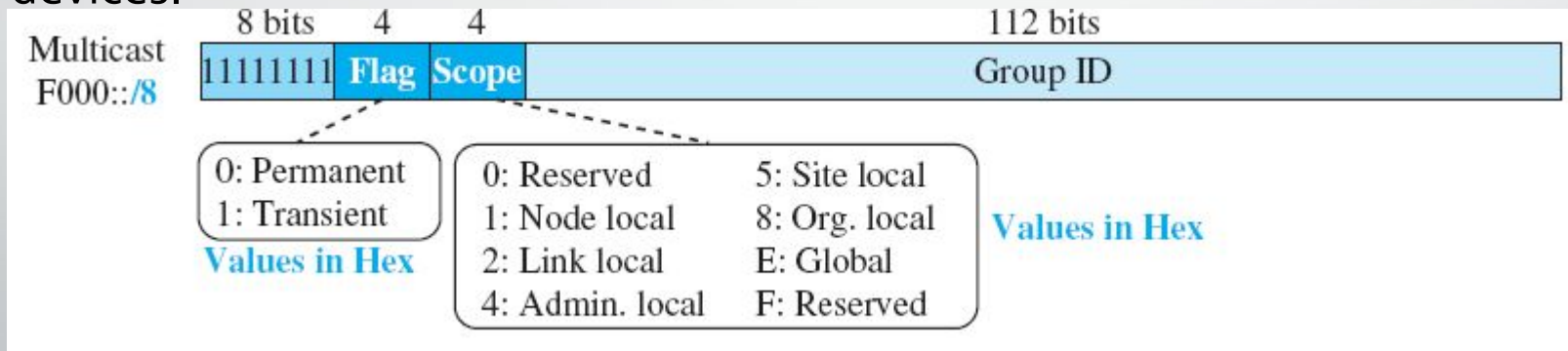
Multicast Addresses

- Consisting of all addresses that begin with "1111 1111" i.e "FF"



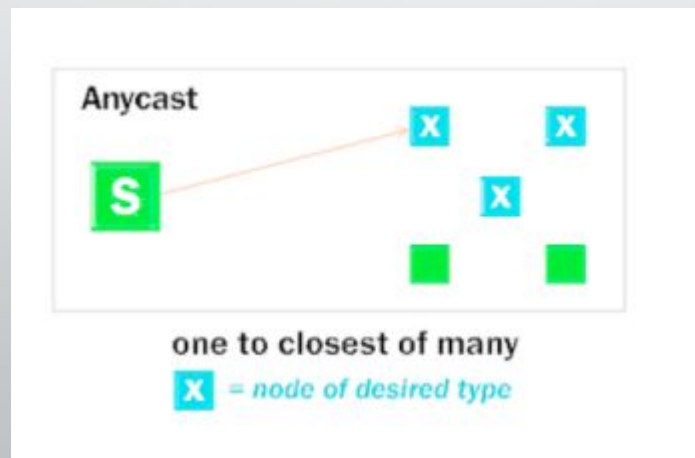
Multicast Addresses

- Multicast addresses are used to send data to a number of devices on an internetwork simultaneously.
- Each multicast address can be specified for a variety of *different scopes*
 - allowing a transmission to be targeted to either a wide or narrow audience of recipient devices.



Anycast Addresses

- To provide flexibility in situations where we need a service that is provided by a number of different servers or routers but don't really care which one provides it.
- In routing, anycast allows datagrams to be sent to **whichever router in a group of equivalent routers is closest**



Anycast Addresses

- There is no special anycast addressing scheme: anycast addresses are the same as unicast addresses.
- An anycast address is created “automatically” when a unicast address is assigned to more than one interface.



Transition from IPv4 to IPv6

IPv4 to IPv6 Transition

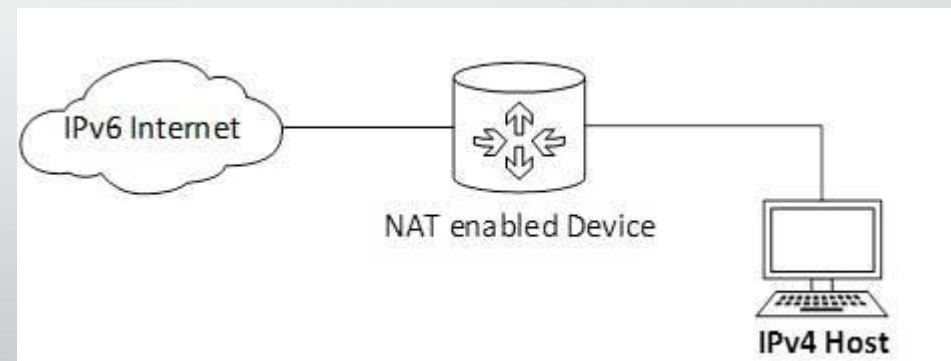
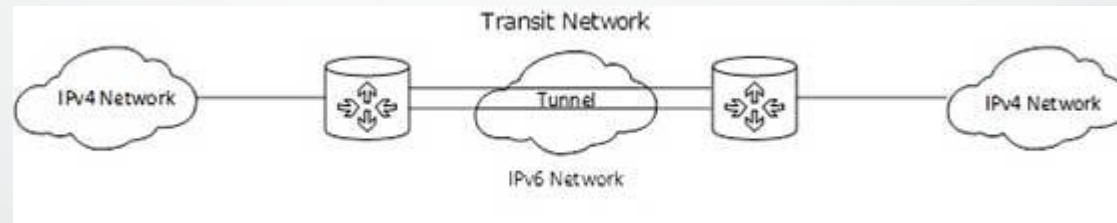
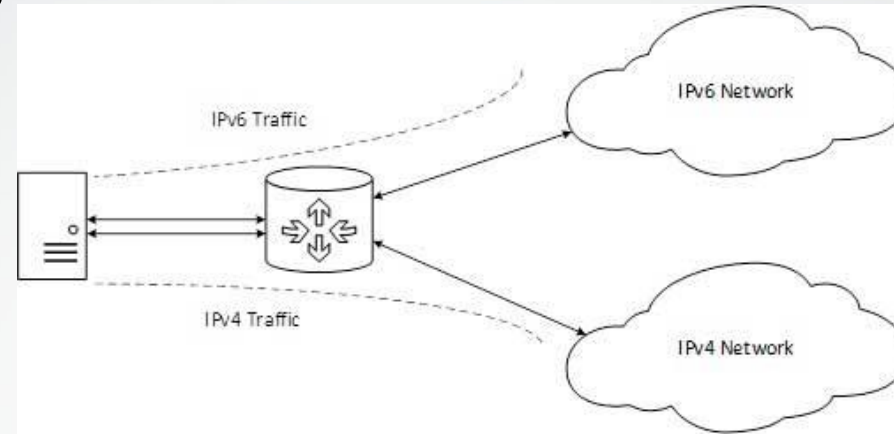
Strategies and mechanisms:

- IPv4 to IPv6 transition is gradual
- IPv6 devices need to communicate to IPv4
- IPv6 needs to communicate over IPv4 links

Transition Techniques

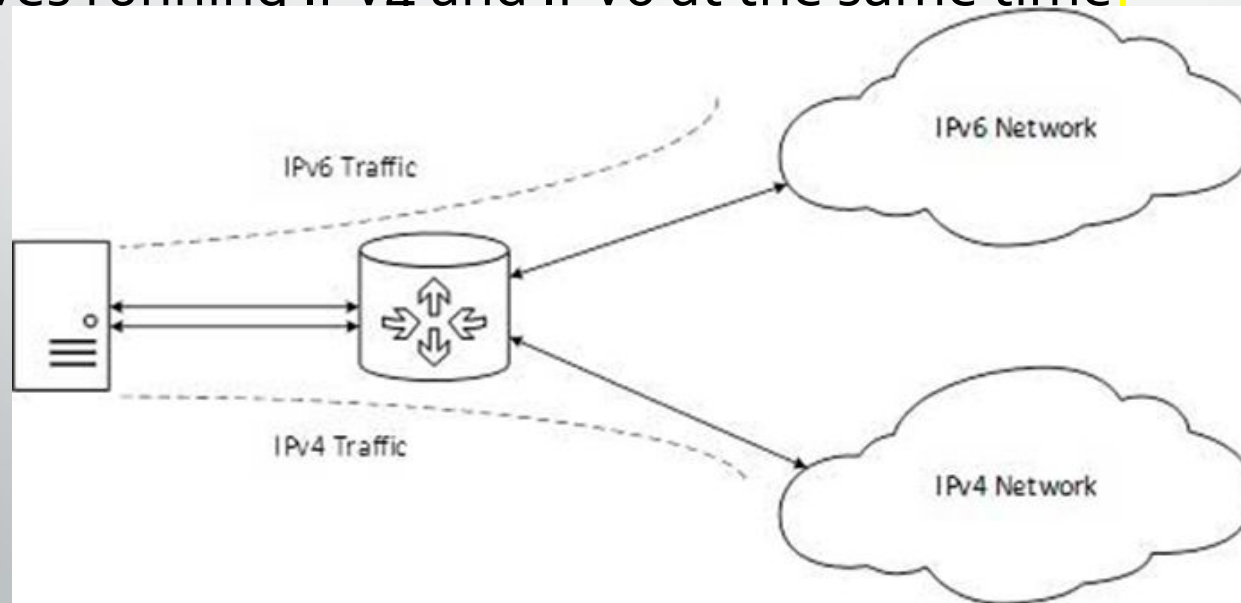
Three categories:

- Dual-stack techniques
- Tunneling Techniques
- Translation techniques

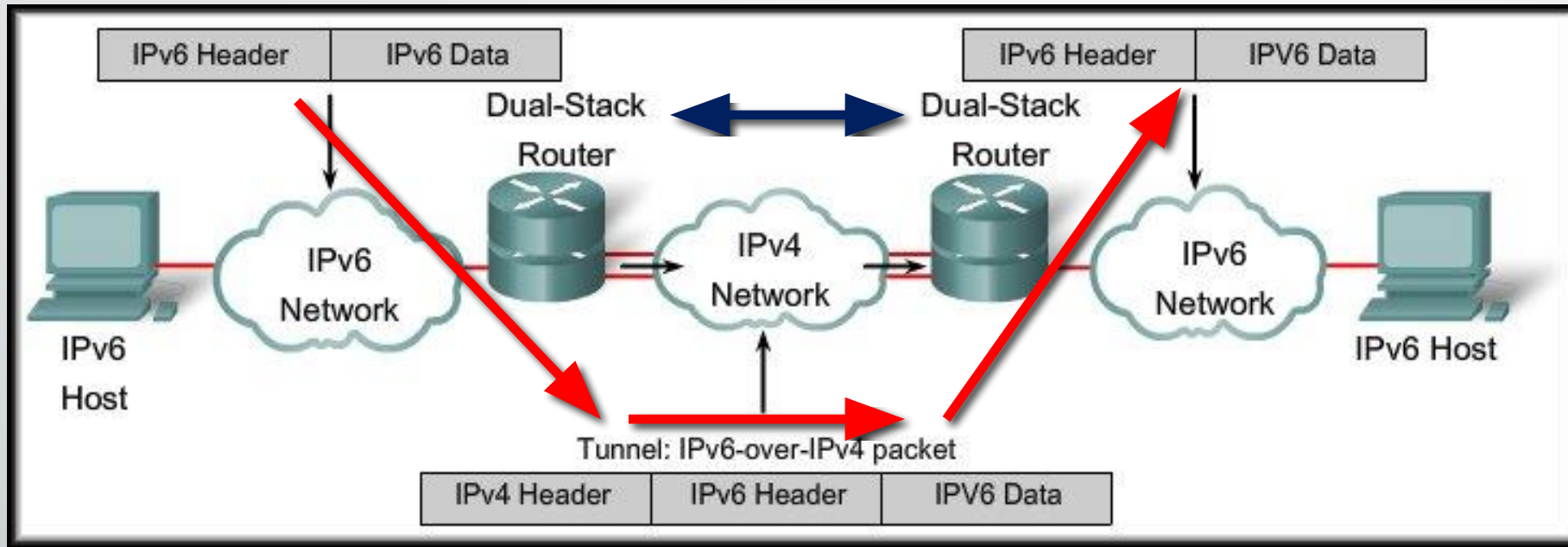


Dual Stack

- Method in which a node has implementation and connectivity to **both an IPv4 and IPv6** network.
- The **recommended** option.
- Involves running IPv4 and IPv6 at the same time.

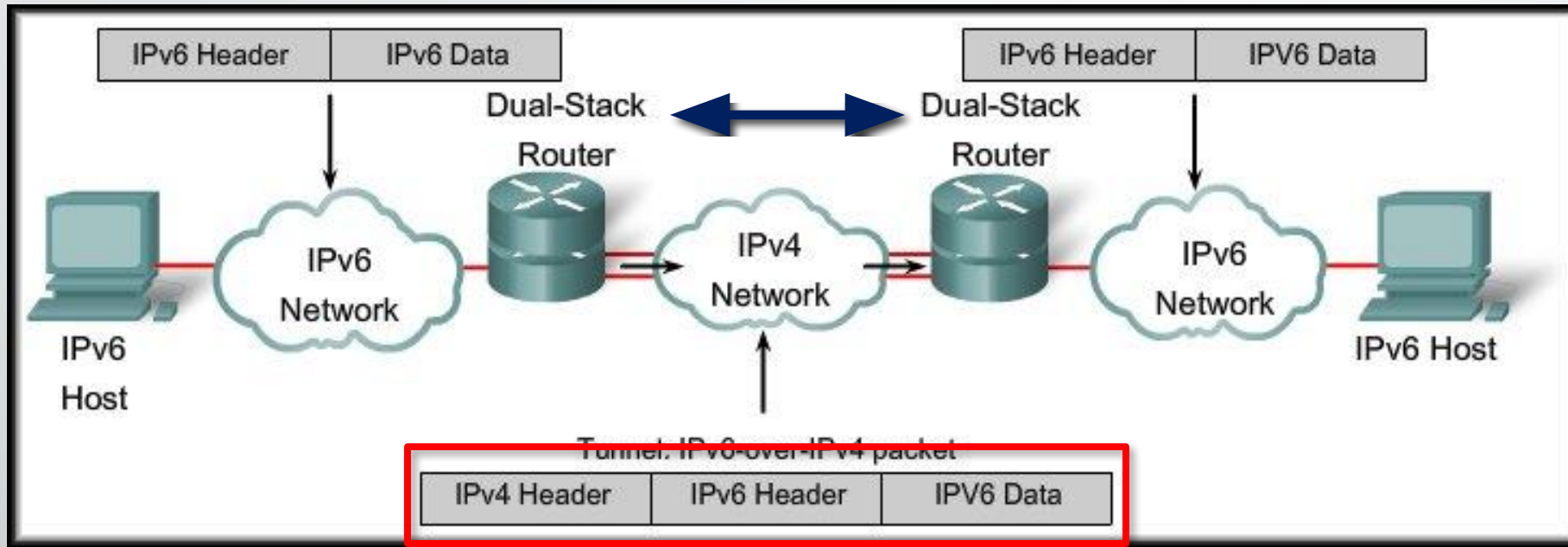


IPv6 Tunneling



- Tunneling is an integration method where an **IPv6 packet is encapsulated within another protocol.**
- Tunneling encapsulates the IPv6 packet in the IPv4 packet.

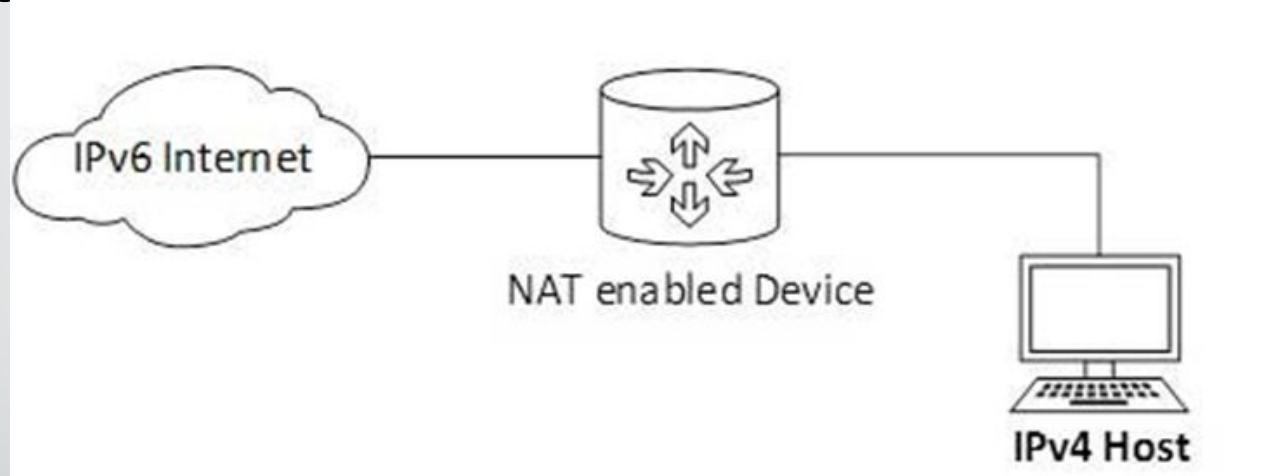
IPv6 Tunneling



- When IPv4 is used to encapsulate the IPv6 packet:
 - Protocol type of 41.
 - 20-byte IPv4 header with no options.
 - IPv6 header and payload.
 - Requires dual stacked routers.

NAT Protocol Translation

- Important method of transition to IPv6 by means of a NAT-PT (Network Address Translation – Protocol Translation) enabled device.



When the IPv4 host sends a request packet to the IPv6 server, the NAT-PT device/router strips down the IPv4 packet, removes IPv4 header, and adds IPv6 header and passes it through the Internet. When a response from the IPv6 server comes for the IPv4 host, the router does vice versa.



THE END