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 x 10^38 or

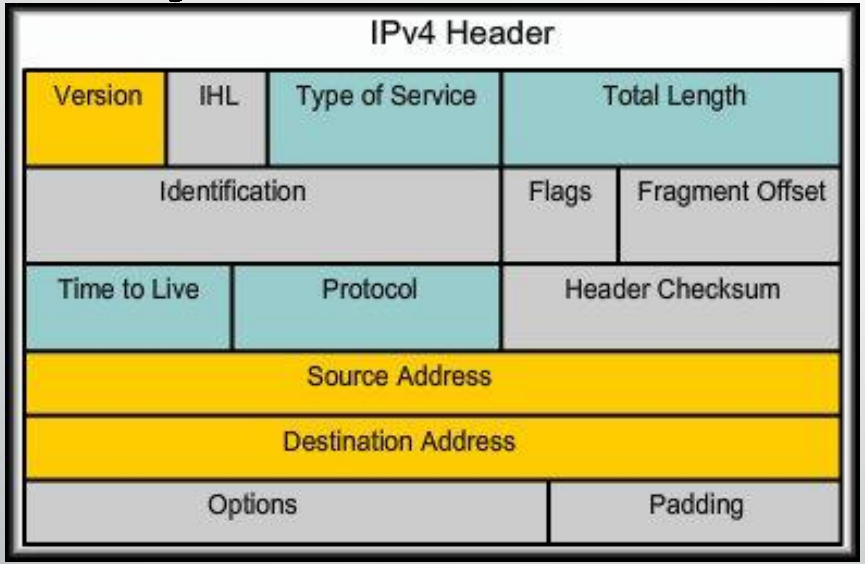
340,282,366,920,938,463,463,374,607,431,768,211,456

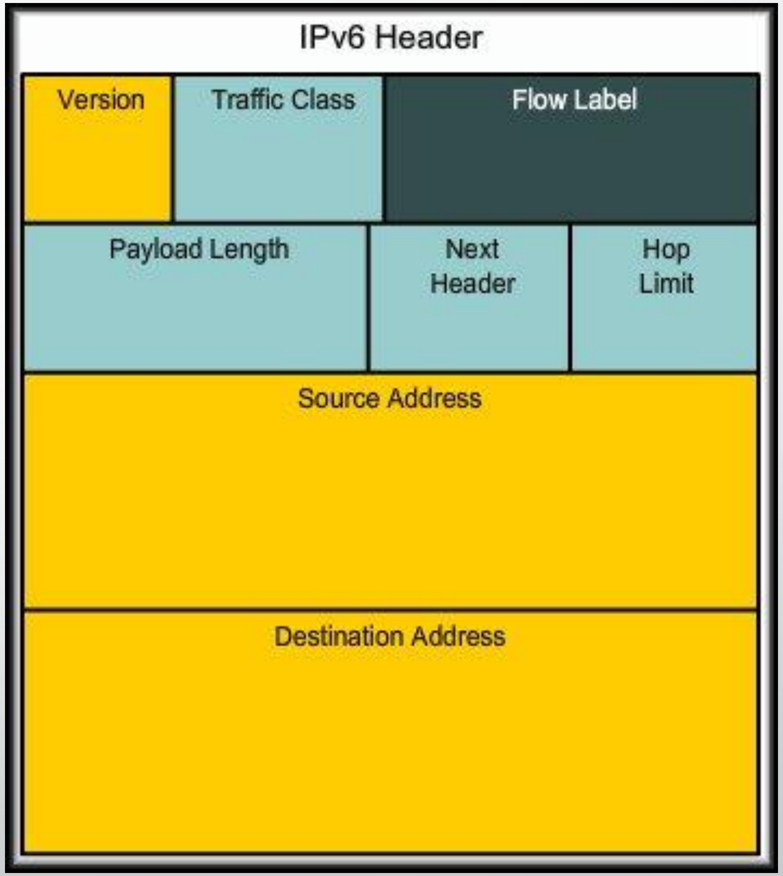
(340 undecillion) IP Addresses.

  - *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

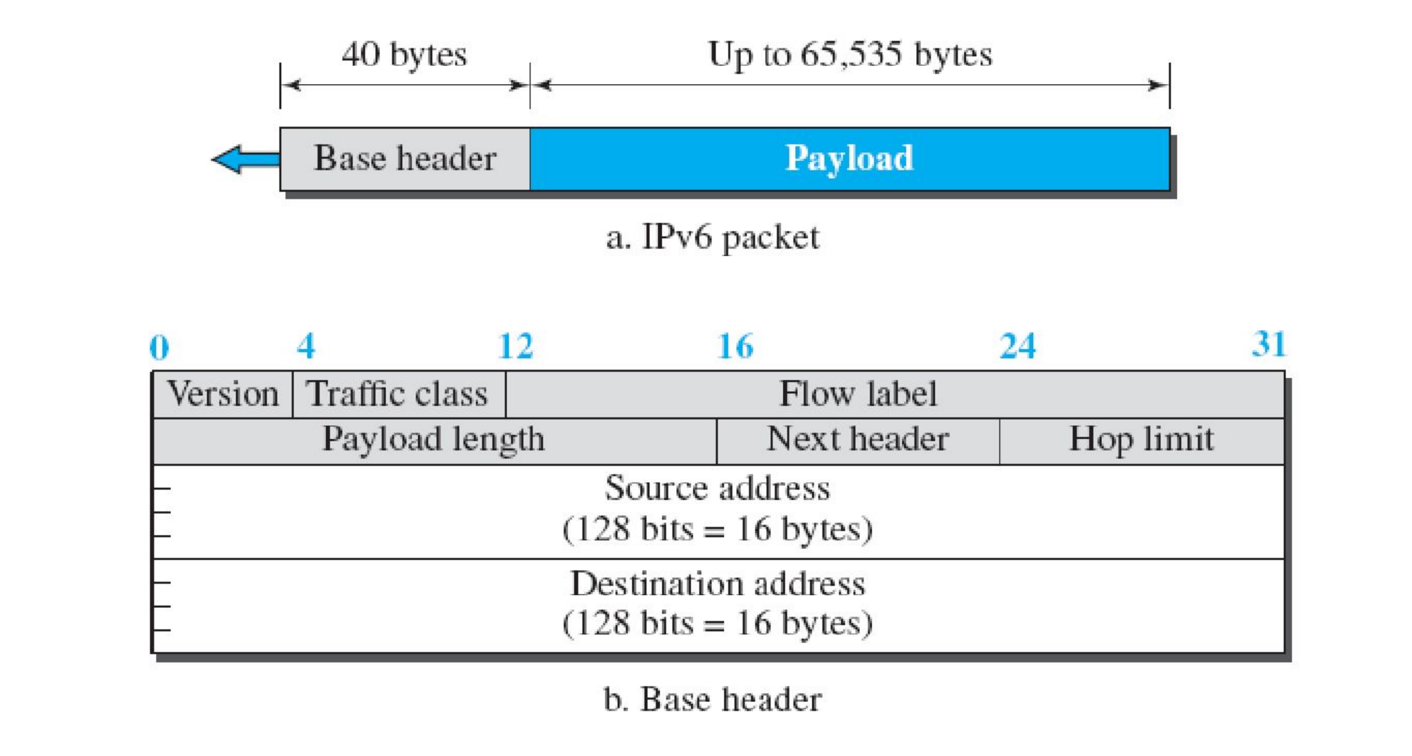
- IPv6 Features:
  - fixed-length 40 byte header
  - no fragmentation allowed





IPv6 Datagram

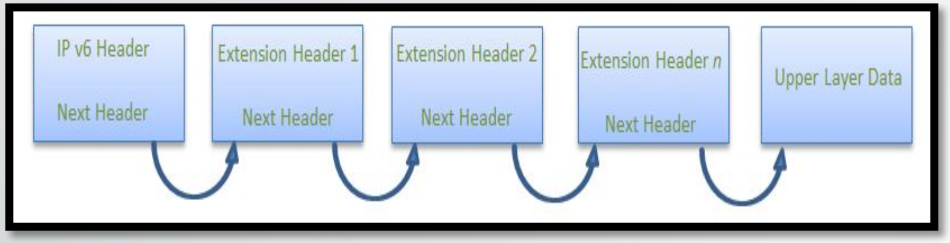
40 Octets, 8 fields

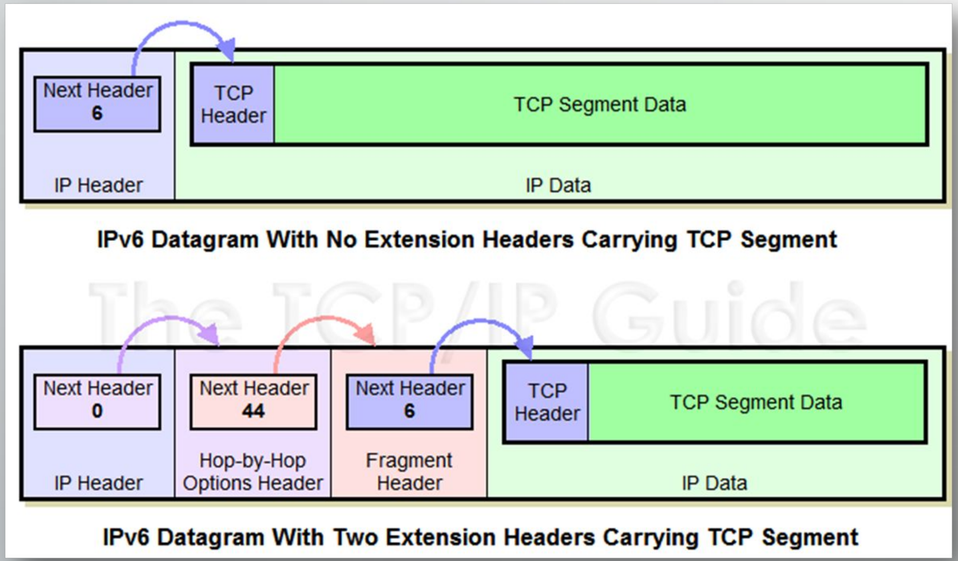


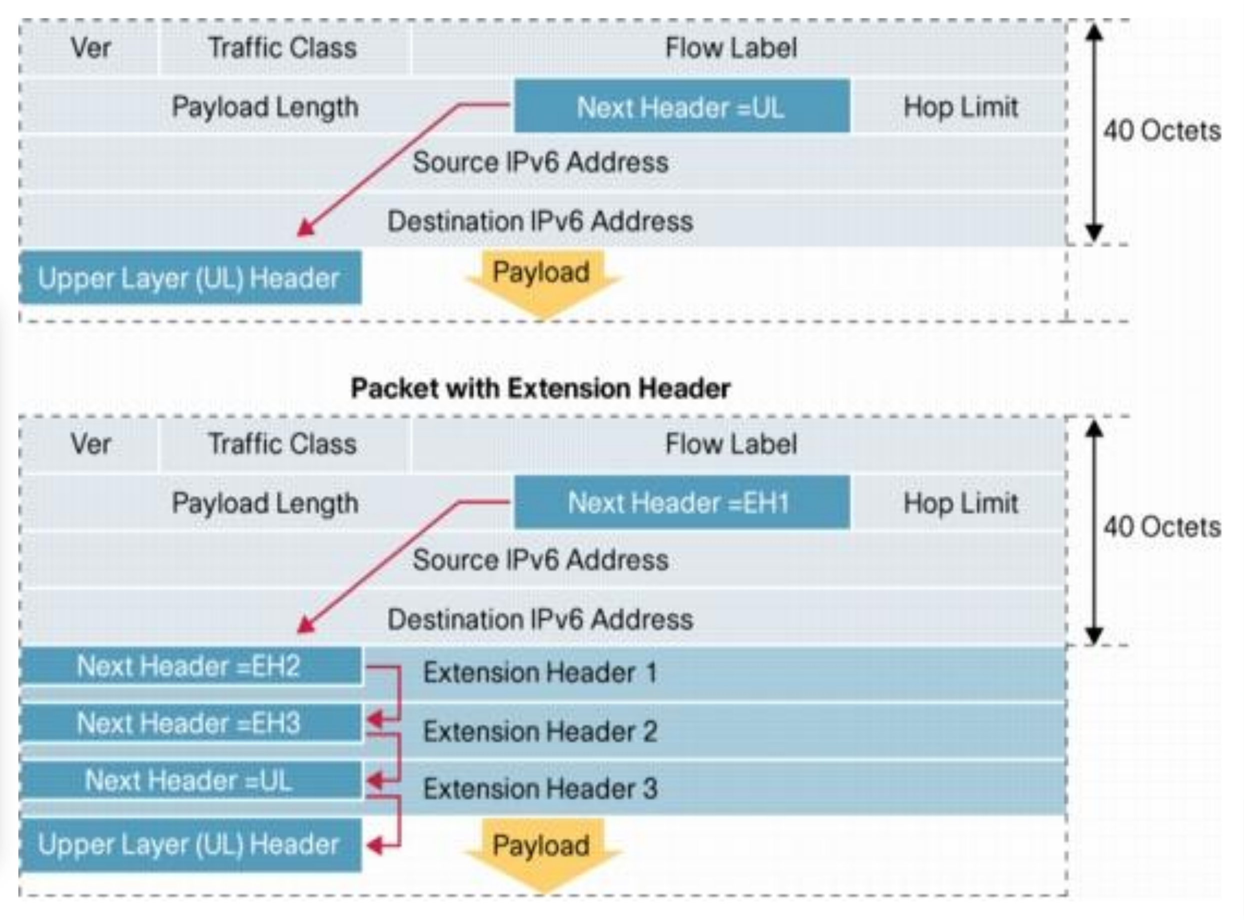
a. IPv6 packet

b. Base header

Extension Headers



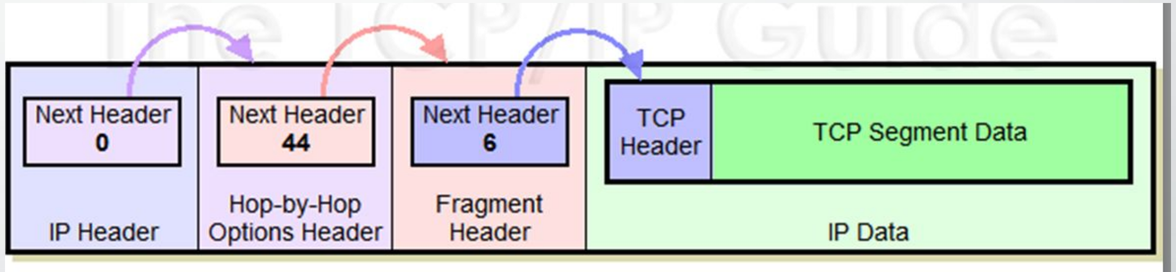




Extension Headers

- Basic header simplified for ease of processing

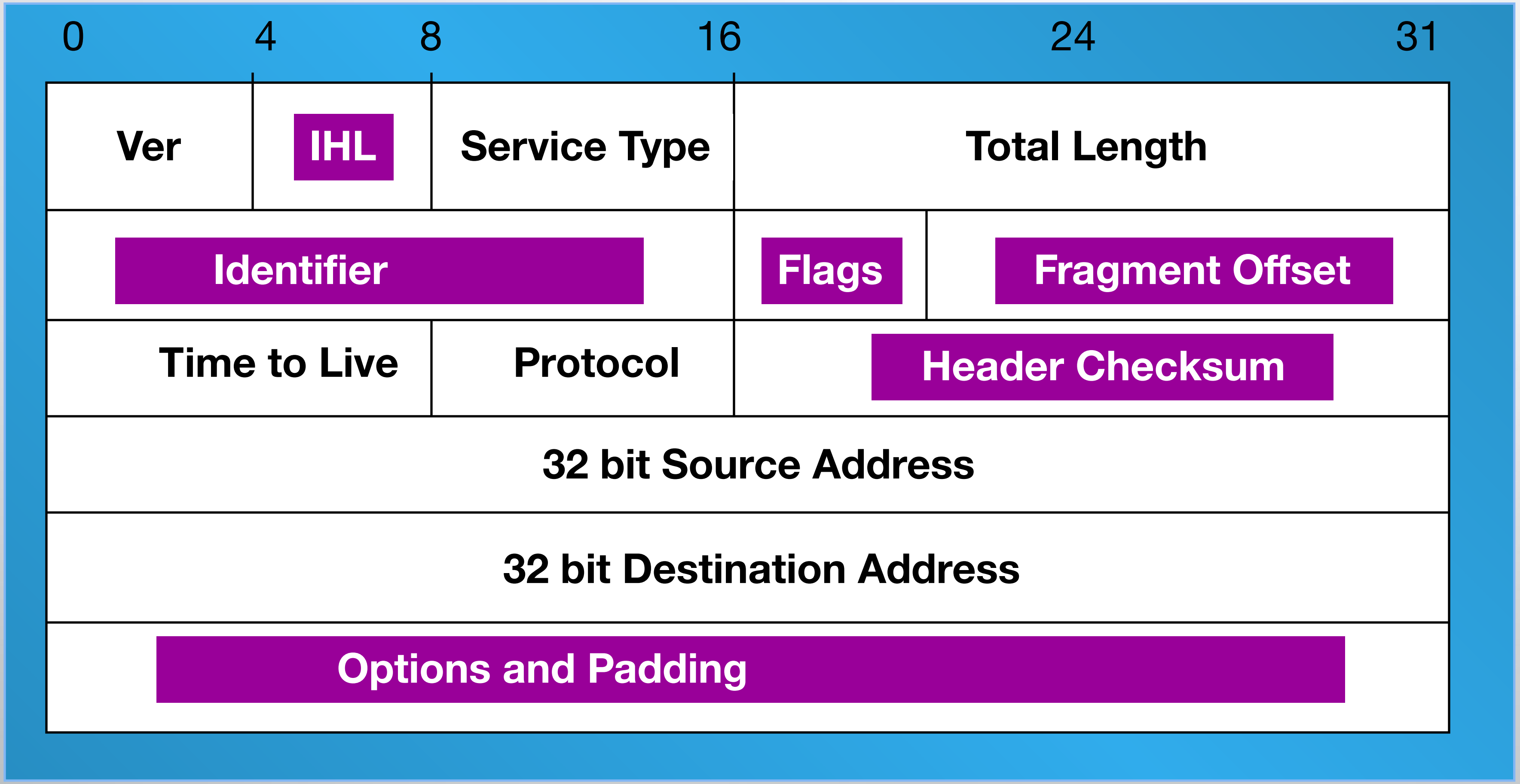
- Additional information carried in extension headers
  - Hop-by-hop options
  - Routing header
  - Fragment header
  - Destination options header
  - Authentication header (AH)
  - Encrypted security payload (ESP) header



IPv6 Datagram With Two Extension Headers Carrying TCP Segment

- 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 1101111111100001
0000000001100011 0000000000000000 0000000000000000 1111111011111011

- Each block is then converted into Hexadecimal and separated by ':' symbol

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

Called **string notation**

IPv6 Addressing

- IPv6 Representation – Rule 1:
  - The leading zeroes in any 16-bit segment do not have to be written. If any 16-bit segment has fewer than four hexadecimal digits, it is assumed that the missing digits are leading zeroes.

2031	0000	130F	0000	0000	09C0	876A	130B
2031	0	130F	0	0	9C0	876A	130B
8105	0000	0000	4B10	1000	0000	0000	0005
8105	0	0	4B10	1000	0	0	5
0000	0000	0000	0000	0000	0000	0000	0000
0	0	0	0	0	0	0	0

IPv6 Addressing

- IPv6 Representation – Rule 2:
  - Any single, contiguous string of one or more 16-bit segments consisting of all zeroes can be represented once with a double colon

1080:0:0:0:8:800:200C:417A	=
FF01:0:0:0:0:0:0:101	=
0:0:0:0:0:0:0:1	=
0:0:0:0:0:0:0:0	=

IPv6 Addressing

- IPv6 Representation – Rule 2:
  - *Any single, contiguous string of one or more 16-bit segments consisting of all zeroes can be represented once with a double colon.*

Example: **1843:f01::22::fa**

  - Illegal because the length of the two all-zero strings is ambiguous.

1843:00f0:0000:0000:0022:0000:0000:00fa

or

1843:00f0:0000:0000:0000:0022:0000:00fa

or

1843:00f0:0000:0022:0000:0000:0000:00fa

Representing IPv6 addresses

- No more net masks
  - Represented by a "/prefixlen" appended to the end of an address where prefixlen indicates the number of bits in the address that make up the network address
    - Similar to classless address representation in IPv4
    - For example:

2001:db8:abcd:0012::0/64 specifies a subnet with a range of IP addresses from:

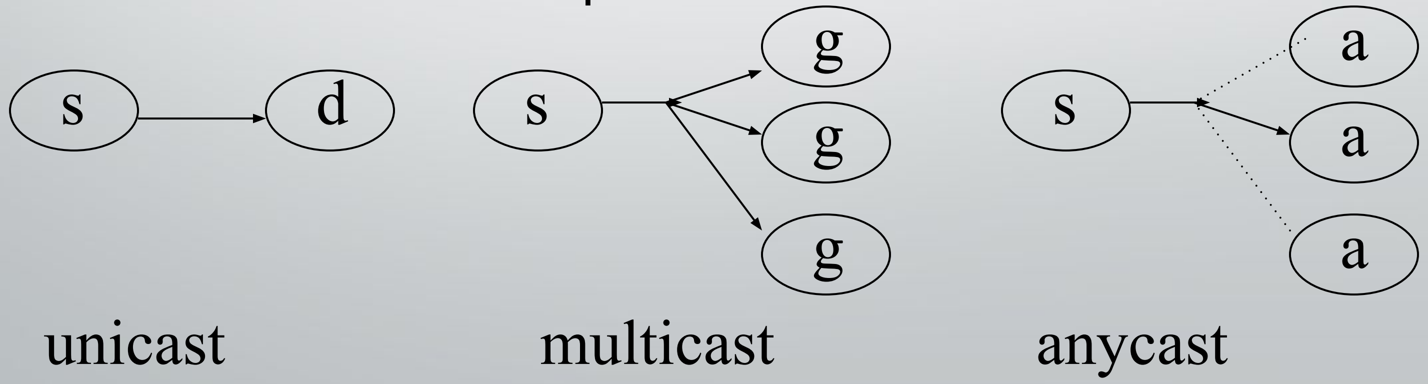
2001:db8:abcd:0012:0000:0000:0000:0000 to
2001:db8:abcd:0012:ffff:ffff:ffff:ffff.

Network part : 2001:db8:abcd:0012

Host part : ::0

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



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

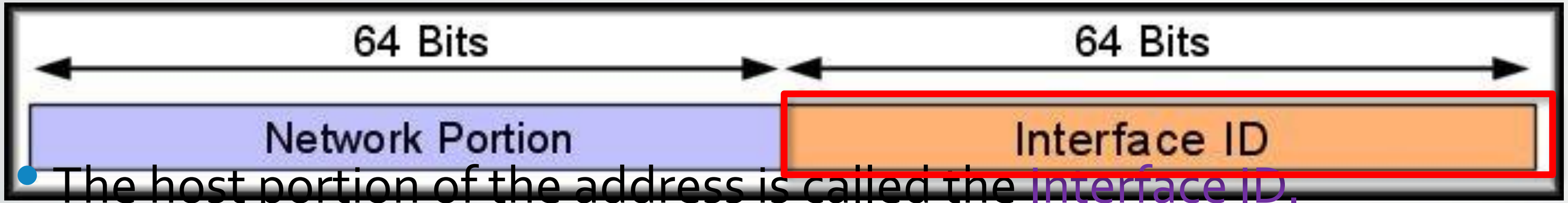
Unicast addresses

- A unicast address is an address that identifies a single device.

- Types of Unicast Addresses:

Block prefix	*CIDR*	*Block assignment*	*Fraction*
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

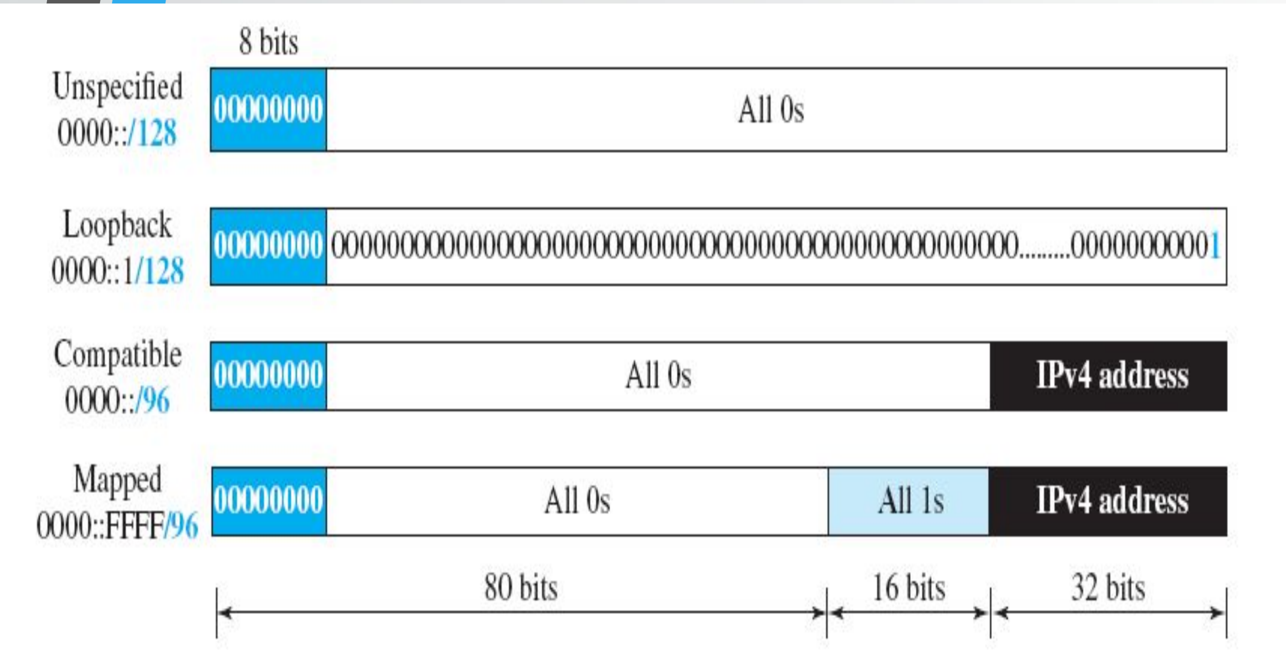
Unicast Global Addresses



- The host portion of the address is called the interface ID.

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

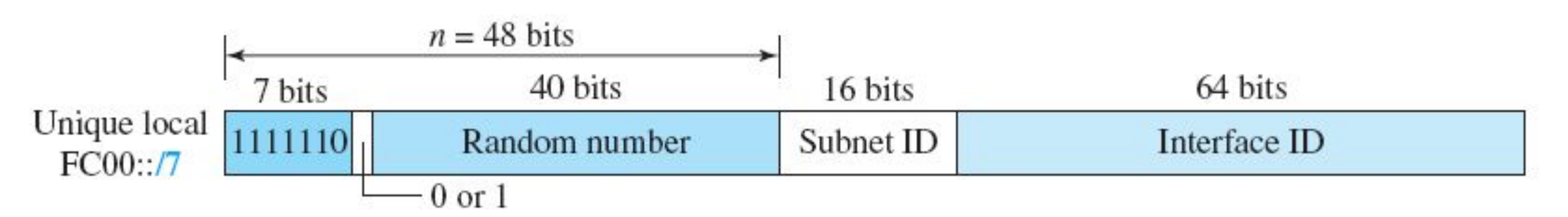
Special Addresses



- **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 a whole block, for this function.

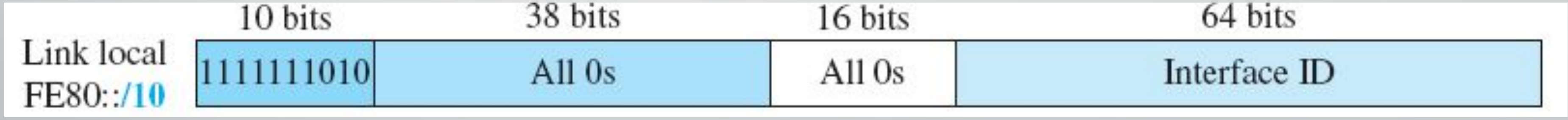
Unique Local Unicast Address

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

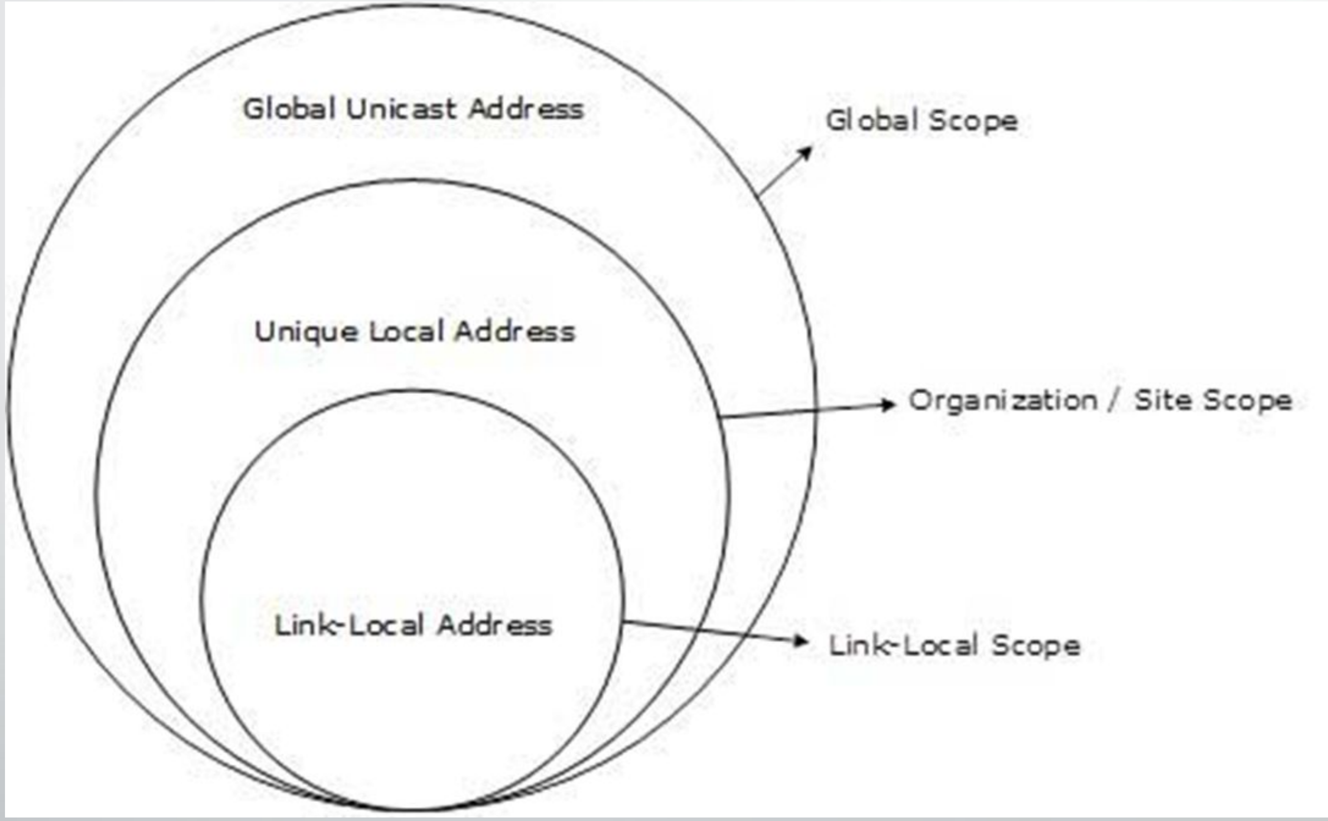


Link Local Unicast Address

- **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.

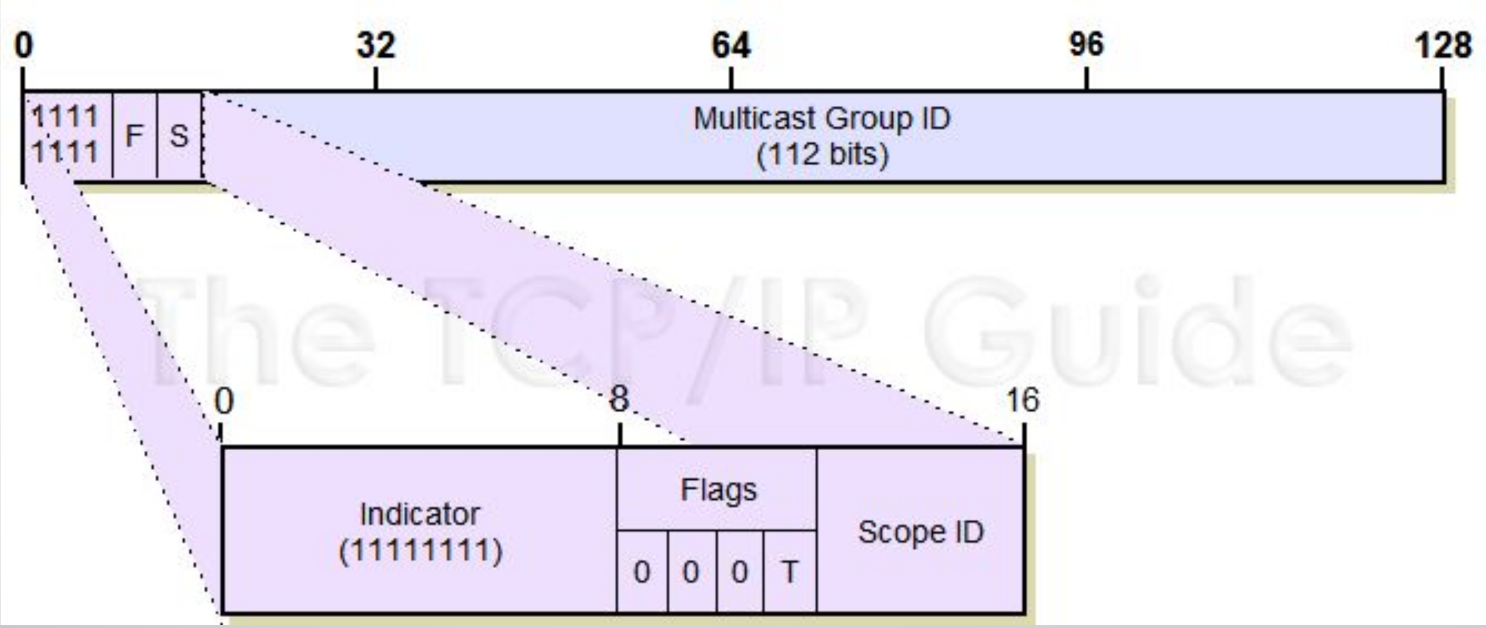


Scope of IPv6 Unicast Addresses



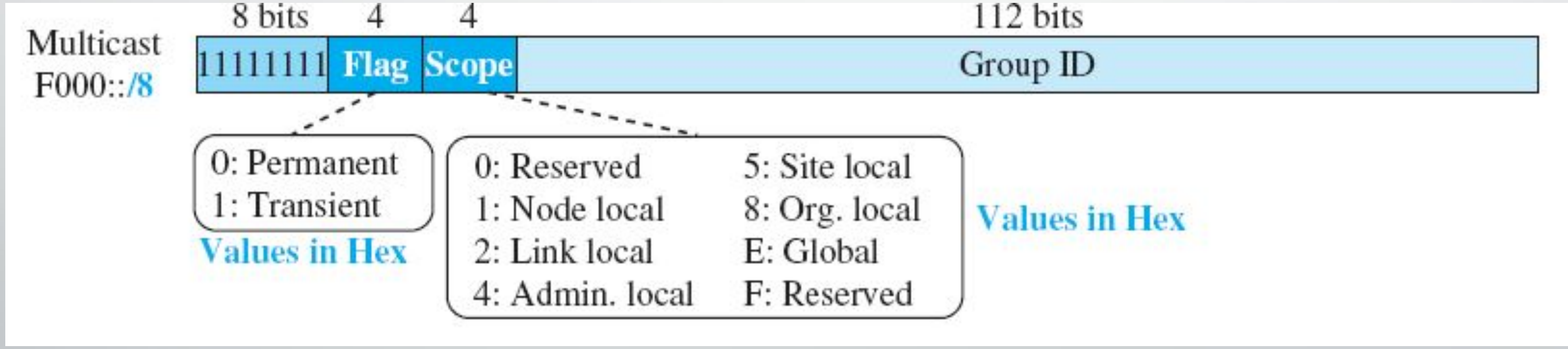
Multicast Addresses

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



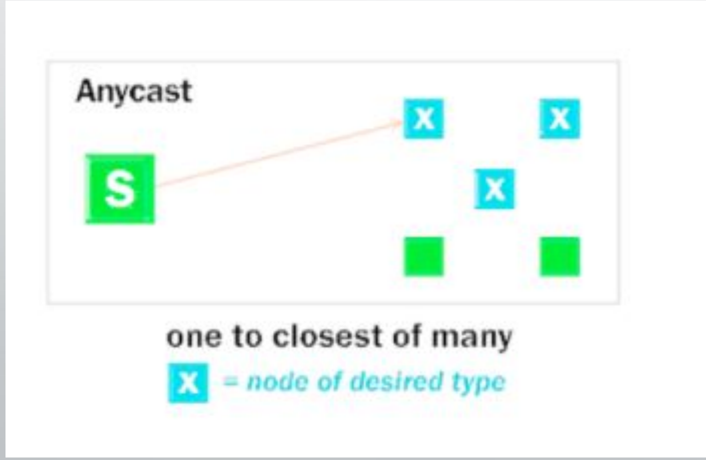
Multicast Addresses

- 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

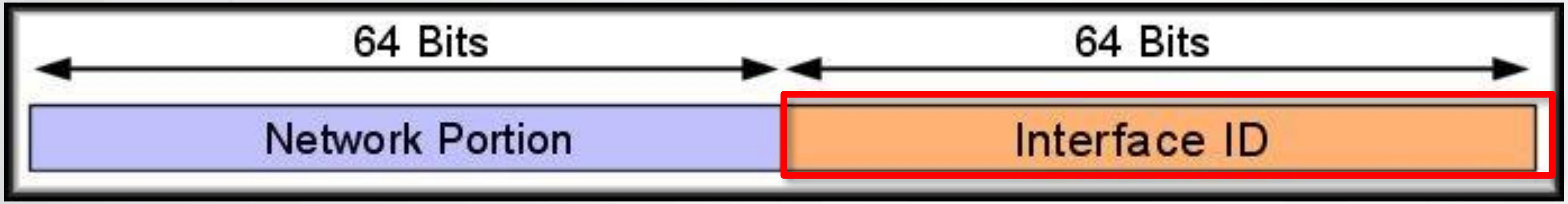
- To provide flexibility in situations where we need a service that is provided by a number of different servers or routers but don't really care which one provides it.
- In routing, anycast allows datagrams to be sent to whichever router in a group of equivalent routers is closest



Anycast Addresses

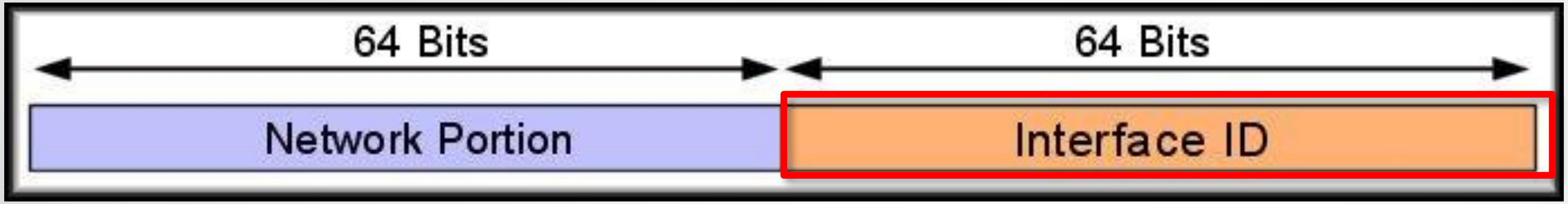
- There is no special anycast addressing scheme: anycast addresses are the same as unicast addresses.
- An anycast address is created "automatically" when a unicast address is assigned to more than one interface.

Interface part



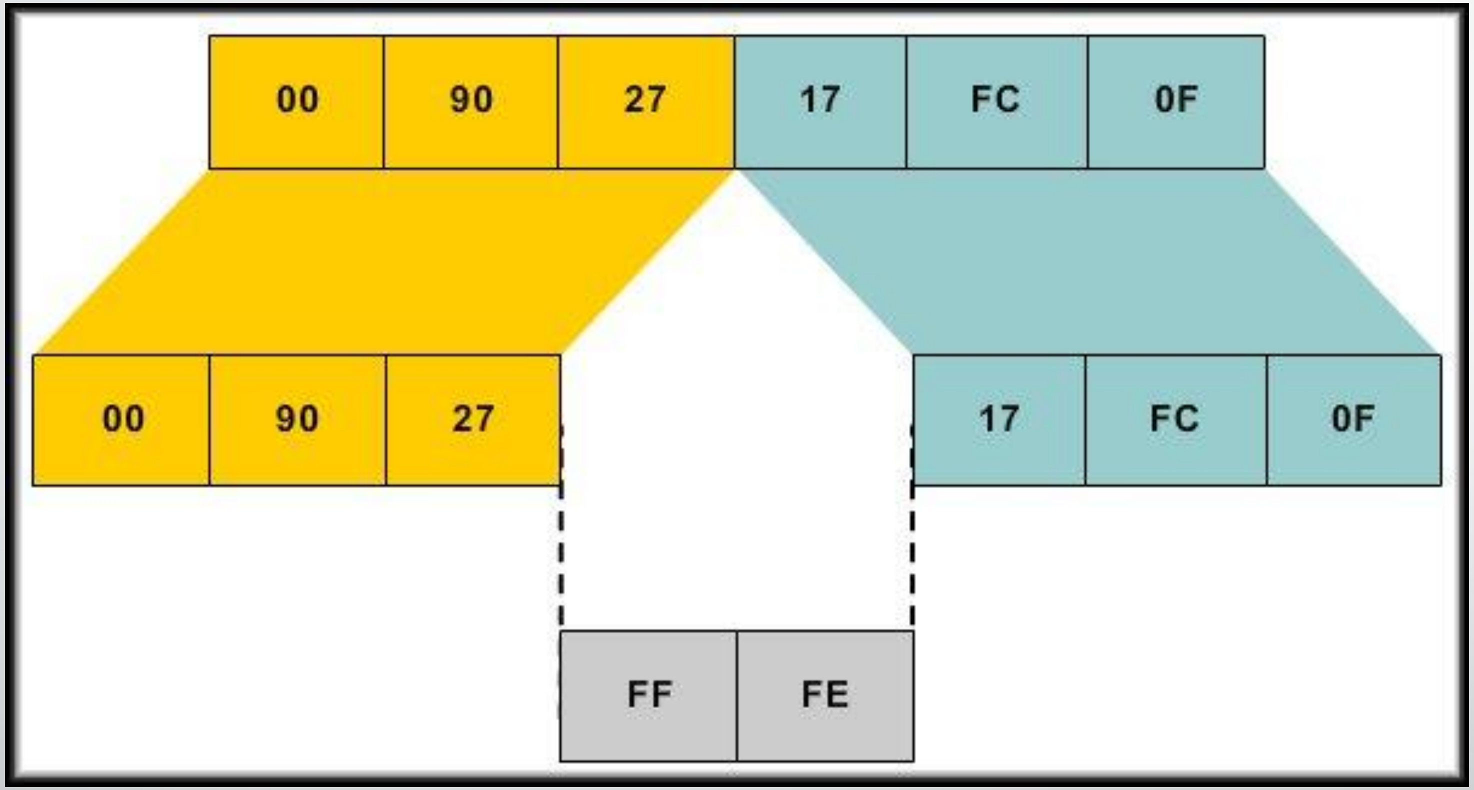
- Manually give the interface ID part
  - **Corp(config-if)#ipv6 address 2001:db8:3c4d:1::1/64**

Interface part : Using an **EUI-64**



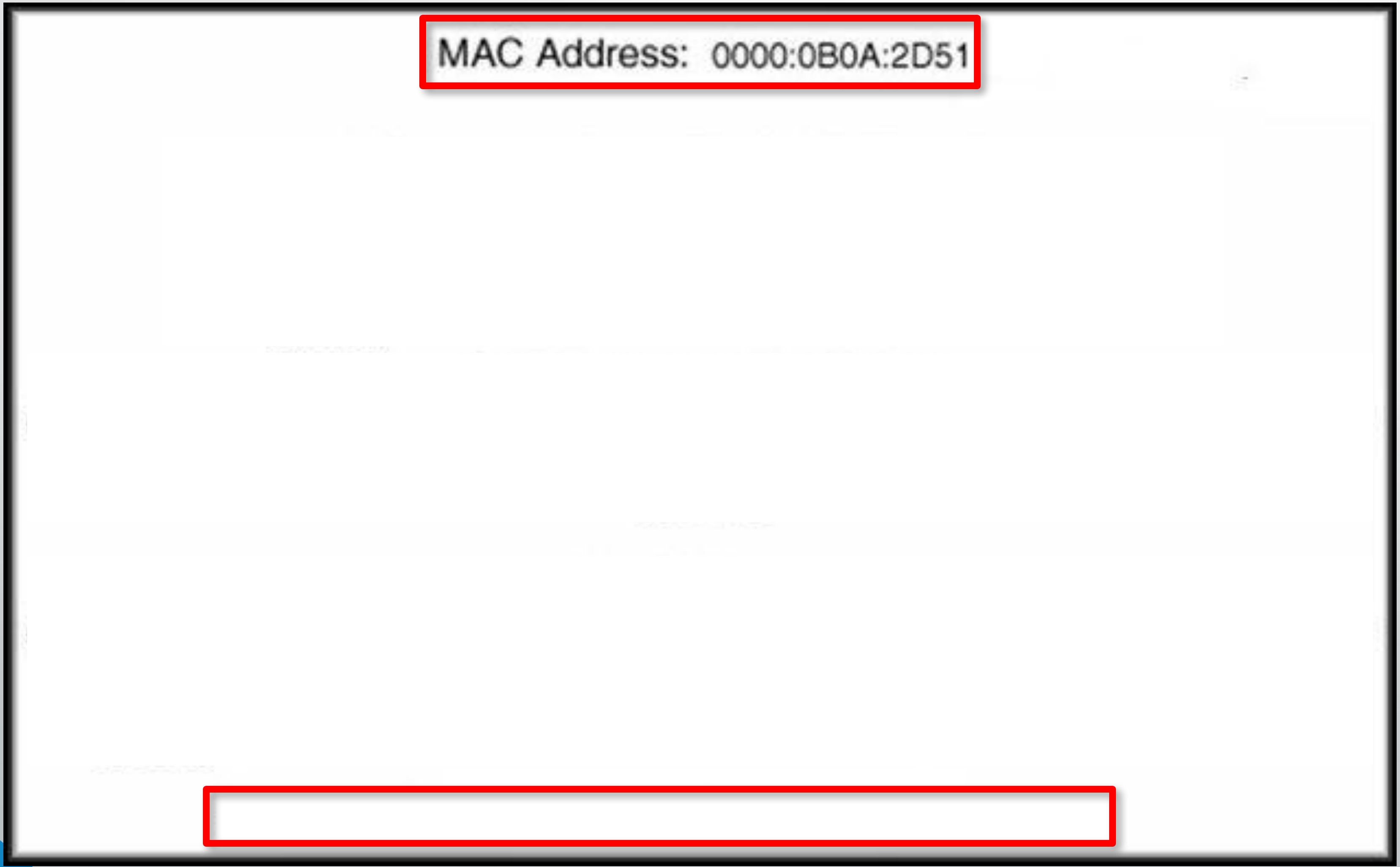
- **EUI-64(extended unique identifier)**
  - How to stretch IEEE 802 MAC addresses from 48 to 64 bits
  - Done by inserting the 16-bit 0xFFFE in the middle at the 24th bit of the MAC address
  - To create a 64-bit, unique interface identifier.
    - **Corp(config-if)#ipv6 address 2001:db8:3c4d:1::/64 eui-64**

Using an **EUI-64**



Using an **EUI-64**

- Using EUI-64.



Transition from IPv4 to IPv6

IPv4 to IPv6 Transition

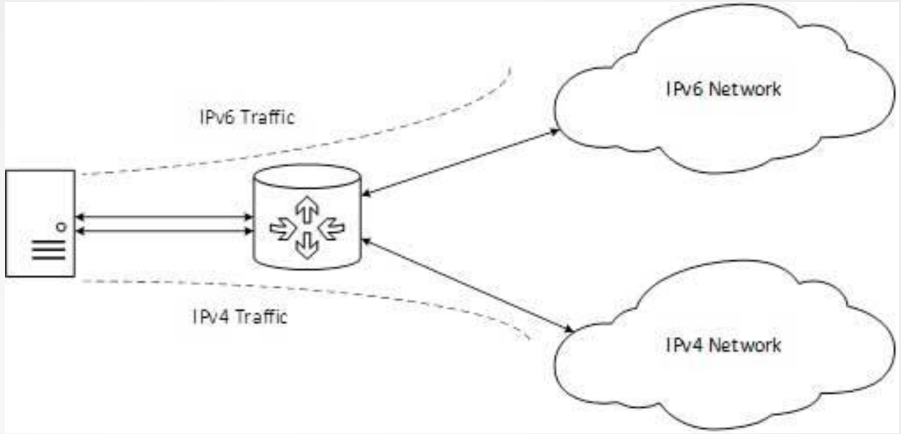
Strategies and mechanisms:

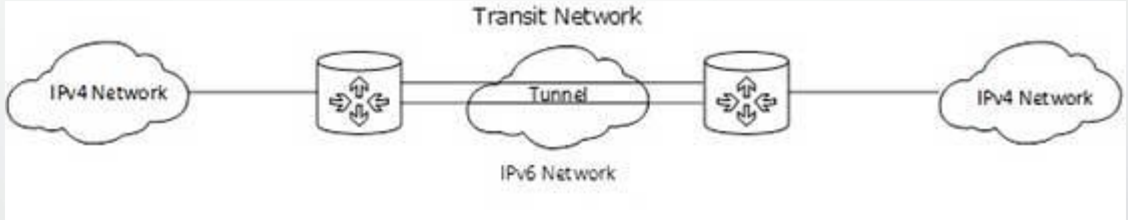
- IPv4 to IPv6 transition is gradual
- IPv6 devices need to communicate to IPv4
- IPv6 needs to communicate over IPv4 links

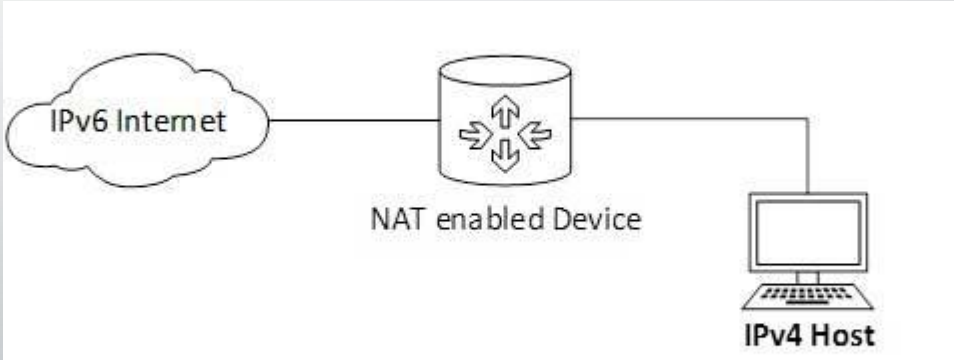
Transition Techniques

Three categories:

- Dual-stack techniques
- Tunneling Techniques
- Translation techniques

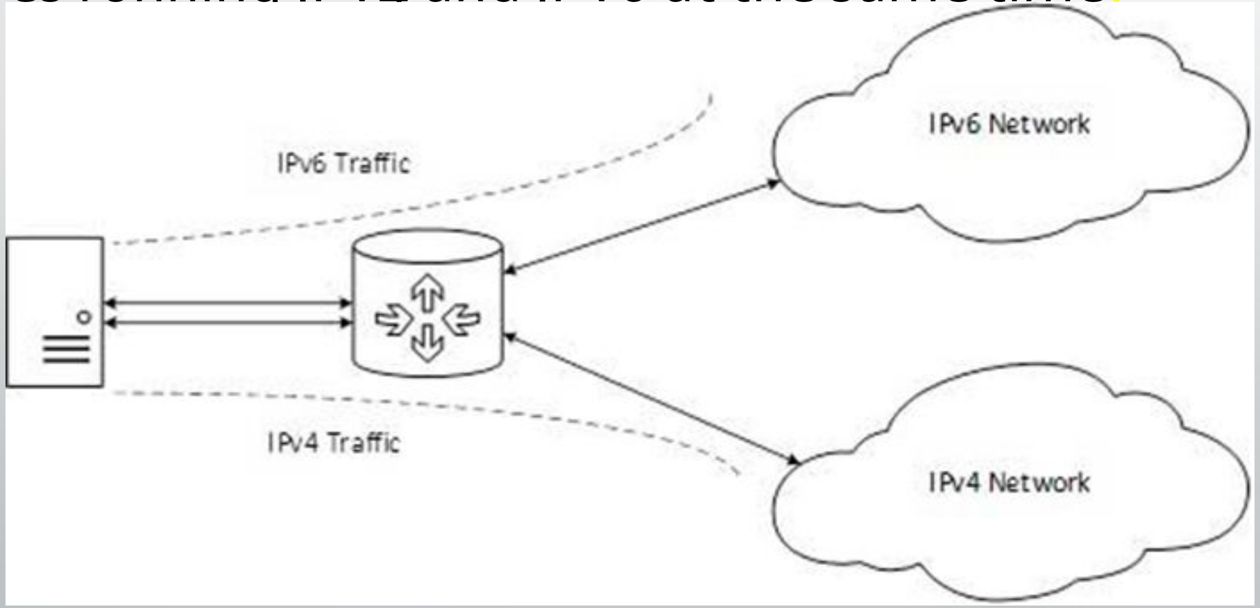




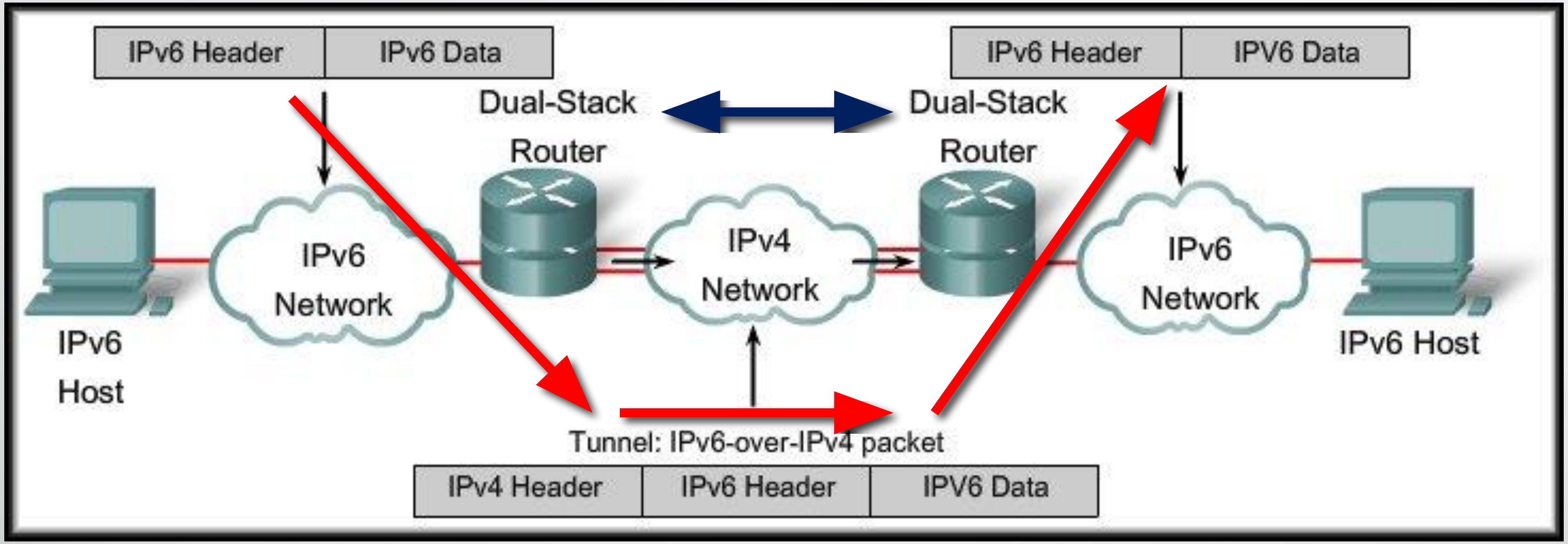


Dual Stack

- 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.

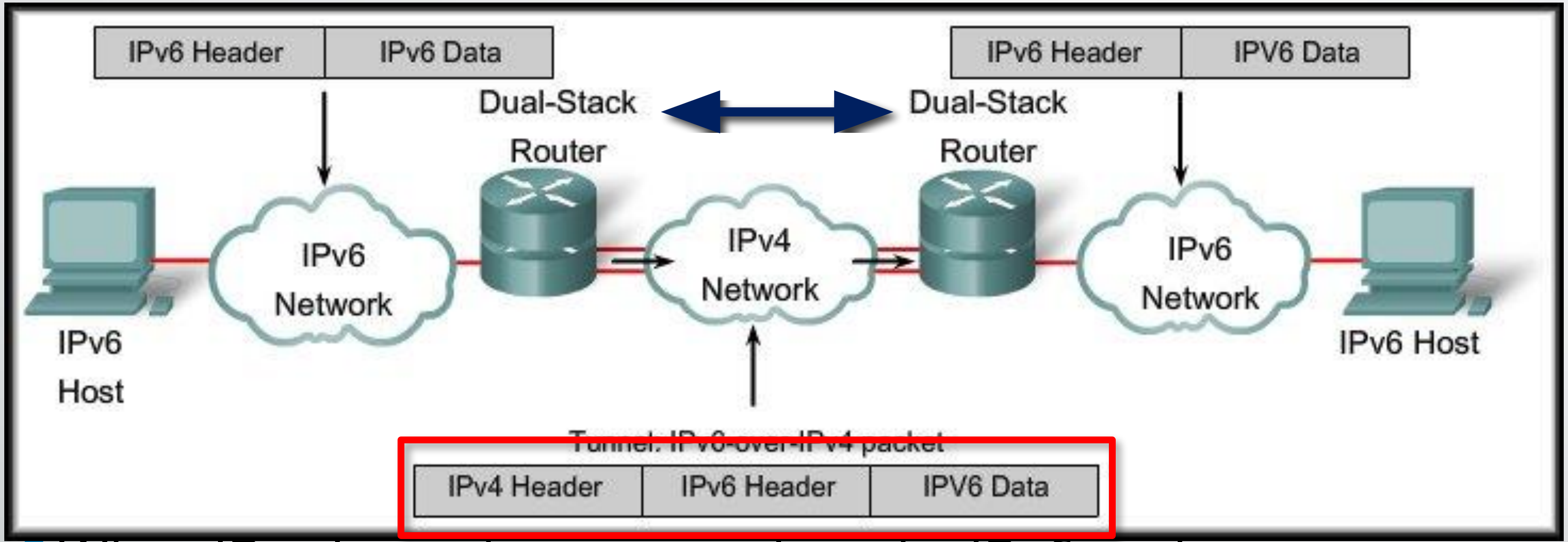


IPv6 Tunneling



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

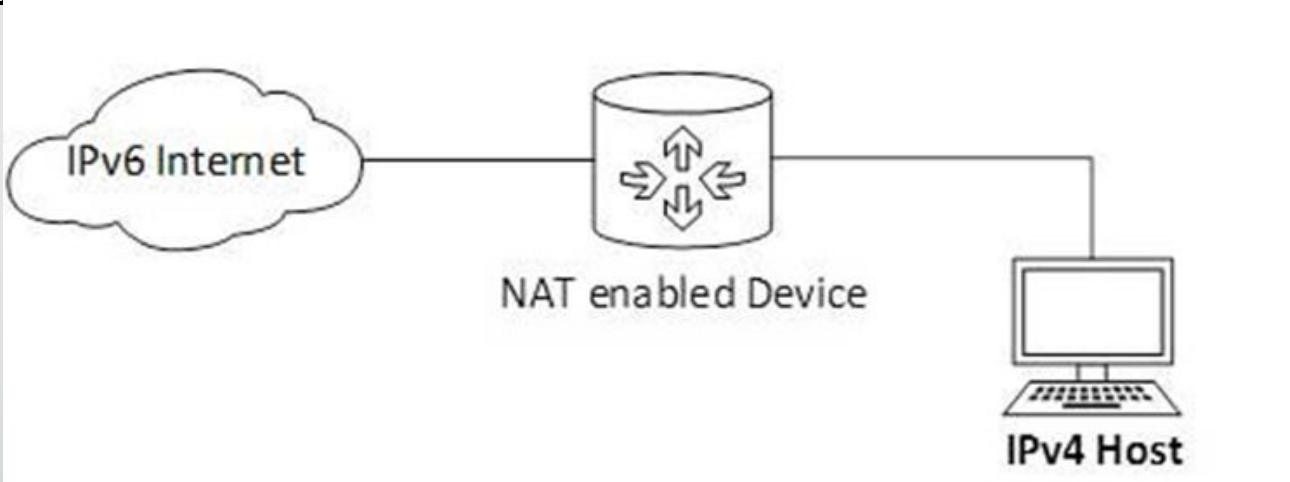
IPv6 Tunneling



- 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