Internet Protocol version 6

Unit-III

Session Objectives

- Discuss the addressing mechanism of IPv6 protocol
- Discuss IPv6 protocol

Session Outcomes

At the end of this session, participants will be able to

- Describing the IPv6 datagram, new packet format format

Agenda

Presentation Outline

IPv6 ADDRESSING - Representation

- Reason for migration from IPv4 to IPv6 is the small size of the address space in IPv4.
- Representations: binary and colon hexadecimal.

Binary (128 bits)	1111111011110110 ... 1111111100000000
Colon Hexadecimal	FEF6:BA98:7654:3210:ADEF:BBFF:2922:FF00

- Hexadecimal notation divides the address into eight sections, each made of four hexadecimal digits separated by colons
- **zero compression:** leading zeros of a section can be omitted
  FDEC:0:0:0:0:BBFF:0:FFFF —> FDEC::BBFF:0:FFFF
- If there is more than one run of zero sections, only one of them can be compressed.

Mixed Notation

- Sometimes a mixed representation of an IPv6 address used: colon hex and dotteddecimal notation.
- Can use the colon hex notation for the leftmost six sections and four-byte dotted-decimal notation instead of the rightmost two sections
- This happens when all or most of the leftmost sections of the IPv6 address are 0s. For example, the address (::130.24.24.18) is a legitimate address in IPv6, in which the zero compression shows that all 96 leftmost bits of the address are zeros.
- **CIDR Notation** FDEC::BBFF:0:FFFF/60

Address Space

- The address space of IPv6 contains 2^{128} addresses. This address space is 2^{96} times the IPv4 address—definitely no address depletion—as shown, the size of the space is 340, 282, 366, 920, 938, 463, 374, 607, 431, 768, 211, 456.
- Each person can have 2^{88} addresses to use. Address depletion in this version is impossible
- **Three Address Types:** In IPv6, a destination address can belong to one of three categories: unicast, anycast, and multicast
- **Unicast Address**: defines a single interface (computer or router).
- **Anycast Address**: defines a group of computers that all share a single address; the addresses are assigned from the unicast block.

- **Multicast Address**: defines a group of computers.
- In anycasting, only one copy of the packet is sent to one of the members of the group; in multicasting each member of the group receives a copy.
- IPv6 considers broadcasting as a special case of multicasting.

Address Space Allocation

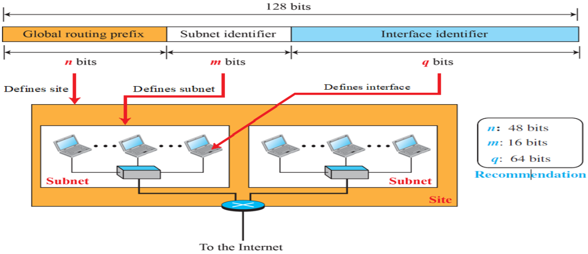
- the address space of IPv6 is divided into several blocks of varying size and each block is allocated for a special purpose.
- Most of the blocks are still unassigned

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

- Shows thw assigned blocks and the last column shows the fraction each block occupies in the whole address space.
- **Global Unicast Addresses** :The block in the address space that is used for unicast (one-to-one) communication between two hosts in the Internet.

Address Space Allocation

- CIDR for the block is **2000::/3**, which means that the three leftmost bits are the same for all addresses in this block (**001**). The size of this block is 2^{125} bits
- An address in this block is divided into three parts: global routing prefix (n bits), subnet identifier (m bits), and interface identifier (q bits)



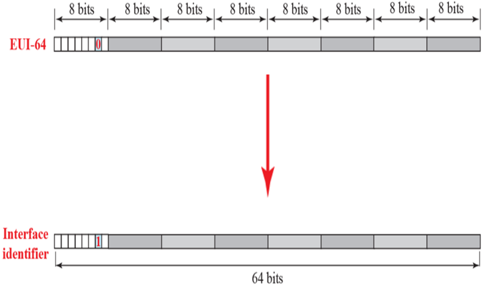
- The global routing prefix is used to route the packet through the Internet to the the ISP that owns the block. up to 2^{45} sites

Address Space Allocation

- The global routers in the Internet route a packet to its destination site based on the value of n.
- The next m bits (16 bits based on recommendation) define a subnet in an organization.
- This means that an organization can have up to $2^{16} =$ 65,536 subnets, which is more than enough.
- In IPv4 addressing, there is **not a specific relation between the hostid** (at the IP level) **and link-layer address** (at the data-link layer) because the link-layer address is normally much longer than the hostid
- Two common linklayer addressing schemes can be considered for this purpose: the **64-bit extended unique identifier (EUI-64)** defined by IEEE and the **48-bit link-layer address defined by Ethernet.**

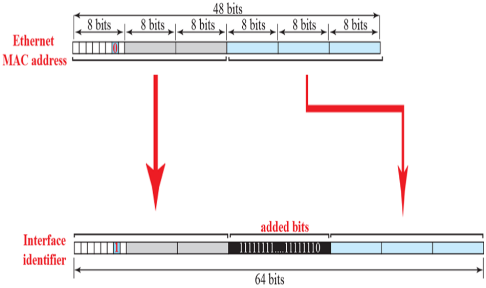
Mapping EUI-64

- To map a 64-bit physical address, the global/local bit of this format needs to be changed from 0 to 1 (local to global) to define an interface address



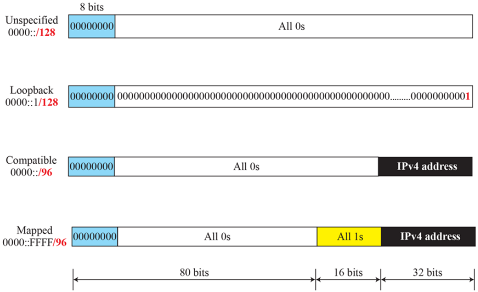
Mapping Ethernet MAC Address

- Mapping a 48-bit Ethernet address into a 64-bit interface identifier is more involved. We need to change the local/global bit to 1 and insert an additional 16 bits
- The additional 16 bits are defined as 15 ones followed by one zero, or FFFE16.



Special Addresses

- Addresses that use the prefix (0000::/8) are reserved, but part of this block is used to define some special addresses.



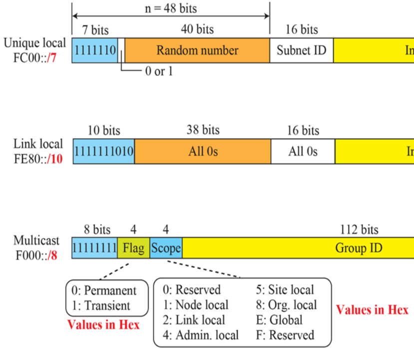
- The **unspecified address** is a subblock containing only one address, which is used during bootstrap when a host does not know its own address and wants to send an inquiry to find it
- The loopback address also consists of one address

Special Addresses

- During the transition from IPv4 to IPv6, hosts can use their IPv4 addresses embedded in IPv6 addresses.
- Two formats have been designed for this purpose: **compatible and mapped.**
- A **compatible address is an address of 96 bits of zero followed by 32 bits of IPv4 address**.
- It is used when a computer using **IPv6 wants to send a message to another computer using IPv6**.
- A mapped address is used when a computer **already migrated to version 6 wants to send an address to a computer still using version 4**.

Special Addresses

- IPv6 uses two large blocks for private addressing and one large block for multicasting



- A subblock in a unique local unicast block can be privately created and used by a site.
- **Multicast addresses**: The packet carrying this type of address as the destination address is not expected to be routed

Special Addresses

- Multicast addresses are used to define a group of hosts instead of just one.
- All these addresses use the prefix 11111111.
- The second field is a flag that defines the group address as either permanent or transient.
- A permanent group address is defined by the Internet authorities and can be accessed at all times.
- A transient group address, on the other hand, is used only temporarily.

Autoconfiguration

When a host in IPv6 joins a network, it can configure itself using the following process:

- 1. The host first **creates a link local address** for itself. This is done by taking the 10-bit link local prefix (1111 1110 10), adding 54 zeros, and adding the 64-bit interface identifier, which any host knows how to generate from its interface card. The result is a 128-bit link local address.
- The host then **tests to see if this link local address is unique** and not used by other hosts. To make sure, the host sends a neighbor solicitation message and waits for a neighbor advertisement message. If any host in the subnet is using this link local address, the process fails and the host cannot autoconfigure itself; it needs to use other means such as DHCP for this purpose

Autoconfiguration

- If the uniqueness of the link local address is passed, the h**ost stores this address as its link local address** (for private communication), but it still needs a global unicast address. The host then sends a router solicitation message to a local router.
- If there is a **router running on the network**, the host receives a **router advertisement message** that includes the **global unicast prefix and the subnet prefix** that the host needs to add to its interface identifier to generate its global unicast address.

Presentation Outline

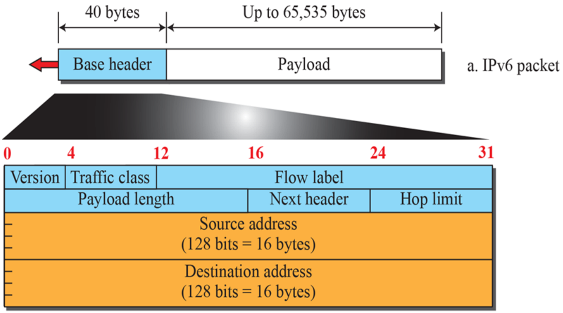
The IPv6 Protocol

changes implemented

- Better header format.
- New options.
- Allowance for extension.
- Support for resource allocation.
- Support for more security.

Packet Format

- Each packet has a base header and by the payload. The base header has 40 bytes and payload up to 65,535 bytes.



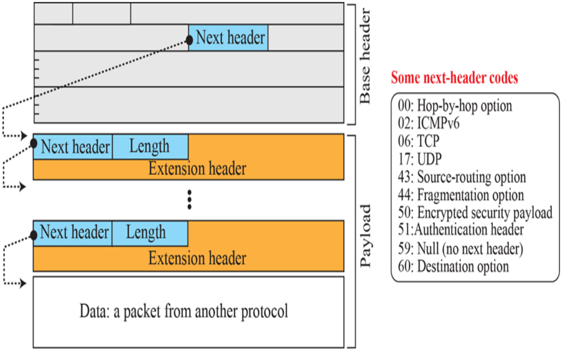
b. Base header

- **Traffic class**: used to distinguish different payloads with different delivery requirements.
- **Flow label**: a 20-bit field to provide special handling for a particular flow of data.

Packet Format

- **Payload length**: The 2-byte field defines the **length of the IP datagram excluding the header**. In IPv6, the length of the base header is fixed (40 bytes); only the length of the payload needs to be defined.
- **Next header**: an 8-bit field defining the type of the first extension header or the data that follows the base header
- **Hop limit**: The 8-bit hop limit field serves the same as that of TTL .
- **Source and destination addresses**: are 16-bytes (128-bit) Internet addresses that identify the original source, destination.
- **Payload**: Compared to IPv4, the payload field in IPv6 has a different format and meaning

IPv6 Payload



- The payload in IPv6 means a **combination of zero or more extension headers** (options) followed by the data from other protocols (UDP, TCP, and so on).
- In IPv6, options, which are **part of the header in IPv4, are designed as extension headers**.

IPv6 Payload

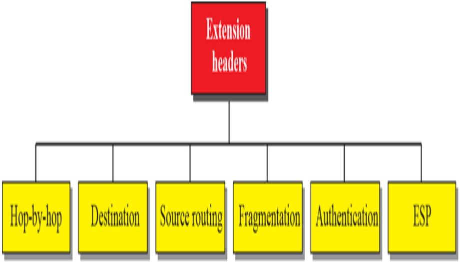
- The payload can **have as many extension headers** as required by the situation.
- Each extension header has **two mandatory fields, next header and the length followed by information related to the particular option**
- Each **next header** field value (code) **defines the type of the next header** (hop-by-hop option, source routing option,)
- **Last next header field defines the protocol** (UDP, TCP) that is carried by the datagram

Fragmentation and Reassembly

- IPv6 datagrams **can be fragmented only by the source**, not by the routers; the reassembly takes place at the destination
- When a **router** receives the packet, it can check the size of the packet and **drop it if the size is larger** than allowed by the MTU of the network ahead.
- The router then sends a **packet-too-big ICMPv6** error message

Extension Header

- An IPv6 packet is made of a **base header and some extension headers**. The length of the **base header is fixed at 40 bytes.**



Extension Headers

- The **hop-by-hop option** is used when the **source needs to pass information to all routers visited** by the datagram
- **Destination Option** : used **when the source needs to pass information to the destination** only. **Intermediate routers** are **not permitted** access to this information
- **Source Routing**: combines the concepts of the strict source route and the loose source route options of IPv4.

Extension Headers

- **Fragmentation**: A source must use a Path **MTU Discovery technique** to find the smallest MTU supported by any network on the path.
- The source then fragments using this knowledge
- **Authentication** has a dual purpose: it **validates** the message sender and ensures the **integrity of data**
- **Encrypted Security Payload**: (ESP) is an extension that provides confidentiality and guards against eavesdropping

Summary

- IPv6 has a 128-bit address space.
- Addresses are presented using hexadecimal colon notation with abbreviation methods available.
- In IPv6, a destination address can belong to one of three categories: unicast, anycast, and multicast
- An IPv6 datagram is composed of a base header and a payload.
- A payload consists of optional extension headers and data from an upper layer.
- Extension headers add functionality to the IPv6 datagram.

Test Your Understanding

- Explain the advantages of IPv6 when compared to IPv4.
- Distinguish between compatible and mapped addresses and explain their applications
- Find the size of the global unicast block and special address block
- Explain the benefit of autoconfiguration