IP Version 6

Introduction

- The IP protocol forms the foundation of the Internet.
  - IP version 4 is used widely today.
  - IPv4 suffers from a number of drawbacks.
  - Need to enhance the capabilities of the protocol.
- IP Next Generation
  - IPng / IPv6

Problems with IPv4

- **Limited address space.**
  - **32-bit address is inadequate today.**
- **Applications demanding real-time response.**
  - **Real-time audio or video.**
  - **Must avoid changing routes frequently.**
- **Need for more complex addressing and routing capabilities.**
  - **Two-level structure of IPv4 may not serve the purpose.**

Main Features of IPv6

- Something is common with IPv4:
  - IPv6 is connectionless – each datagram contains destination address and is routed independently.
  - Header contains the maximum number of hops a datagram can make before being discarded.
  - Some of the other general characteristics are also retained.

- New features of IPv6:
  - Address size: 128-bit addresses are used.
    - $6x10^{23}$ unique addresses per square meter of the earth's surface.
  - Header format:
    - IPv6 uses a series of fixed-length headers to handle optional information.
    - A datagram consists of a base header followed by zero or more extension headers.

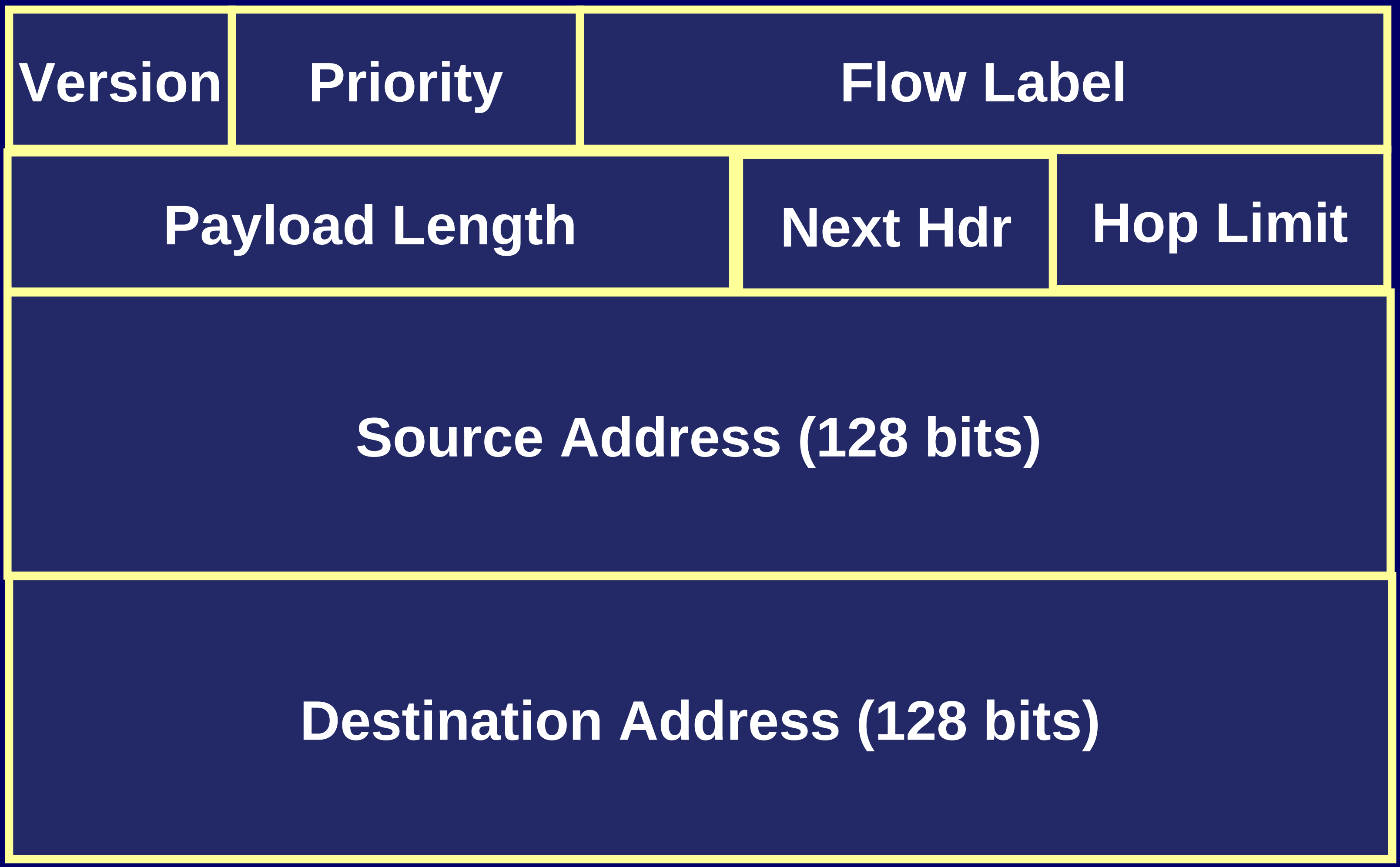
- **Support for real-time traffic:**
  - Allows a pair of stations to establish a high quality path between them.
  - All datagrams flow through this path.
- **Increased flexibility in addressing:**
  - Includes the concept of an anycast address, where a packet is delivered to one of a set of nodes.
  - Provides for dynamic assignment of IP addresses.

IPv6 Datagram Format

- An IP datagram begins with a base header, followed by zero or more extension headers, followed by data (transport-layer PDU).
  - 40 bytes base header

Base Header	Extension Header 1	. . .	Extension Header N	Transport Layer PDU

IPv6 Base Header Format



The Fields

- **Version (4 bits):** contains the value 6.
- **Priority (8 bits):** specifies routing priority class.
- **Flow Label (20 bits):** used with applications that require performance guarantee.
- **Payload Length (16 bits):** total length of the extension headers and the transport-level PDU.
- **Next Header (8 bits):** identifies the type of information that immediately follows the current header (IP extension, TCP or UDP).

Base Header Next=TCP	TCP Data

Base Header Next=Route	Route Header Next=TCP	TCP Data

- **Hop Limit:** decremented by 1 at each hop; discarded when it reaches 0.
- **Source/destination addresses:** 16 octets (128 bits) each.

IPv6 Extension Headers

- Routing Header
  - Provides source routing.
- Hop-by-hop Options Header
  - Defines special options that are processed at each hop.
- Fragment Header
  - For fragmentation and reassembly.
- Authentication Header
  - For packet integrity & authentication.
- All Extension headers chained in a linked list through Next Hdr field.

A Point About Fragmentation

- IPv6 fragmentation is similar to that in IPv4.
- Required information contained in a separate fragment extension header.
  - Presence of the fragment header identifies the datagram as a fragment.
  - Base header copied into all the fragments.

IPv6 Addressing

- Addresses do not have defined classes.
  - A prefix length associated with each address (flexibility).
- Three types of addresses:
  - Unicast: corresponds to a single computer.
  - Multicast: Refers to a set of computers, possibly at different locations. Packet delivered to every member of the set.

- **Anycast:** Refers to a set of computers with the same address prefix. Packet delivered to exactly one of the computers in the set.
  - Required to support replication of services.

Colon Hexadecimal Notation

- An IPv6 address is 128 bits long.
  - Dotted decimal notation too long.
  - Use colon-hexadecimal notation. Each group of 16 bits written in hex, with a colon separating groups.
  - Example:

    7BD6:3DC:FFFF:FFFF:0:2D:F321:FFFF
  - Sequence of zeros is written as two colons.

    7BD6:0:0:0:0:0:0:B6 $\rightarrow$ 7BD6::B6

Aggregate Global Unicast Address

001	TLA Id (13)	NLA Id (32)	SLA Id (16)	Interface Id (64)

- **TLA: top-level aggregation**
- **NLA: next-level aggregation**
- **SLA: site-level aggregation**
- **Interface Id: typically based on hardware MAC address**

IPv4-Mapped IPv6 Addresses

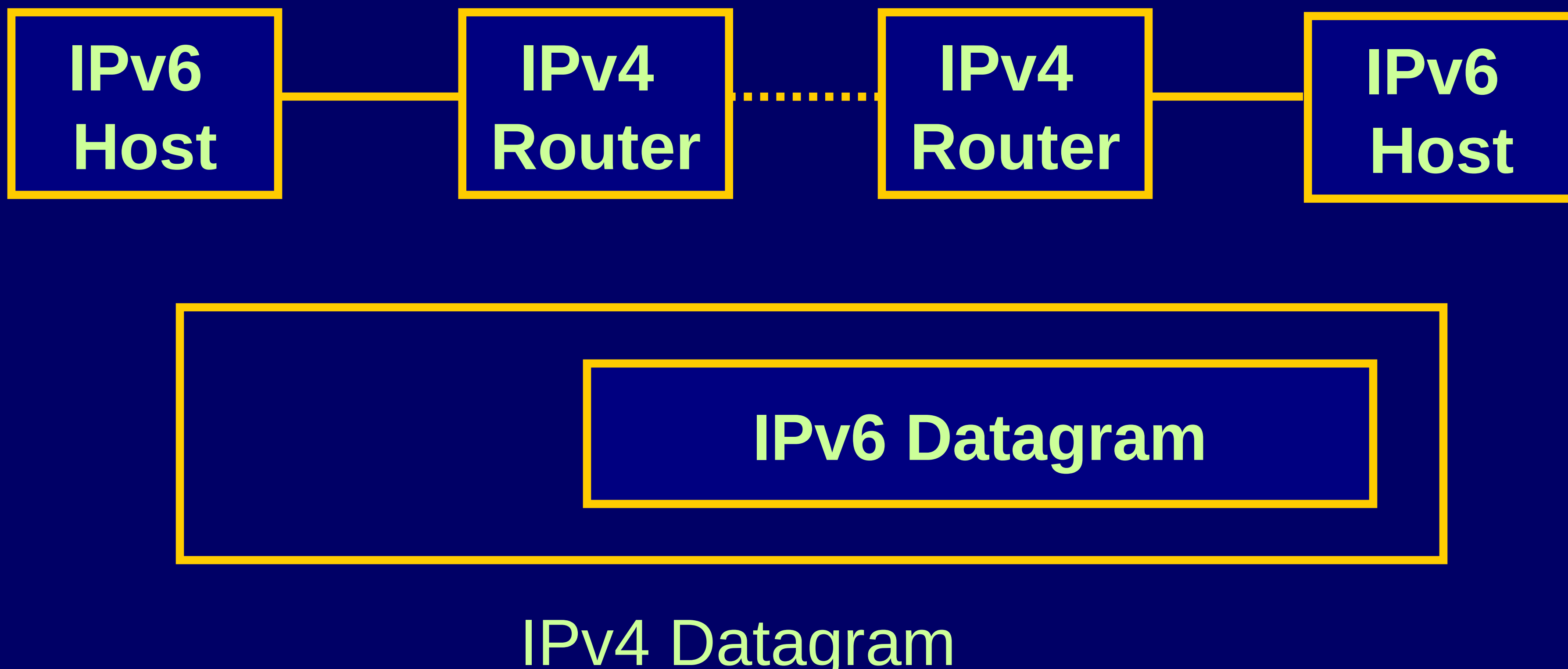
- Allow a host that supports both IPv4 and IPv6 to communicate with a host that supports only IPv4.
  - IPv6 address is based on IPv4 address.
  - 80 0's, followed by 16 1's, followed by a 32-bit IPv4 address.

IPv4 Compatible IPv6 Addresses

- Allows a host supporting IPv6 to talk IPv6 even if the local routers do not talk IPv6.
  - Tell endpoint software to create a tunnel by encapsulating the IPv6 packet in an IPv4 packet.
  - 80 0's, followed by 16 0', followed by a 32-bit IP address.

Tunnelling

- **Done automatically by the OS kernel when IPv4-compatible IPv6 addresses are used.**



Transition from IPv4 to IPv6

- Three alternate transition strategies:
  1. **Dual stack:** Both IPv4 and IPv6 protocol stacks supported in the gateway.
  2. **Tunneling:** An IPv6 datagram flows through an intermediate IPv4 network by encapsulating the whole IPv6 packet as payload.
  3. **Header translation:** An IPv4 address is translated into a IPv6 address, and vice versa.

The Scenario Today

- Very few organizations have actually moved over to IPv6.
- IPv6 networks mostly confined to laboratories.
- Transition has to take anyway …. The sooner the better.