CSC 402 – Internet Technology

Recap

- Internetworking Terms
- IEEE 802 Model
- Internet Layer
- IP Overview
- Endinannes
- IPv4 Packet Structure (Continued)

Additional Terminologies

- **Maximum Transmission Unit (MTU):** Each physical network usually imposes a certain-size limitation on the packets that can be carried, called **the Maximum Transmission Unit (MTU)**.
  - RFC 791 requires that ”Every internet destination must be able to receive a packet of 576 bytes either in one piece or in fragments to be reassembled”.
  - When IP has to sent a packet that is larger than the MTU of the physical network, IP must break the packet into smaller fragments whose size can be no bigger than the MTU.
- **Fragment**: A fragment consists of an IP header and a data part.
  - The minimum fragment payload size is 8 bytes.
  - Each fragment is sent independently to the destination.
    - If the MTU of some other network downstream is found to be smaller than the fragment size, the fragment will be broken again into smaller fragments.

IPv6

- Why IPv6?
  - The Internet Protocol (IP) has been the foundation of the Internet and virtually all multivendor private internetworks.
  - This protocol is reaching the end of its useful life and a new protocol, known as IPv6 (IP version 6, 1994, originally: IPng), has been defined to ultimately replace IP.
  - IPv4 Address space exhaustion. IANA IP v4 addresses exhausted on 03.02.2011.
  - Two level addressing (network & host) is wasteful.
    - Network addresses used even if not connected (to the Internet).
    - Growth of networks and the Internet.
    - Extended use of TCP/IP.
    - Single/multi addresses per interface.
    - Requirements for new types of services.
- https://ipv6.he.net/statistics/

IPv6

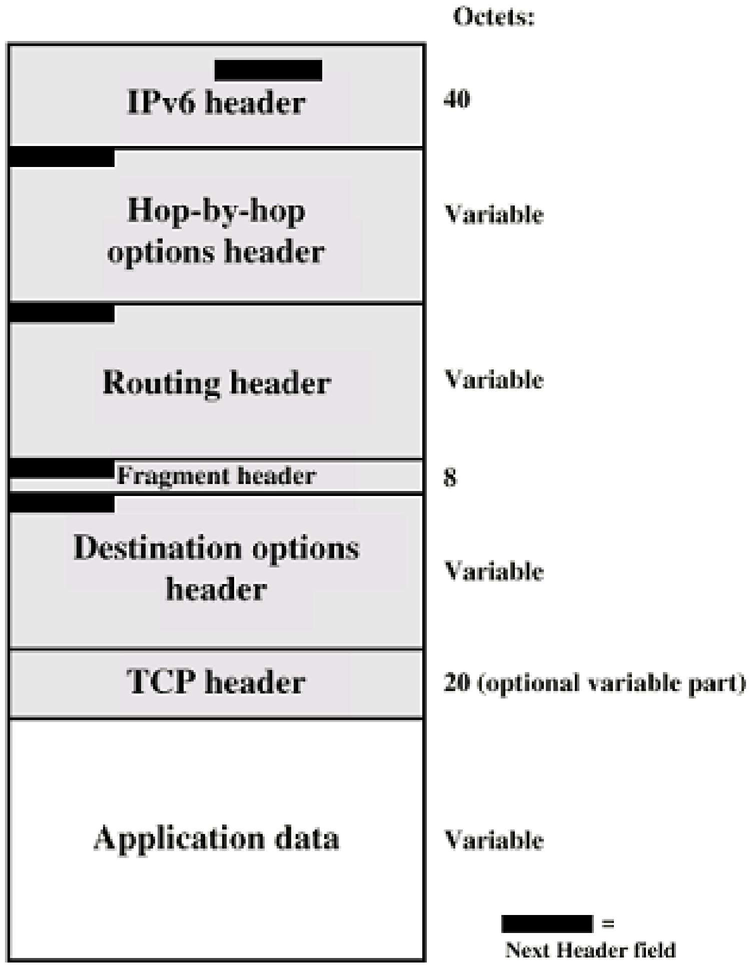
- RFCs
  - 1752 - Recommendations for the IP Next Generation Protocol
  - 2460 - Overall specification
  - 2373 - Addressing structure
  - Others…
- Enhancements:
  - Expanded 128 bit address space (vs 32bit of IPv4)
  - Host ID portion was fixed to 64 bits
  - Improved option mechanism
  - Separate optional headers between IPv6 header and transport layer header
  - Most not examined by intermediate routes
  - Improved speed and simplified router processing
  - Easier to extend options
  - Dynamic address assignment
  - Address auto-configuration
  - Increased addressing flexibility
  - Anycast & multicast (NO broadcast)

IPv6

- Other changes:
  - Checksum: removed entirely to reduce processing time at each hop
  - Support for resource allocation
    - Labeled packet flows (**QoS)**
    - Allows special handling e.g. real time video
  - Integrates security (**IPsec)**
  - ICMPv6: new version of ICMP
    - Additional message types, e.g. “Packet Too Big”
    - Multicast group management functions

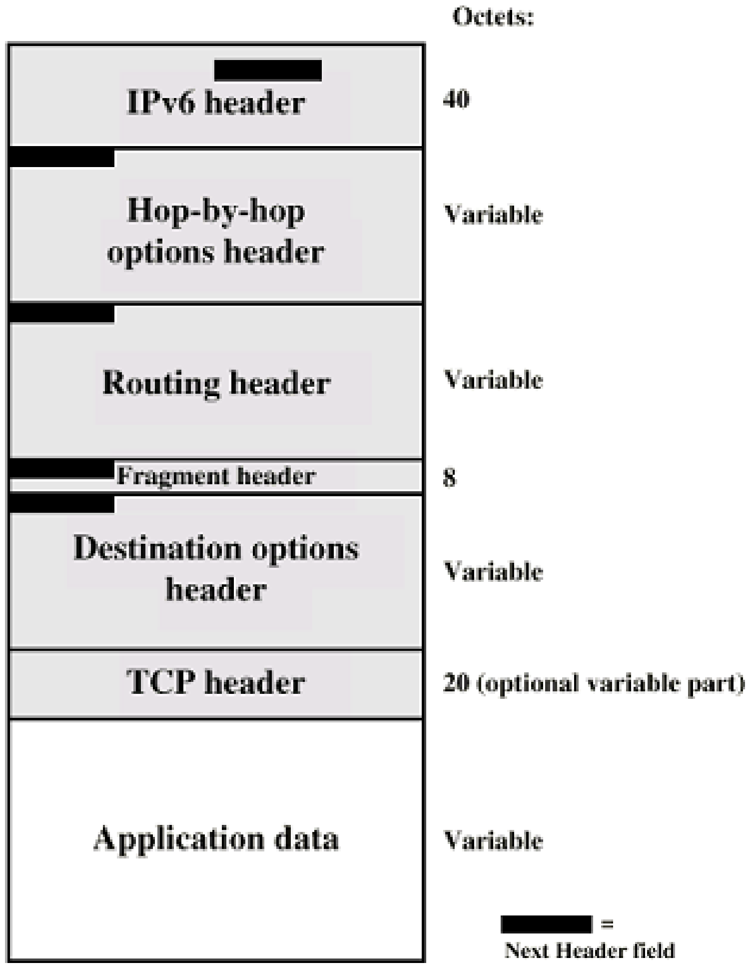
IPv6 Packet Structure

- Hop-by-Hop Options header: Defines special options that require hop-by-hop processing. Options:
  - Jumbo payload: over 2^16 = 65,535 octets
  - Router alert
    - Tells the router that the contents of this packet is of interest to the router
    - Provides support for RSVP
- Routing header: Provides extended routing, similar to IPv4 source routing
  - List of one or more intermediate nodes to be visited
  - Next Header
  - Header extension length
  - Routing type
  - Segments left i.e. number of nodes still to be visited



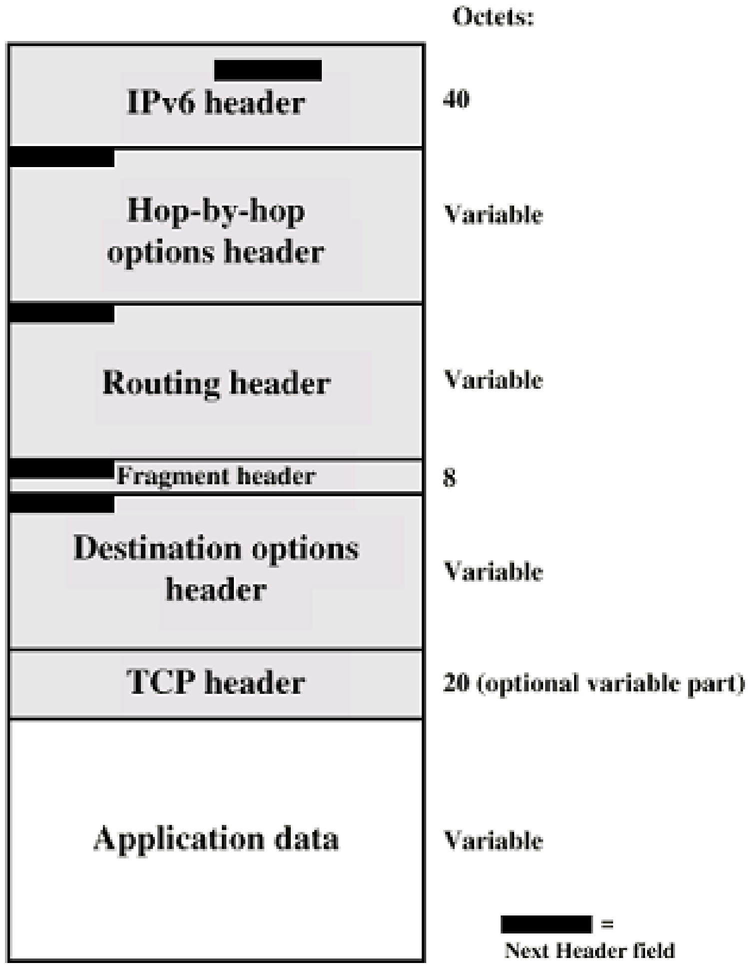
IPv6 Packet Structure

- Fragment header: fragmentation and reassembly information
  - Fragmentation only allowed at source
  - No fragmentation at intermediate routers
  - Node must perform path discovery to find smallest MTU of intermediate networks
  - Source fragments to match MTU
  - Otherwise limit to 1280 octets
- Fragment header fields:
  - Next Header
  - Reserved
  - Fragmentation offset
  - Reserved
  - More flag
  - Identification



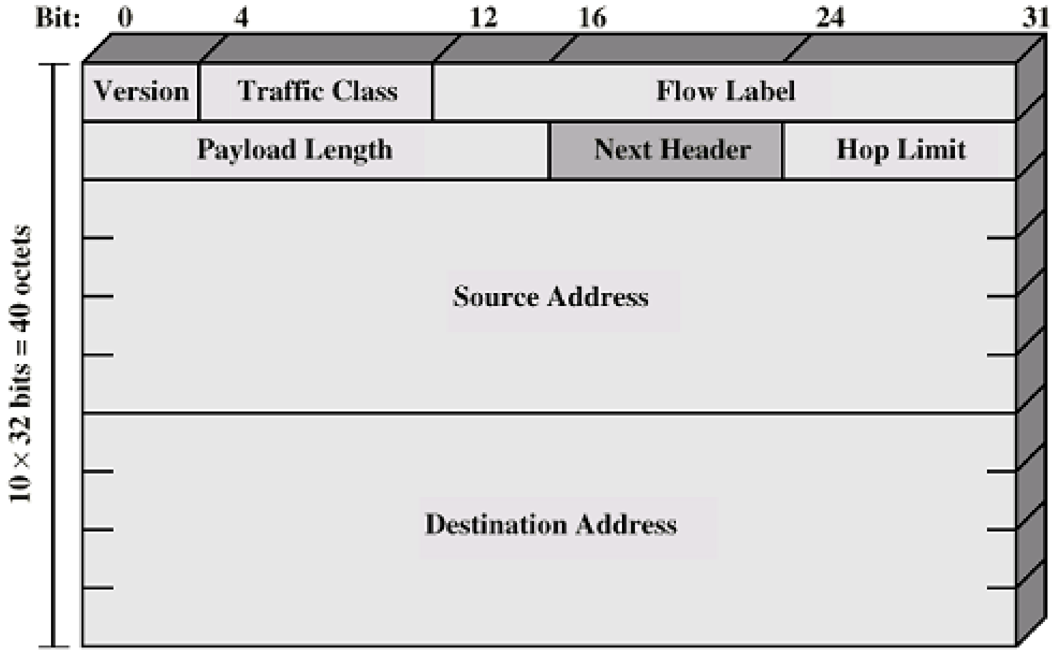
IPv6 Packet Structure

- Destination Options header: Contains optional information to be examined by the destination node
  - Authentication header: Provides packet integrity and authentication
  - Encapsulating Security Payload header: Provides privacy
  - Both belong to IPsec – identical to the way it's implemented in IPv4



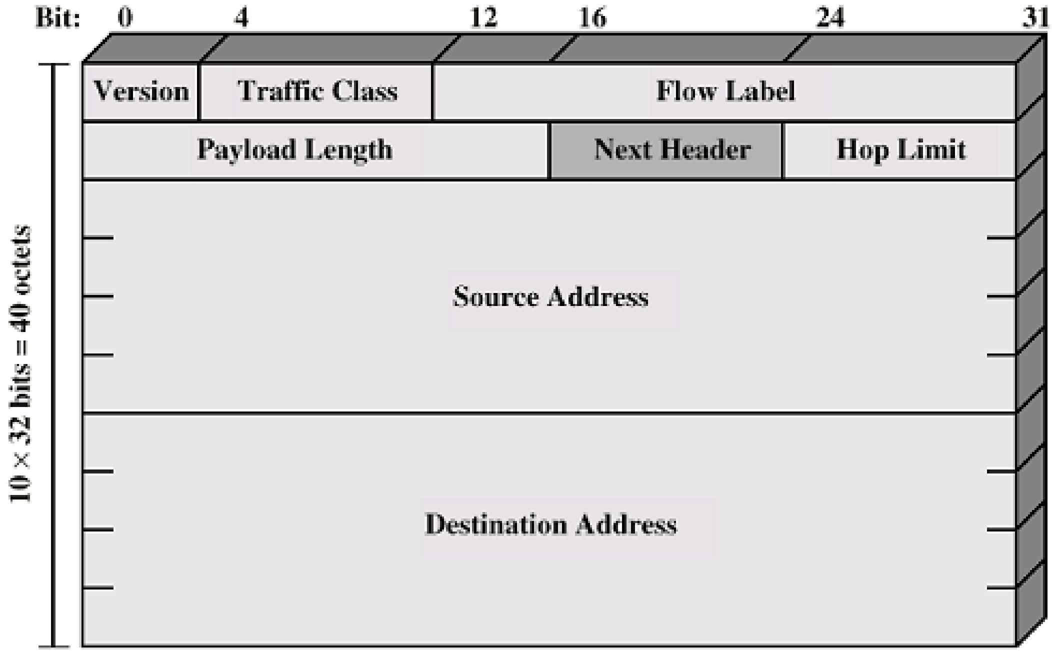
IPv6 Header

- **Version** (4 bits): 6
- **Traffic Class** (8 bits): classes or priorities of packet
- **Flow Label** (20 bits): used by a host to label those packets for which it is requesting special handling by routers within a network.



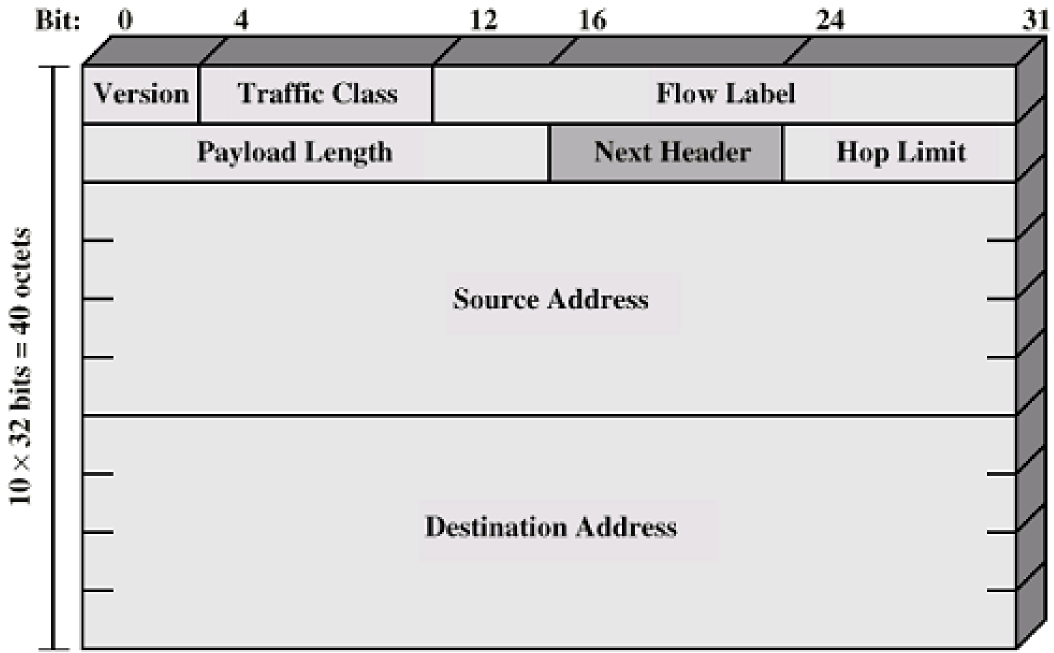
IPv6 Header

- **Payload Length** (16 bits): Length of the remainder of the IPv6 packet following the header, in octets: this is the total length of all of the extension headers plus the transport-level segment
- **Next Header** (8 bits): Identifies the type of header immediately following the IPv6 header; this will either be an IPv6 extension header or a higher layer header, such as TCP or UDP



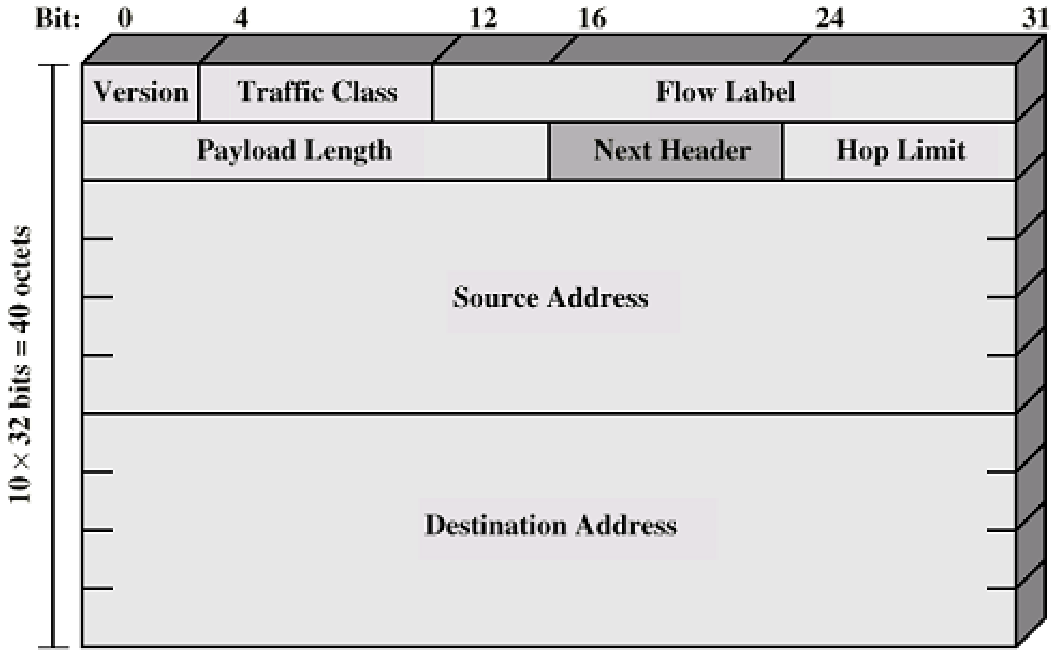
IPv6 Header

- **Hop Limit** (8 bits): The remaining number of allowed hops for this packet. The hop limit is set to some desired maximum value by the source and decremented by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.
- **Source Address** (128 bits): address of originator of the packet
- **Destination Address** (128 bits): address of intended recipient of the packet



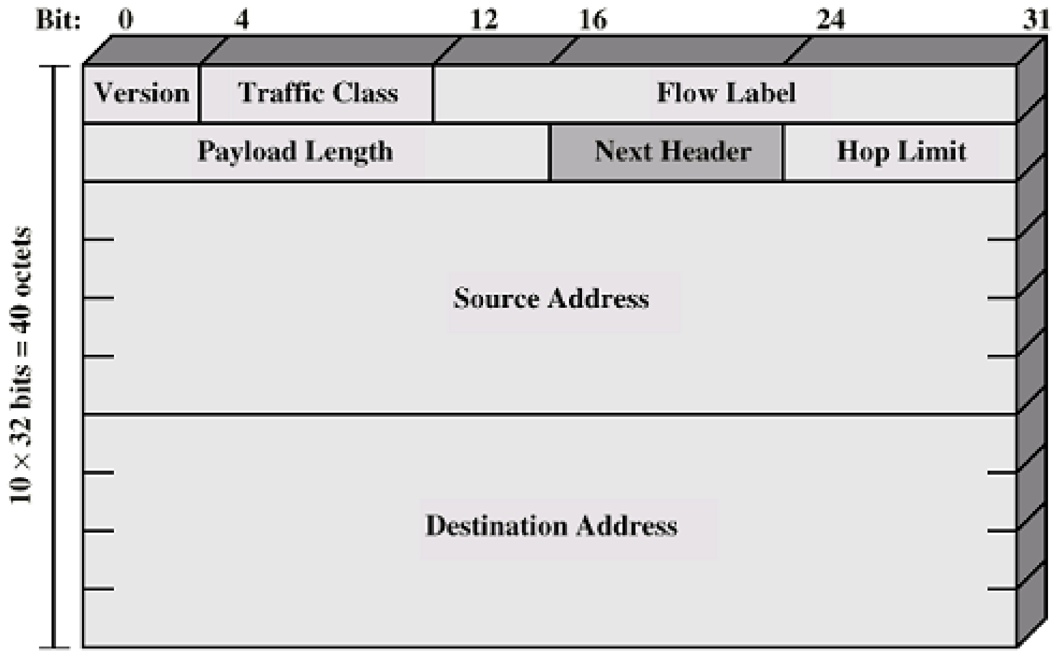
Flow Label

- A flow is uniquely identified by the combination of a source address, destination address, and a nonzero 20-bit flow label
- All packets that are to be part of the same flow are assigned the same flow label by the source
- A “flow” may be a single TCP connection or even multiple TCP connections.
- From the router's point of view a flow is a sequence of packets that share attributes that affect how these packets are handled by the router including:
    - Path
    - Resource allocation
    - Discard requirements
    - Accounting
    - Security attributes



Flow Label

- The router may treat packets from different flows differently in a number of ways, including:
  - Allocating different buffer sizes,
  - Giving different precedence in terms of forwarding, and requesting different quality of service from networks.
- User's requirements for a particular flow could be defined in an extension header and included with each packet.
- Alternative, for IPv6, using the flow label, in which the flow requirements are defined prior to flow commencement and a unique flow label is assigned to the flow.
- The router must save flow requirement information about each flow



IPv6 Migration Techniques

- Problem statement
  - There will be extreme difficulties with address allocation and routing if the Internet is to continue be run indefinitely using IPv4.
  - It is impossible to switch the entire Internet over to IPv6 overnight.
- Dual Stack
  - Solving first problem
  - Nodes with dual IP stacks will have both and IPv4 protocol stack and an IPv6 one. When communicating with IPv6 nodes, they use IPv6 and when communicating with IPv4 nodes, they revert to IPv4.
- Tunneling
  - Solving second problem
  - Tunneling IPv6 packets over IPv4 network infrastructure is simple in theory as it just prepend an IPv4 header and send them via the normal IPv4 mechanisms to a router with a dual IP stack.

IPv6 Addressing

- Like IPv4…
- Unicast
  - An identifier for a single interface. A packet sent to a unicast address is delivered to the interface identified by that address.
- Multicast
  - An identifier for a set of interfaces (typically belonging to different nodes).
  - A packet sent to a multicast address is delivered to all interfaces identified by that address.
- Anycast:
  - An identifier for a set of interfaces (typically belonging to different nodes). A packet sent to an anycast address is delivered to one of the interfaces identified by that address (the "nearest" one, according to the routing protocols' measure of distance).
- Specified in the IPv6 address architecture RFC
- Broadcast?
  - There is no broadcast in IPv6.
  - This functionality is taken over by multicast.
  - A consequence of this is that the “highest” address may be used freely

IPv6 Addressing

- IPv6 addresses of all types are assigned to interfaces, not nodes
  - An IPv6 unicast address refers to a single interface
  - As each interface belongs to a single node, any of that node's interfaces‘ unicast addresses may be used as an identifier for the node
- The same interface identifier may be used on multiple interfaces on a single node.
- All addresses are 128 bits
- Written as sequence of eight sets of four hex digits (16 bits each) separated by colons
- Leading zeros in group may be omitted
  - Continuous all-zero groups may be replaced by “::”
  - Only one such group can be replaced
- Example:
  - 3ffe:3700:0200:00ff:0000:0000:0000:0001
  - This can be written as: 3ffe:3700:200:ff:0:0:0:1 or 3ffe:3700:200:ff::1
- All reduction methods are used here

Unicast Addressing

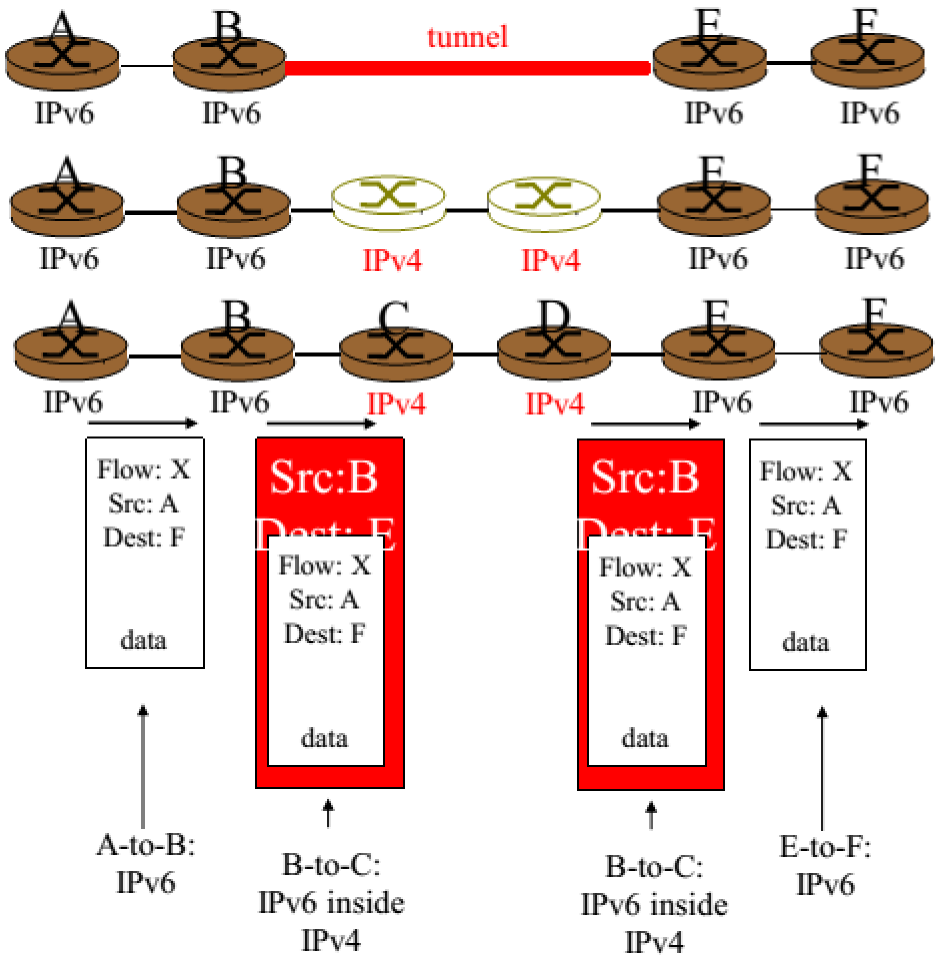
- Unspecified address
  - All zeros (::)
  - Used as source address during initialization
  - Also used in representing default
- Loopback address
  - Low-order one bit (::1)
  - Same as 127.0.0.1 in IPv4
- Mapped IPv4 addresses
  - Of form ::FFFF:a.b.c.d
  - Used by dual-stack machines to communicate over IPv4 using IPv6 addressing
  - End nodes and routers/switches run both IPv4 and IPv6 protocols, however if IPv6 communication is possible that is the preferred protocol.
- Compatible IPv4 addresses
  - Of form ::a.b.c.d
  - Used by IPv6 hosts to communicate over automatic tunnels

From IPv4 to IPv6

- IPv4 and IPv6 are not interoperable – essentially they create two pararel, independent networks
- Not all routers can be upgraded simultaneously
  - no “flag days”
  - IPv4 needed for at least a decade (note: IPv6 was introduced already 12 years ago)
  - How will the network operate with mixed IPv4 and IPv6 routers?
- Several transitional solutions available, depending on the current configuration:
  - Dual stack transition
    - But IPv6 server + non-IPv6 network + dual-stack server fail
  - NAT IPv4 $\leftrightarrow$ IPv6 [**Network Address Translator/Protocol Translation (NAT-PT)**]: longer term, RFC 1918 (192.168.*.*) + global IPv6 address
  - Tunneling: IPv6 carried as payload in IPv4 datagram among IPv4 routers

Tunneling

- Logical view:
- Physical view:



IPv6

- Go to http://ipv6.google.com and find out!