Chapter5 Network Layer(8)

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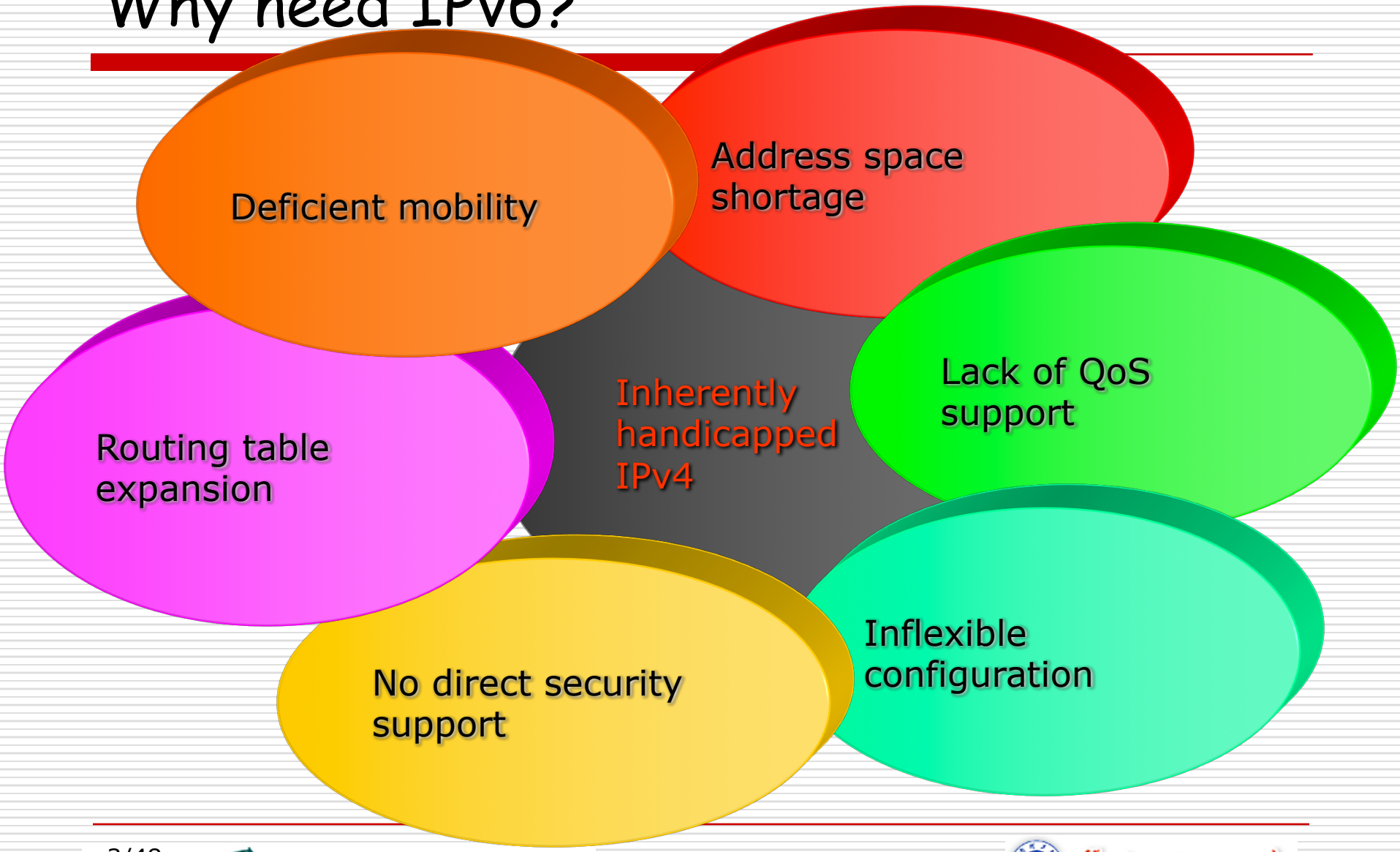
Outline

- IPv6 introduction
- IPv6 header format
- IPv6 addressing
- ICMPv6
- Internet transition

Why need IPv6?



Solution to address space shortage

- **Solution:**
  - **Private networks are introduced to cope with address space shortage problem.**
  - **NAT is required to interconnect private networks and public networks.**

IPv6 features

- IPv6 offers the following significant features:
  - A dramatically larger address space
  - Globally unique and hierarchical addressing, based on prefixes rather than address classes, to keep routing tables small and backbone routing efficient
  - A mechanism for the auto-configuration of network interfaces without servers
  - Support for encapsulation of itself and other protocols
  - Class of service that distinguishes types of data
  - Improved multicast routing support
  - Built-in authentication and encryption
  - Transition methods to migrate from IPv4
  - Compatibility methods to coexist and communicate with IPv4

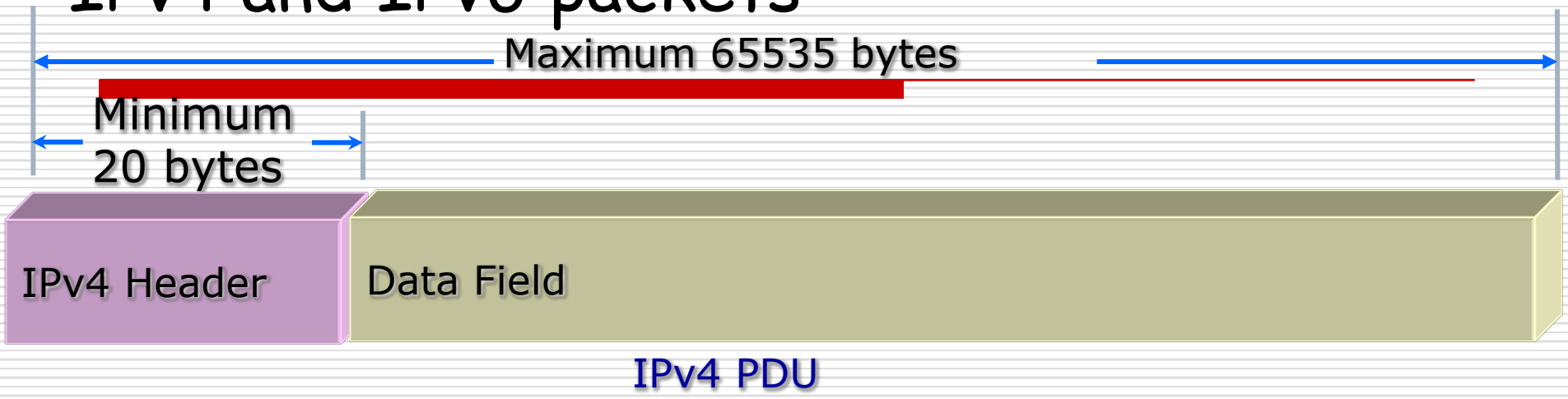
Milestones for IPv6 over the world

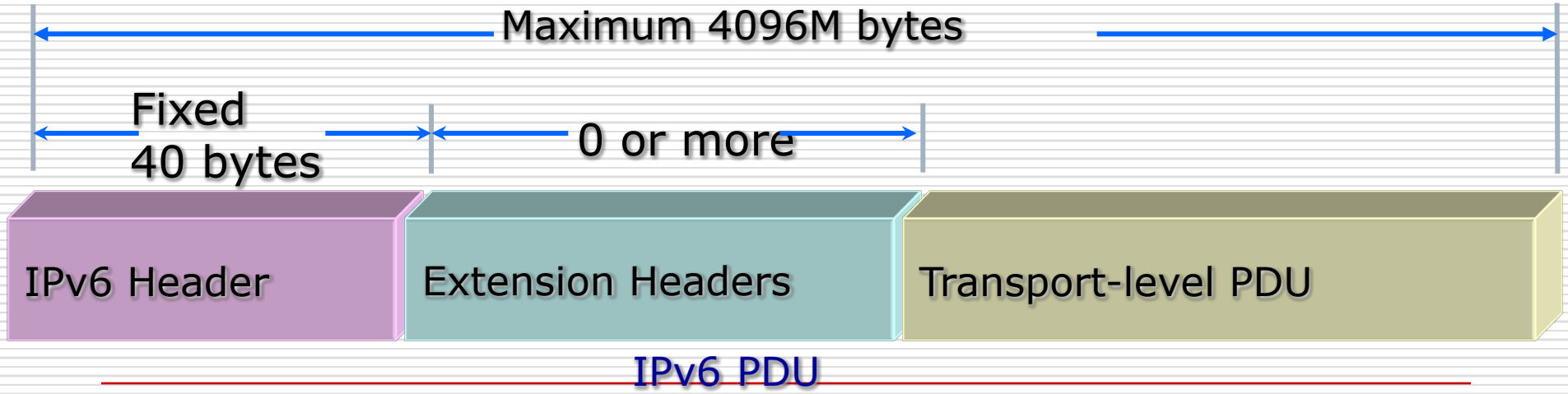
- 6Bone has been operational since June 1996
- IPv6 core specifications reached draft standard before X-mas 1998
- IPv6 Forum started in March 1999
- IANA issues IPv6 addresses since July 1999
- Cisco will have full IPv6 support
- Microsoft will include IPv6 in the next major release of Windows 2000
- Nokia are building their 3rd G products to run over IPv6
- 3GPP mandated IPv6 for release 00 of GPRS
- MWIF mandated IPv6 in May 2000

Overview of IPv6 protocols

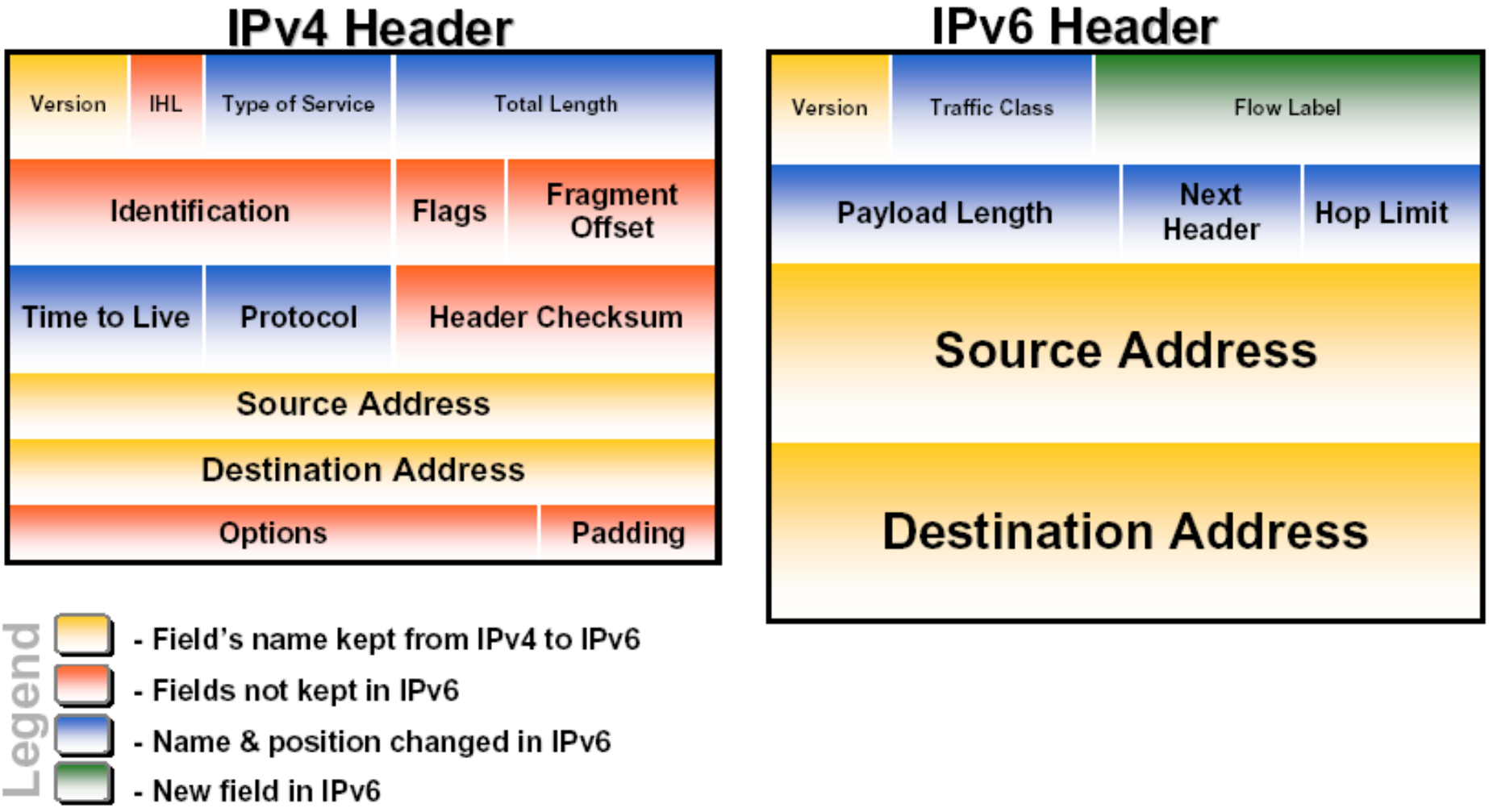
- **Essential protocols:**
  - **IPv6**
  - **ICMP**
    - **ICMP**
    - **ND: Neighbor Discovery (instead of ARP for IPv4)**
    - **MLD: Multicast Listener Discovery (instead of IGMP for IPv4)**
  - **Routing protocols**
  - **DNS for IPv6**
  - **DHCP for IPv6**

IPv4 and IPv6 packets

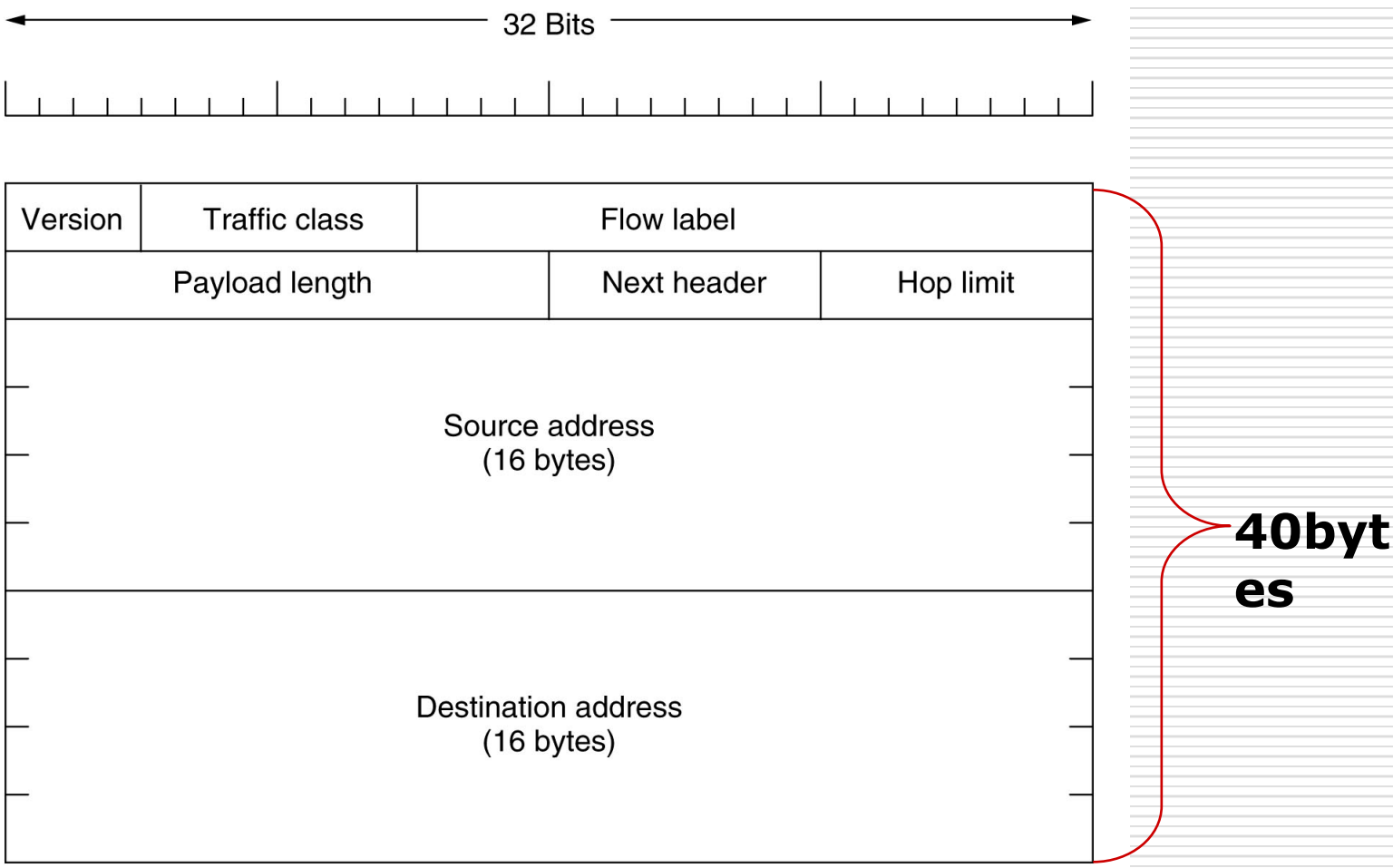




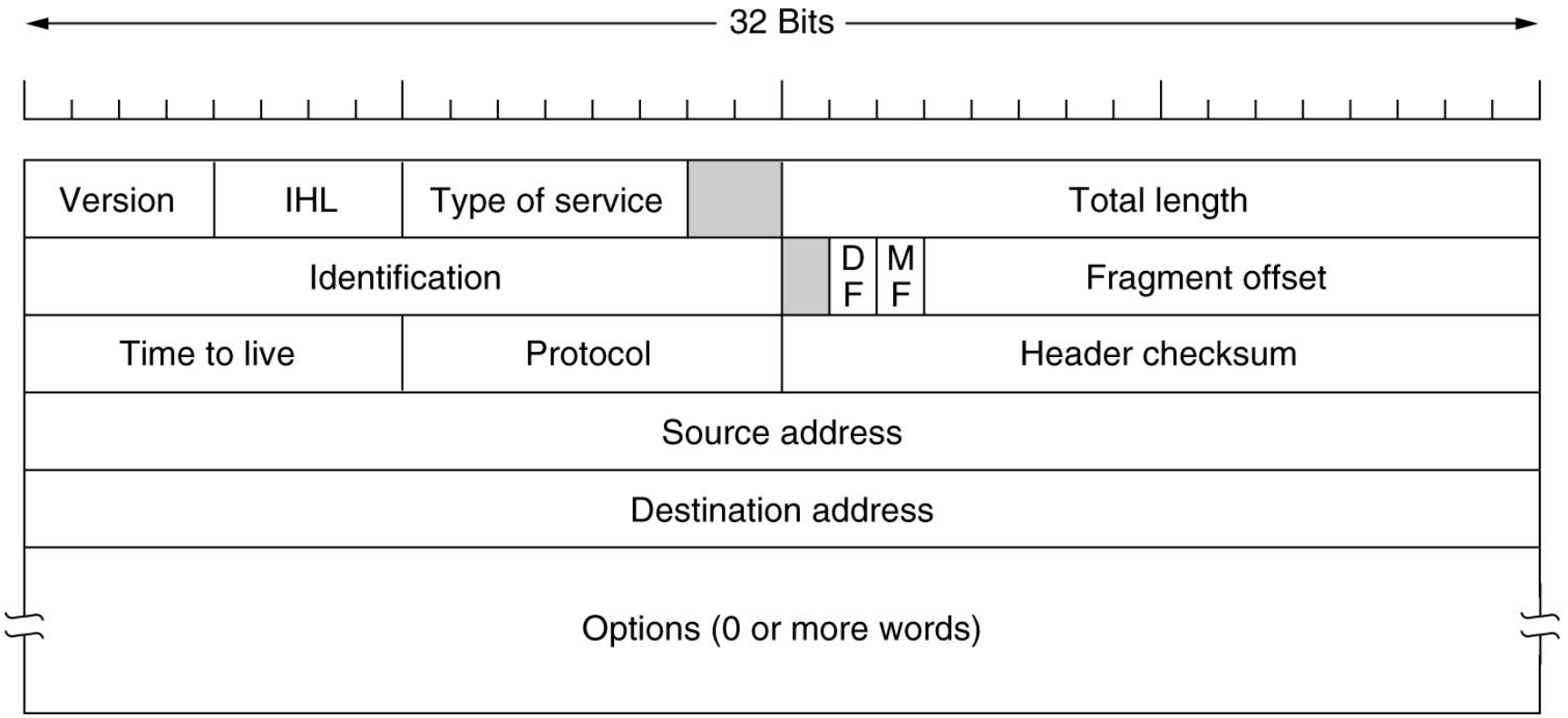
IPv4 and IPv6 header



Main IPv6 Header



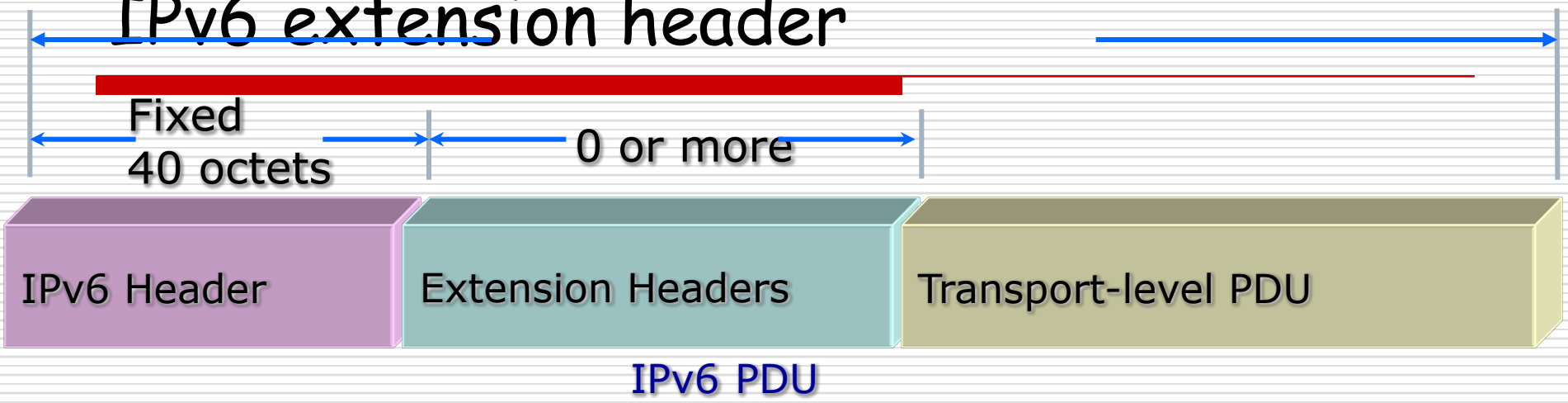
IPv4 packet format



Differences in packet header

- Revised
  - Addresses increased 32 bits -> 128 bits
  - Time to Live -> Hop Limit（跳数限制）
  - Protocol -> Next Header
  - Type of Service -> Traffic Class（流量类别）
- Streamlined
  - Fragmentation fields moved out of base header(主头部)
  - IP options moved out of base header
  - Header Checksum eliminated
  - Header Length field eliminated
  - Length field excludes IPv6 header
- Extended
  - Flow Label field added

IPv6 extension header



Hop-by-hop options header
Routing header
Fragment header
Authentication header
Encapsulating security payload header
Destination options header

Larger address space

IPv4 = 32 bits

IPv6 = 128 bits

IPv4:

32 bits

= 4,294,967,296 possible address devices

IPv6:

128 bits ---- 4 times the size in bits

= 3.4×10^{38} possible address devices

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

~ 5×10^{28} addresses per person on the earth

Flexibility and scalability

- **The IPv6 address provides flexibility and scalability:**
  - **It allows multilevel subnetting and allocation from a global backbone to an individual subnet within an organization.**
  - **It improves multicast scalability and efficiency through scope constraints.**
  - **It adds a new address for server node clusters, where one server can respond to a request to a group of nodes.**
  - **The large IPv6 address space is organized into a hierarchical structure to reduce the size of backbone routing tables.**

Hexadecimal representation

- 16 bits fields in case insensitive colon hexadecimal representation:
  - 2031:0000:130F:0000:0000:09C0:876A:130B
- Leading zeros in a field are optional:
  - 2031:0:130F:0:0:9C0:876A:130B
- Successive fields of 0 represented as ::, but only once in an address:
  - 2031:0:130F::9C0:876A:130B is ok
  - 2031::130F::9C0:876A:130B is NOT ok
  - 0:0:0:0:0:0:0:1 → ::1 loopback address
  - 0:0:0:0:0:0:0:0 → :: unspecified address

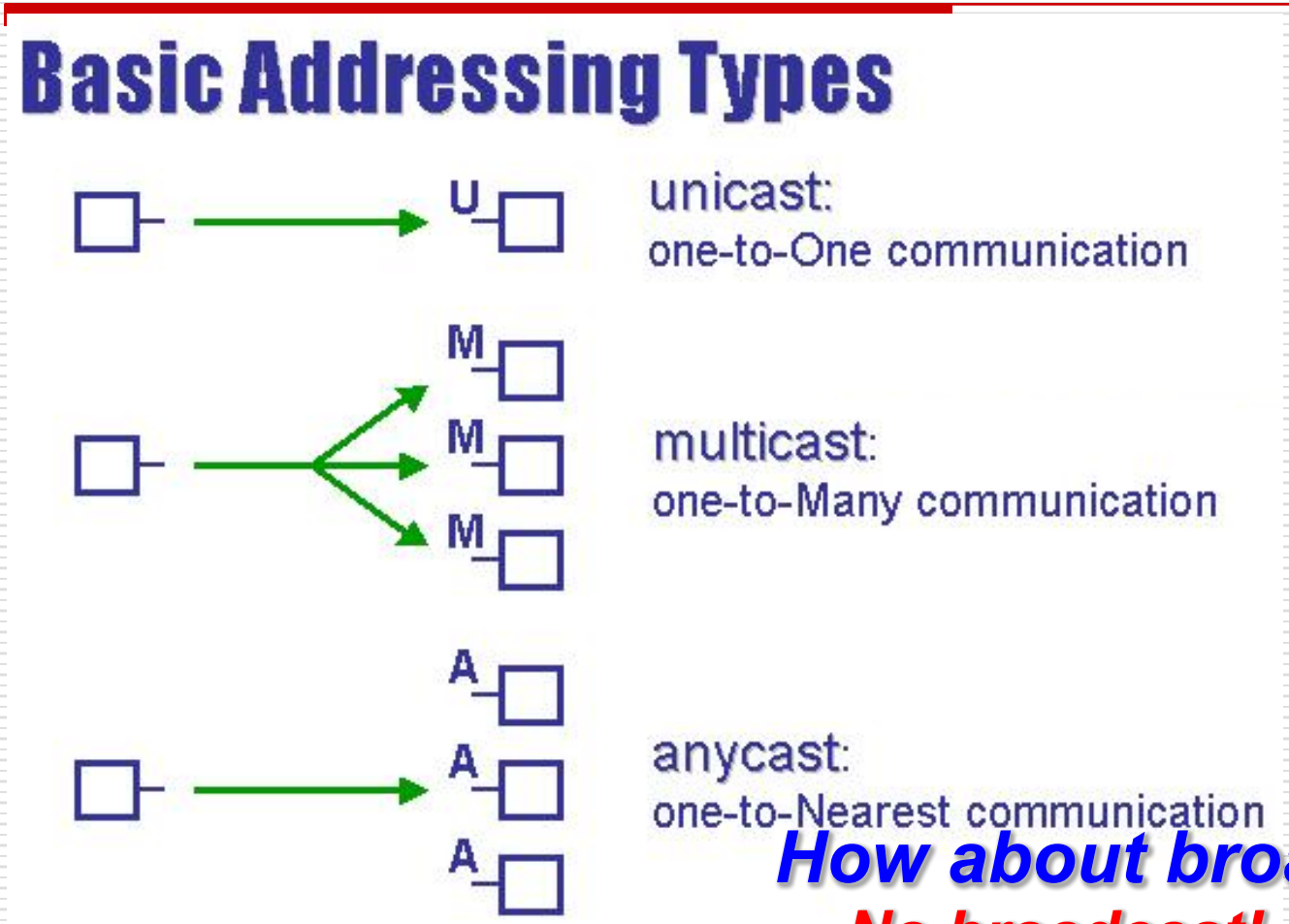
Hexadecimal representation

- **In a URL, it is enclosed in brackets:**

  http://[2001:1:4F3A::206:AE14]:8080/index.html

  - **Cumbersome for users**
  - **Mostly for diagnostic purposes**
  - **Use fully qualified domain names (FQDN)**
- **For the convenience of users, DNS has to work!**

Addressing types



How about broadcast?

No broadcast!

It's superseded by multicast!

Special purpose unicast addresses

- **Special purpose unicast addresses are defined as follows:**
  - **Loopback address (::1)**
  - **Unspecified address (::)**
  - **IPv4-compatible address (::<IPv4_address>)**
    - **IPv4 address of 1.2.3.4**
    - **In IPv6 it becomes ::0102:0304**
  - **IPv4-mapped address (::FFFF:<IPv4_address>)**
    - **IPv4 address of 1.2.3.4**
    - **IPv4-mapped address: ::FFFF:0102:0304**
  - **Link-local address**
  - **Site-local address**

Global unicast address format

Global Routing Prefix:

- The global routing prefix is designed to be structured hierarchically by the RIRs and ISPs.

Subnet ID:

- The subnet identifier is designed to be structured hierarchically by site administrators.

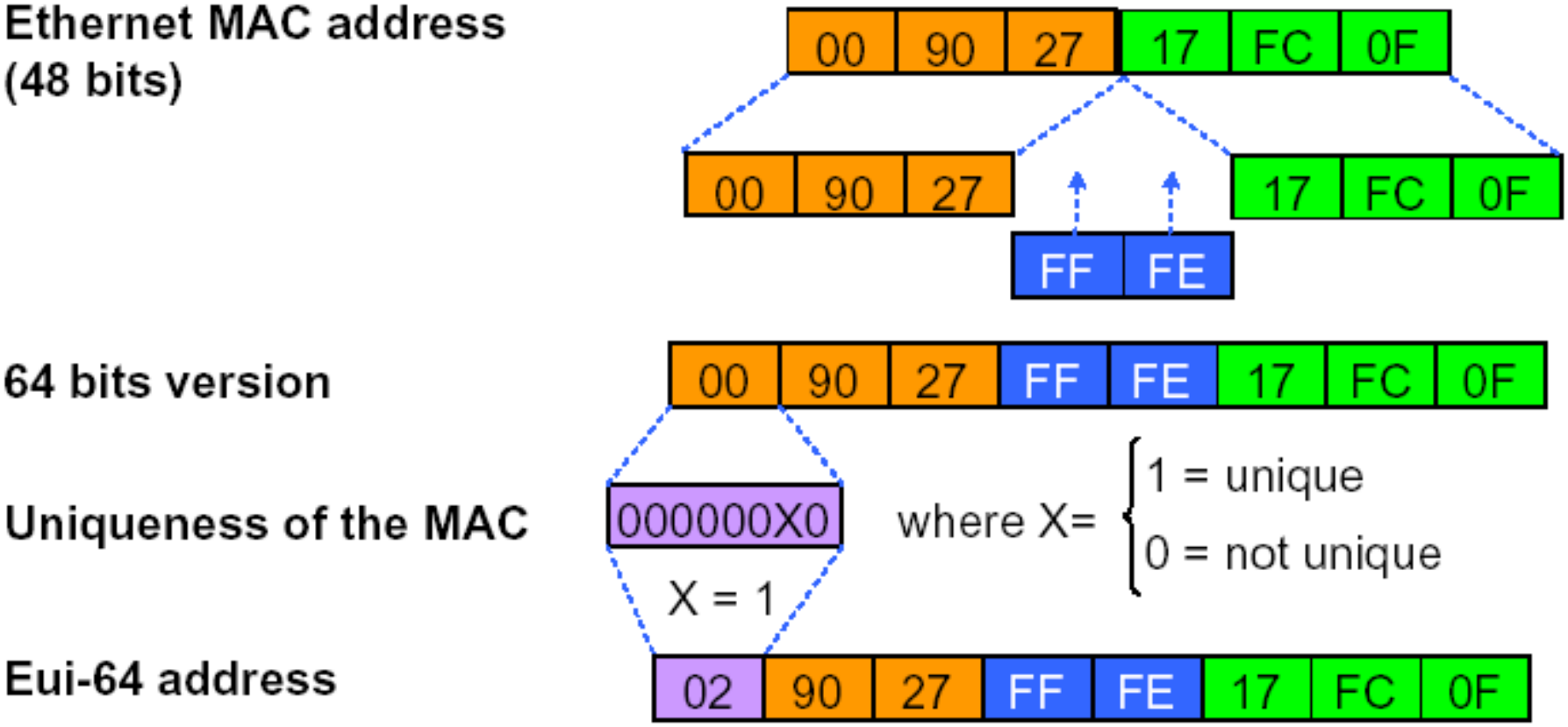
Interface ID:

- Interface identifiers in IPv6 unicast addresses are used to identify interfaces on a link.

Interface ID in unicast address

- **Interface ID in unicast address:**
  - **All unicast addresses, except those that start with binary value 000, have interface IDs that are 64bits long and constructed in Modified EUI-64 format.**
- **It can be assigned according to the following methods:**
  - **Mapping 48 bit MAC address into EUI-64 format**
  - **Randomly generated number**
  - **Assigned by DHCP**
  - **Manually configuration**

EUI-64 format



- **EUI-64 address is formed by inserting FFFE and OR'ing a bit identifying the uniqueness of the MAC address**

Anycast address format

- **What's the anycast address?**
  - **It's a special type of unicast address that is assigned to interfaces on multiple hosts.**
  - **Packets sent to such an address will be delivered to the nearest interface with that address. Routers determine the nearest interface.**
- **Currently restrictions on anycast addresses:**
  - **An anycast address must not be used as the source address of a packet.**
  - **Any anycast address can only be assigned to a router.**

IPv6 security

- There are two optional headers defined for security purposes:
  - Authentication Header (AH)
    - AH conveys the authentication information in an IP package.
  - Encapsulated Security Payload (ESP)
    - ESP carries the encrypted data of the IP package.
- AH and ESP in IPv6 support:
  - Authentication
  - Data integrity
  - Confidentiality (optional)

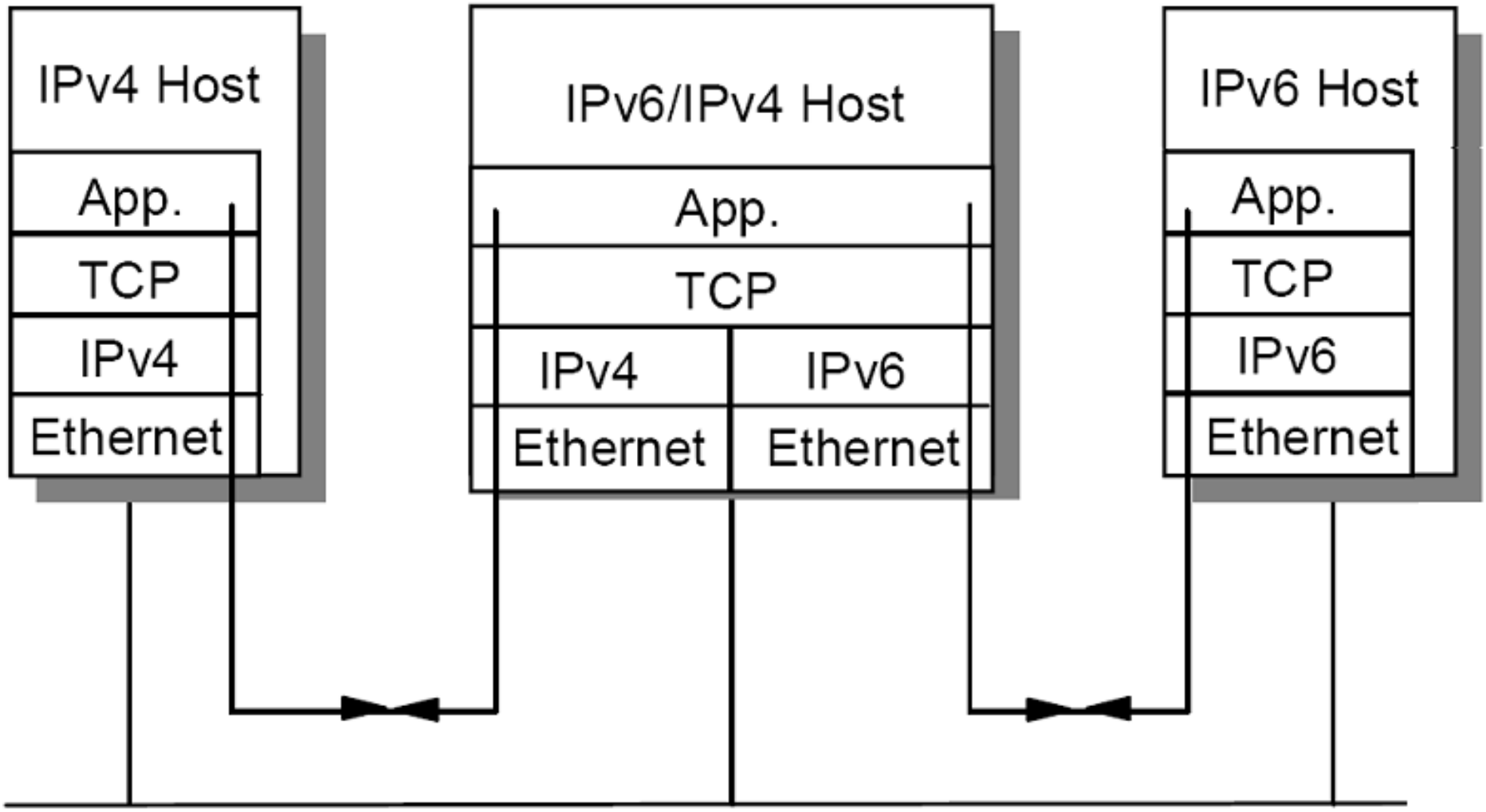
ICMPv6

- ICMPv6 is consisted of three parts:
  - ICMP
    - ICMP for IPv4
  - ND: Neighbor Discovery
    - ARP for IPv4
  - MLD: Multicast Listener Discovery
    - IGMP for IPv4

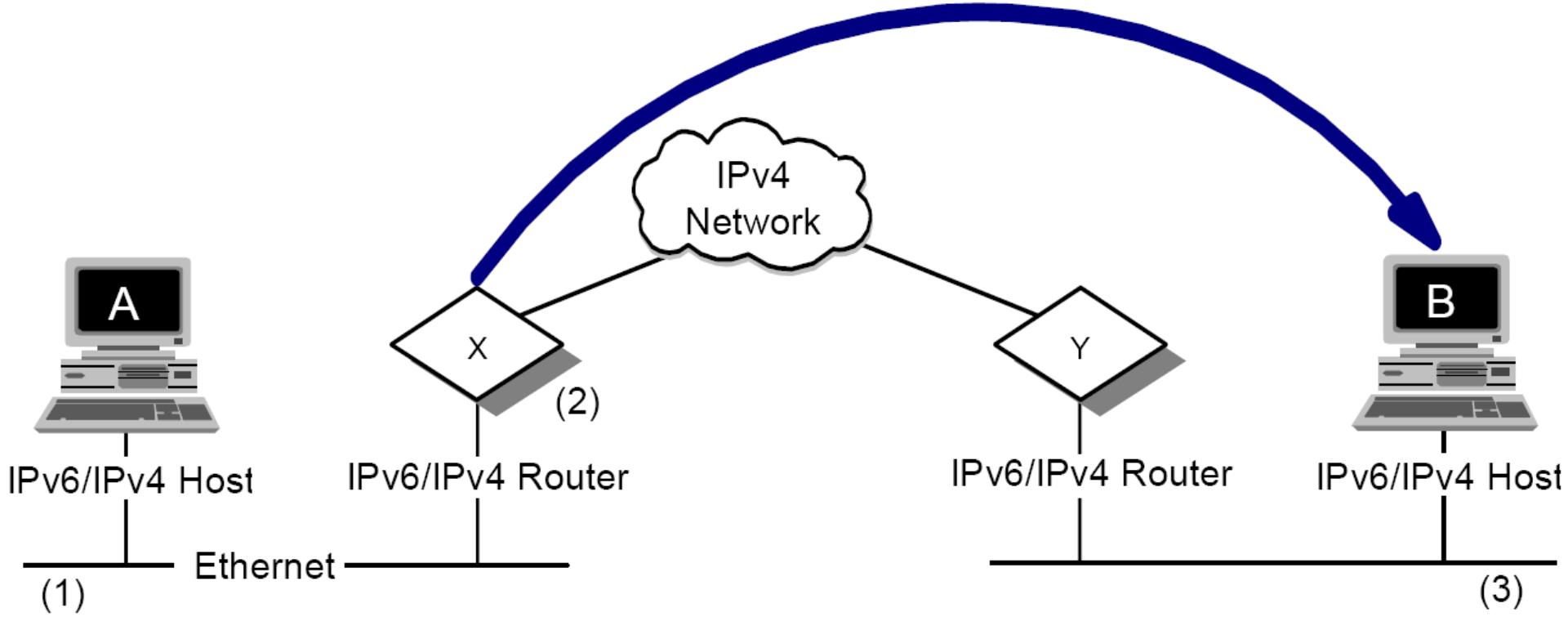
Migrating techniques

- **Four Simple Internet Transition (SIT) techniques:**
  - **Dual-stack IP implementations**
  - **Imbedding of IPv4 addresses in IPv6 addresses**
  - **IPv6-over-IPv4 tunneling mechanisms**
    - **Automatic tunneling**
    - **Configured tunneling**
  - **IPv4/IPv6 header translation**
    - **Only a few IPv4-only systems**

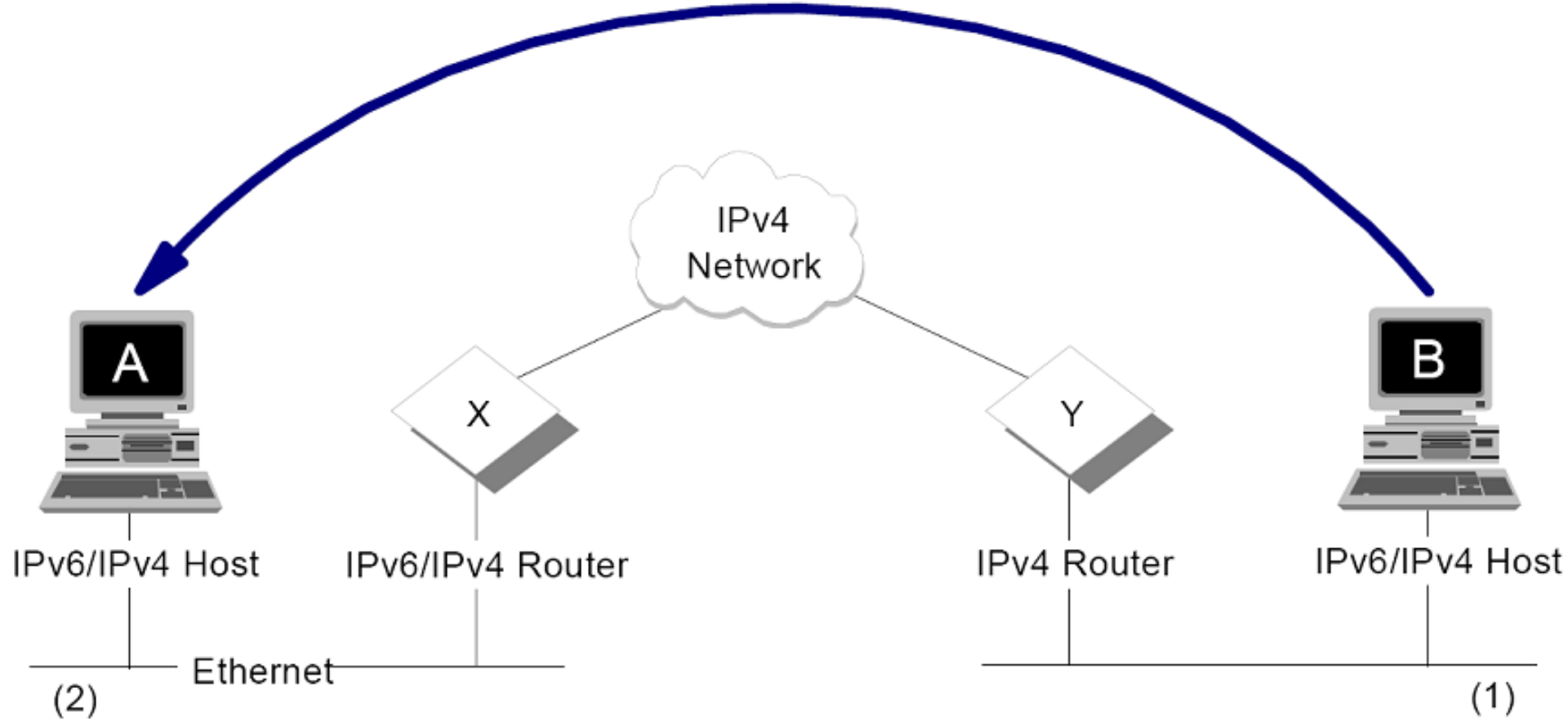
IPv6/IPv4 dual stack system



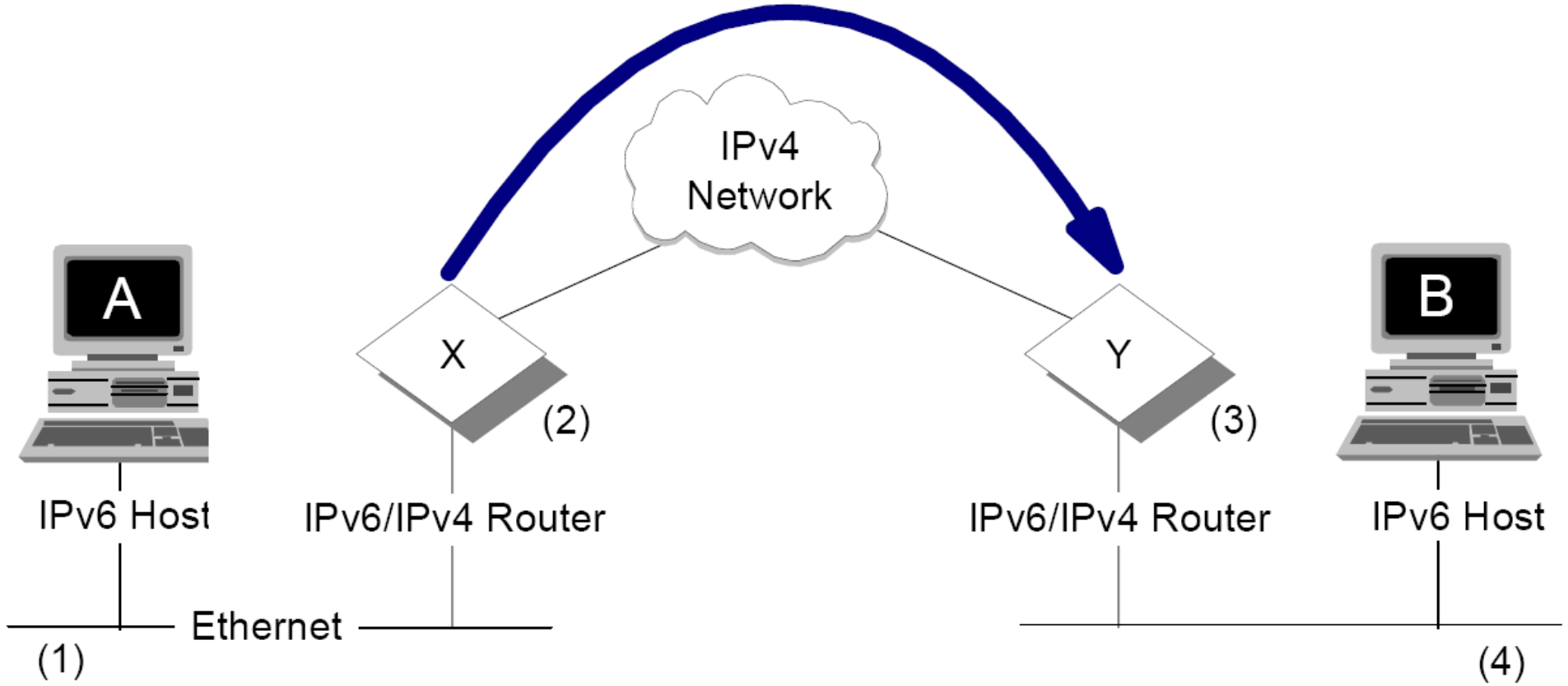
Router-to-host automatic tunneling



Host-to-host automatic tunneling



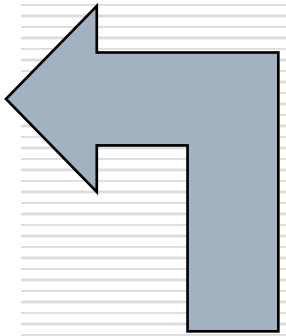
Router-to-router configured tunneling



Wireshark

```
⊟ Ethernet II, Src: 00:0d:56:6d:6f:fc, Dst: 00:e0:fc:06:7a:d8
    Destination: 00:e0:fc:06:7a:d8 (HuaweiTe_06:7a:d8)
    Source: 00:0d:56:6d:6f:fc (DellPcba_6d:6f:fc)
    Type: IPv6 (0x86dd)
⊟ Internet Protocol Version 6
    Version: 6
    Traffic class: 0x00
    Flowlabel: 0x00000
    Payload length: 40
    Next header: ICMPv6 (0x3a)
    Hop limit: 128
    Source address: 1::7146:ab89:3e23:e38c
    Destination address: 1::1
⊟ Internet Control Message Protocol v6
    Type: 128 (Echo request)
    Code: 0
    Checksum: 0x9675 (correct)
    ID: 0x0000
    Sequence: 0x0001
    Data (32 bytes)
```

- 一个IP V6数据包



```
00 e0 fc 06 7a d8 00 0d  56 6d 6f fc 86 dd 60 00
00 00 00 28 3a 80 00 01  00 00 00 00 00 00 71 46
ab 89 3e 23 e3 8c 00 01  00 00 00 00 00 00 00 00
00 00 00 00 00 01 80 00  96 75 00 00 00 01 61 62
63 64 65 66 67 68 69 6a  6b 6c 6d 6e 6f 70 71 72
73 74 75 76 77 61 62 63  64 65 66 67 68 69
```

ENDING

- **Comparison between IPv4 and IPv6**
- **Review of Network layer.**

thanks !