新一代 IPv6 網路協定

Course Agenda

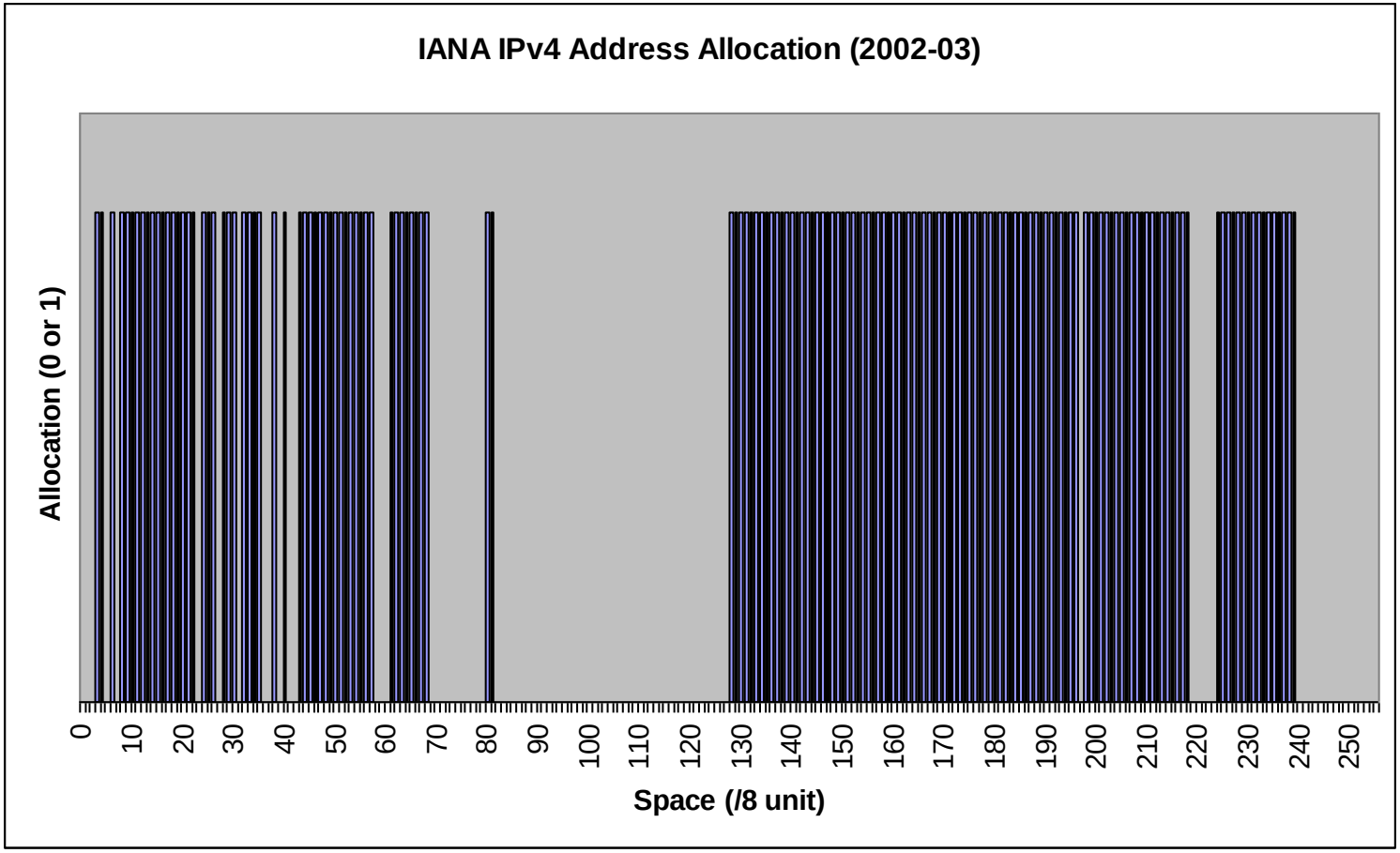
- **Module I: Introduction to IPv6**
- **Module II: IPv6 Operation**
- **Module III: IPv6 Configuration**

Module I
Introduction to IPv6

- **Module 1.1: Rationale for IPv6**
- **Module 1.2: IPv6 Features and Benefits**
- **Module 1.3: IPv6 Header Format**

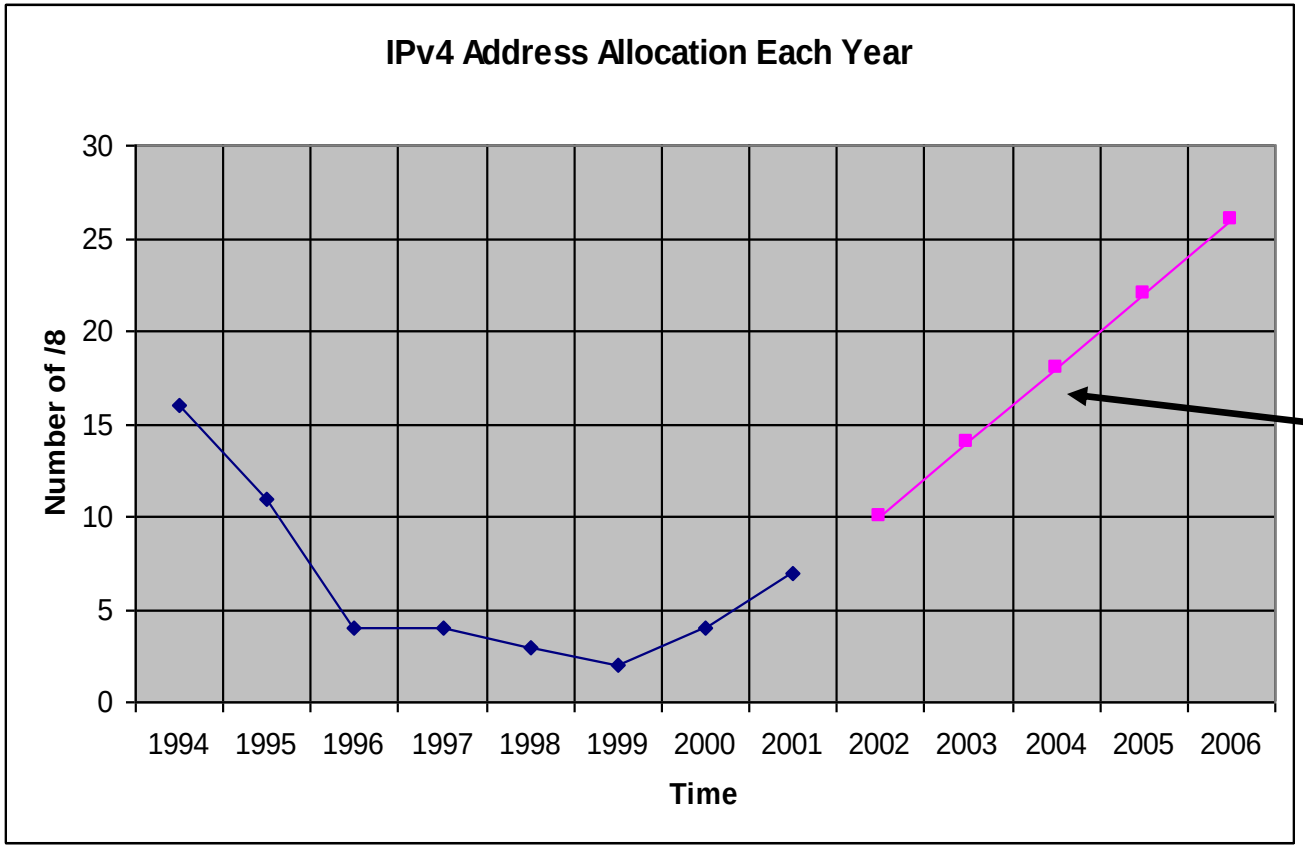
Module 1.1:
Rationale for IPv6

IPv4 Address Space



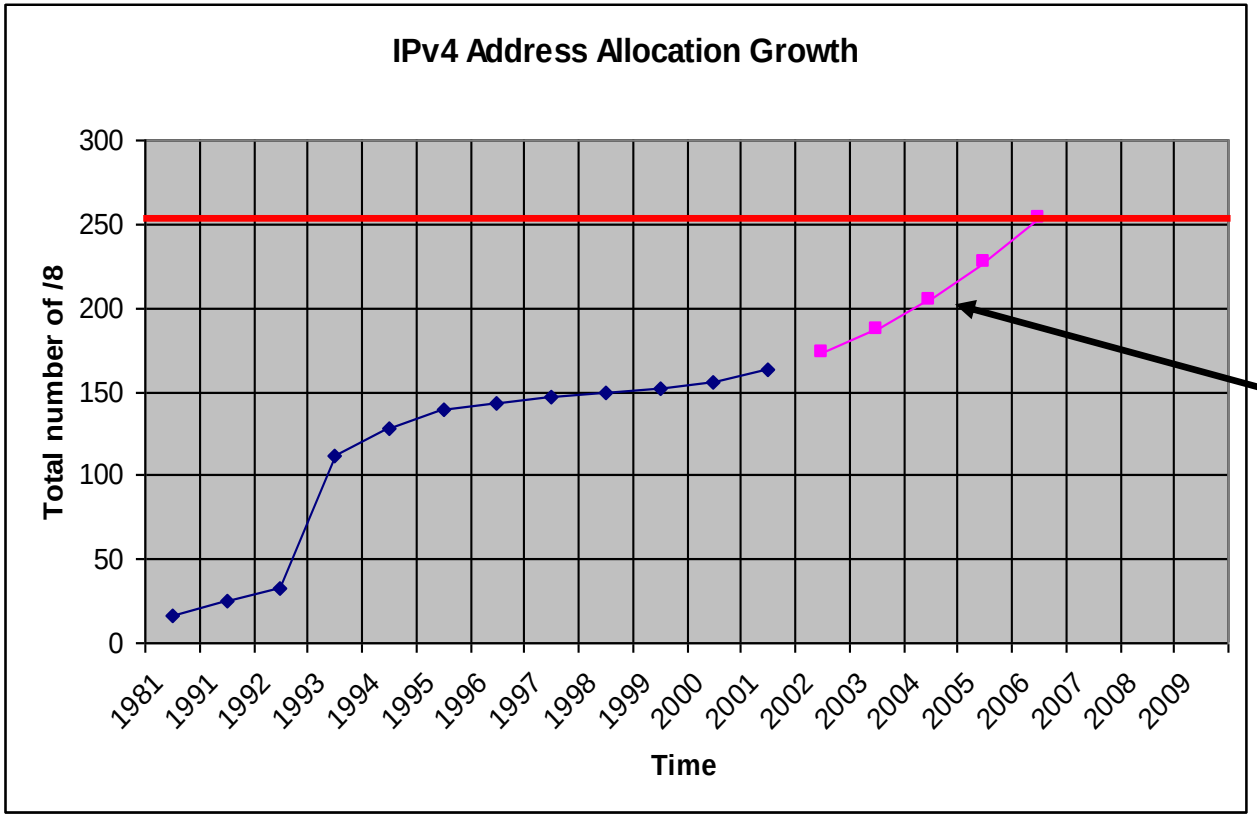
69% of space is allocated as of 2002-03 (Source: IANA registry)

Number of IPv4 Address Allocation in Recent Years



Linear extrapolation

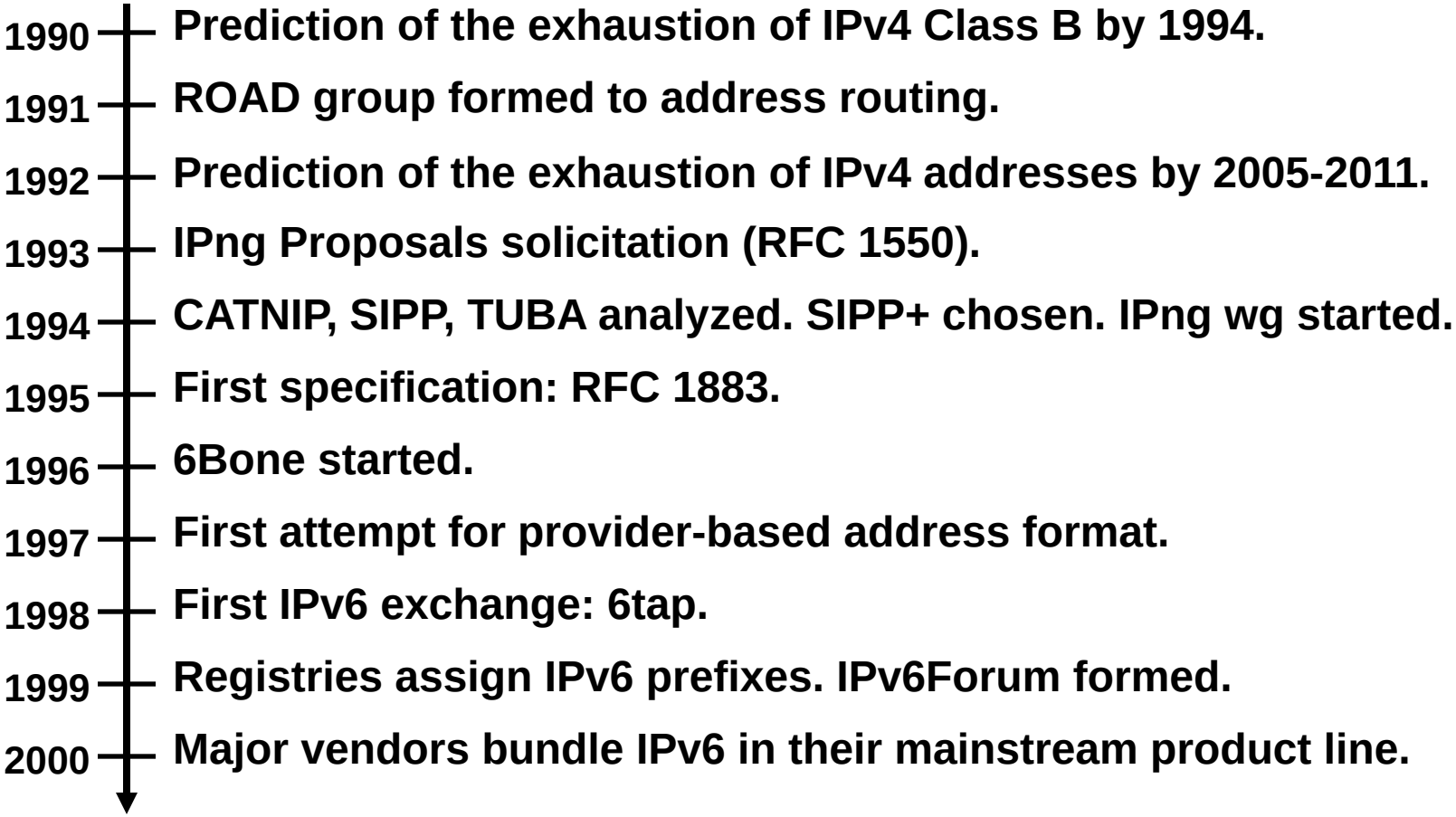
IPv4 Allocation Growth



Cumulative using previous slide linear prediction

A linear model on the first derivative gives 2006 as complete exhaustion.

Short History of IPv6

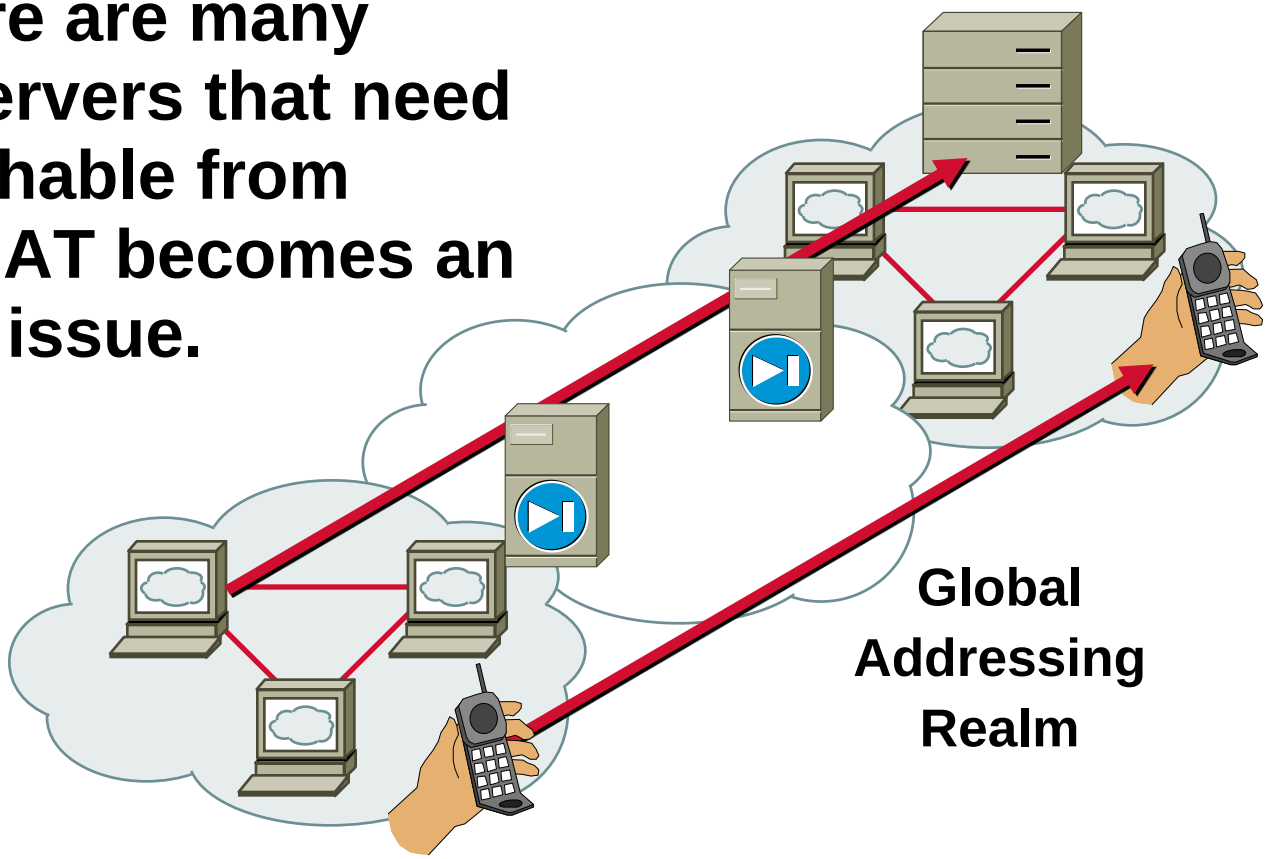


Network Address Translation

- **Private address space and Network Address Translation (NAT) can be used instead of a new protocol**
- **NAT has many implications:**
  - **Breaks the end-to-end model of IP**
  - **Mandates that the network keeps the state of the connections**
  - **Makes fast rerouting difficult**

NAT Inhibits Access to Internal Servers

When there are many internal servers that need to be reachable from outside, NAT becomes an important issue.



Module 1.2:
IPv6 Features and Benefits

IPv6 Main Features

Larger address space:

- Global reachability and flexibility
- Aggregation
- Multihoming
- Autoconfiguration
- Plug-and-play
- End-to-end without NAT
- Renumbering

Mobility and security:

- Mobile IP RFC-compliant
- IPsec mandatory (or native) for IPv6

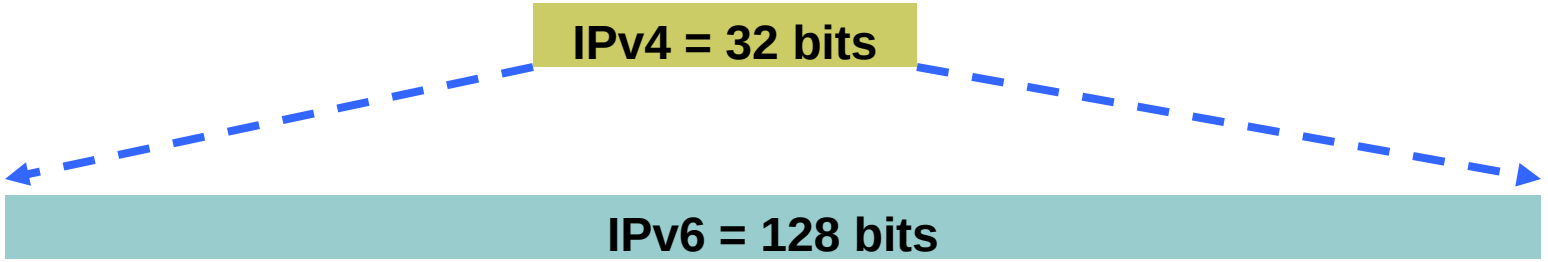
Simpler header:

- Routing efficiency
- Performance and forwarding rate scalability
- No broadcasts
- No checksums
- Extension headers
- Flow labels

Transition richness:

- Dual stack
- 6to4 and manual tunnels
- Translation

Larger Address Space



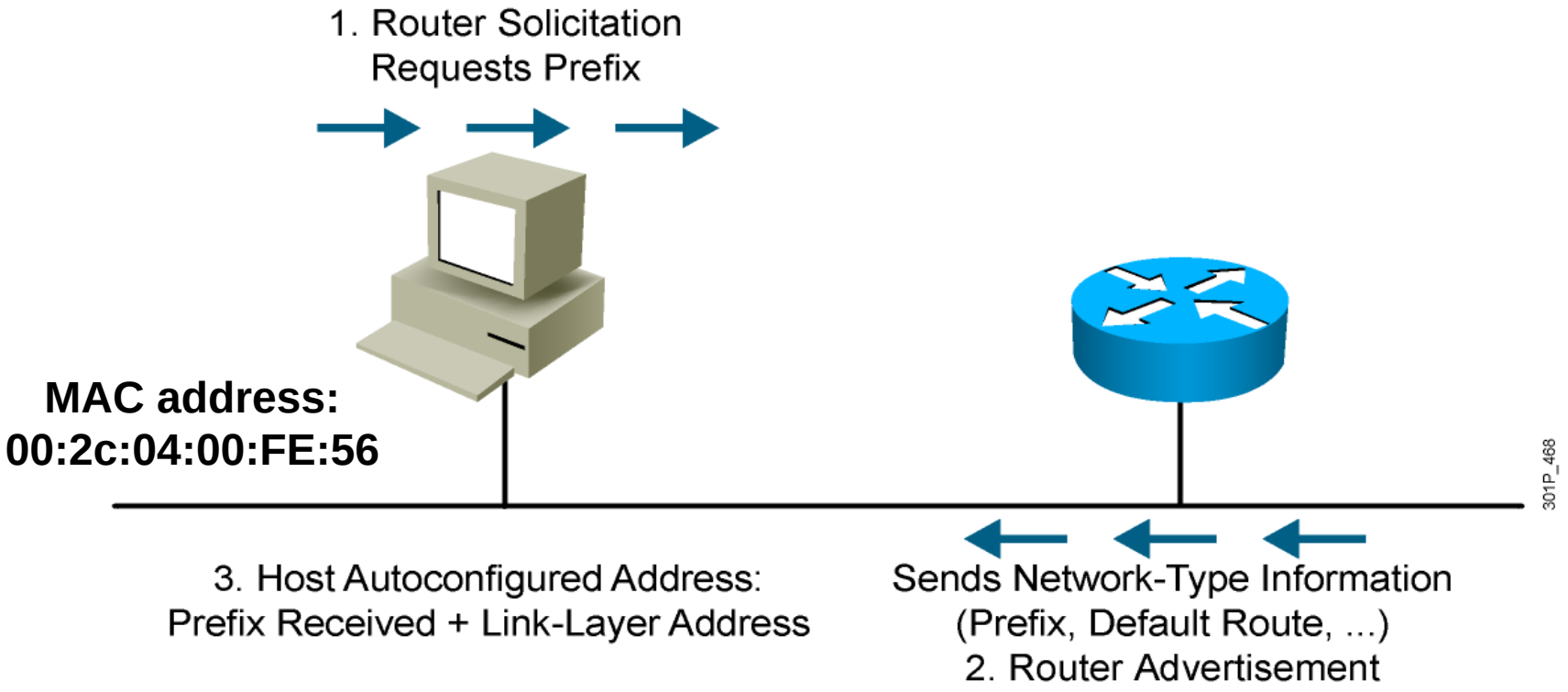
IPv4

- 32 bits
- =~ 4,200,000,000 possible addressable nodes

IPv6

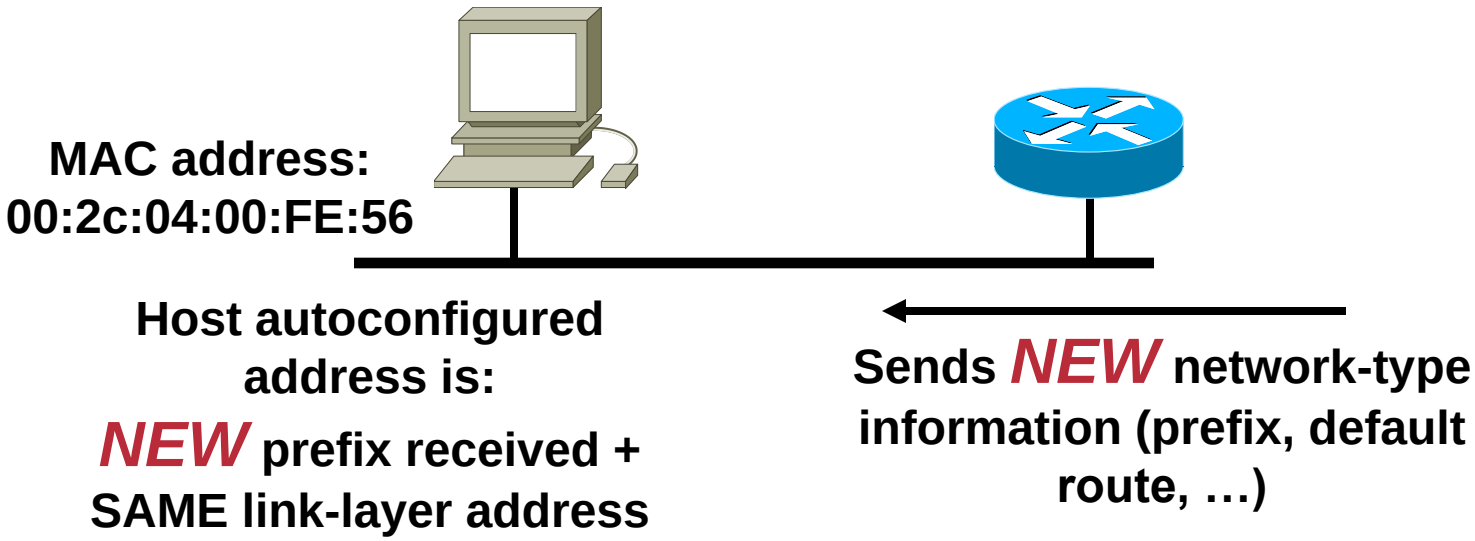
- 128 bits: 4 times the size in bits
- =~ $3,4 * 10^{38}$ possible addressable nodes
- =~340,282,366,920,938,463,374,607,432,768,211,456
- =~ 10^{30} addresses per person on the planet

Stateless Autoconfiguration



- **The use of link-layer addresses inside the address space**
- **Autoconfiguration with "no collisions"**
- **Offers “Plug-and-play”**

Renumbering



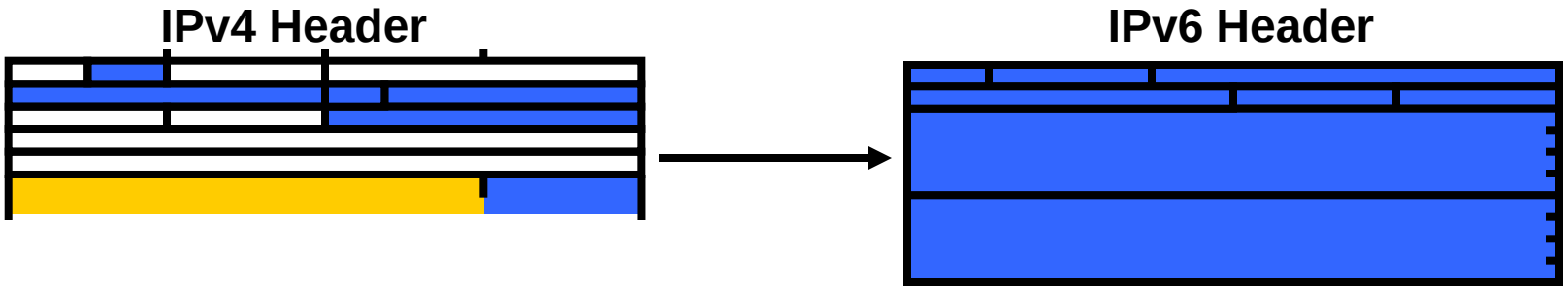
Larger address space enables:

- Renumbering, using autoconfiguration and multiple addresses

Multicast Use

- Broadcasts in IPv4
  - Interrupts all computers on the LAN even if the intent of the request was for one or two computers
  - Can completely bring down a network ("broadcast storm")
- No broadcast in IPv6
  - Replaced by multicast
- Multicast
  - Enables the efficient use of the network
  - Multicast address range is much larger

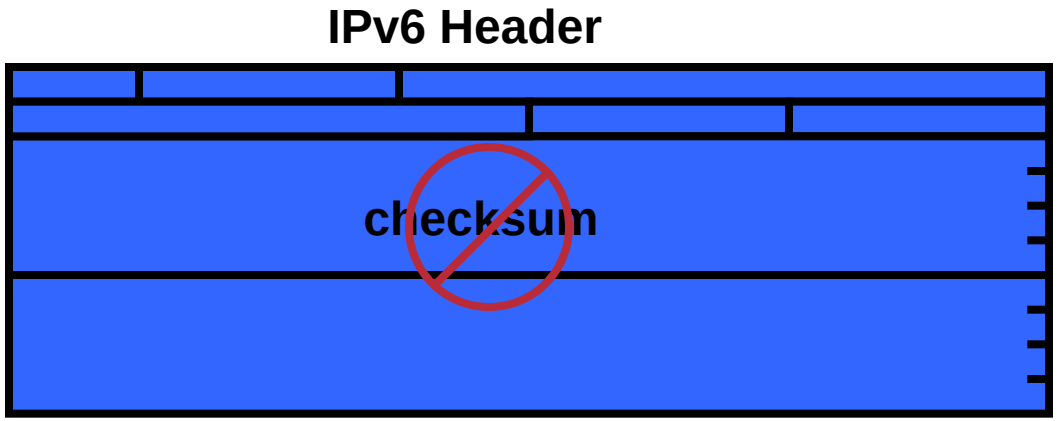
Simple and Efficient Header



Simpler and efficient header means:

- 64-bit aligned fields and fewer fields
- Hardware-based efficient processing
- Improving routing efficiency, performance, and forwarding rate scalability

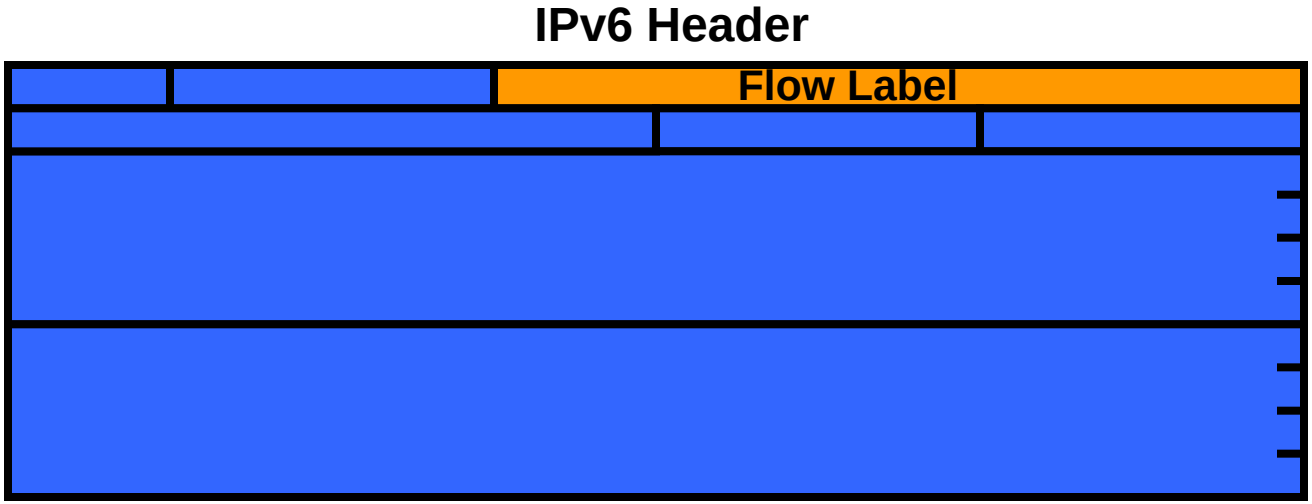
No Checksum



Simpler and efficient header means:

- No checksum at the IP layer, no recalculation by the routers
- Improved routing efficiency, performance, and forwarding rate scalability
- Error detection is done by link layer and transport layer

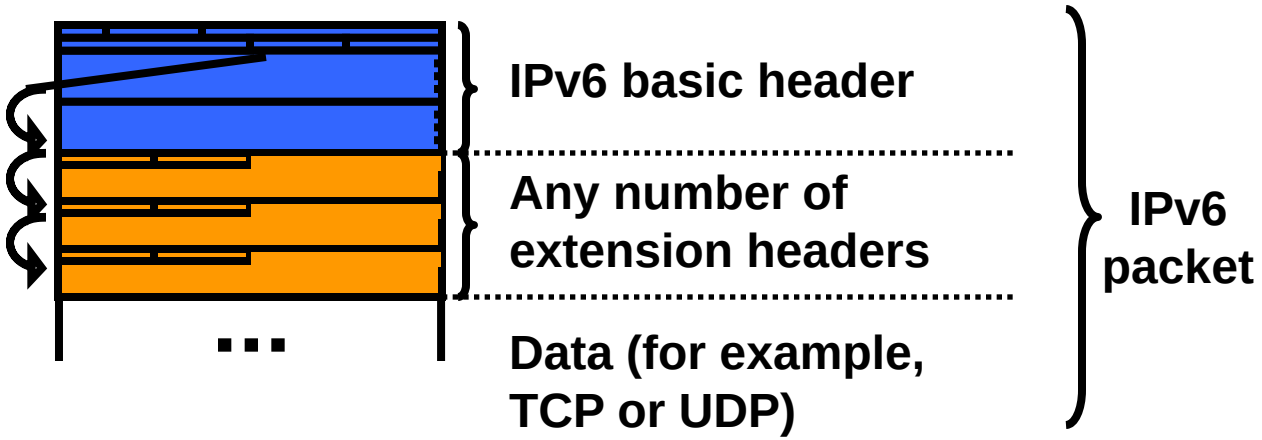
Flow Label Field Enables Per-flow Processing



Simpler and efficient header means:

- A new flow label inside the IP header
- Enables per-flow processing for differentiation at the IP layer
- Length of 20 bits

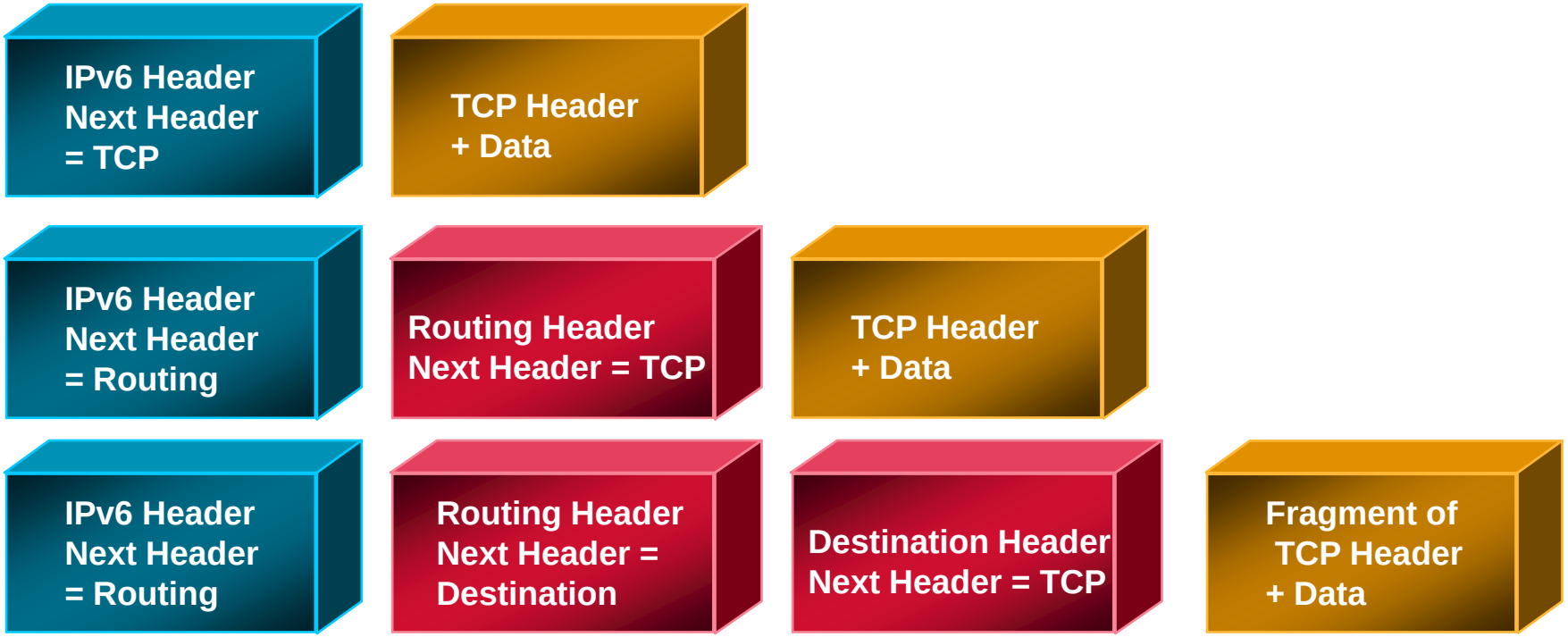
Extension Headers



Simpler and efficient header means:

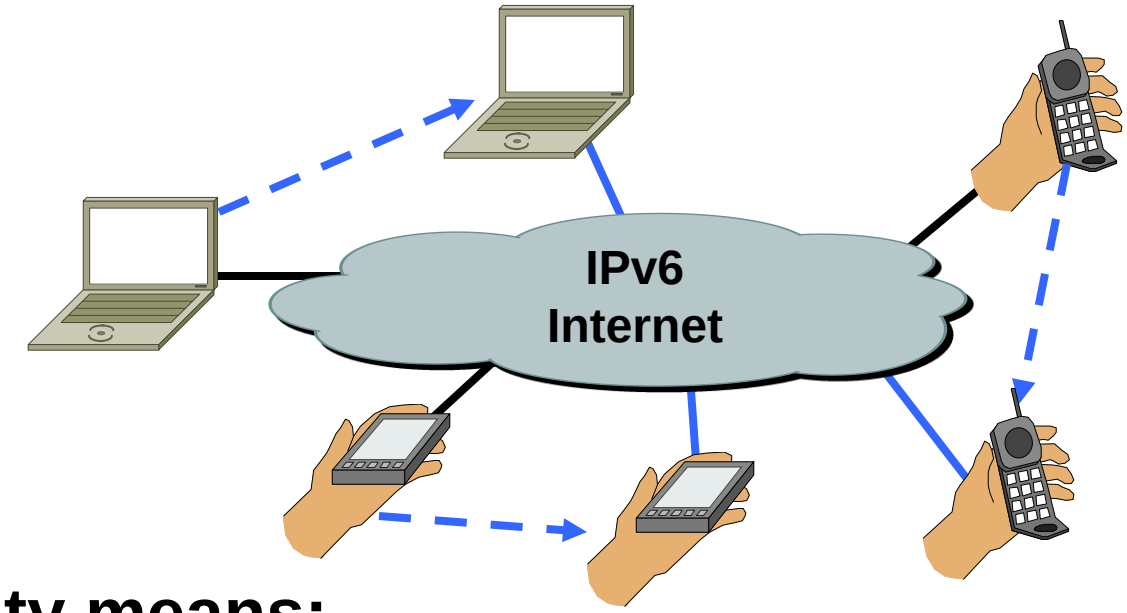
- Extension headers
- Handles the options more efficiently
- Enables faster forwarding rate and end-nodes processing

Extension Headers



Extension headers are daisy chained

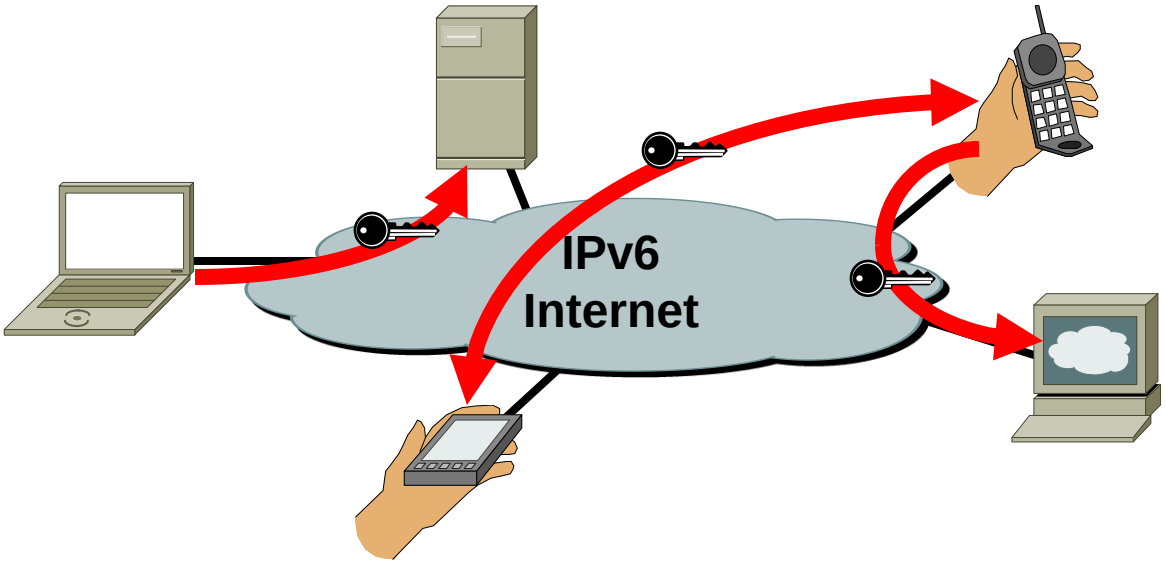
Mobility



Mobility means:

- Mobile devices are fully supported while moving
- Built-in on IPv6
  - Any node can use it
- Efficient routing means performance for end users

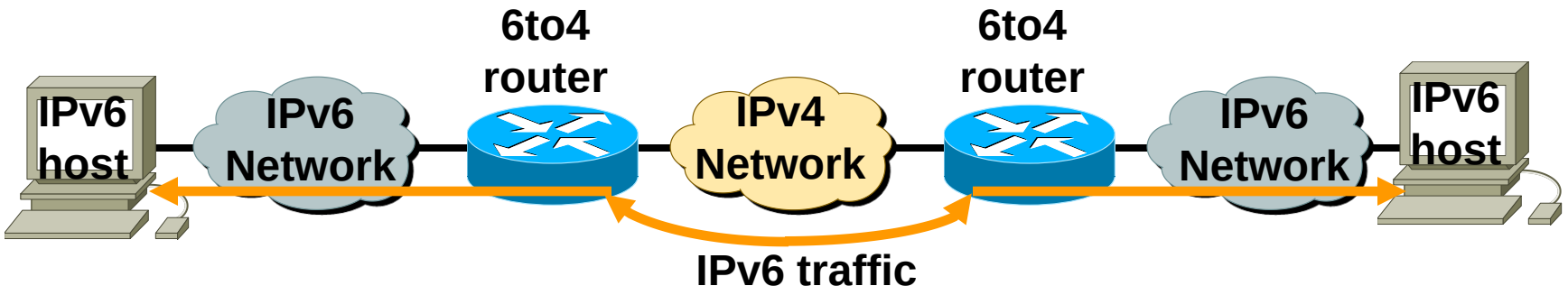
Security



Security means:

- End-to-end network security (integrity, authentication, confidentiality)
- Built-in on IPv6
  - Any node can use it

Transition Richness

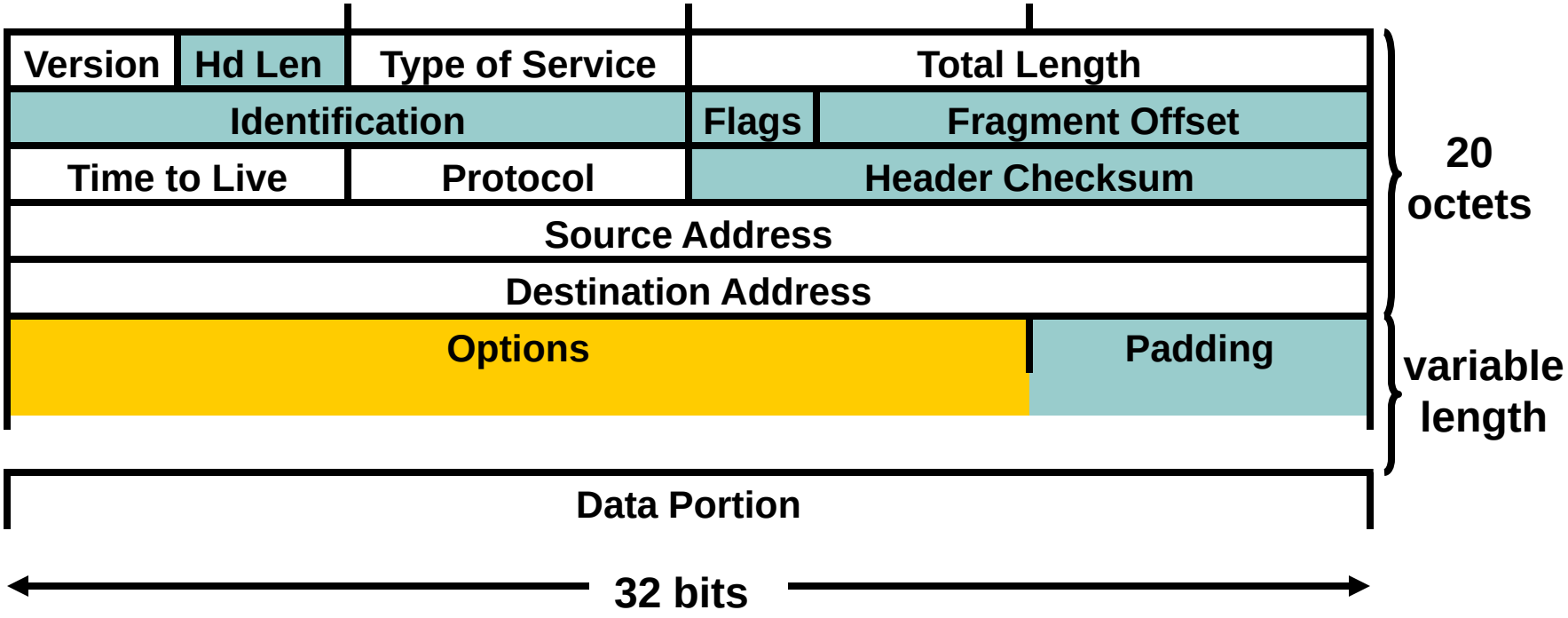


Transition richness means:

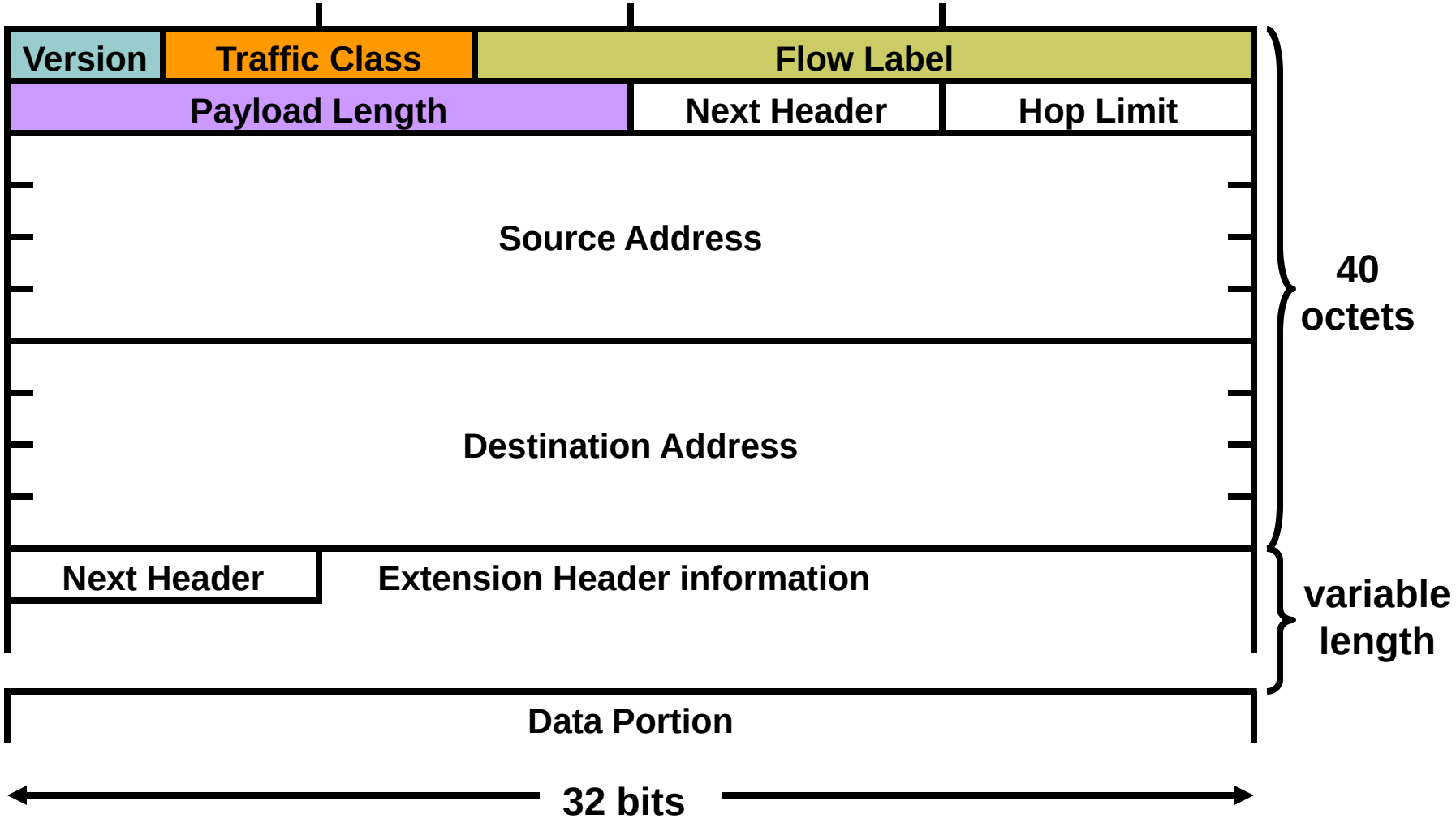
- No fixed day to convert, no need to convert all at once
- Different transition mechanisms are available
  - Smooth integration of IPv4 and IPv6
- Different compatibility mechanisms
  - IPv4 and IPv6 nodes can talk communicate

Module 1.3:
IPv6 Header Format

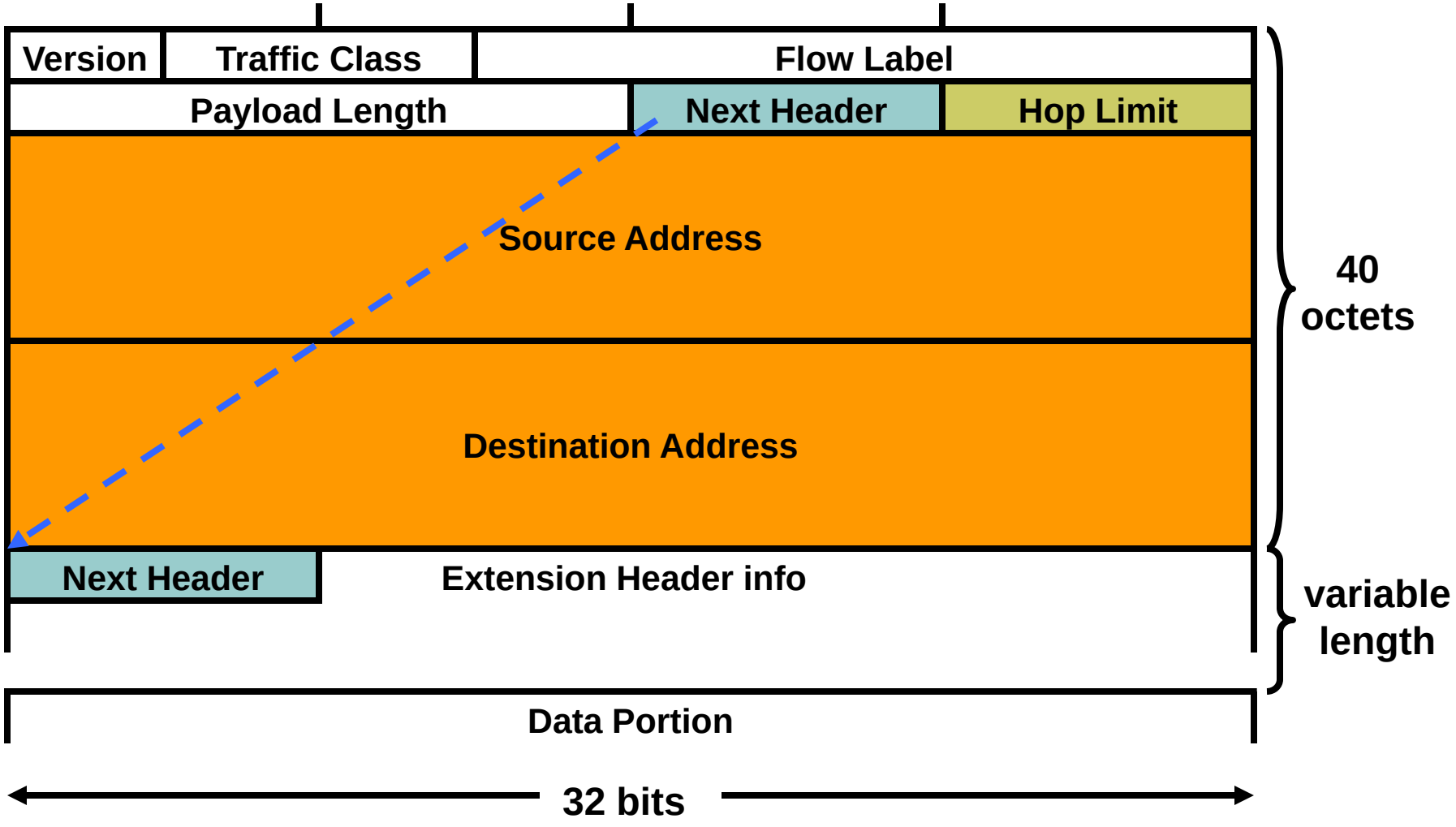
IPv4 Header Format



IPv6 Header Format

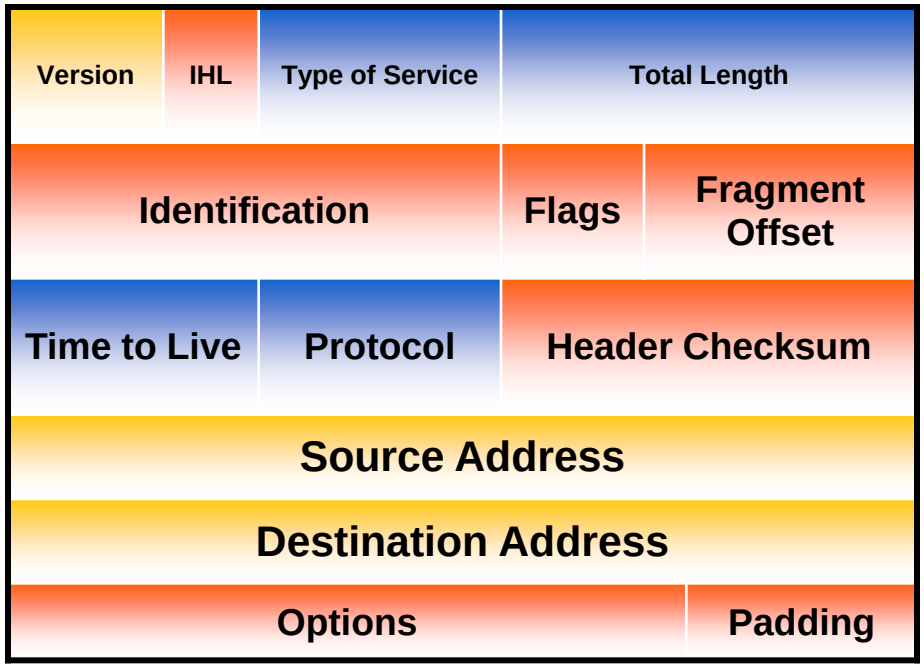


IPv6 Header Format (Cont.)

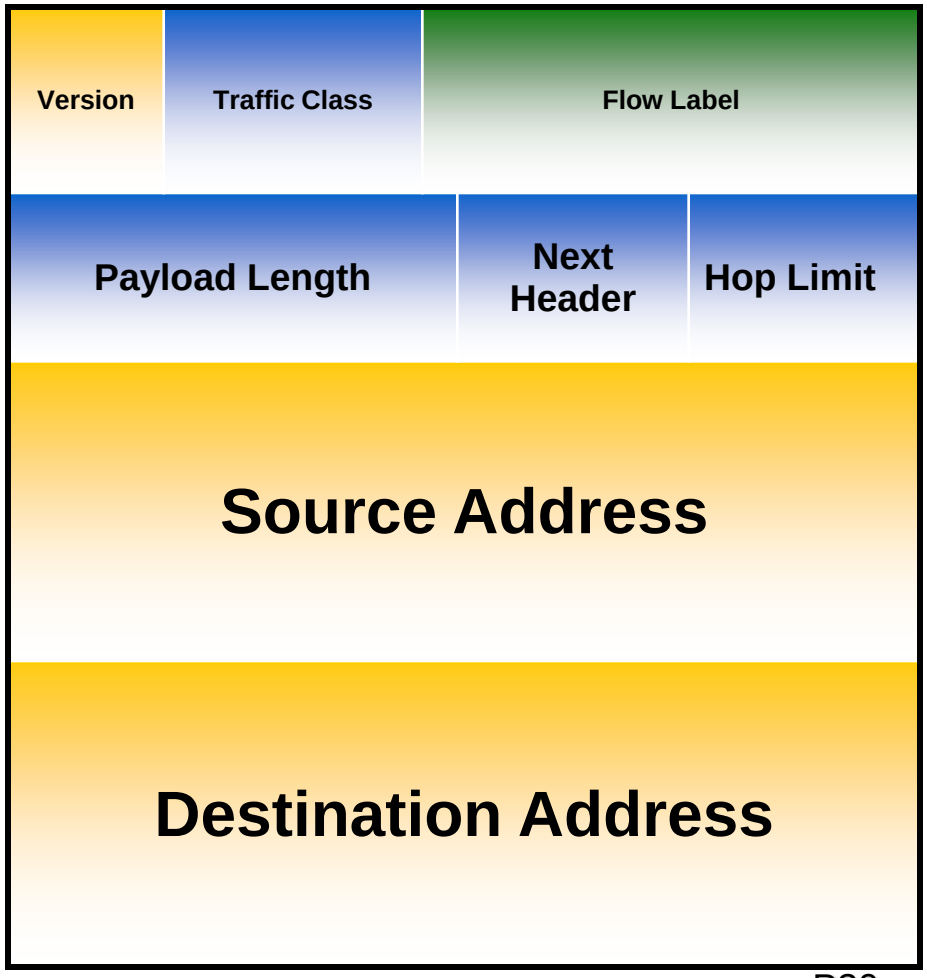


IPv4 & IPv6 Header Comparison

IPv4 Header



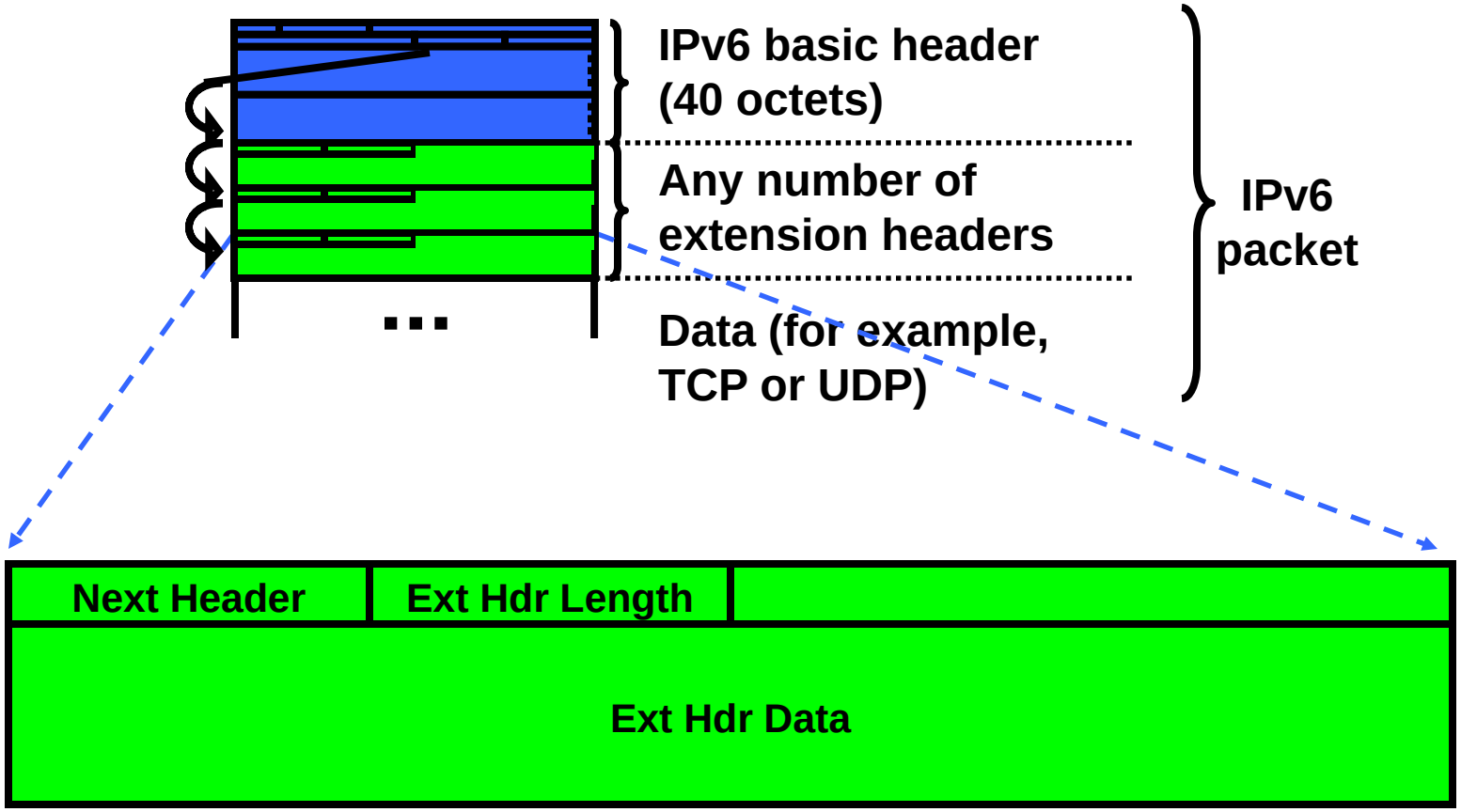
IPv6 Header



Legend

- Field name kept from IPv4 to IPv6
- Fields not kept in IPv6
- Name and position changed in IPv6
- New field in IPv6

Extension Headers



Extension Headers

Hop-by-Hop header

- **Processed by all hops in the path**

Destination Option header

- **Processed only by the destination node**

Source Routing header

- **Combines IPv4 strict/loose source routing concepts**

Fragment header

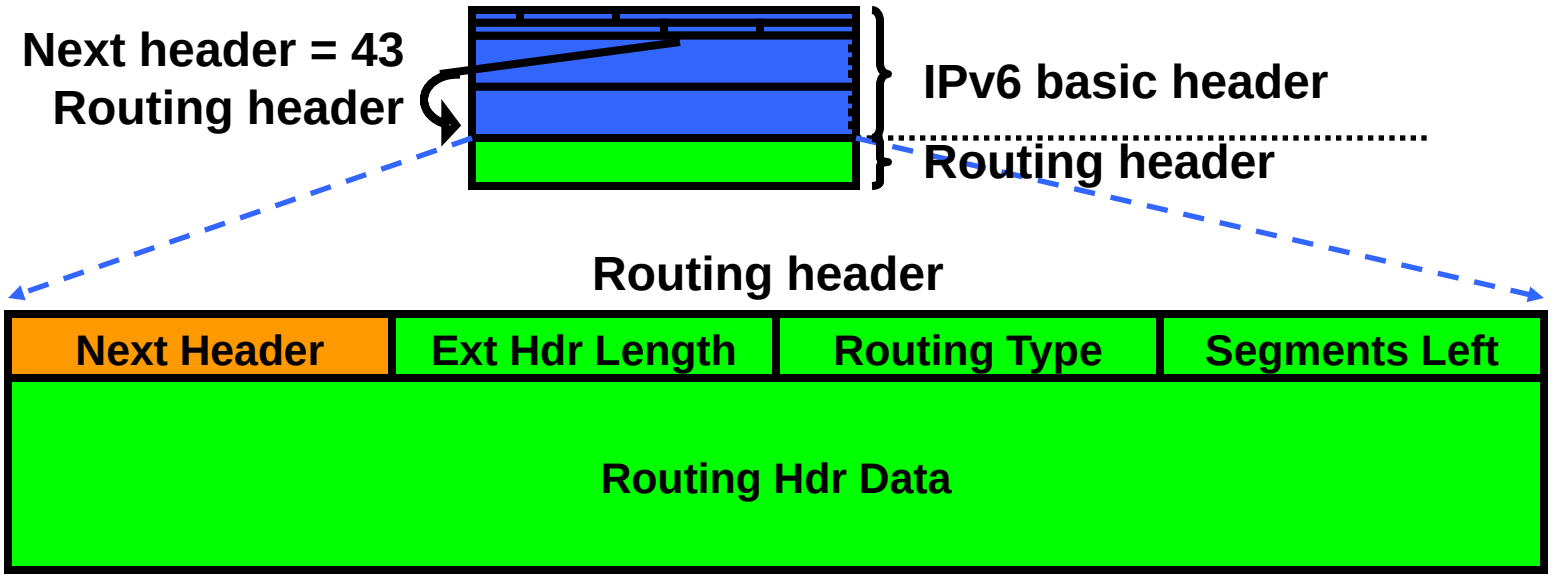
AH and ESP header

- **Used within IPSec**
- **Identical to the IPv4 version**

Upper-layer header:

- **Used for the transport function (TCP or UDP)**

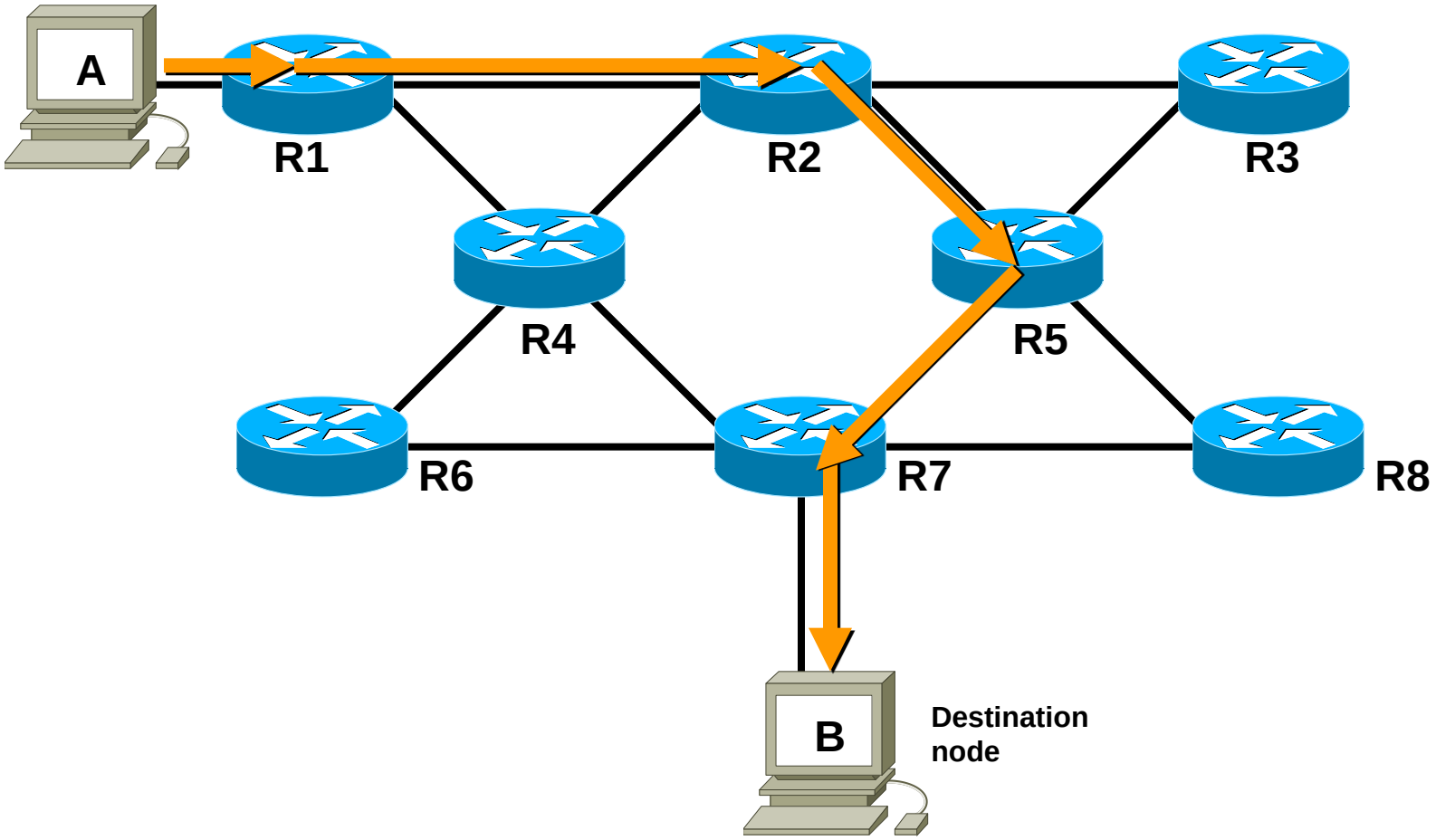
Routing Header Format



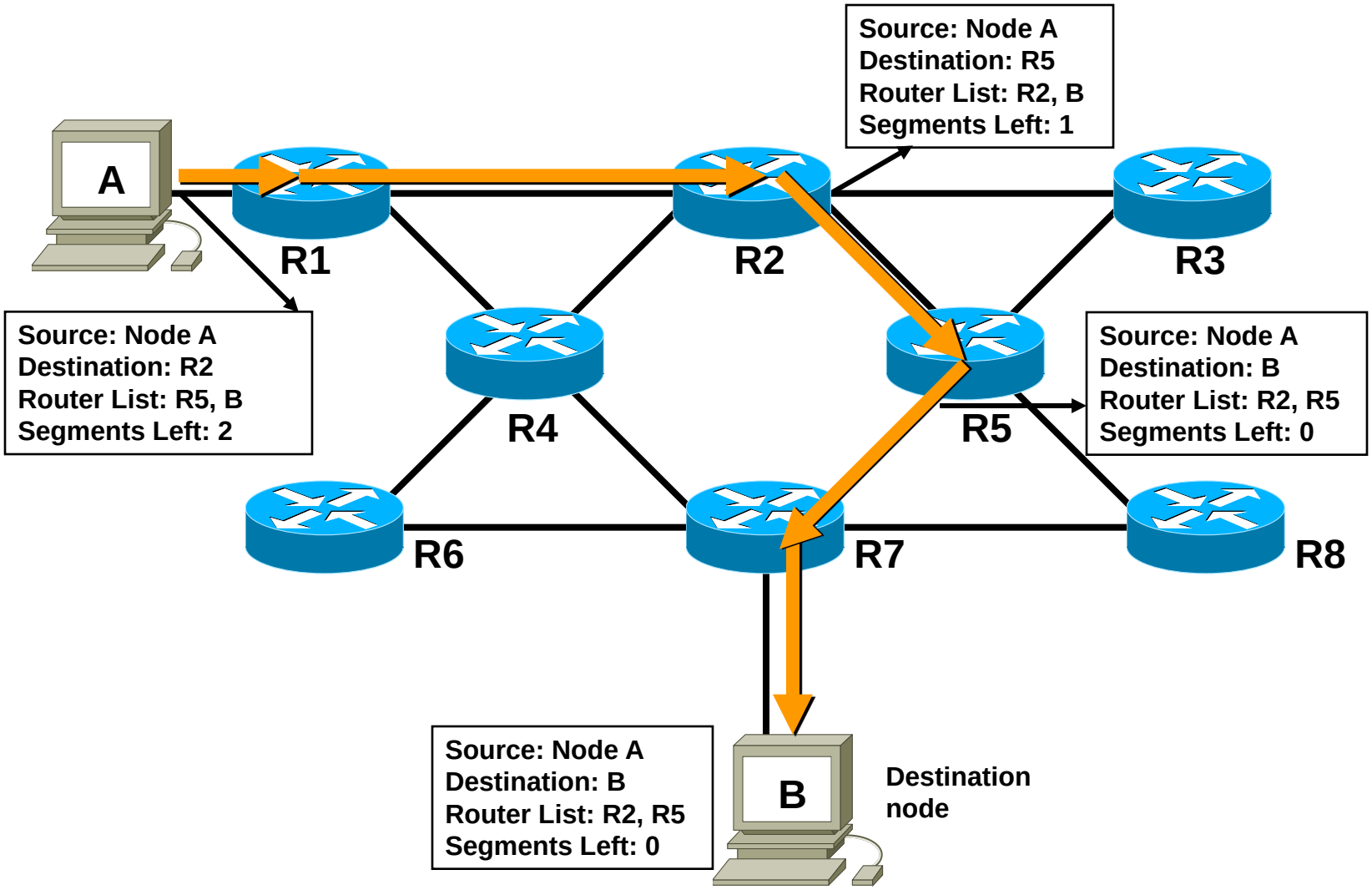
Routing header is:

- An extension header
- Processed by the listed intermediate routers

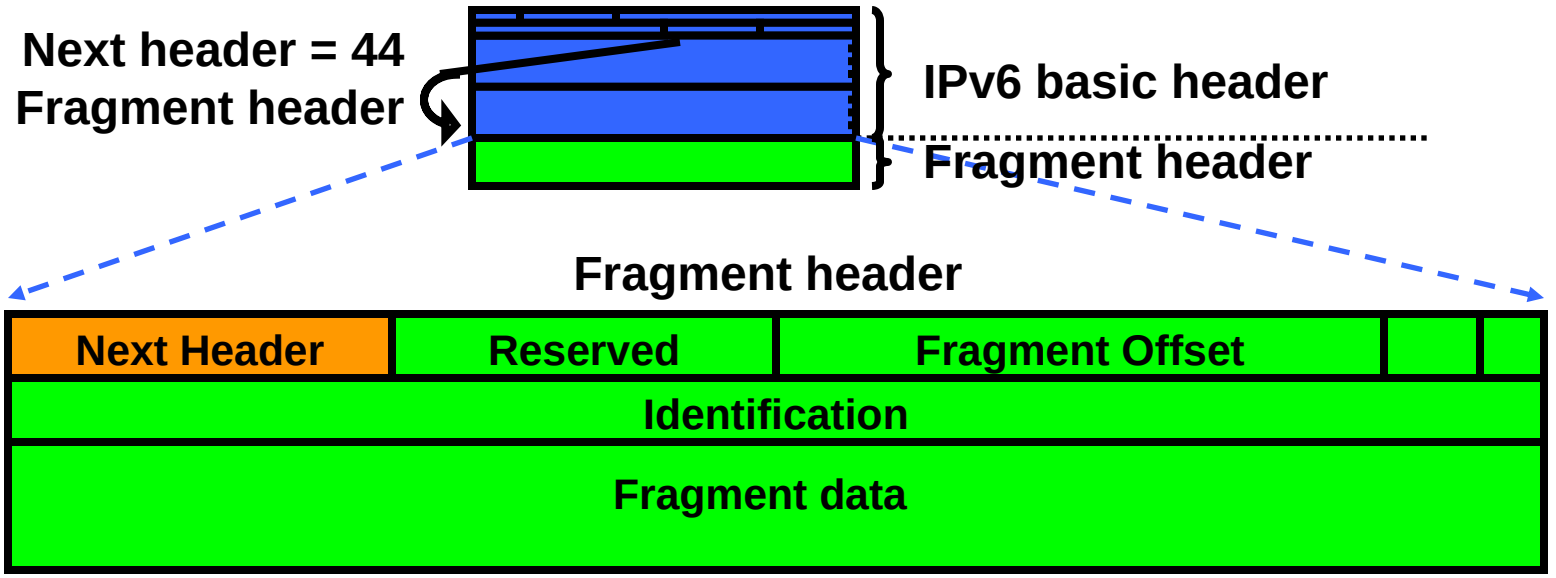
Source Routing Header Operation



Source Routing Header Operation (Cont.)

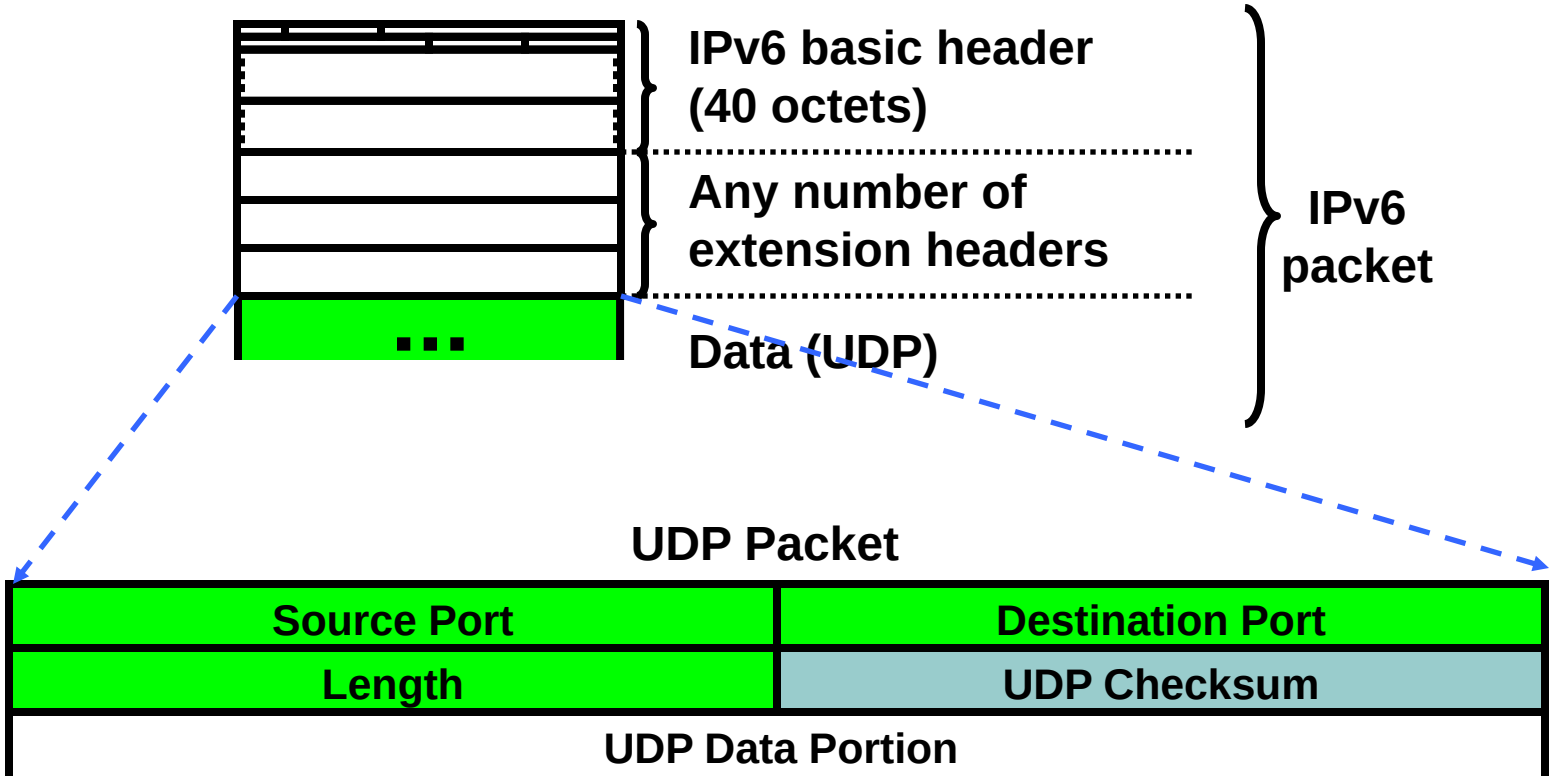


Fragment Header



A fragment header is used when a node must send a packet larger than the path MTU.

User Datagram Protocol



UDP checksum must be computed.