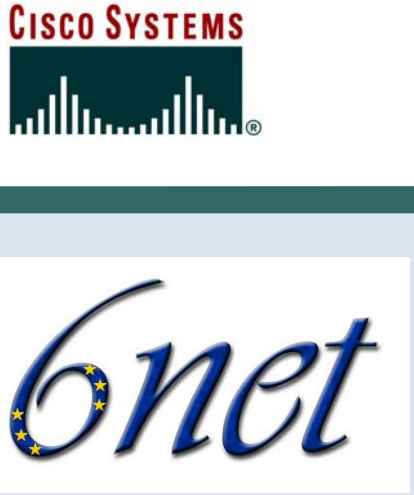

Introduction to IPv6

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Agenda

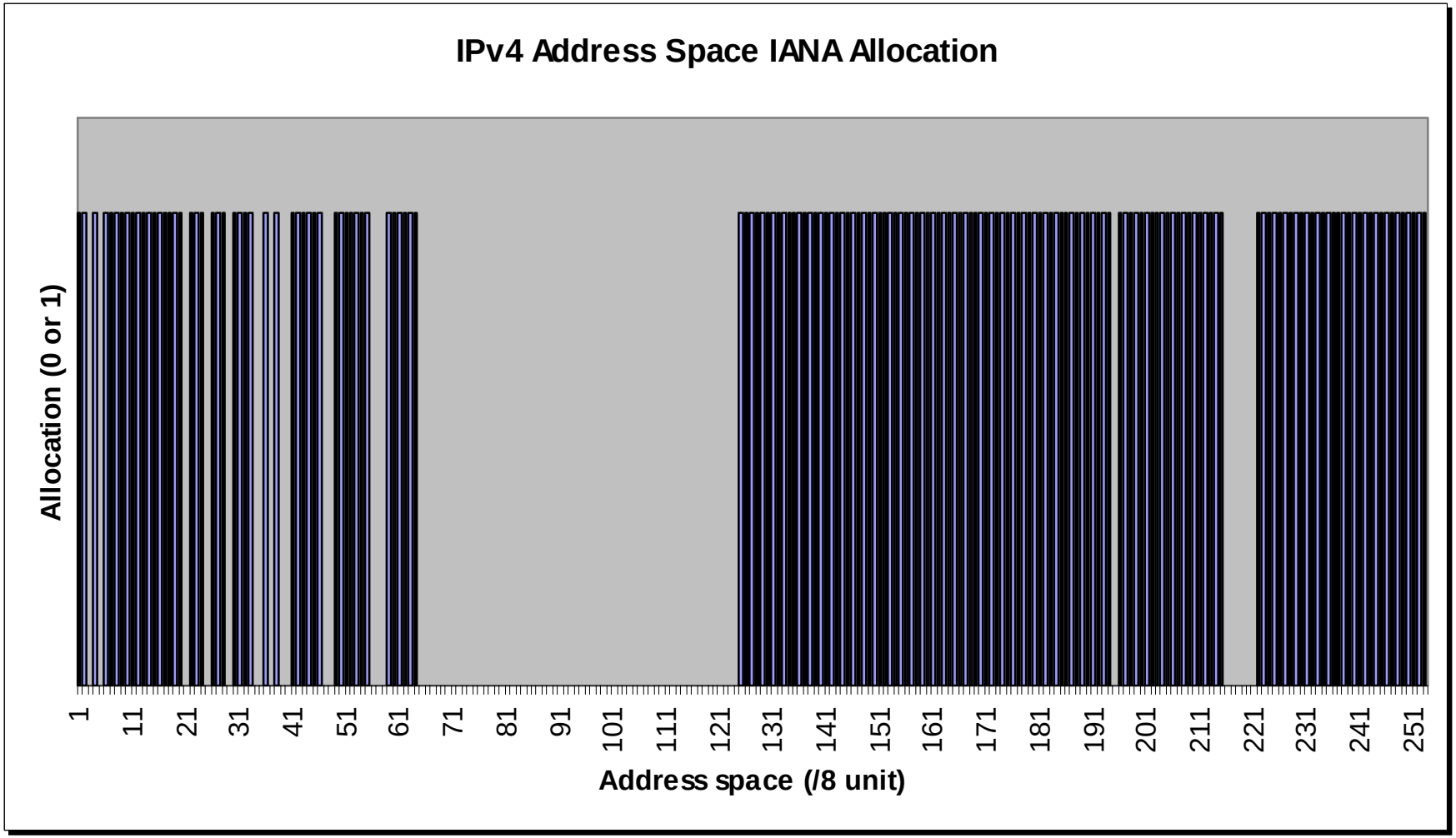
- **Rationale**
- **Features**

Agenda

Rationale

Features

IPv4 Address Space



Address Space Exhaustion

- **Preliminary study in 1990:**

  Exhaustion of IPv4 Class B in 1994

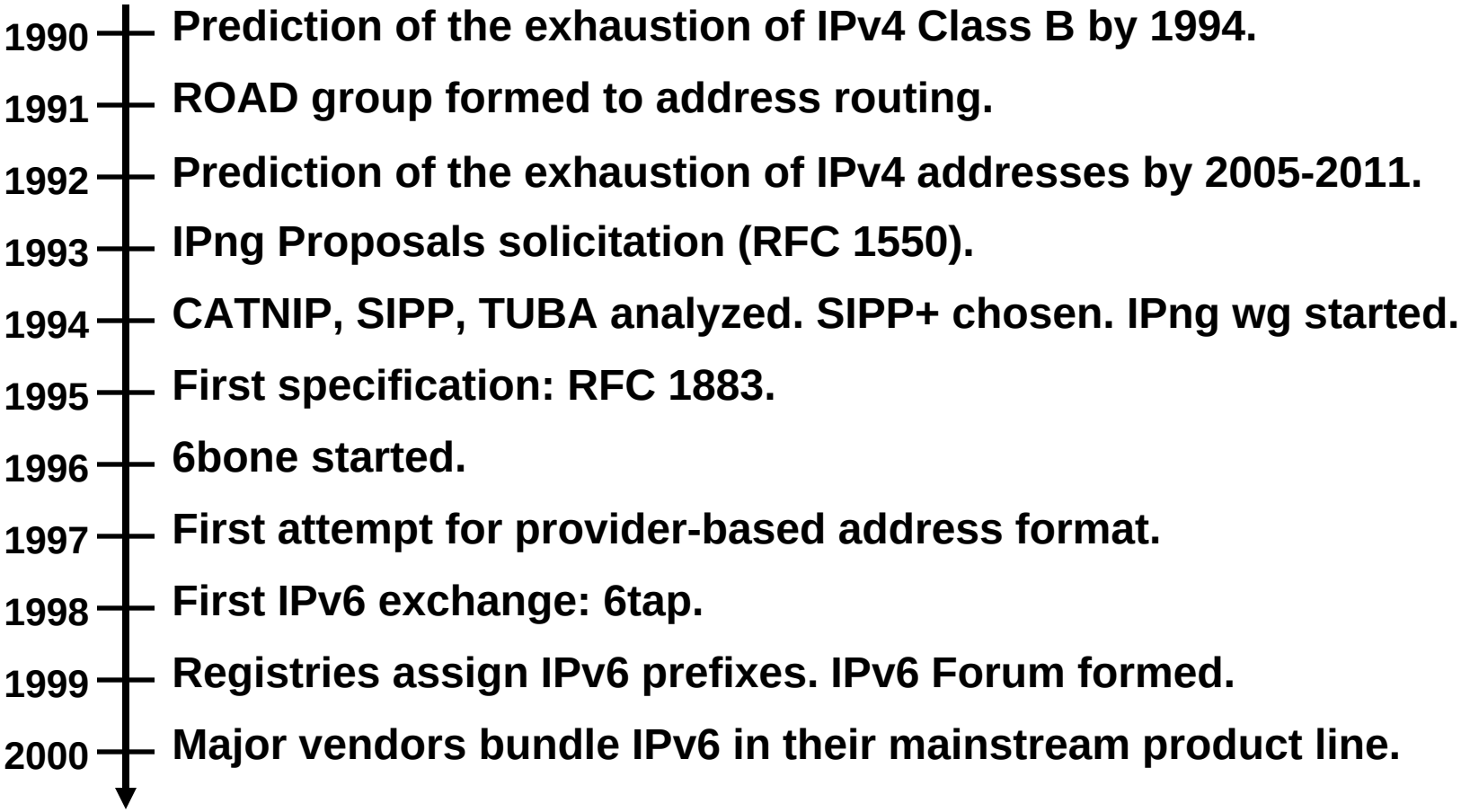
  Solution: classless interdomain routing (CIDR) with multiple Class C

- **New study:**

  Projection for 2005-2011 before complete exhaustion of addresses

  Consequence: "enough" time to design a new protocol

Short History of IPv6



IPv5

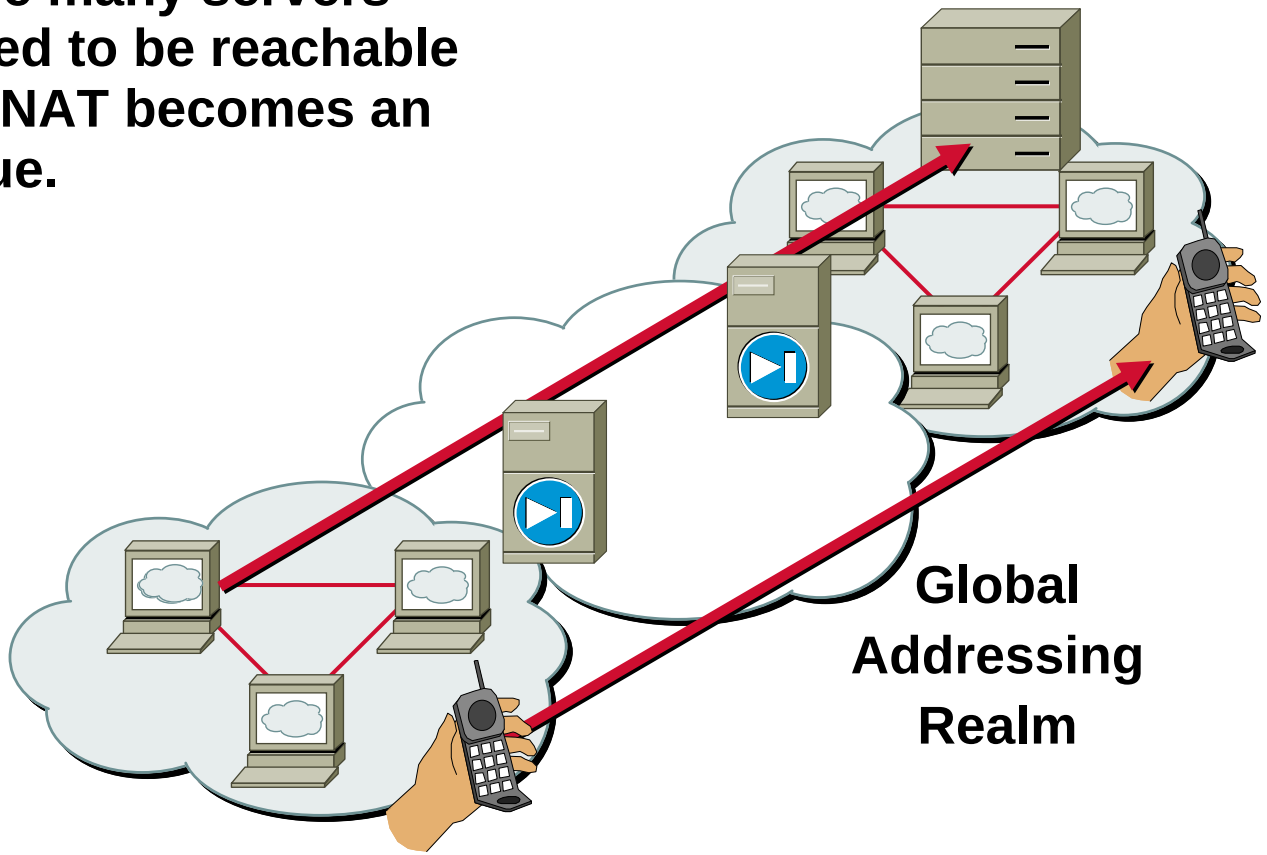
- IPv5 is the IP protocol number of the Stream Protocol (ST), as it uses the same link-layer framing as IPv4
- Experimental protocol
- Addresses resource reservation
- Designed to coexist with IPv4, not a replacement—same addressing scheme
- Resource reservation is now done using other protocols

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
  - Inhibits end-to-end network security
  - When a new application is not NAT-friendly, NAT device requires an upgrade
  - Application-level gateways (ALG) are not as fast as IP routing
  - Merging of private-addressed networks is difficult

NAT Inhibits Access To Internal Servers

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



Agenda

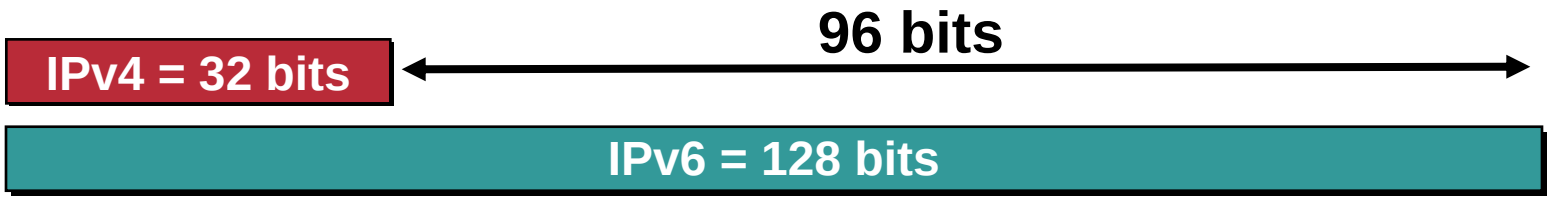
Rationale

Features

IPv6 Main Features

- **Larger address space enables:**
  - **Global reachability, flexibility, aggregation, multihoming, autoconfiguration, plug and play" and renumbering**
- **Simpler header enables:**
  - **Routing efficiency, performance and forwarding rate scalability**
- **Security and mobility**
- **Transition richness**

Larger Address Space



- **IPv4**

  32 bits

  =~ 4,200,000,000 possible addressable nodes

- **IPv6**

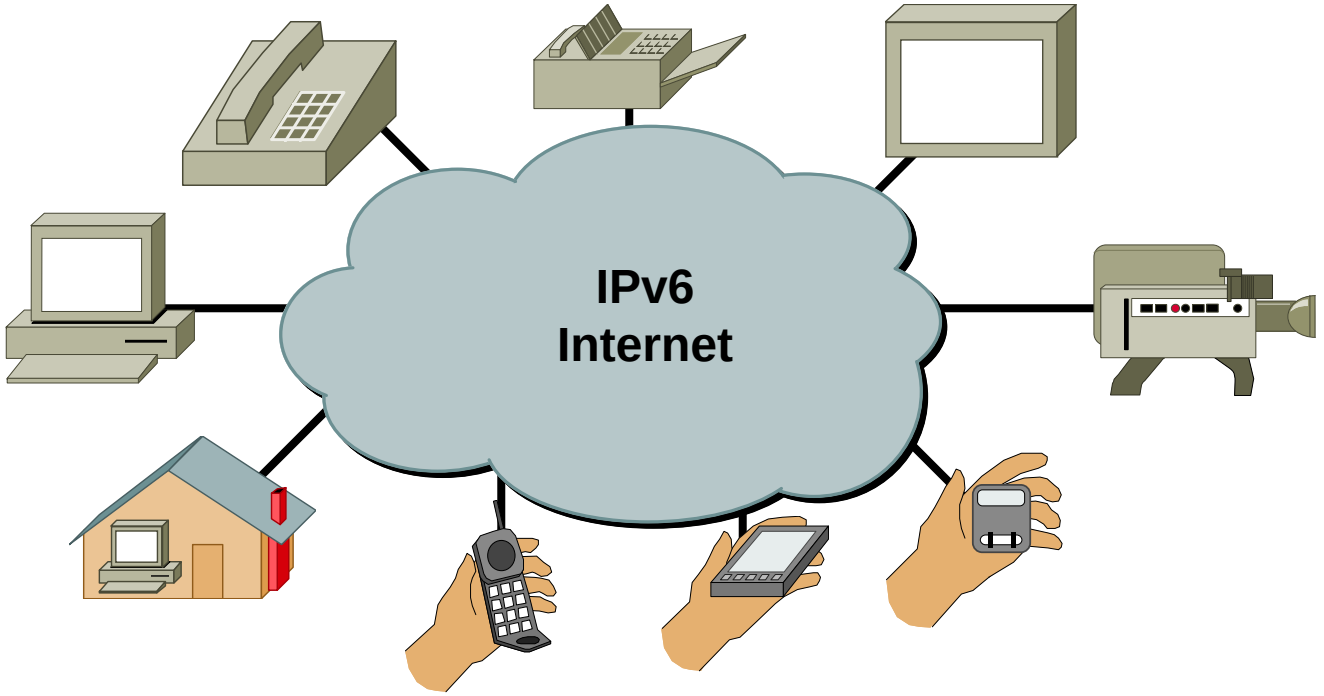
  128 bits: 4 times the size in bits

  =~ 3,4 * 10^{38} possible addressable nodes

  =~340,282,366,920,938,463,374,607,432,768,211,456

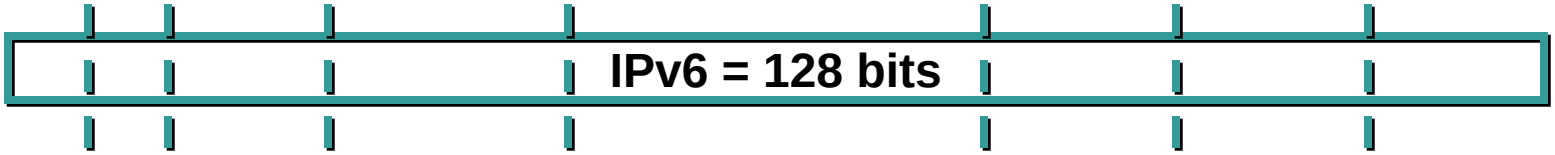
  =~ 10^{30} addresses per person on the planet

Global Reachability



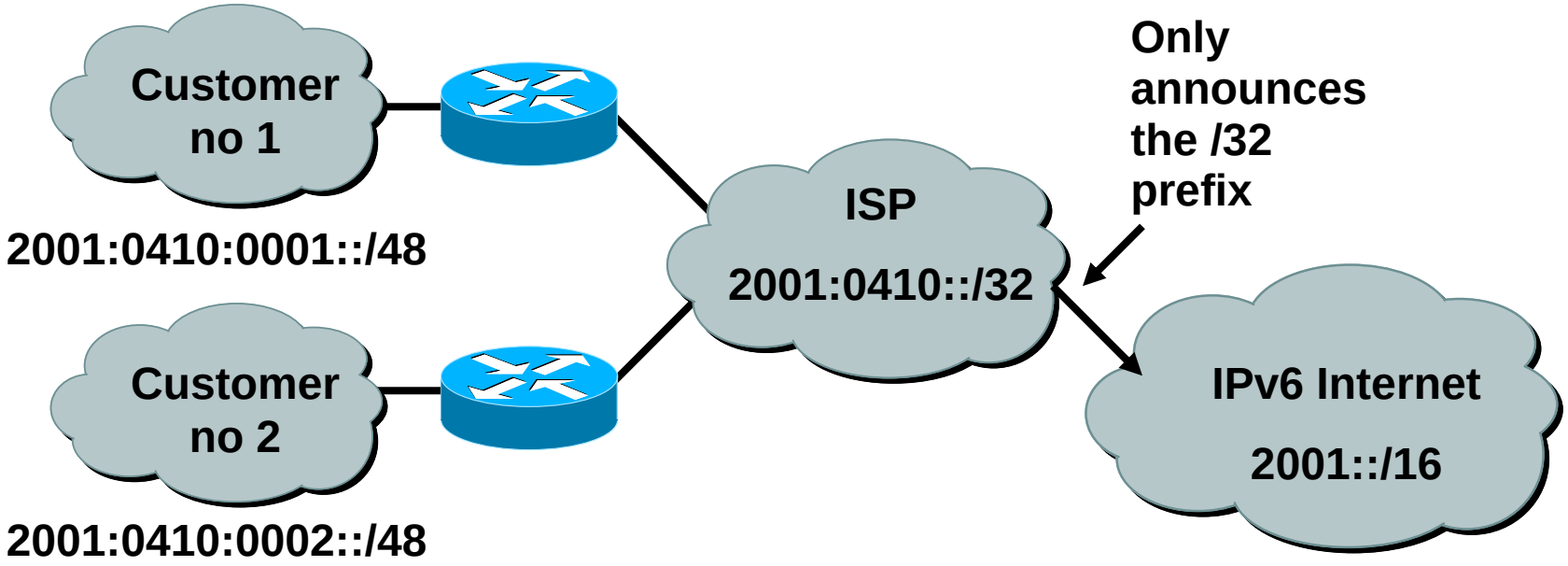
- **Larger address space enables:**
  - **A globally reachable address for everything**
  - **End-to-end reachability, full support of application protocols, end-to-end security**

Multiple Levels of Addressing Hierarchy



- **Larger address space enables:**
  - **Possibility of multiple levels of hierarchy inside the address space**
  - **More flexibility, new functionalities**

Aggregation

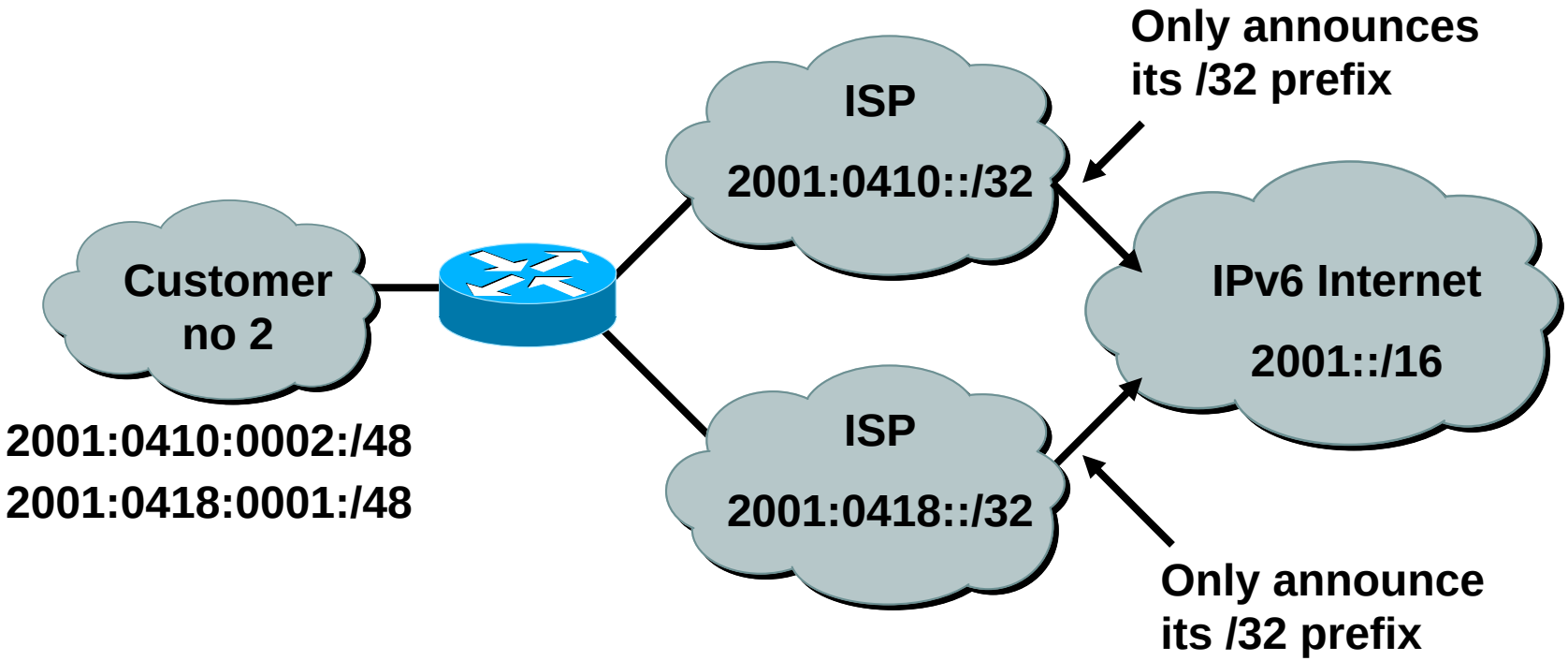


Larger address space enables:

Aggregation of prefixes announced in the global routing table

Efficient and scalable routing

Multiple Addresses

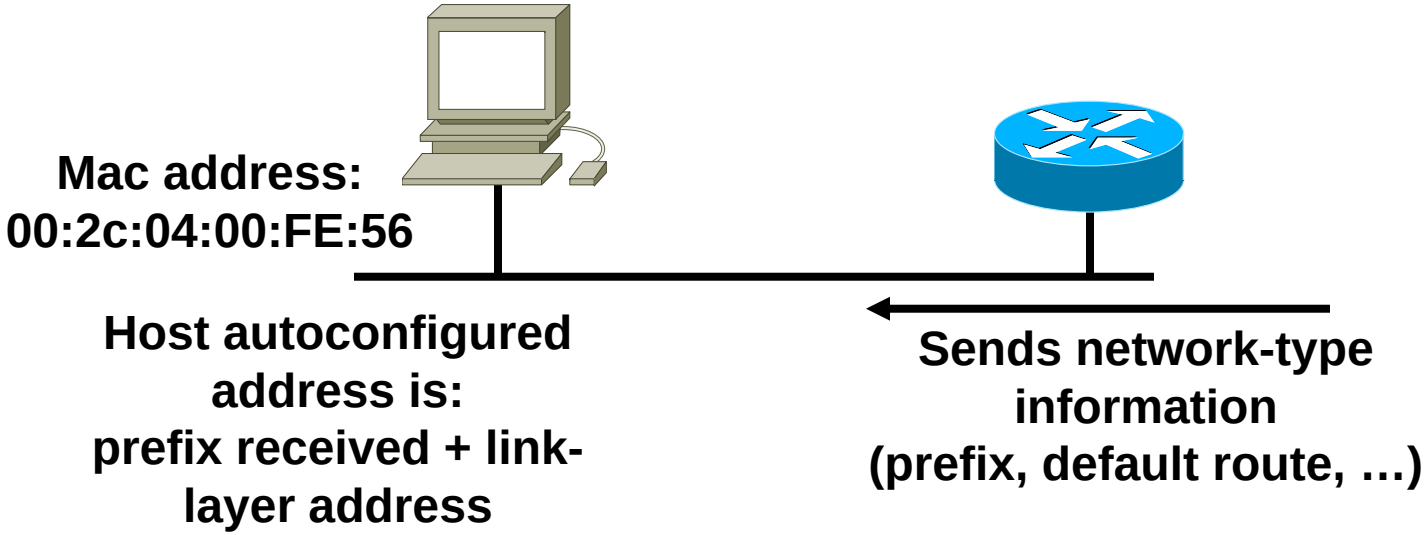


Larger address space enables:

Multiple simultaneous addresses for hosts and networks

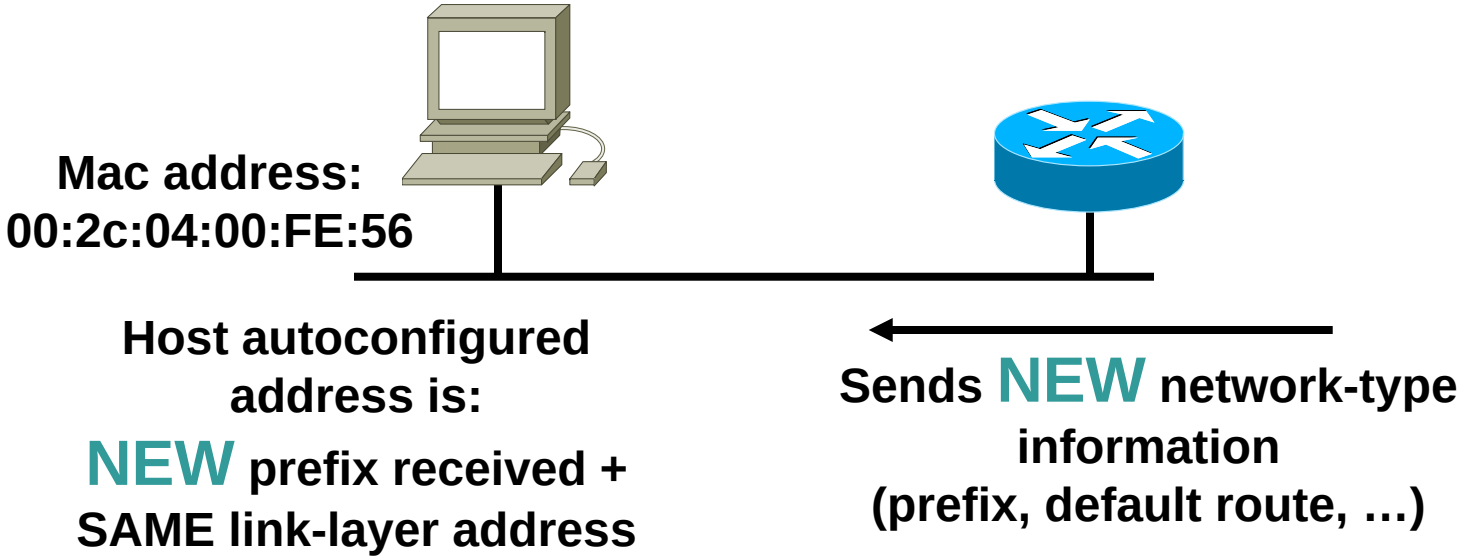
Support of multihoming

Autoconfiguration



- **Larger address space enables:**
  - **The use of link-layer addresses inside the address space**
  - **Autoconfiguration with "no collisions"**
  - **Offers "plug and play"**

Renumbering



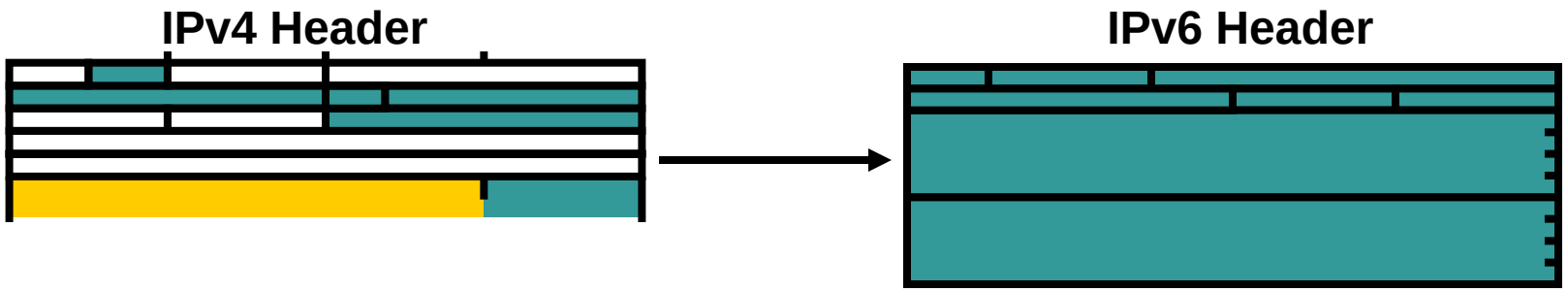
Larger address space enables:

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 hang up a network ("broadcast storm")**
- **Broadcasts in IPv6**
  - **Are not used and replaced by multicast**
- **Multicast**
  - **Enables the efficient use of the network**
  - **Multicast address range is much larger**

Simple and Efficient Header



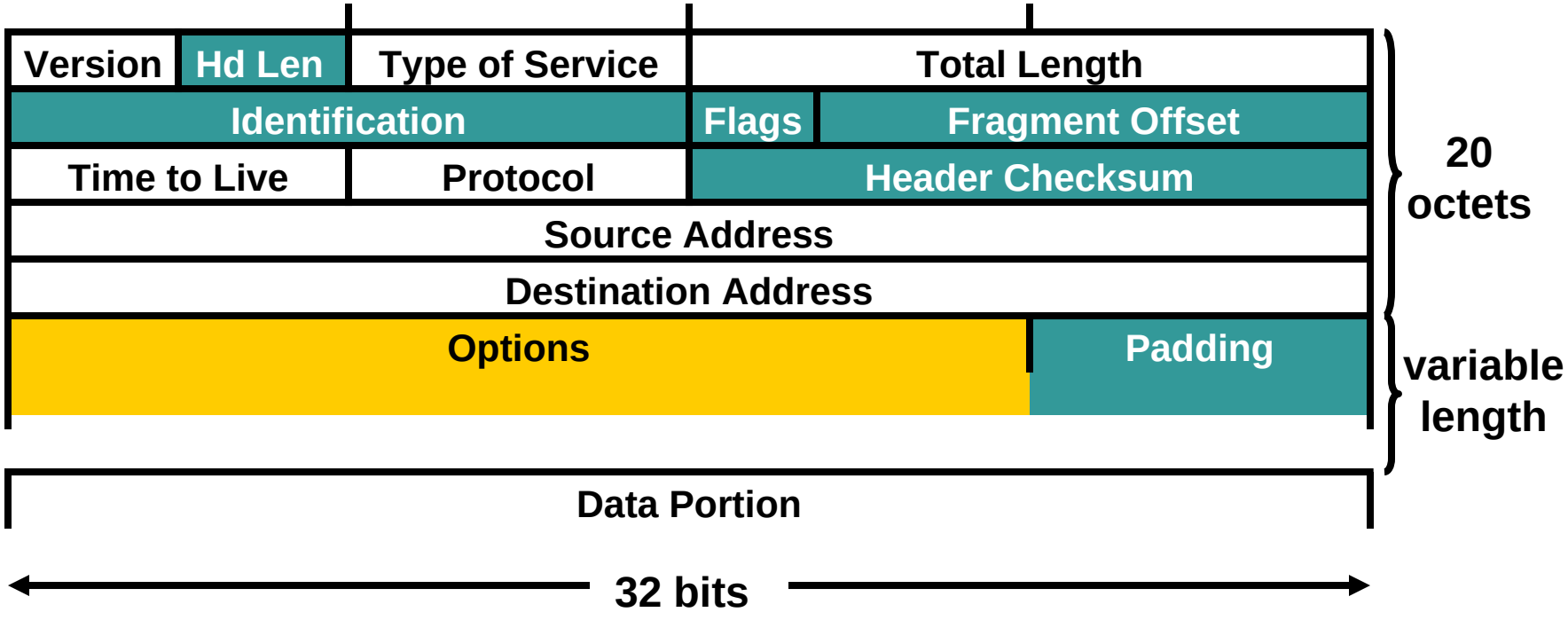
- **Simpler and Efficient Header means:**

  64-bit aligned fields and fewer fields

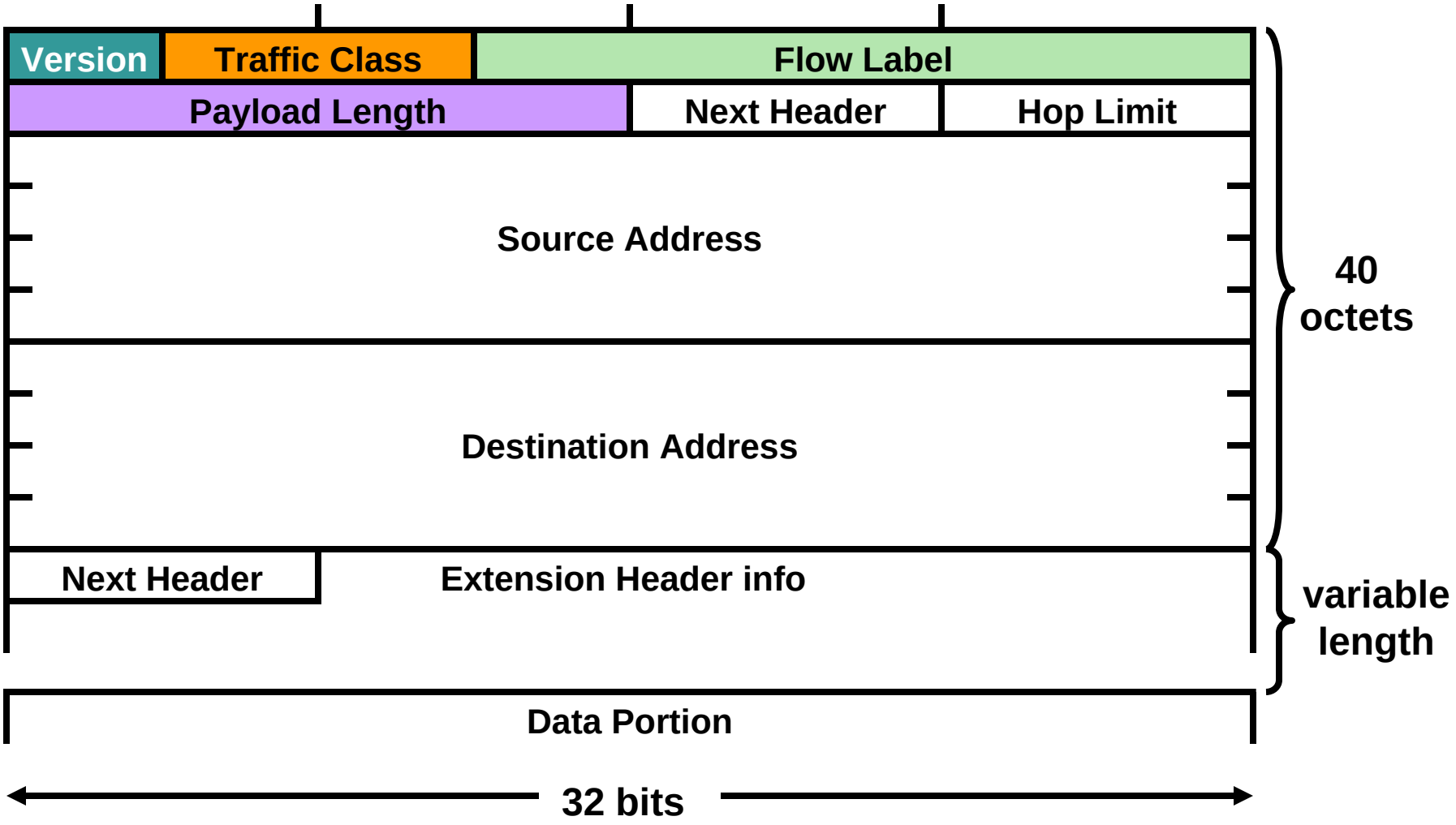
  Hardware-based efficient processing

  Improving routing efficiency, performance and forwarding rate scalability

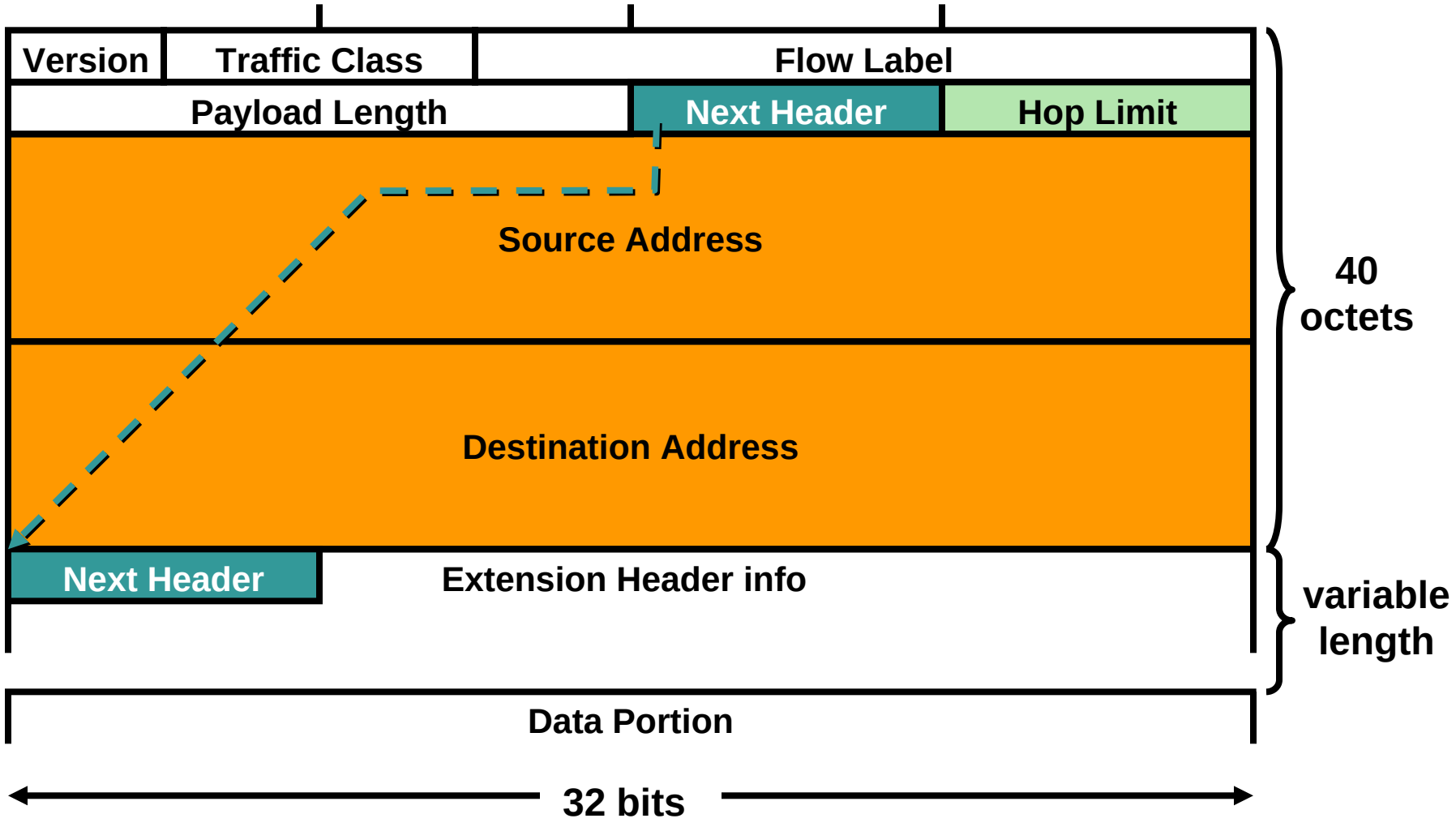
IPv4 Header Format



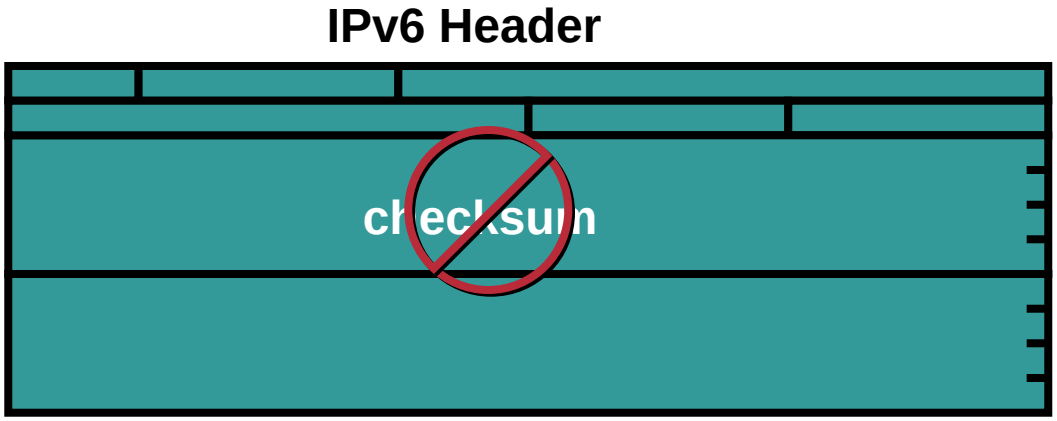
IPv6 Header Format



IPv6 Header Format (cont.)



No Checksum



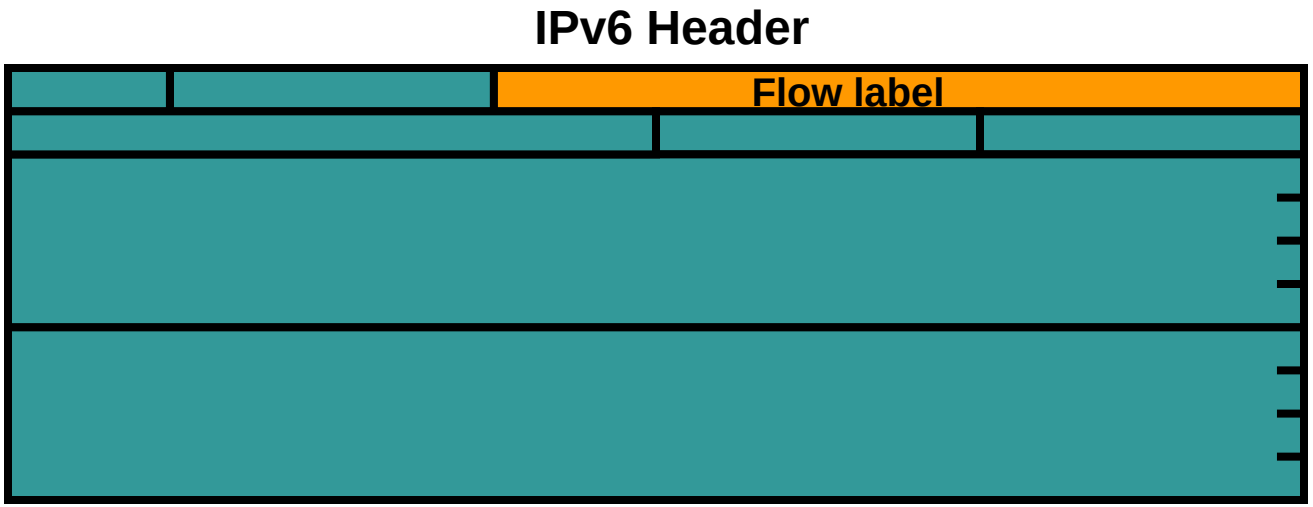
- **Simpler and Efficient Header means:**

No checksum at the IP layer. No recalculation by the routers.

Improved routing efficiency, performance and forwarding rate scalability.

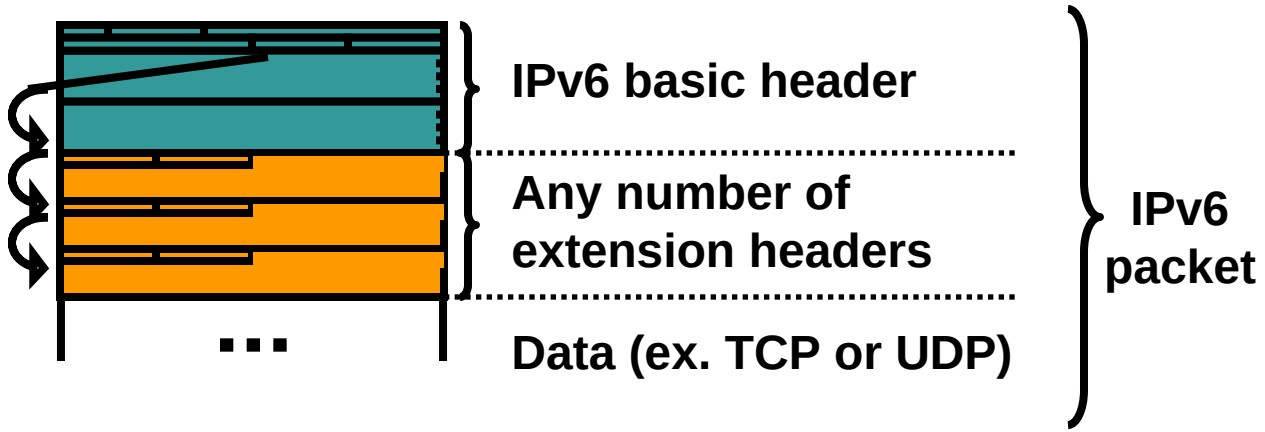
Error detection is done by link layer and transport layer.

New Flow Label



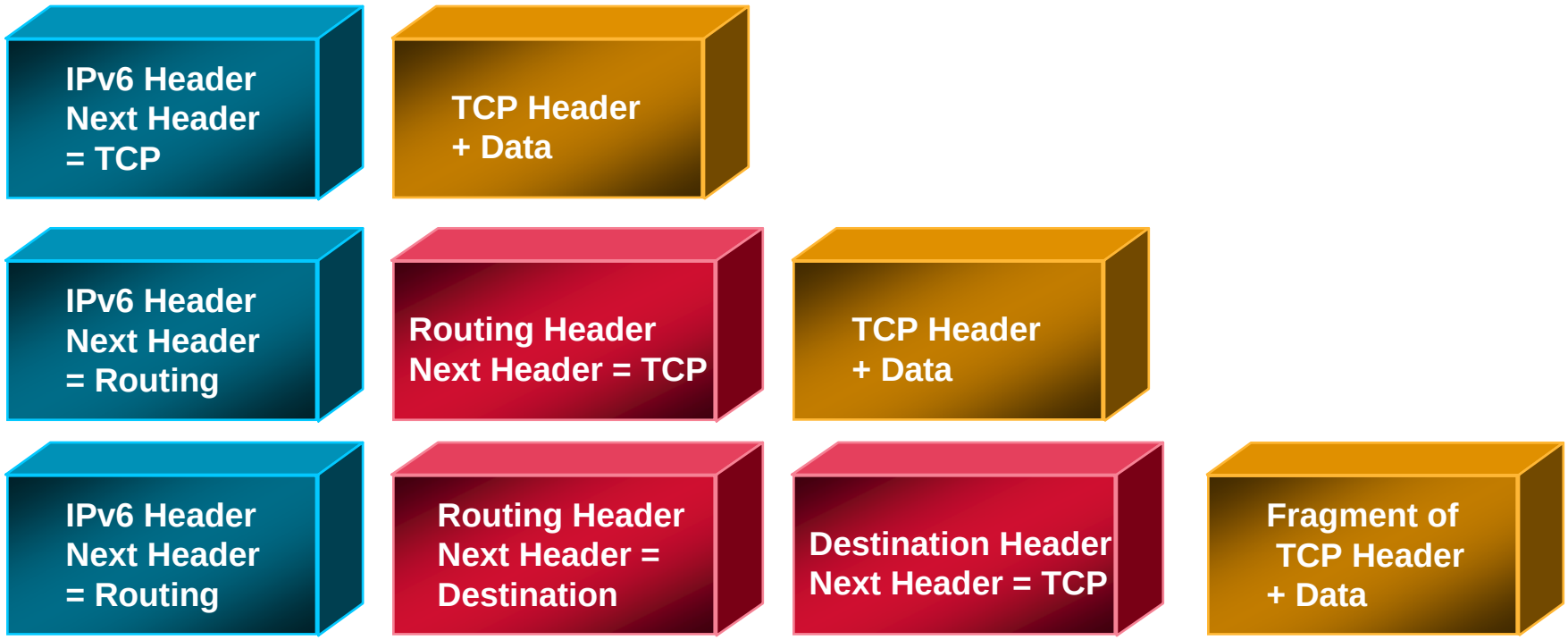
- **Simpler and Efficient Header means:**
  - **A new flow label inside the IP header**
  - **Enables per flow processing for differentiation at the IP layer**
  - **Length of 20 bits**

Extension Headers



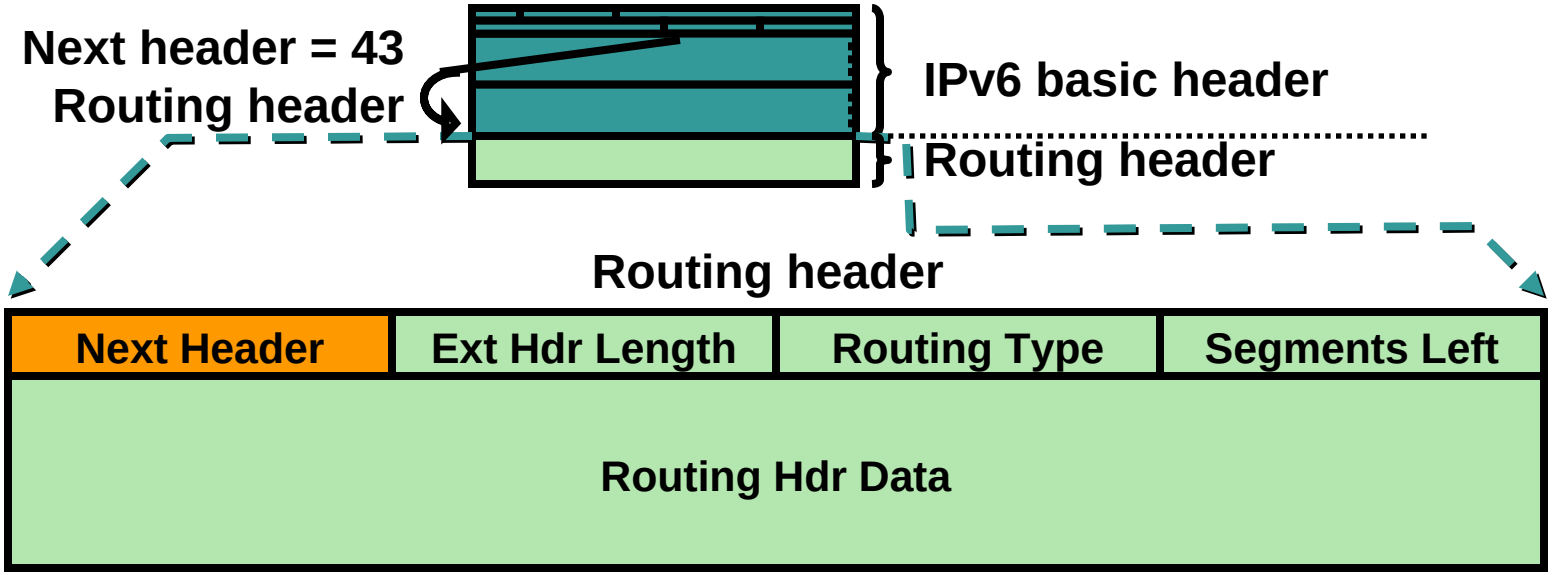
- **Simpler and more efficient Header means:**
  - **Extension headers**
  - **Manages the options more efficiently**
  - **Enables faster forwarding rate and end-nodes processing**

Extension Headers



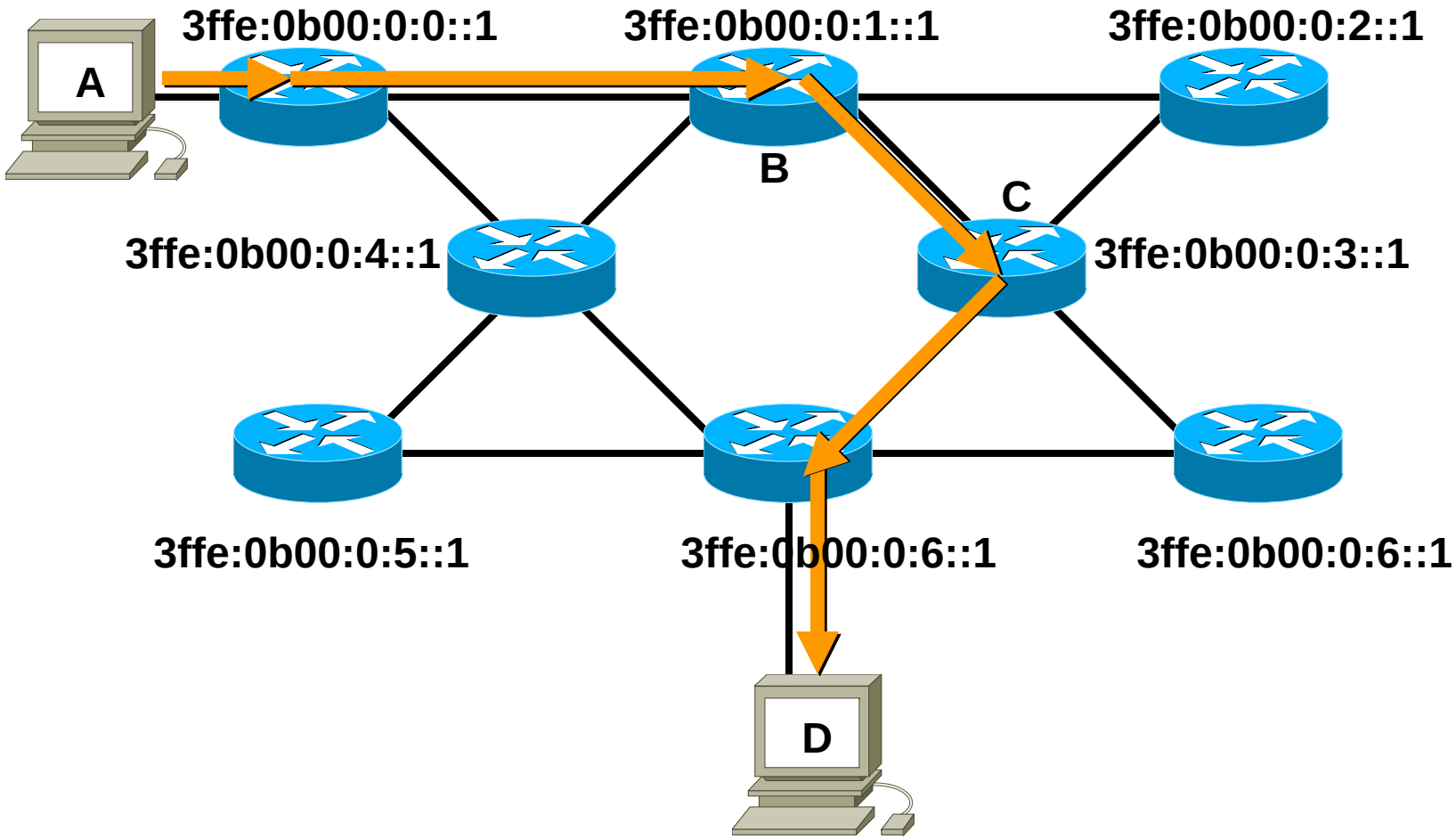
Extension headers are daisy chained

Routing Header



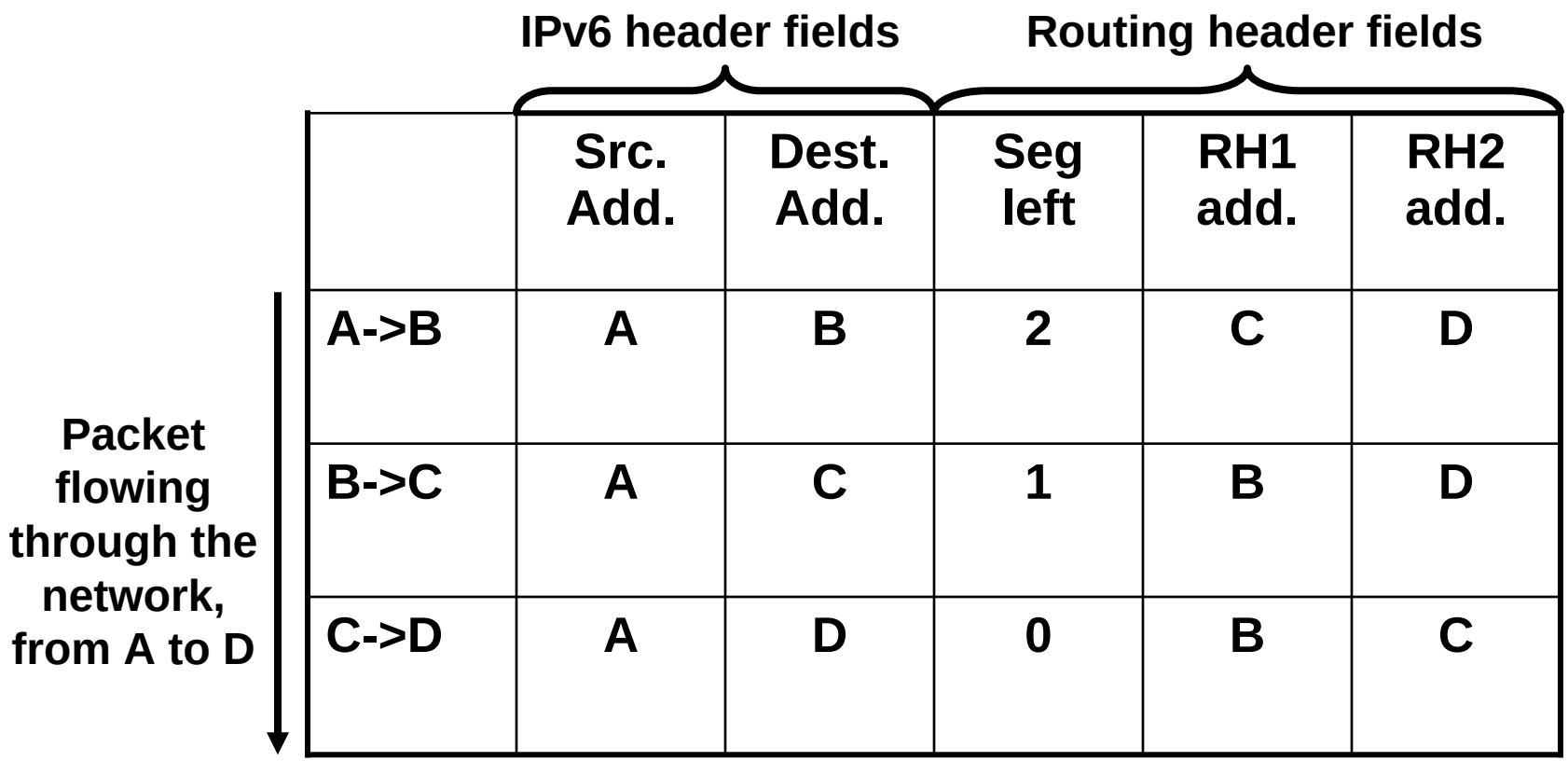
- **Routing header is:**
  - **An extension header**
  - **Processed by the listed intermediate routers**

Routing Header (cont.)

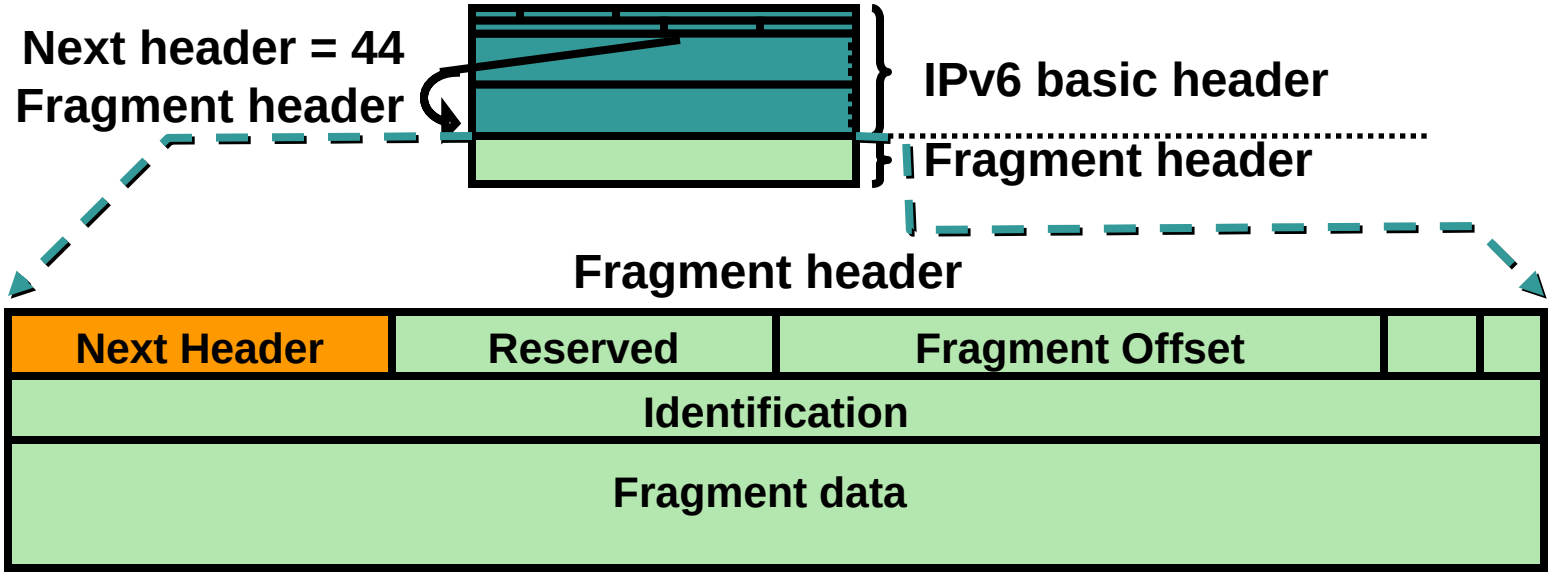


- Routing type 0: Routers list = 3ffe:0b00:0:1::1, 3ffe:0b00:0:3::1

Routing Header (cont.)



Fragment Header



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

Other Extension Headers

Hop-by-Hop header:

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

Destination Options header:

- **Processed only by the destination node**

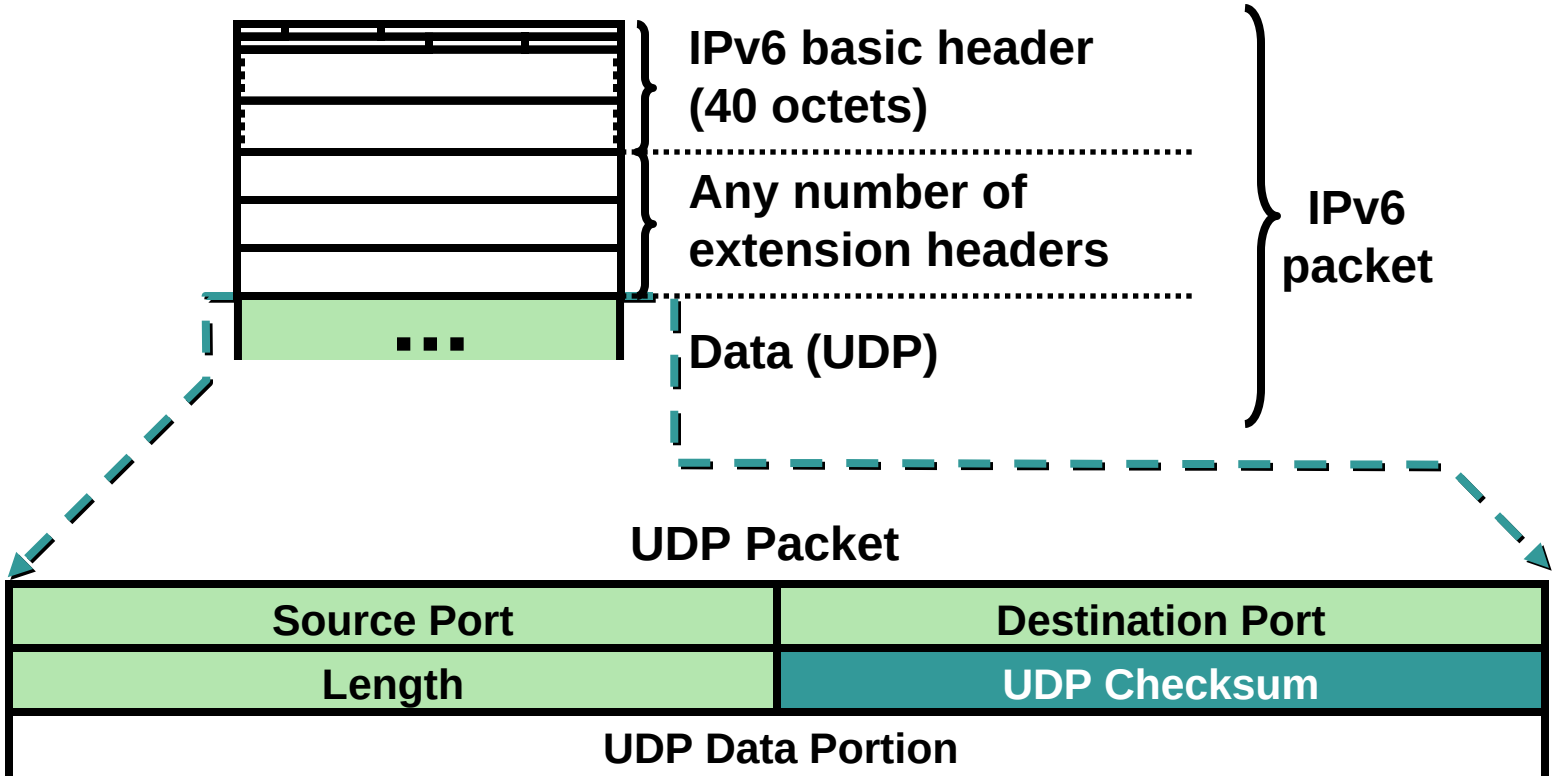
Authentication and Encapsulating Security Payload headers:

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

Upper-Layer headers:

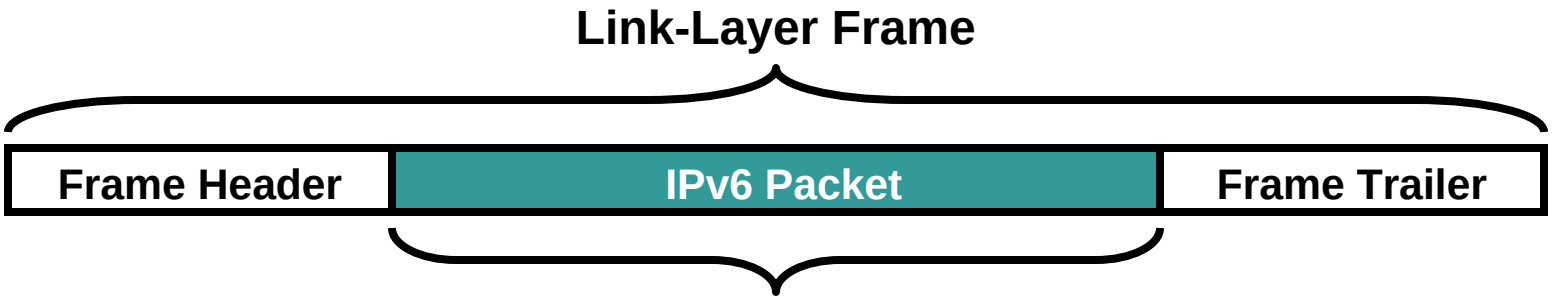
- **Used for the transport function (TCP or UDP)**

User Datagram Protocol



- UDP checksum must be computed.

Maximum Transmission Unit



IPv4

MTU >= 68 octets

IPv6

MTU >= 1280 octets

Path MTU is used

Address Representation

- **Format:**

x:x:x:x:x:x:x:x where x is 16 bits hexadecimal field

2031:0000:130F:0000:0000:09C0:876A:130B

Case insensitive

Leading zeros in a field are optional:

2031:0:130F:0:0:9C0:876A:130B

Successive fields of 0 are represented as ::, but only once in an address:

2031:0:130F::9C0:876A:130B

2031::130F::9C0:876A:130B

FF01:0:0:0:0:0:1 => FF01::1

0:0:0:0:0:0:1 => ::1

0:0:0:0:0:0:0 => ::

Address Representation

- **Format:**

  IPv4-compatible:

  0:0:0:0:0:0:192.168.30.1

  = ::192.168.30.1

  = ::C0A8:1E01

  In a URL, it is enclosed in brackets

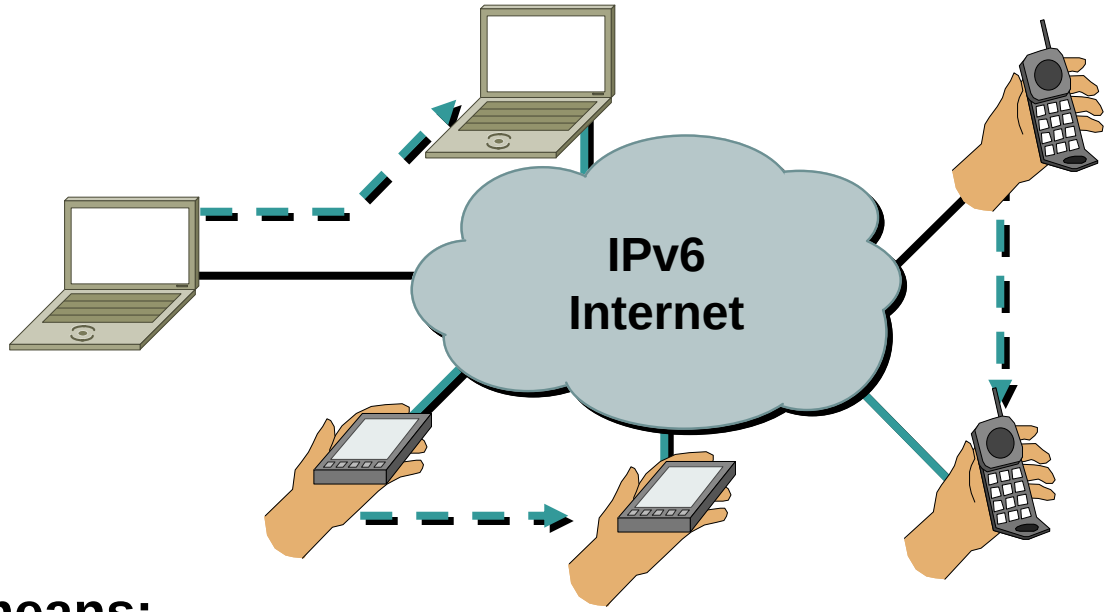
  http://[2001:1:4F3A::206:AE14]:8080/index.html

  Cumbersome for users

  Mostly for diagnostic purposes

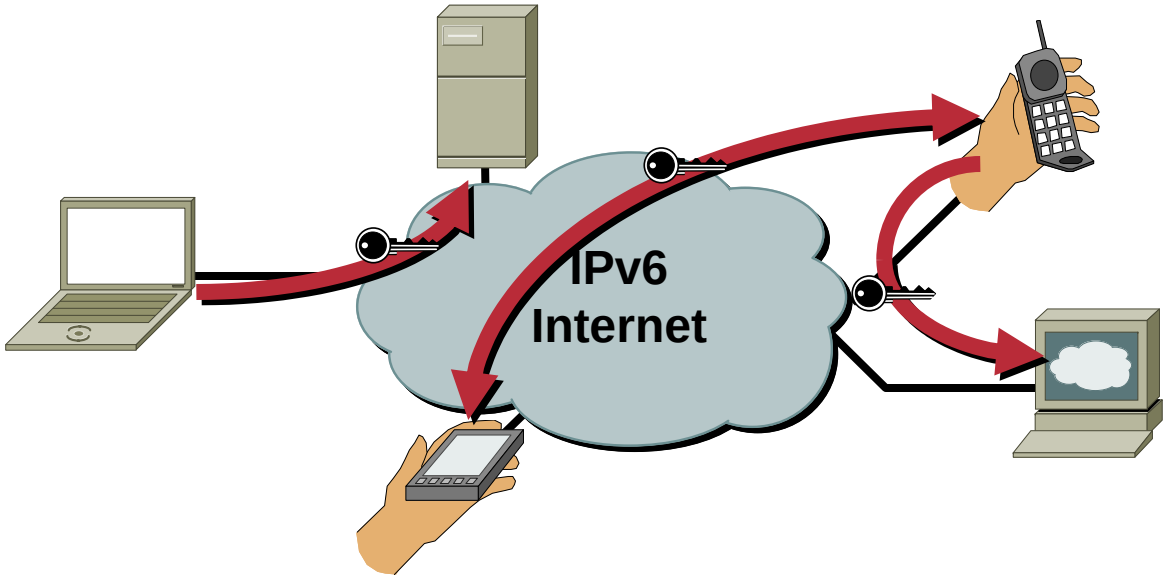
  Use fully qualified domain names (FQDN)

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



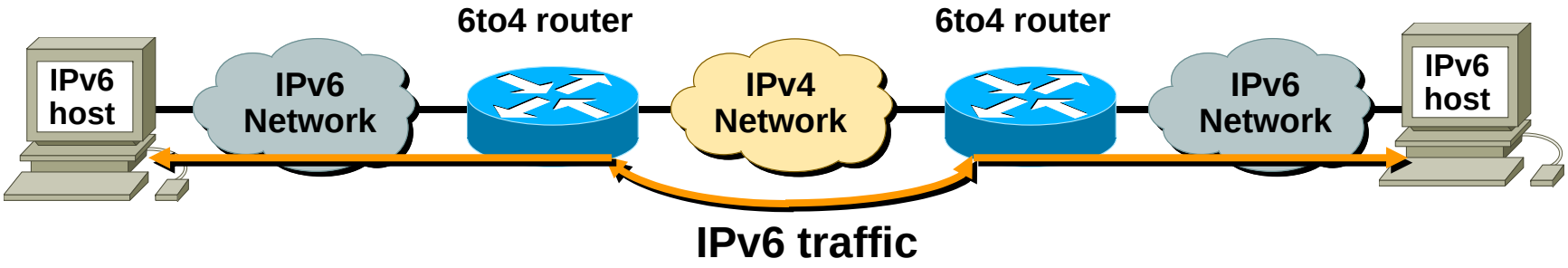
- **Security means:**

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 together

Not a Feature

Quality of service

QoS has been mentioned as an IPv6 feature—in fact, it is not

No difference on protocols and methods to do QoS in IPv4 and IPv6

The IPv6 flow label can be used for QoS devices to identify specific flows

The flow label itself is not a QoS feature

Questions?