# PART XXXI

# THE FUTURE OF TCP/IP (IPv6)

# Current Version

- TCP/IP has worked well for over 25 years
- Design is flexible and powerful
- Has adapted to
  - New computer and communication technologies
  - New applications
  - Increases in size and load

# Most Significant Technical Problem

- Address space limitation
- IPv4 address space may be exhausted by the year 2020

# History Of The New Version

- Developed by IETF
- Started in early 1990s
- Input from many groups, including: computer manufacturers, hardware and software vendors, users, managers, programmers, telephone companies, and the cable television industry

# History Of The New Version (continued)

- Three main proposals
- Eventually new version emerged
- Assigned version number 6, and known as *IPv6*
- RFC in 1994
- Defined over 10 years ago!

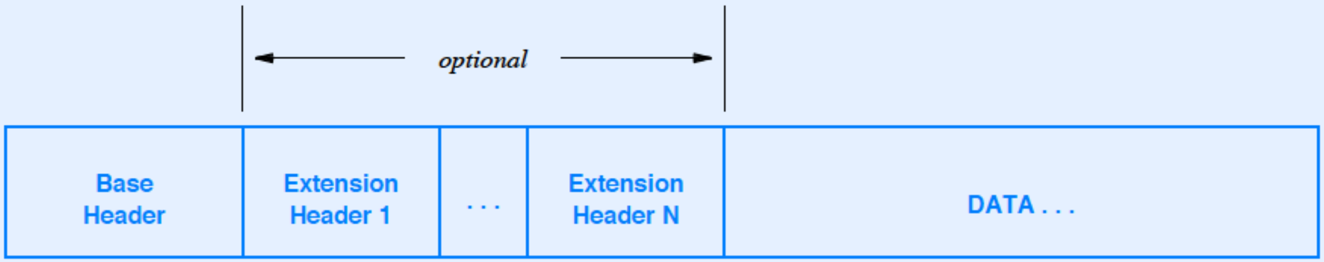
# Major Changes From IPv4

- Larger addresses
- Extended address hierarchy
- Variable header format
- Facilities for many options
- Provision for protocol extension
- Support for autoconfiguration and renumbering
- Support for resource allocation

# IPv6 Address Size

- 128 bits per address
- Absurd increase in capacity
- IPv6 has $10^{24}$ addresses per square meter of the Earth's surface!

# General Form Of IPv6 Datagram




- Base header required
- Extension headers optional

# IPv6 Base Header Format


- Alignment is on 64-bit multiples
- Fragmentation in extension header
- Flow label intended for resource reservation

# Size Of Base Header

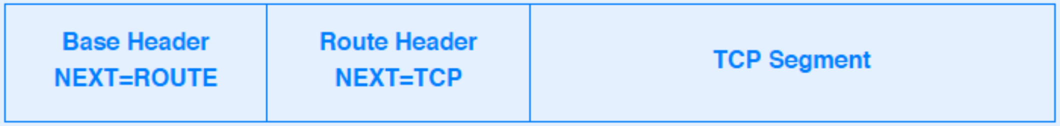
*Each IPv6 datagram begins with a 40-octet base header that includes fields for the source and destination addresses, the maximum hop limit, the traffic class, the flow label, and the type of the next header. Thus, an IPv6 datagram must contain at least 40 octets in addition to the data.*

# IPv6 Extension Headers

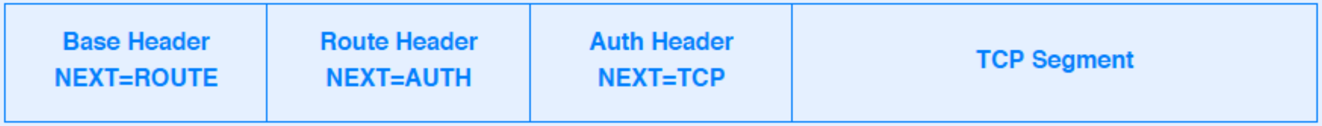
- Sender chooses zero or more extension headers
- Only those facilities that are needed should be included

# Parsing An IPv6 Datagram


*(a)*




*(b)*




*(c)*

- Each header includes *NEXT HEADER* field
- *NEXT HEADER* operates like type field

# IPv6 Fragmentation And Reassembly

- Like IPv4
  - Ultimate destination reassembles
- Unlike IPv4
  - Routers avoid fragmentation
  - Original source must fragment

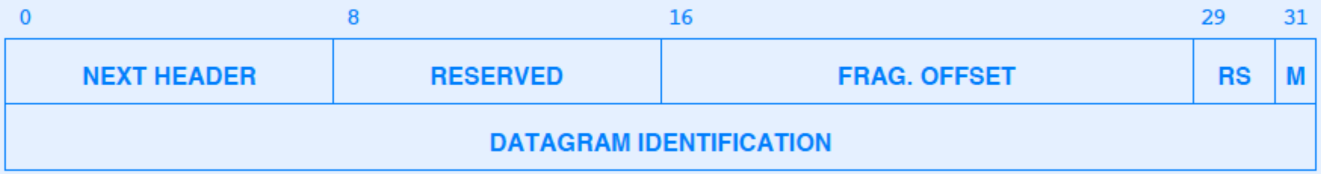
# How Can Original Source Fragment?

- Option 1: choose minimum guaranteed MTU of 1280
- Option 2: use path MTU discovery

# Path MTU Discovery

- Guessing game
- Source sends datagram without fragmenting
- If router cannot forward, router sends back ICMP error message
- Source tries smaller MTU

# Fragmentation Details




- Fragmentation information carried in extension header

# Discussion Questions

- Is fragmentation desirable?
- What are the consequences of the IPv6 design?

# IPv6 Colon Hexadecimal Notation

- Replaces dotted decimal
- Example: dotted decimal value

104.230.140.100.255.255.255.255.0.0.17.128.150.10.255.255

- Becomes

68E6:8C64:FFFF:FFFF:0:1180:96A:FFFF

# Zero Compression

- Successive zeroes are indicated by a pair of colons
- Example

FF05:0:0:0:0:0:0:B3

- Becomes

FF05::B3

# IPv6 Destination Addresses

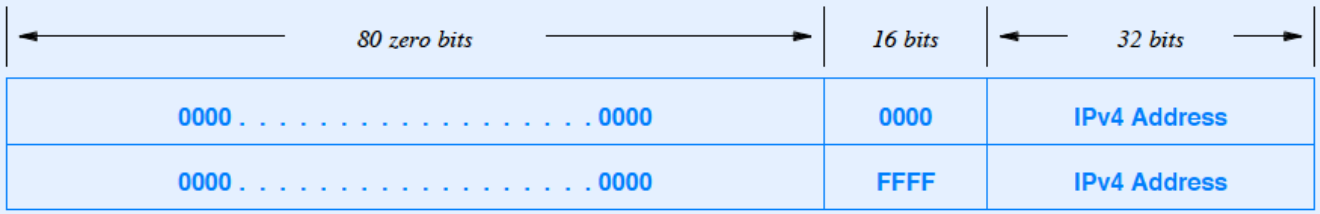
- Three types
  - Unicast (single host receives copy)
  - Multicast (set of hosts each receive a copy)
  - Anycast (set of hosts, one of which receives a copy)
- Note: no broadcast (but special multicast addresses (e.g., ‘‘all hosts on local wire’’)

# Proposed IPv6 Address Space

| Binary Prefix | Type Of Address | Part Of Address Space |
|---|---|---|
| 0000 0000 | Reserved (IPv4 compatibility) | 1/256 |
| 0000 0001 | Unassigned | 1/256 |
| 0000 001 | NSAP Addresses | 1/128 |
| 0000 01 | Unassigned | 1/64 |
| 0000 1 | Unassigned | 1/32 |
| 0001 | Unassigned | 1/16 |
| 001 | Global Unicast | 1/8 |
| 010 | Unassigned | 1/8 |
| 011 | Unassigned | 1/8 |
| 100 | Unassigned | 1/8 |
| 101 | Unassigned | 1/8 |
| 110 | Unassigned | 1/8 |
| 1110 | Unassigned | 1/16 |
| 1111 0 | Unassigned | 1/32 |
| 1111 10 | Unassigned | 1/64 |
| 1111 110 | Unassigned | 1/128 |
| 1111 1110 0 | Unassigned | 1/512 |
| 1111 1110 10 | Link-Local Unicast Addresses | 1/1024 |
| 1111 1110 11 | IANA - Reserved | 1/1024 |
| 1111 1111 | Multicast Addresses | 1/256 |

# Backward Compatibility

- Subset of IPv6 addresses encode IPv4 addresses
- Dotted hex notation can end with 4 octets in dotted decimal



# Myths About IPv6
# According To Geoff Huston

- IPv6 is
  - More secure
  - Required for mobility
  - Better for wireless networks
- IPv6 offers better QoS
- Only IPv6 supports auto-configuration
- IPv6 solves route scaling

# Myths About IPv6 According To Geoff Huston (continued)

- IPv6 provides better support for
  - Rapid prefix renumbering
  - Multihomed sites
- IPv4 has run out of addresses

Source: G. Huston, ‘‘The Mythology Of IP Version 6,’’ *The Internet Protocol Journal* vol. 6:2 (June, 2003)

# Summary

- IETF has defined next version of IP to be IPv6
- Addresses are 128 bits long
- Datagram starts with base header followed by zero or more extension headers
- Sender performs fragmentation
- Many myths abound about the advantages of IPv6
- No strong technical motivation for change