MODULE 11: The Internet Protocol Suite

Lecture 11.4
IP version 6

Prepared By:
- Scott F. Midkiff, PhD
- Luiz A. DaSilva, PhD
- Kendall E. Giles, PhD

Electrical and Computer Engineering
Virginia Tech

Lecture 11.4 Objectives

- Enumerate the main new features of IPv6 as compared to IPv4
- Enumerate the fields in an IPv6 header and explain some of the uses of optional extension headers
- Explain how the transition to IPv6 can occur and discuss changes brought about by the widespread deployment of IPv6

IPv6: Extended Address Space

- The primary motivation for a new version of IP is an extended address space
  - IPv4 uses 32-bit addresses while IPv6 uses 128-bit addresses
  - Larger address space to deal with more hosts and networks in the Internet
  - Promote the use of IP for embedded devices
  - Large address space also provides more flexibility in address assignment
    - Automatic configuration

IPv6: Simplified Processing at Routers

- IPv6 also addresses the problem of processing load on high-capacity backbone routers
- Increased address hierarchy reduces size of forwarding tables and routing updates
- Simplified header structure to reduce processing overhead
- Use of optional headers for additional functionality
- Fragmentation not allowed at intermediate routers
- Elimination of IP checksum (rely on other layers)
- New flow label allows routers to easily associate a packet with a flow for quality of service

IPv6: New Functionality

- Anycast addressing so that a packet can be addressed to one of a set of hosts
  - For example, a client request can be routed to the closest available server
- Simplified security using new security header
  - Authentication, data integrity, confidentiality
- Scope field for improved multicast addressing
  - For example, limit multicasts to an organization's network
- Improved support for mobility
  - More efficient than Mobile IP for IPv4

IPv6: Other Functionality

- Improved design for options using option headers
  - Option headers permit longer option fields
  - Easier to add options for new functions
- Interoperability with IPv4
  - Transition from IPv4 to IPv6 is explicitly considered in the design of IPv6

IPv6 Addressing

- One or more IPv6 addresses can be assigned to an interface
- Three types of addresses
  - Unicast – single interface
  - Anycast – delivered to one out of a set of interfaces
  - Multicast – delivered to all out of a set of interfaces
- An additional address type for automatic tunneling for transition from IPv4 to IPv6

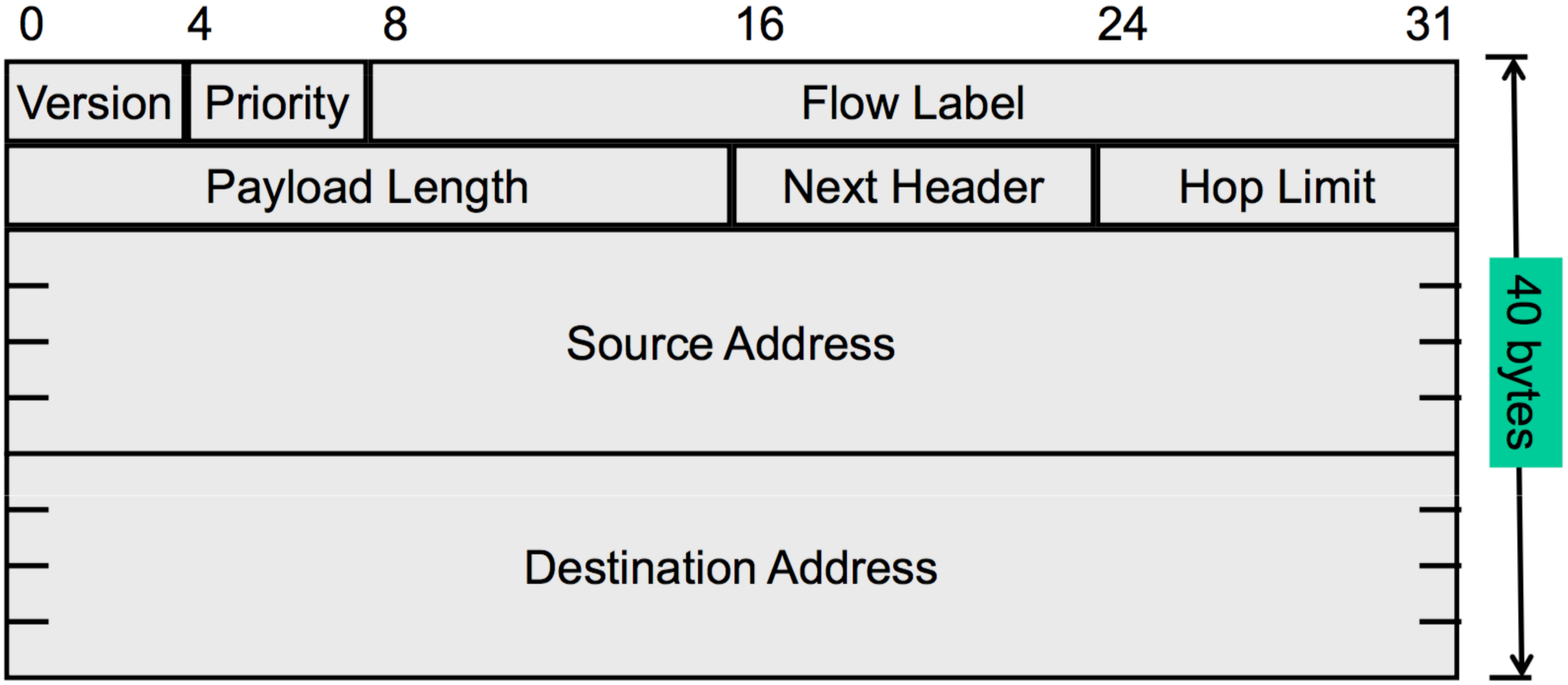
CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Enumerate the main new features of IPv6 as compared to IPv4

If you have any difficulties, please review the lecture video before continuing.

Header Format



IPv6: Header Fields

- Version: Internet Protocol version = 6 (4 bits)
  - Field is in the same location as the version field in the IPv4 header, thus a device can identify if an IP datagram is version 4 or version 6
- Priority: Priority value (4 bits)
  - Similar to use of IPv4 TypeofService (TOS) field for precedence or priority
- Flow Label: Flow label (24 bits)
  - Used to identify an IP flow
  - IPv4 relies on matching IP addresses, port numbers, and protocol

IPv6: Header Fields (2)

- Payload Length: Length of payload, does not include header in bytes (16 bits)
- Next Header: Identifies type of header immediately following the IPv6 header (8 bits)
  - Same values as the IPv4 Protocol field
  - Enables “extension headers”

IPv6: Header Fields (3)

- Hop Limit: Maximum hops allowed (8 bits)
  - Similar to IPv4 TTL field
  - Decremented by 1 by each node that forwards the packet
  - Packet is discarded if Hop Limit is decremented to zero
- Source Address: Address of the packet originator (128 bits)
- Destination Address: Address of the intended recipient of the packet (128 bits)
  - Addressed node may possibly not be the ultimate recipient if a Routing header is present

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Enumerate the fields in an IPv6 header and explain some of the uses of optional extension headers

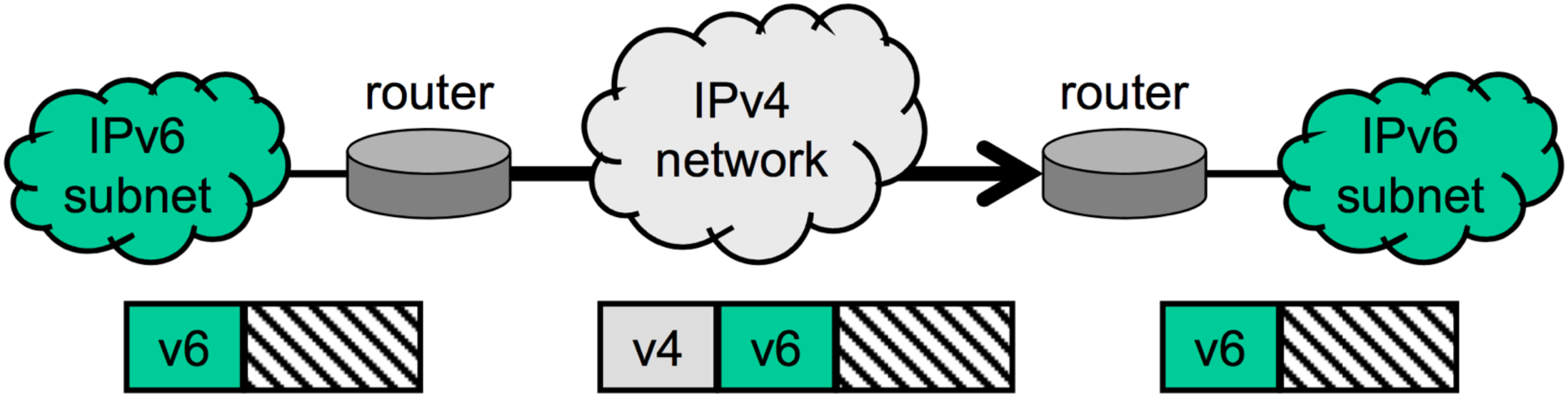
If you have any difficulties, please review the lecture video before continuing.

IPv4 to IPv6 Transition

- Transition
  - A HUGE undertaking
  - Explicitly considered and supported in IPv6
- Transition approaches
  - Dual stack – support IPv4 and IPv6 on the same node
  - Tunneling – carry IPv6 over IPv4 backbone networks
- Some transport layer and applications support both versions of IP
  - But, transport layer and application changes may be needed to support 128-bit addresses

Example Topology for Transition

- Initial IPv6 topology built by “tunneling” over IPv4
  - IPv6 datagram carried as payload of IPv4 datagram



When Will IPv6 Happen?

- IPv6 is already happening, but not yet universally deployed
  - Still resistance from major ISPs, especially in the U.S.
- Operating system support
  - Support in Microsoft Windows OSs
  - Support in Apple OSs
  - Versions available for Linux, NetBSD, Solaris, etc.
  - Commonly supported by commercial routers

IPv6 Deployment

- The end of Network Address Translation (NAT)
  - Larger address space and hierarchical address structure reduce the need for private networks
- The end of the Dynamic Host Control Protocol (DHCP)?
  - Better support for automatic configuration and mobility
- The end of security add-ons and overlays?
  - Integrated security support removes need for virtual private networks, security tunnels, and similar security overlays

IPv6 Deployment (cont'd)

- Lots of globally addressable devices?
  - Large address space allows IP addresses to be assigned to embedded devices (Internet of Things)
- IPv6 as the core of the next Generation cellular network?
  - Large address space and strong support for mobility and security to enable end-to-end IP in networks for mobile voice/data devices

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Explain how the transition to IPv6 can occur and discuss changes brought about by the widespread deployment of IPv6

If you have any difficulties, please review the lecture video before continuing.

Summary

- IPv6 significantly extends the available address space, simplifies the processing of a datagram at each intermediate router, and introduces new functionality such as anycast addressing and a security header
- The transition from IPv4 to IPv6 is a complex undertaking
    - Approaches: dualstack and tunneling
- IPv6 is already happening and is supported by all major operating systems, but not yet universally deployed

MODULE 11: The Internet Protocol Suite

Lecture 11.4
IP version 6

Prepared By:
- Scott F. Midkiff, PhD
- Luiz A. DaSilva, PhD
- Kendall E. Giles, PhD

Electrical and Computer Engineering
Virginia Tech