CS 372 Lecture #33

IP version 6

- addressing
- other features
- compared to IPv4

Note: Many of the lecture slides are based on presentations that accompany *Computer Networking: A Top Down Approach,* 6th edition, by Jim Kurose & Keith Ross, Addison-Wesley, 2013.

IPv6

- Initial motivation:
  - 32-bit address space exhaustion
    - predicted for decades … not really an issue, because of NAT
    - IETF bypassed IPv5 via IPng (IP next generation)
- Changes from IPv4:
  - Address space: 128-bit
  - Support for audio and video
    - "flow labels" allow AV applications to establish appropriate connections
  - Fragmentation no longer allowed
    - drop packet if too big
  - Checksum removed to reduce processing time
    - already done at transport and link layers
  - Optional headers (outside of base header)
    - indicated by "Next Header" field
    - easily add new headers for new features
  - ICMPv6: new version of Internet Control Message Protocol
    - additional message types
    - more effective inter-router collaboration

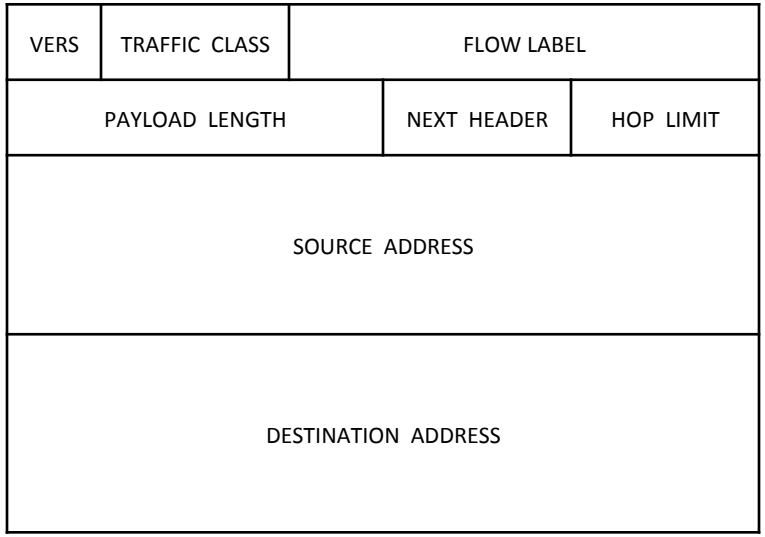
IPv6 addressing

- 128-bit addresses
  - 3.4×10^{38} addresses
  - routers use longest matching prefix
  - dotted-decimal would not make sense
    - example (don't use): 105.220.136.100.255.255.255.255.0.0.18.128.140.10.255.255
- IPv6 represents addresses in *colon hexadecimal* (***colon hex***), with ***/bits*** to specify netmask
  - example:
    - 69DC:8864:FFFF:FFFF:0:1280:8C0A:FFFF /64
- Zero-compression
  - series of zeroes indicated by two colons
  - example: FF0C:0:0:0:0:0:0:B1 → FF0C::B1
  - An IPv6 address with 96 leading zeros is interpreted as an IPv4 address

IPv6 header format

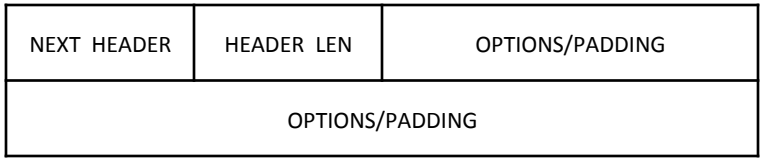
- VERSION (4 bits)
- TRAFFIC CLASS (8 bits)
  - specifies the traffic class (used to specify priority)
- FLOW LABEL (20 bits)
  - used to associate datagrams belonging to a *flow* or communication between two applications (helps packets to arrive in order)
- PAYLOAD LENGTH (16 bits)
  - indicates the length of data (i.e. payload) excluding header
- NEXT HEADER (8 bits)
  - type of first extension header
- HOP LIMIT (8 bits) (old TTL)
  - specifies the maximum number of hops a packet can transit before being discarded
- SOURCE ADDRESS (128 bits)
- DESTINATION ADDRESS (128 bits)

Base header (40 bytes)



Size of optional "next header" depends on header type. Each header has a "next header" field … a linked-list of headers.

Example extension header (8 – 16 bytes)

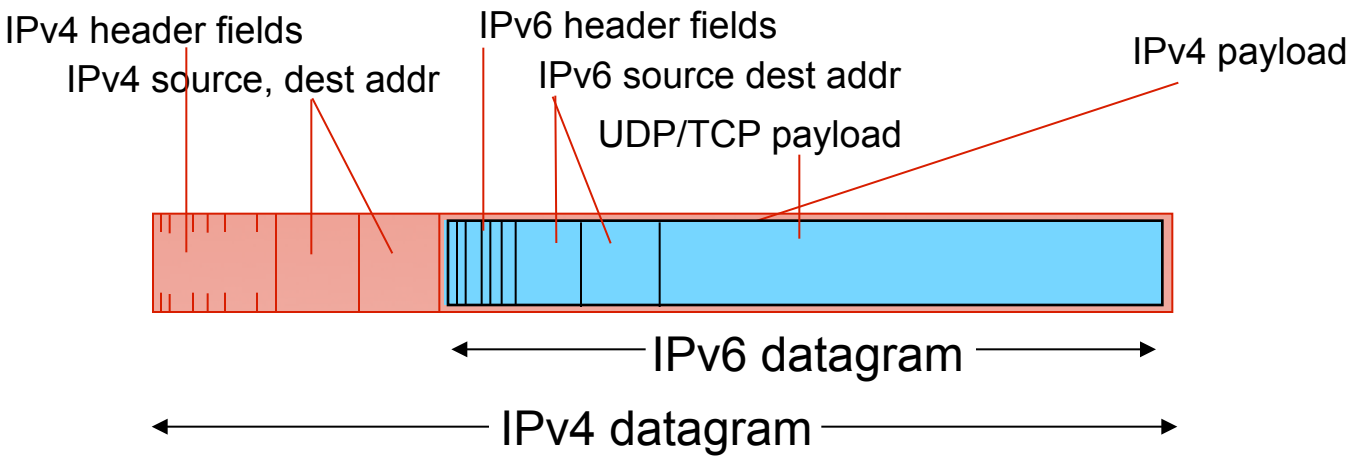


Fragmentation and Path MTU

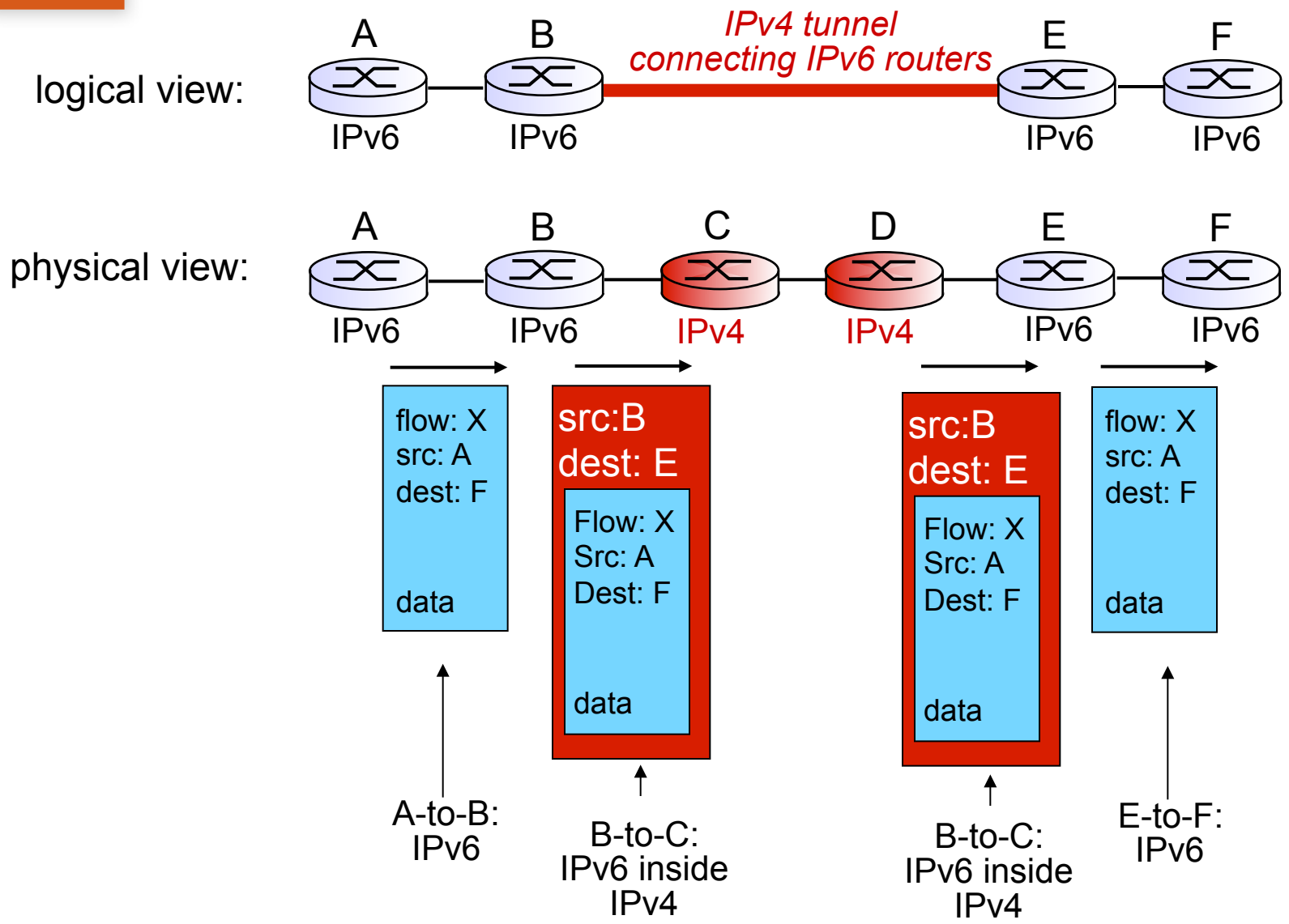
- Fragmentation information is in fragmentation extension header
  - IPv6 source (*not* intermediate routers) is responsible for fragmentation
  - Source determines *path MTU*
    - Uses *path MTU discovery*
    - Source sends probe message of various sizes
    - Gets ICMP messages until destination reached
  - Constructs datagram fragments to fit within that MTU
- Routers simply drop datagrams larger than path MTU
  - No more fragmenting by routers
  - ICMP message sent to source

Transition from IPv4 to IPv6

- Not all routers can be upgraded simultaneously
  - networks must operate with mixed IPv4 and IPv6 routers
- *tunneling:* IPv6 datagrams are carried (among IPv4 routers) as *payload* in IPv4 datagram



Tunneling


logical view:
A
B
IPv4 tunnel
connecting IPv6 routers
E
F
IPv6
IPv6
IPv6
IPv6
physical view:
A
B
C
D
E
F
IPv6
IPv6
IPv4
IPv4
IPv6
IPv6
flow: X
src: A
dest: F
data
src:B
dest: E
Flow: X
Src: A
Dest: F
data
src:B
dest: E
Flow: X
Src: A
Dest: F
data
flow: X
src: A
dest: F
data
A-to-B:
IPv6
B-to-C:
IPv6 inside
IPv4
B-to-C:
IPv6 inside
IPv4
E-to-F:
IPv6

Comparing IPv4 and IPv6

IPv4	IPv6
32-bit addresses	128-bit addresses
Service type	Traffic class / flow labels
Payload Len = Total Len – Headed Len	Payload Len is actual size of payload
Transport layer protocol (TCP, UDP) specified in header	Destination determines transport layer protocol
Fragmentation by routers	Fragmentation by source
Checksum: required	No checksum
Options: included in variable-size header	Options: in header extensions added after fixed-size base header
ICMP	ICMPv6
Dotted-decimal	Colon-hex

Summary Lecture #33

- IPv4 basic abstractions have been very successful
  - IPv4 will be around for a long time
- IPv6 carries forward IPv4 abstractions
  - For now, need to know both
- IPv6
  - changes/additions to IPv4
  - address format
  - datagram header
- Transition from IPv4 to IPv6
  - tunneling