Computer Networks and Data Systems

Internet Protocol (IP)
Basic properties

• Connectionless service
  • w/o anything else, its one-way, fire and forget
  • no reliability, performance or security guarantee
• Its relatively simple (its the thin waist remember?)
• You can add some features to it
  • installed base makes this extremely difficult
• You can easily add features below or above
  • with varying degrees of success/benefit/harm
What does IP do for us?

- Abstracts multiple and various data link nets below
- Provides a common, global, standard format
  - it is glue we can use to connect things together
- Hardware, application and packet independence
- Scalable routing (mostly, so far anyway)
IPv4

- Widely implemented and successful
  - our primary focus for practical reasons
- Well known for limited address size
- Originally specified in IETF RFC 791
  - updated only slightly (e.g. ToS → DiffServ/ECN)
  - with some BCPs in implementation / operation
IPv6

• Basically an IPv4 tweak
  • bigger addresses 32 bit → 128 bit
  • simplified header
    • 4 x the address size, but only 2 x header size
• Becoming increasingly common
  • particular regions of the world (e.g. Asia-Pacific)
  • Comcast, T-Mobile, R&E's
• There will be implementation challenges
  • e.g. new bugs, management issues
IP versions less than v4

- See IANA IP Version numbers
  - currently unassigned or reserved
- But also see RFC 790 and IEN 117 for history
  - closely integrated with early TCP
IPv5

- Experimental, never widely deployed
- Service guarantees through network state
- Motivated by voice apps
- Includes multicast support
- Do you see recurring design challenges?
IP versions greater than v6

• See IANA IP version numbers
  • TP/IX, PIP, TUBA
    • original competing IP-ng designs
    • note, TUBA had IP replaced with CLNP
    • see RFC 1752 for some discussion
Please note

As of this writing and likely for some time, there are no serious, practical alternatives to IP versions 4 or 6.
The IPv4 datagram header

- Version
- IHL
- DiffServ + ECN (formerly ToS)
- Total Length
- Identification
- Flags
- Fragment Offset
- Time to Live
- Protocol
- Header Checksum
- Source Address
- Destination Address
- Options
- Padding
Inside an IPv4 header

• Version field
  • 0100 in binary

• Header length
  • length of IP header in 32-bit words (4 octets)
  • typically set to 5 (as in 5 * 4 octets = 20 bytes)

• Type of Service (ToS) / DiffServ
  • an indication of quality/class of service
  • rarely used with success outside a single AS
IPv4 header continued...

• Explicit Congestion Notification (ECN)
  • signals congestion by marking packet
  • as opposed to dropping
• Total length
  • total IP datagram length in octets
  • maximum value is 65535, but rarely > 1500
• Identification
  • to identify fragments of a single IP datagram
  • has had other operational/research use
Still inside an IPv4 header...

- Flags
  - bit 0 reserved (RFC 3514 “evil” bit)
  - others for fragmentation handling (DF/MF)
- Fragment offset
  - helps piece together fragments
- Time to live (TTL)
  - limit number of router hops datagram traverses
  - counts down to zero, at zero it is discarded
End of an IPv4 header

- Protocol type
  - indicates next (upper?) layer protocol in payload
  - does it have to be an “upper” layer?
- Header checksum
  - used to verify header validity at each hop
- Source/Destination address
  - 32-bit addresses
- Options (optional, duh)
  - little use today, padded to 32-bit boundary
The IPv6 datagram header

```
0 1 2 3 4 5 6 7 8 9 0 1
0 1 2 3 4 5 6 7 8 9 0 1
Version | DiffServ + ECN (traffic class) | Flow Label

Payload Length | Next Header | Hop Limit

Source Address

Destination Address
```
Inside an IPv6 header

- Version (IPv4 version field)
- DiffServ + ECN (IPv4 DiffServ + ECN)
  - formerly called traffic class
- Flow label
  - not widely used
  - could be used to differentiate / route traffic
- Payload length
  - self explanatory, no?
End of IPv6 header

- Next header (IPv4 Protocol)
  - specifies next protocol or option
- Hop Limit (IPv4 TTL)
  - name better describes its usage
- Source / Destination address (IPv4 addresses)
  - 128-bit addresses