

Lecture 9: Internetworking

CSE 123: Computer Networks
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HW 2 due Wednesday



Lecture 9 overview



- IP Service Model
- ICMP, the *other* network-layer protocol

IP philosophy



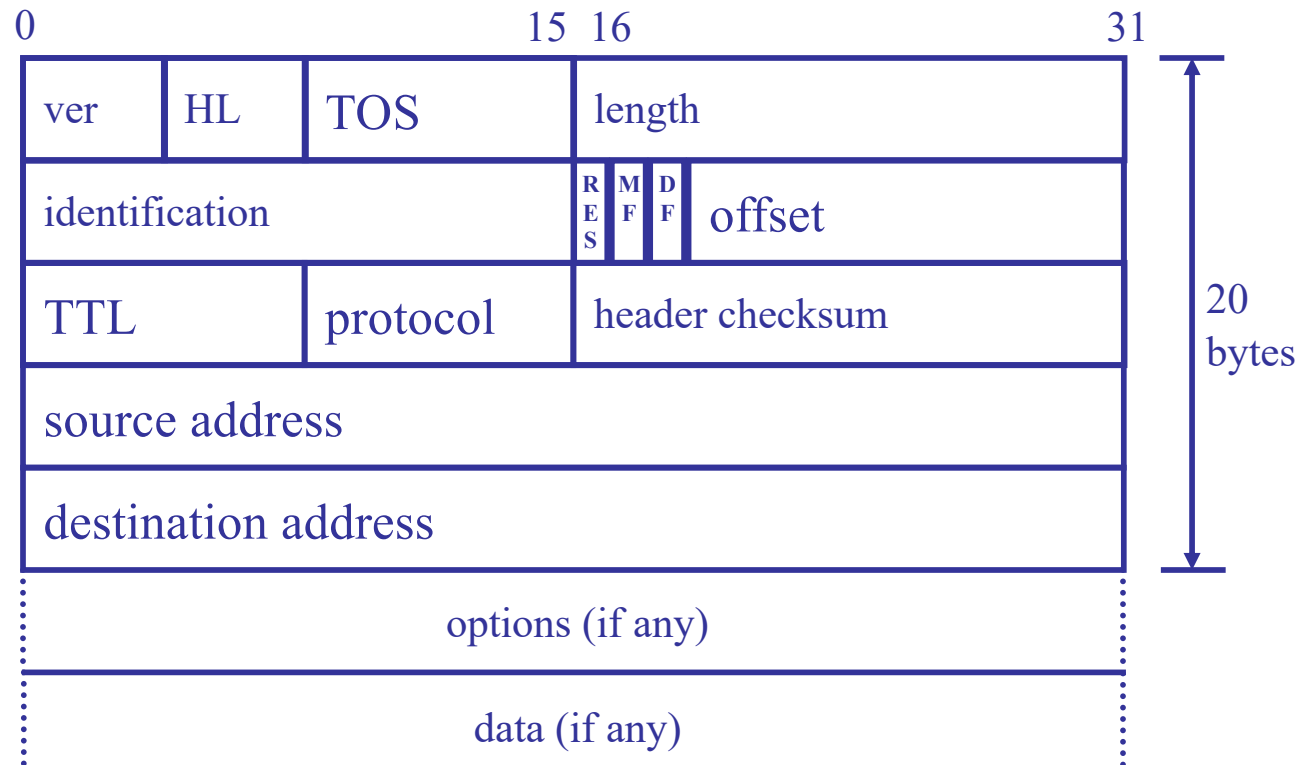
- Impose few demands on network
 - ◆ Make few assumptions about what network can do
 - ◆ No QoS, no reliability, no ordering, no large packets
 - ◆ No persistent state about communications; no connections
- Manage heterogeneity at hosts (not in network)
 - ◆ Adapt to underlying network heterogeneity
 - ◆ Re-order packets, detect errors, retransmit lost messages...
 - ◆ Persistent network state only kept in hosts (fate-sharing)
- Service model: **best effort**, a.k.a. *send and pray*

So what does IP do?



- Addressing (complicated, topic for next lecture)
- Fragmentation (rarely these days)
- *Some* error detection
- Routers only forward packets to next hop. They do *not*:
 - » Detect packet loss, packet duplication
 - » Reassemble or retransmit packet

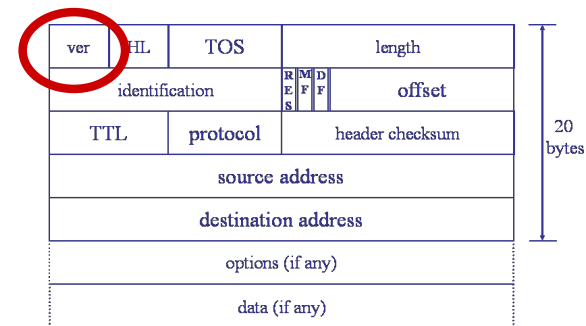
IPv4 packet header



Version field



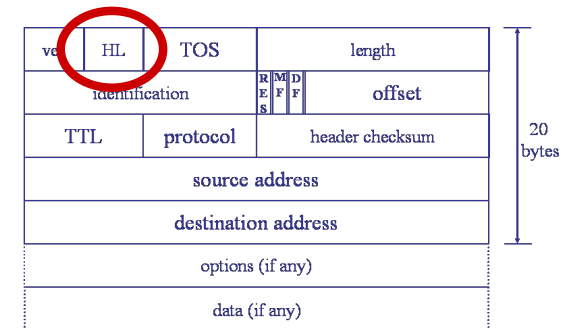
- Which version of IP is this?
 - ◆ Plan for change
 - ◆ Very important!



Header length



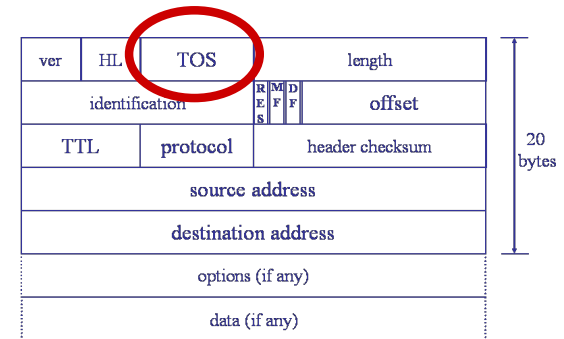
- How big is IP header?
 - ♦ Counted in 32-bit words
 - ♦ Variable length
 - » Options
 - ♦ Engineering consequences of variable length...
- Most IP packet headers are 20 bytes long



Type-of-Service



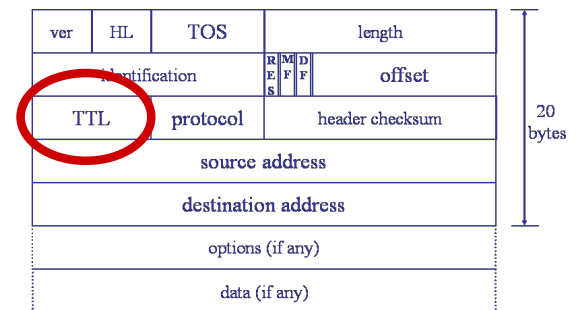
- How should this packet be treated?
 - ◆ Care/don't care for delay, throughput, reliability, cost
 - ◆ How to interpret, how to apply on underlying net?
 - ◆ Largely unused until 2000 (hijacked for new purposes, ECN & Diffserv)



TTL (Time-to-Live)



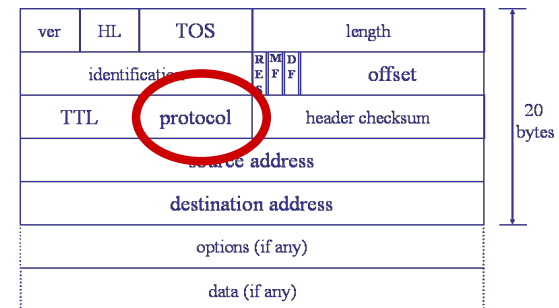
- How many more routers can this packet pass through?
 - ◆ Designed to limit packet from looping forever
- Each router decrements TTL field
- If TTL is 0 then router discards packet



Protocol



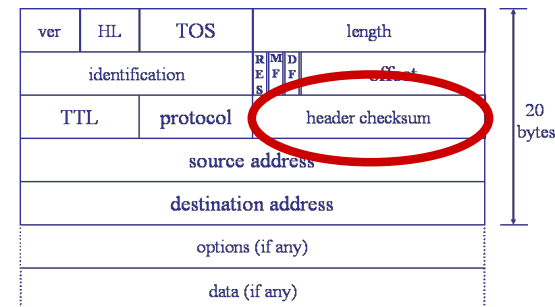
- Which transport protocol is the data using?
 - ◆ i.e. how should a host interpret the data
- TCP = 6
- UDP = 17



IP Checksum



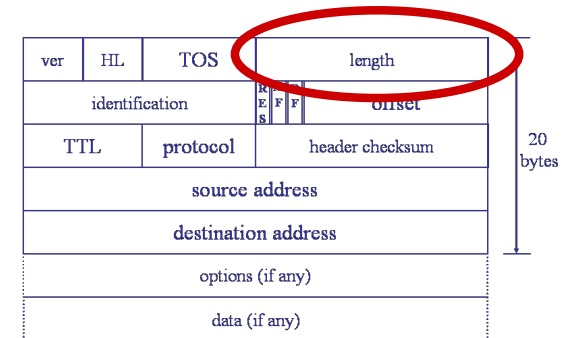
- Header contains simple checksum
 - ◆ Validates content of header *only*
- Recalculated at each hop
 - ◆ Routers need to update TTL
 - ◆ Hence straightforward to modify
- Ensures *correct* destination receives packet



Length



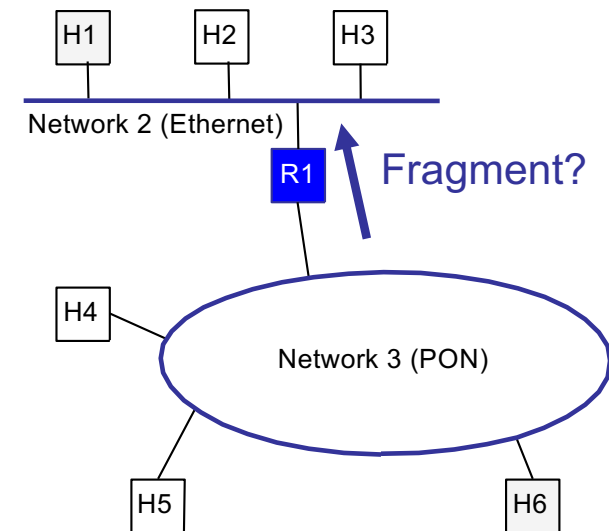
- How long is whole packet in bytes?
 - ◆ Includes header
 - ◆ Limits total packet to 64K
 - ◆ Redundant?



Fragmentation



- Different networks may have different maximum frame sizes
 - ◆ Maximum Transmission Unit (MTUs)
 - ◆ E.g., Ethernet 1.5K, PON 2K
- Router breaks up single IP packet into two or more smaller IP packets
 - ◆ Each **fragment** is labeled so it can be correctly **reassembled**
 - ◆ *End host* reassembles them into original packet





Costs of fragmentation

- Interplay between fragmentation and retransmission
 - ◆ A single lost fragment may trigger retransmission
 - ◆ Any retransmission will be of entire packet (why?)
- Packet must be completely reassembled before it can be consumed on the receiving host
 - ◆ Takes up buffer space in the mean time
 - ◆ When can it be garbage collected?
- Why not reassemble at each router?



Path MTU discovery

- Path MTU is the smallest MTU along path
 - ◆ Packets less than this size don't get fragmented
- Fragmentation is a burden for routers
 - ◆ We already avoid reassembling at routers
 - ◆ Avoid fragmentation too by having hosts learn path MTUs
- Hosts send packets, routers return error if too large
 - ◆ IPv4 hosts can set "don't fragment" flag; IPv6 doesn't fragment
 - ◆ Hosts discover limits, can size packets at source

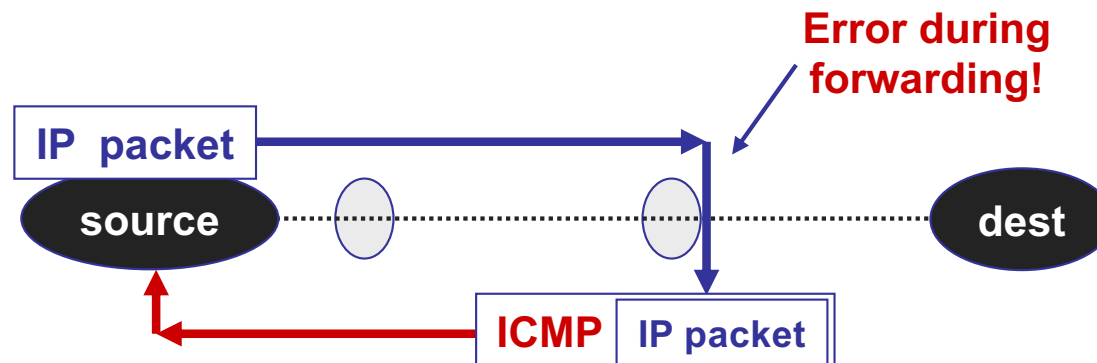
Aside: ICMP



- What happens when things go wrong?
 - ◆ Need a way to test/debug a large, widely distributed system
- ICMP = Internet Control Message Protocol (RFC792)
 - ◆ Companion to IP – required functionality
 - ◆ Technically a network protocol, but implemented “above” IP
 - ◆ 8-byte header “extension”, IP protocol field set to 1
- Used for error and information reporting:
 - ◆ Errors that occur during IP forwarding
 - ◆ Queries about the status of the network



ICMP error message generation



- ICMP messages include portion of IP packet that triggered the error (if applicable) in their payload

For next time



- Read 6.2.2 and 6.3.1 in P&D
- HW 2 due Wednesday