ECE 435 – Network Engineering
Lecture 13

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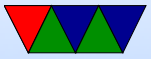
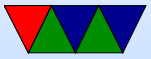
Announcements

- HW#6 was posted (forgot to send e-mail)
- HW#5 grades out soon

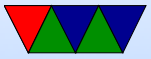


Midterm Preview

- Remote exam, I send it by e-mail, you have all class period, send document with results at end.
- Open book/notes, but no talking to other people.
- Mostly short answer questions. No long coding exercises or protocol memorization. Maybe some sockets code, but analyzing it not writing it.
- Know the OSI layers and what each one is for.
- Know at a high level the following protocols:
  - WWW/http

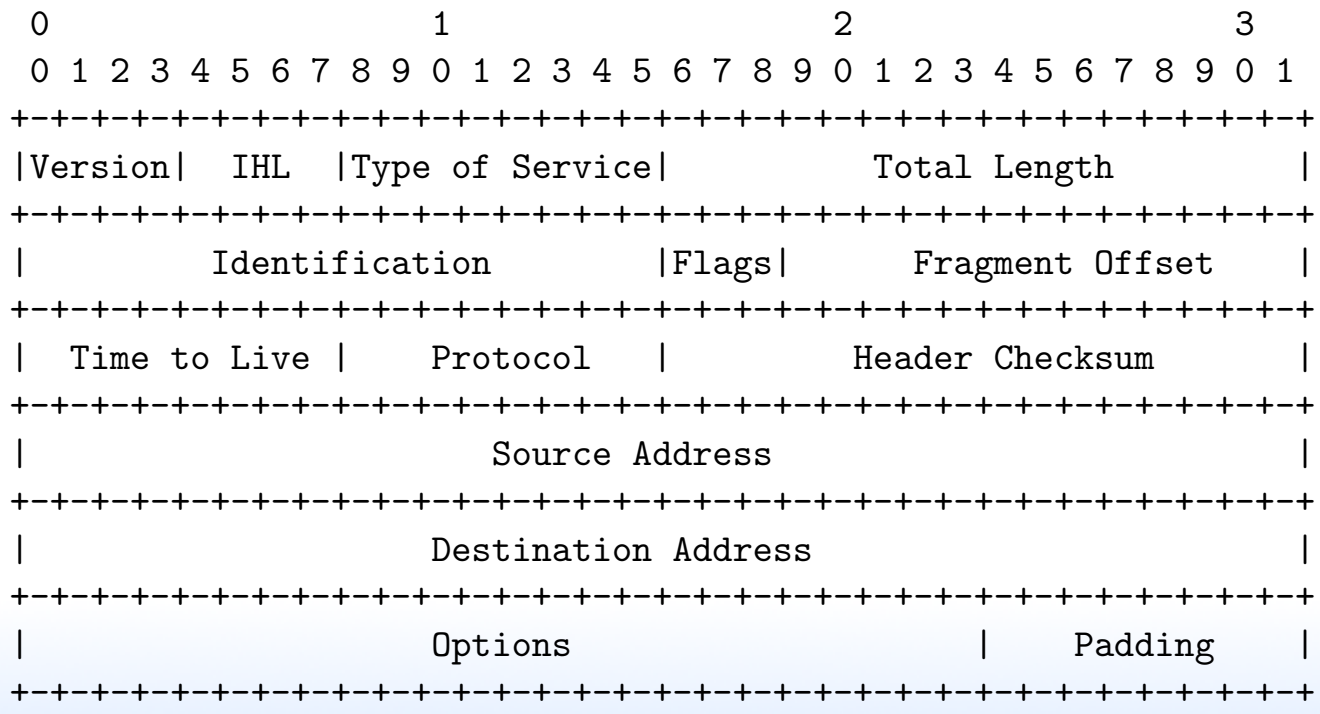


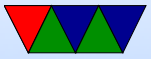
  - e-mail
  - DNS
- Encryption (at a high level)
- UDP + TCP
  - Know the 3-way handshake
  - Know the tradeoffs between UDP and TCP
  - Why does DNS use UDP
  - Why do webservers use TCP



IPv4 Packet Format

- Header, followed by data, multiple of 4-bytes, big-endian
- ASCII from RFC791 — `https://tools.ietf.org/html/rfc791`





- **Version** (4-bits) version number: IPv4 this is 4
- **Header Length** (4-bits) in 4-byte chunks: variable in size

  Often is 5 (20 bytes) the minimum, max is 15 (60 bytes)
- **Precedence / Type of Service** (1 byte)

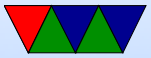
  - Precedence (RFC 791, high bits):

    111 (net control)

    110 (internetwork control)

    101 (critic/ecp)

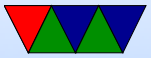
    100 (Flash override)



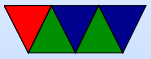
011 (flash)
010 (intermediate)
001 (priority)
000 (routine)

- TOS (RFC 1349):

1000 minimize delay
0100 maximize throughput
0010 maximize reliability
0001 minimize cost
0000 normal
1111 maximize security

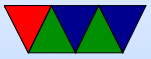


  - R: reserved
- **Total Length** (2 bytes) – max is 64kB
- **Identification** (2 bytes) – also called sequence, used in fragmentation
- **Fragmentation** (2 bytes) – fragmentation:
  - **flags** (3 bits): for fragmentation control.
    high bit is always 0, (joke April Fools proposal 'evil bit'
    next is "do not fragment"
    last is "more fragments"
  - **fragmentation offset** (13-bits): all but last fragment must be a multiple of 8-bytes as only have 13 bits to



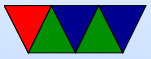
work with)

- **TTL** (1 byte) time-to-live, max routers allowed to pass though
  - (was supposed to be time, but ended up as a hop limit)
  - each router decreases TTL by one, if reaches zero discarded and ICMP error sent to source
  - Max is 255. why? prevent packets from wandering lost forever
- **Upper-layer protocol** (1 byte)
  Originally in RFC 1700, now see `www.iana.org`

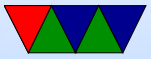


(ICMP=1, TCP=6, UDP=17)

- **Header Checksum** (2 bytes)
  - Sum using 16-bit 1s complement, then complementing.
  - Not as strong as CRC-16, but faster and easier in software.
  - Only checksums header (not payload).
  - Must be recomputed each hop as TTL changes
- **Source address** (4 bytes)
- **Destination Address** (4 bytes)
- **Options** – not required. rare, debugging
  - security: how secret it is (usually ignored)

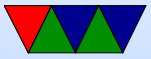


  - strict source: gives a list of IPs of routers to traverse
  - loose: list of routers not to miss
  - record route: record ips pass on way (debugging)
  - timestamp(debugging)
- Data



IPv4 Packet Fragmentation

- Ethernet MTU 1500 but IP MTU is 64k, so must break up larger packets
- Can be further broken up depending on MTU along way
- Final destination is responsible for reassembling
- Can mark packet "do not fragment". What happens then if too big?
- All fragments have same sequence number. Last

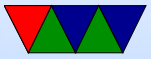


fragment marked with “more fragments” flag. Position from fragmentation offset field

- Example: original, 3200 bytes of data
  header id=x, more=1, offset=0, 1480 bytes
  header id=x, more=1, offset=185 1480 bytes (x8?)
  header id=x, more=0, offset=370 240 bytes

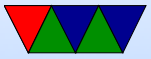
- Each fragment is a valid IP packet

- Problems with fragments: no way to notify other side of missing fragments last fragment is usually short (wasting



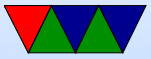
resources) receiver must hold in RAM fragments to be reassembled. can DoS by sending lots of fragments but none complete fragments do not have TCP or UDP header so firewall can't easily filter

TCP always sets DNF and does discovery?



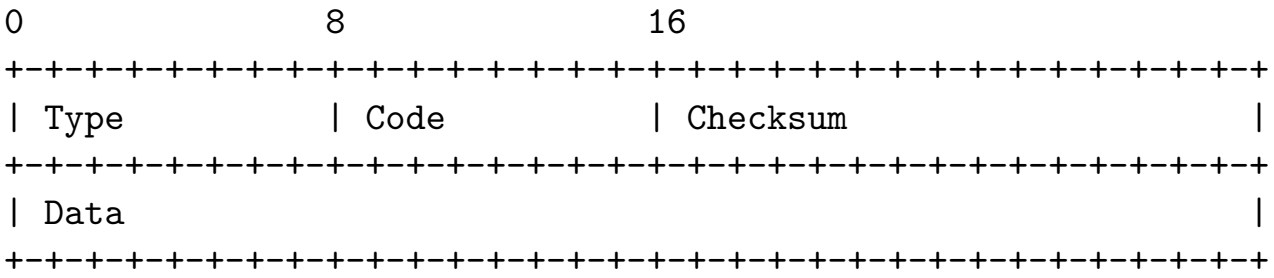
Errors

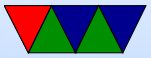
- What happens when something goes wrong with your packet?
- Does a router just drop it?
- Or does it try to let the sender know?



ICMP

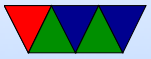
- Internet Control Message Protocol
- Carried as a payload in an IP packet
- IP header type 1
- Some sysadmins block ICMP. Why?





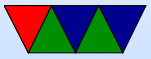
A Selection of ICMP Types/Codes

- `DESTINATION UNREACHABLE`, Also if MTU is too small but do-not-fragment set
- `SOURCE QUENCH` – should slow transmission rate (congestion), This is now usually done in transport layer
- `REDIRECT` – try the other router path
- `TIME EXCEEDED` – exceeded TTL, traceroute uses this
- `PARAMETER PROBLEM` – illegal value in header
- `ECHO`, `ECHO_REPLY` – see if machine is up
- `TIMESTAMP`, `TIMESTAMP_REPLY` – performance debug



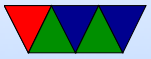
ping

- Mike Muuss in 1983
  `http://ftp.arl.army.mil/~mike/ping.html`
- Like sonar ping (Hunt for Red October), not any of the backronyms you might find.
- Ping the duck
- ICMP ECHO packet, waits for ECHO reply. Prints timing info, etc.
- Used to just say "host is alive". People would make machines called elvis.

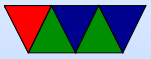


Malicious pings

- Ping of death – crash any machine on network (late 90s)
  - Technically not a ping bug, but fragmentation
  - Ping typically 56 bytes, but can be 64k
  - Technically not valid, but most will try anyway
  - 64k ping broken into 8 fragments
  - Maximum can specify is 65528, add in 20 for header, 65548
  - This is bigger than 65536, buffer overflow on reassemble

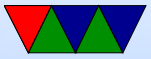


- Ping flood
- Broadcast ping to x.x.x.255 (no longer works)



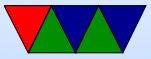
traceroute

- Van Jacobson in 1987 (also wrote tcpdump)
- Uses ICMP
- *not* tracer-t
- Send packet with TTL=1, when sends ICMP error message know where first hop is
- Send packet with TTL=2, find next
- Linux traceroute sends UDP packets as originally ICMP requests weren't supposed to generate ICMP errors
- Sends 3 packets, lists all 3 results

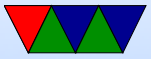


Dynamic Host Configuration Protocol (DHCP)

- RFC2131
- To get on network need IP, subnet mask, default router
- Can we automatically get this?
- Broadcasts, asking for address
- Server can respond with a fixed one (setup in config file) or handle out dynamically from range
- To avoid need for server on each subnet, can pass through



- Broadcast DHCPDISCOVER on UDP port 67.
- All servers send DHCPOFFER on port 68
- Send DHCPREQUEST, respond with DHCPACK
- Timer, needs to re-request before timer is out or server might give to someone else
- Get a “lease” from the server. Why short vs long lease/
- Can see this all inaction with `dhclient -v`
- DHCP format based on BOOTP



Setting up DHCP server

- Static vs Dynamic (how hand out static addresses?)
- Be careful to not hand out on network you don't own