ICS 451: Today's plan

- closing TCP connections
- TCP Header
- UDP

Closing TCP connections

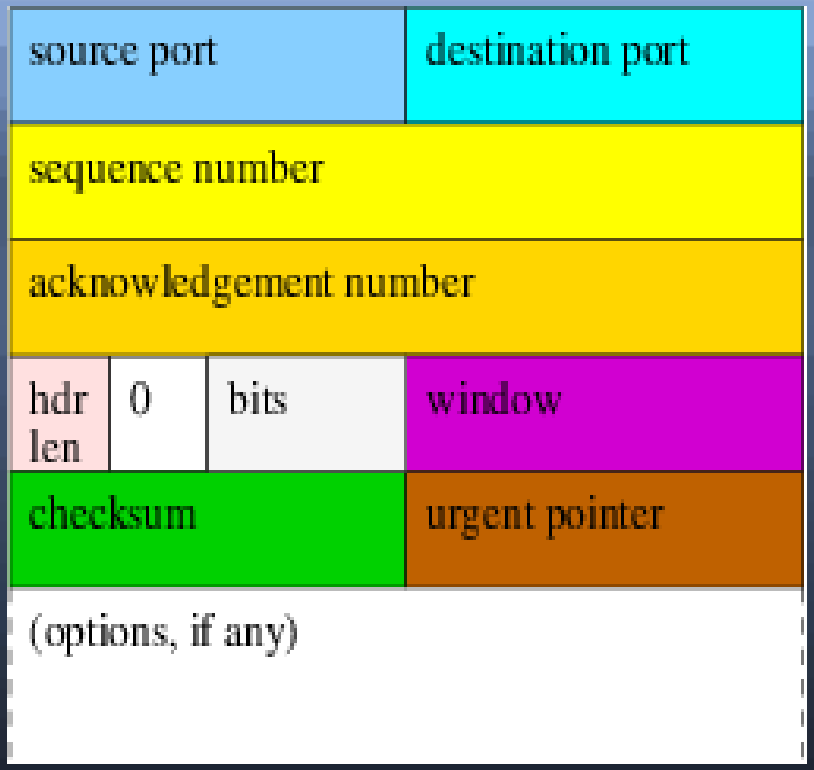
- each side sends a FIN segment
  - after sending all its data
- each FIN is acked
- once both FINs have been acked, the connection is closed

- but what if the last ack is lost?

Last ack problem

- If the last ack is lost, the sender of the corresponding FIN (Alice) may retransmit it
- if the other side (Bob) has no record of the connection, Bob will send a RST
- this is wrong – the connection was closed
- so Bob should keep a record of the closed connection for up to two Maximum Segment Lifetimes (MSLs)
  - i.e. for two minutes in the Internet
- That means Bob's port remains in use for 2min

TCP Header



- Header has room for 12 control bits
- 8 are defined:
  - CWE, ECE, URG, ACK, PSH, RST, SYN, FIN
- the other four must be zero

TCP Header Bits

- SYN, FIN, RST report connection status
- ACK says “the **ack** field is valid”
  - set on all but the first packet
- CWE, ECE used for congestion reporting
- PSH says “push this data to the application”
  - but cannot be used as a record boundary
- URG says “the **urgent** field is valid”

TCP/UDP ports

- header has source port and destination port
- socket has local port and remote port

- port numbers < 1024 are reserved for “system”
- some port numbers are “well known”:
  - 80 (http), 443 (https), 25 (smtp)
- `bind` selects the local port for a server
  - otherwise local ports are selected by the OS

Connection Identification

- A connection is identified by:
- source IP address (32 bits, or 128 bits)
- destination IP address (32 bits, or 128 bits)
- source TCP/UDP port (16 bits)
- destination TCP/UDP port (16 bits)
- IP protocol number (8 bits)

Window

- Window is 16 bits
  - so largest window is 65,535 bytes
  - unless window scaling option is used!
  - window scaling multiplies window by 2^n
- window always begins at ACK number

Checksum

- Checksum includes Header, Payload, and a Pseudo-Header
- Pseudo-Header has values from the IP header:
  - IP source and destination addresses
  - length of TCP segment or UDP datagram
  - the protocol number (6 TCP, 17 UDP)
    - extended to the left with 8 bits of zeros
- checksum adds all 16-bit units
  - padding with a zero byte for odd-sized payload
  - sum is 1's complement arithmetic

Other fields

- Data Offset (Header length): the length of the header, in 32-bit words
- urgent pointer: spot in the data where an “urgent” character may be found

UDP

- ports, length, checksum
  - no options
  - length is superfluous
    - IP also records length
- checksum can be sent as zero (no checksum)
  - but bad practice
- maximum payload size is 8 less than maximum IP payload
  - 65,507 bytes
- exercise: what is the IP header size?