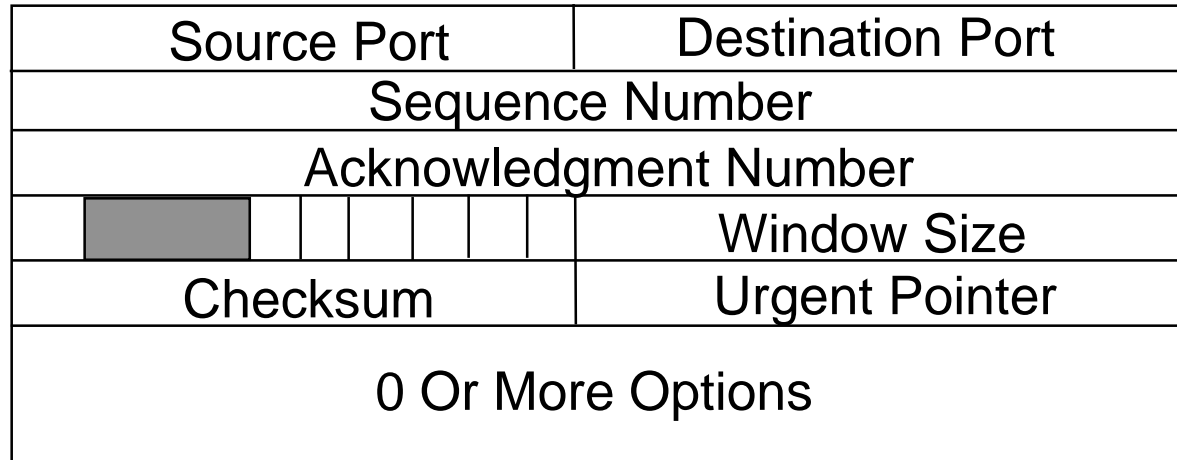# Announcements

- **Reading**
  - Chapter 6 (6.3 & 6.4)

- **Project #3**
  - Is on the web

- **Midterm #1**
  - Last day to request a re-grade is Th 10/18

# TCP Protocol

- ## TSAPs
  - Use <host, port> combination
  - Well known ports provide services
    - first 256 ports
    - SMTP 25, Telnet 23, Ftp 21, HTTP 80

- ## Provides a **byte** stream
  - this is **not** a message stream
  - a message (single call to send) may be split, merged, etc.

- ## Urgent Data field
  - provides cut through delvery *within* a trasport connection
  - used to send breaks or other high priority info

# TCP Packet Format

- Permits ACKs to be piggy packed
  - ACK is next byte expected
  - ACK is only valid if ACK bit is set
- Sequence number
  - first byte in packet
- Also used for connection establishment

| Source Port | Destination Port |
|---|---|
| Sequence Number | |
| Acknowledgment Number | |
| | Window Size |
| Checksum | Urgent Pointer |
| 0 Or More Options | |

← 32 bits →

# TCP Connection Management

- **Three-way Handshake**

- **Initial Sequence Numbers**
  - Use a 4 micro-second clock
  - hosts must wait T (120 seconds) before a reboot

- **Connection Closure**
  - Each side uses a FIN and FIN_ACK message
  - A FIN times out after 2 T (240 seconds)
  - Keep alives used to timeout half dead connections

# TCP Flow Control

- **Use Variable Sized Sliding Window**
  - ACK indicates start of window
  - Window size indicates current size of window
- **Receiver can send a window of 0**
  - indicates that it want to pause connection
  - urgent data need not follow this request
- **Window size of 16 bits is too small**
  - 64K Bytes
  - only a small fraction of the in-flight bytes when
    - bandwidth is high
    - delay is high
  - solution: window shift option:
    - bit shift window up to 16 bits
    - permits up to $2^{32}$ byte windows
    - reduces window granularity

# TCP Congestion Control

- **Detecting Congestion**
  - In general it is difficult
  - But, consider why a packet might be dropped
    - link error - but links are very reliable now
    - buffer overflow --> congestion
  - Use re-transmission timeouts as an estimate of congestion
- **Dealing with Congestion**
  - add a second window (congestion window)
    - limit transmissions to min(recv window, congestion window)
  - start with congestion window = max segment window
    - initial max segment is one kilo-byte
    - on a ACK without a timeout
        if  window < threshold, increment by one max segment
        otherwise increment by initial max segment
  - on timeout
    - cut threshold in half
    - set window size to initial max segment

# TCP Congestion Window
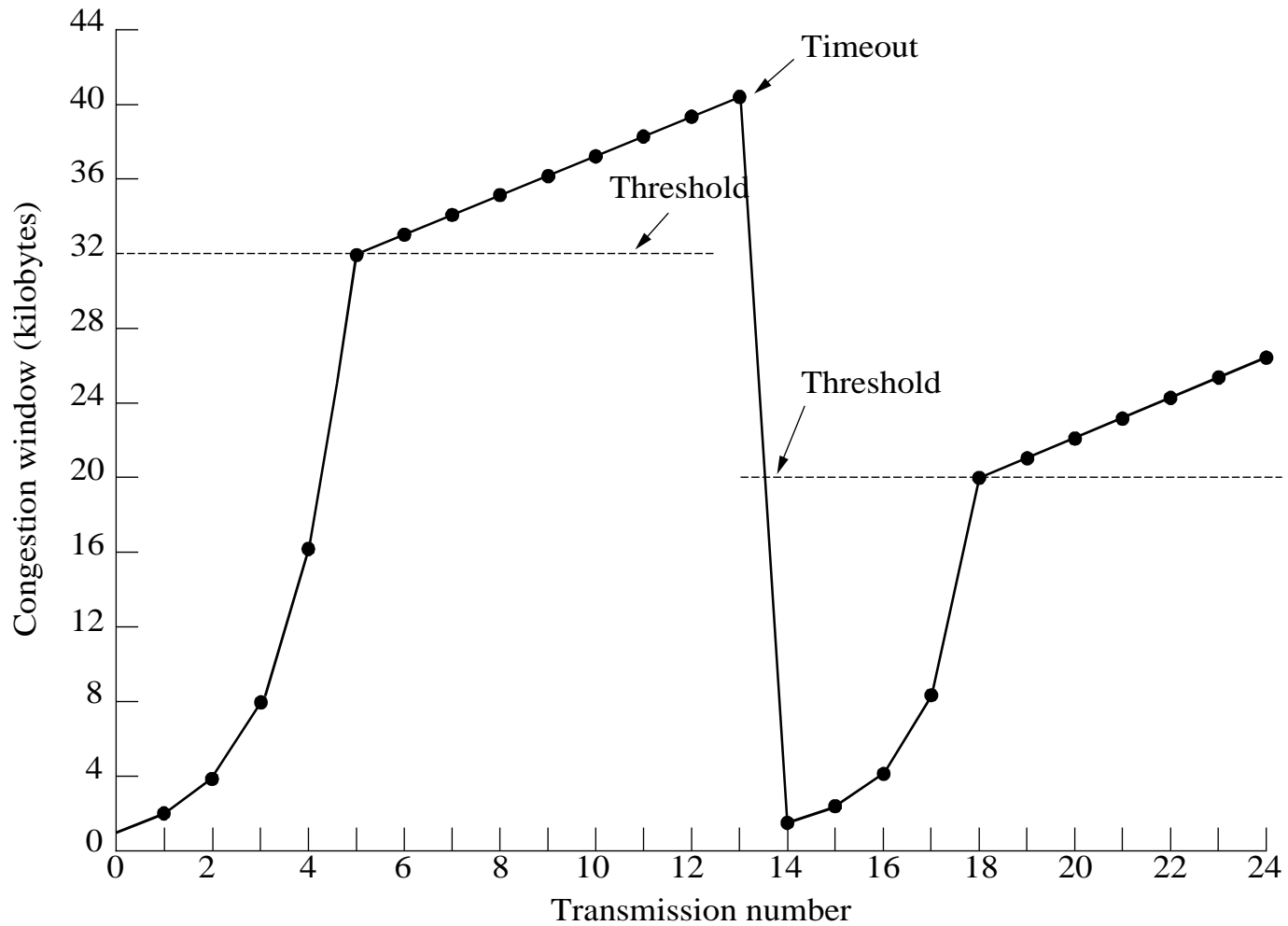


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