Transport Layer

- Layer
- Services
- UDP
- TCP

Transport Layer - Remarks

- Only in end hosts
- (However ....)
- Multiple versions of TCP; we focus on the most widely used (Reno)
UDP
- Multiplexing (Ports)
- Error detection (if required)

TCP: Phases
- SYN k
- 3-way handshake
- SYN n; ACK k+1
- DATA k+1; ACK n+1
- ACK k+n+1
- data exchange
- FIN
- FIN ACK
- ½ close

TCP Algorithm: AIMD
- Window = min{RAW - OUT, W}
- x = y

TCP: Flow Control
- Objective: Avoid saturating destination
- Algorithm: Receiver advertizes window RAW
  window = min{RAW - OUT, W}
  where
  OUT = Outstanding = Last sent - last ACKed
  W = Cong. Window from AIMD + refinements

Socket Programming
- Socket = API (APP – Network)
- socket == file [integer]
- bind (attach) to port [address...]
  - Client: to any port
  - Server: to receiving port
- listen, accept connection, receive, send
A Quick Summary: Datagram

**Server**
- `socket()` to create socket
- `bind()` to a receiving port
- `recvfrom()` to `sendto()`

**Client**
- `socket()` to create socket
- `bind()` to any port
- `recvfrom()` to `sendto()`

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A Quick Summary: Stream

**Server**
- `socket()` to a receiving port
- `listen()` to `accept()` connection
- `send()` to `recv()`

**Client**
- `socket()` to any port
- `connect()` to server
- `recv()` to `send()`

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**Multicast**
- Tree instead of replicated 1-1
- Multicast routers replicate packets to multiple ports
- Source sends to group address G
- Receivers subscribe to G
- Routers keep track of groups associated to ports

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**Review: Check List**

- **Network Architecture**
  - Multiplexing (Frequency, Statistical, Time Division, ...)
  - Circuit Switching vs. Packet Switching
  - Layering (Physical, Link Network, Transport, Application, ...)

- **Models**
  - Timing Diagrams
  - Transmission time, prop time, store and forward delays, etc.
  - Little’s Result $L = RW$

- **Physical Layer**
  - Shannon Capacity: $C = \log_2(1+\frac{S}{N})$, Error Coding, Clock skew problems

- **Ethernet**
  - Shared medium concept.
  - MAC - algorithm, analysis, (ex: relation of prop delay to min frame size)
  - Bridges - Learning bridge (spanning tree algorithm), Switched Ethernet

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**Review: Check List**

- **WIFI**
  - Hidden Node, Exposed Node
  - 802.11 MAC Algorithm, RTS/CTS, efficiency.

- **IP**
  - CIDR, DHCP, ARP, NAT
  - Routing: BGP, Link State – Djikstra’s – OSPF, Distance Vector – Bellman Ford – RIP

- **TCP/UDP**
  - Headers, Port Numbers
  - TCP 3 way handshake ½ closes
  - TCP congestion control algorithms
    - Automatic Repeat Request (ARQ), Slow Start, Fast Re-transmit, Fast Recovery.

- **Socket Programming**

- **Applications**
  - DNS – Iterated Query, Recursive Query, caching
  - HTTP – What it does, Caching, etc.
  - RTP
  - VoIP

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**Review: Check List**

- **WFQ**
  - Relationship between rates and weights
  - Virtual Finish Times
  - Multicast