

Basic Concepts (II)

Common Functions of a Layer

- **Encapsulation** and **decapsulation**
 - **Error Control**
 - error detection, error correction
 - encoding/decoding for data integrity (A), out of order detection (T), cyclic redundancy check (CRC) (L)
 - **Flow Control**
 - traffic management, congestion control
 - sliding window (T), conflict detection (L)
 - **Addressing**
 - Hostname (A), port (T), IP address (N), MAC (L)
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Basic Devices

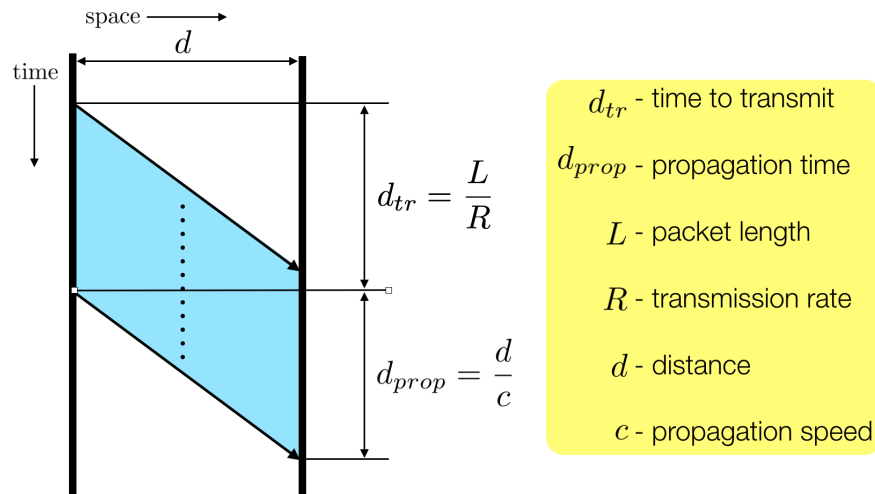
- **Router**
 - A network layer device (examines IP addresses)
 - route packets among LANs or WANs
 - **Switch**
 - A link layer device (examines MAC addresses)
 - forward packets between LAN segments
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Performance Measures

- **Throughput** — number of bits/bytes/packets delivered per second
 - **Latency** — time to deliver a packet
 - typically measured from the first bit transmission to the last bit reception
 - **RTT** (round-trip-time) — two-way latency
 - **Packet Loss Rate**
 - The percentage of unreceived packets during a period of time
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Time-Space Diagram

- End-to-end delay (latency) = $d_{tr} + d_{prop}$ over a direct link
- d_{tr} : transmission delay, time to send a packet out of the door
- d_{prop} : propagation delay, time between the moment the last bit out of the door and the moment it's received
- R : the width of the door
- d : the distance between the two ends
- c : the speed of bits (m/s)



- Example: How long does it take to deliver three packets back-to-back to the destination? Assume that the packet length is L , the distance between the source and destination is d , the transmission rate is R , and the propagation speed is C .
 - $3 * d_{tr} + d_{prop} = 3L/R + d/c$
- What if the link between two ends goes over several routers, what else need to be considered in the latency calculation?
 - Queuing delay.
 - Each router has its queue for the incoming packets. Depending on the load of a router, the queuing delay can be long or short.
- Processing delay is another factor plays in the latency, which is the time for hosts to process the packets (e.g., encapsulation and decapsulation). Comparing with other factors, this delay is minor, based on the processing ability of modern computers.

Disclaimer: Notes adapted from the textbook and online resources.