

Before Today: Datagrams, User Datagrams, Reliable byte streams on top of unreliable service abstraction

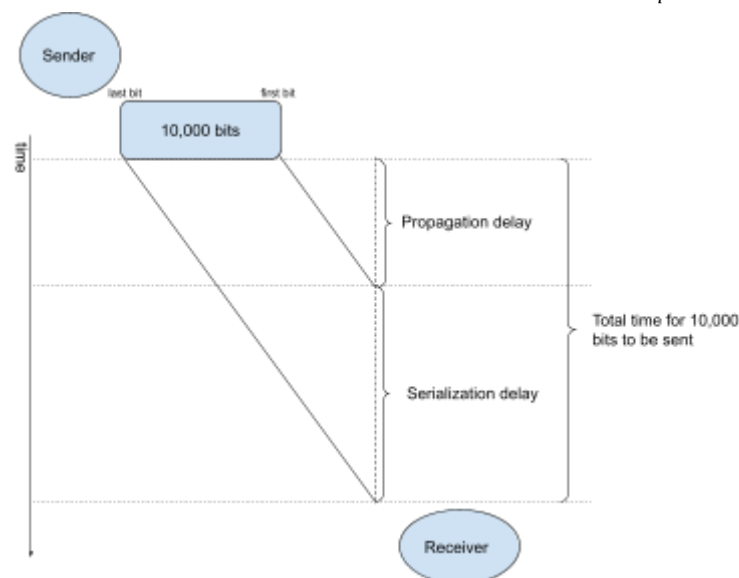
Today: Packet Switching

Logistics:

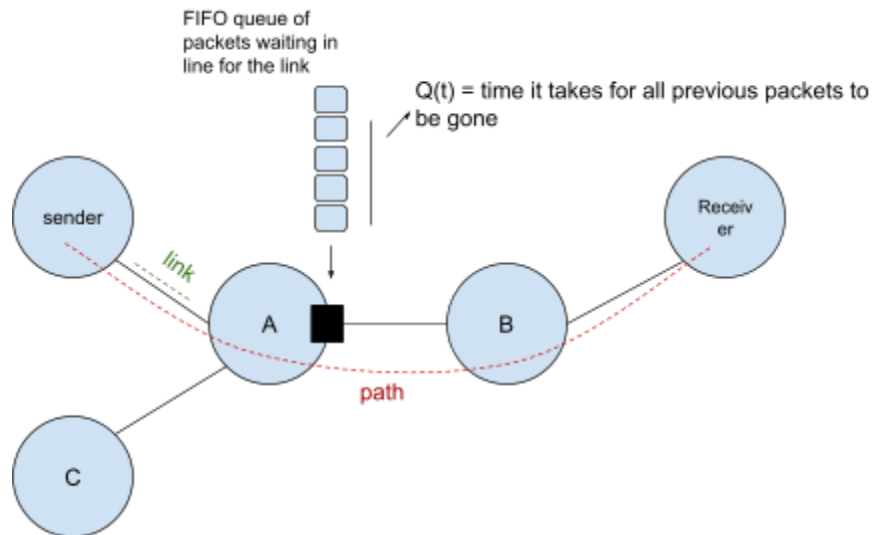
- Come to the lab
- Help each other out both in the lab and on Ed
- Extra credits will be given in upcoming checkpoints for new test cases

How does end point drop a “postcard” to its destination?

- Circuit-switched networks (e.g. telephones)
 - Each telephone is connected to a center office
 - And a staff worked in the office would connect the wires upon customers' request
 - If the person you want to call does not belong to the same office as you, there are circuits between main offices
 - Any phone call has a real direct electrical circuit
 - BUT: setting up and tearing down circuit is expensive, it works for telephone calls, but would not make sense if you only want to send a short piece of data
- Packet Switching
 - The time it takes for the first bit to be received – **Propagation Delay**:
$$t_l = \frac{l}{c} \text{ (} l = \text{distance, } c = \text{light speed in that medium) (seconds)}$$
 - $c = 2 \times 10^8 \text{ m/s}$ in cable
 - The time it takes for the whole packet to be received after the first bit is received — **Serialization delay**: $t_p = \frac{\text{size of packet}}{\text{link rate (bits per second)}} = \frac{p}{r}$
 - **Total time to send a packet across a link**: $t = t_p + t_l = \frac{p}{r} + \frac{l}{c}$

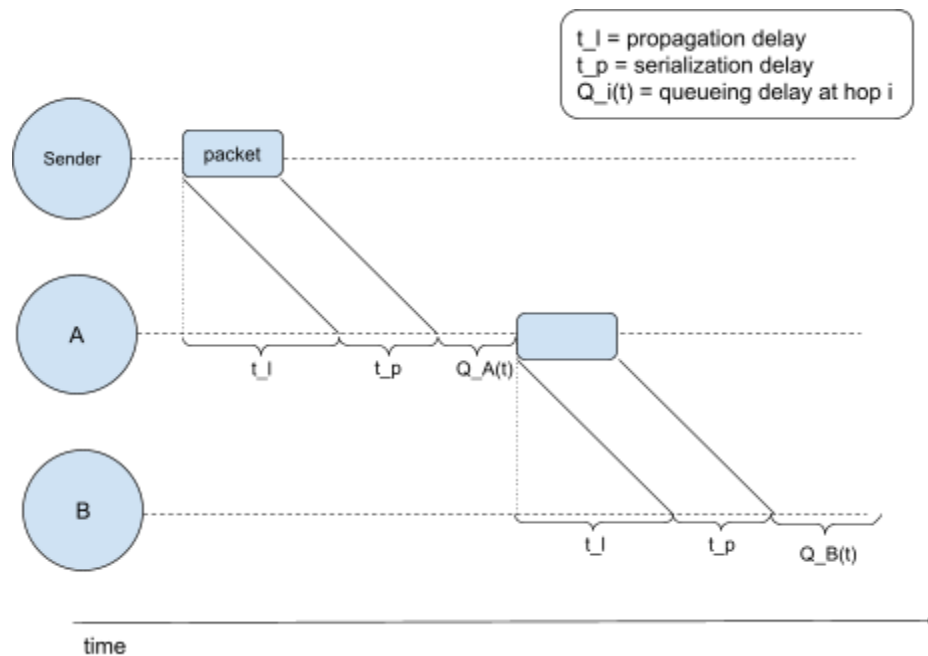


- The path between sender and receiver consists of multiple links



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- Each hop on the link receives the whole packet before sending it out, and therefore each hop would have propagation delay + serialization delay
- And there is **Queueing delay** if the link is busy (a packet needs to wait in line at the FIFO queue).
- Time until packet begins transmission on a link — **Queueing delay**:

$$Q(t) = \sum \text{serialization delay of any packet before this packet in the queue}$$



- **End-to-end delay:** $\sum_{i \in \{hops\}} (t_p + t_l + Q_i(t))$