CS244a: An Introduction to Computer Networks

Final Review

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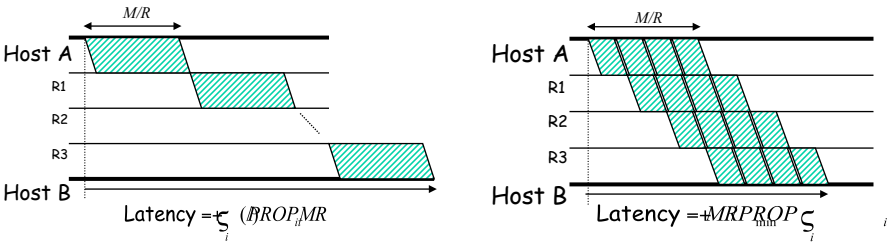
Outline

- The Basics
- Where next?
  - Classes to take

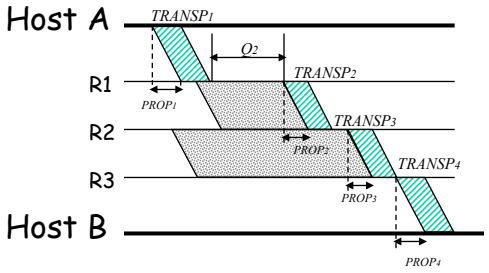
Packet Switching



Breaking message into packets allows parallel transmission across all links, reducing end to end latency. It also prevents a link from being "hogged" for a long time by one message.

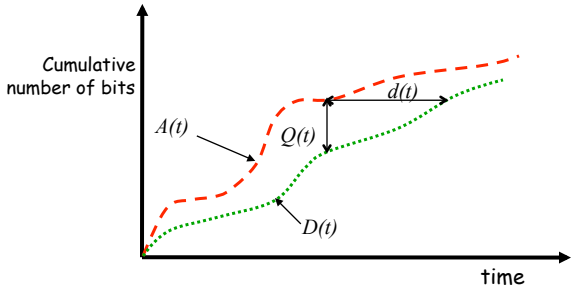
Packet Switching
Queueing Delay

Because the egress link is not necessarily free when a packet arrives, it may be queued in a buffer. If the network is busy, packets might have to wait a long time.



Actual end to end latency = Σ (TRANSP + PROP + Q)

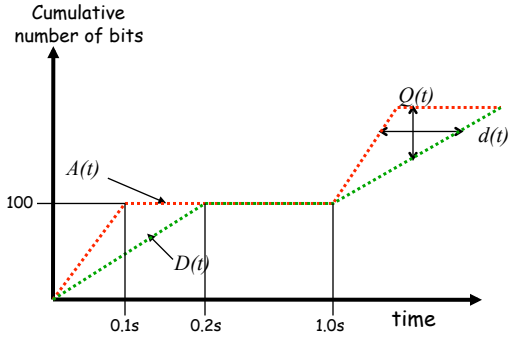
Simple Deterministic Model



Queue occupancy: $Q(t) = A(t) - D(t)$.

Queueing delay, $d(t)$, is the time spent in the queue by a bit that arrived at time t, and if the queue is served first-come-first-served (FCFS or FIFO)

Example



Example: Every second, a train of 100 bits arrive at rate 1000b/s. The maximum departure rate is 500b/s. What is the average queue occupancy?

Solution: During each cycle, the queue fills at rate 500b/s for 0.1s, then drains at rate 500b/s for 0.1s.The average queue occupancy when the queue is non-empty is therefore: $\bar{Q}(t) = 0.5(0.1 \times 100) = 5$. bits

The queue is empty for 0.8s each cycle, and so: $\bar{Q}(t) = 0.2 \times (0.80)5$.

(You'll probably have to think about this for a while...).

Review of Basic Principles

- Basic ideas:
  - Packet switching, statistical multiplexing, deterministic models of queues.
- Physical Layer:
  - Channel capacity, encoding and clock recovery, elasticity buffers.
- Link Layer:
  - CSMA/CD
  - Ethernet switching
- Network Layer:
  - Routing: Bellman-Ford, Dijkstra and multicast
  - Addresses and lookups

Review of Basic Principles (2)

- Transport Layer:
  - Flow control, congestion control, retransmissions and sliding windows, congestion avoidance (RED).
- Quality of Service:
  - Fairness
  - Guarantees, WFQ and leaky-buckets.

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Classes to take

- Networking classes (not all offered every year)
  - CS244b: Distributed Systems
  - CS155: Computer and Network Security (Spring)
  - EE384a: Network Protocols and Standards (Winter)
  - EE384b: Multimedia Networking (Spring)
  - EE384c: Wireless LANs (Spring)
  - EE384m: Network Algorithms (Spring)
  - EE384s: Network Arch. and Performance Engineering (Spring)
  - EE384x,y: Packet Switch Architectures (Winter,Spring)
  - **CS344: Build an Internet Router - Design Project (Spring)**
- Related
  - CS255: Cryptography and Computer Security (Winter)
  - Stats 116, EE178, EE278: Probability and random processes
  - CS249: Object Oriented Modeling (Winter)
  - EE376A: Information theory
- Seminars
  - Stanford Networking Seminar (http://netseminar.stanford.edu)