CSE/EE 461 – Lecture 17

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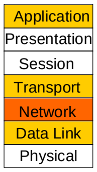
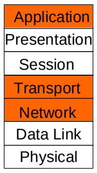
Last Time

- Multicast. See Keshav 11.11.
- Focus
  - How do we communicate efficiently with a group of participants
- Topics
  - Group communication
  - Multicast routing (DVMRP, PIM/CBT)
  - Future: reliable multicast



This Time

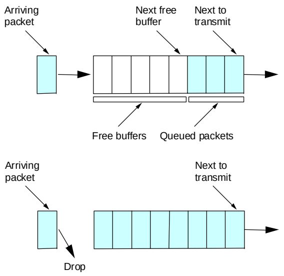
- Quality of Service. Keshav Ch 9, 13.
- Focus
  - What types of service can the network offer, and what do applications want?
- Topics
  - Queuing and Scheduling (FIFO, WFQ)
  - Congestion avoidance (RED w/ECN)
  - Integrated Services (RSVP)
  - Differentiated Services (Diffserv)



Revisiting “Best Effort” Service

- Our models so far:
  - IP at routers: a first come first serve queue [next slide]
  - TCP at hosts: probes for available bandwidth to causing loss
- The mechanisms at routers and hosts determine the kind of service applications will receive from the network
  - e.g., TCP causes loss and delay as it competes for bandwidth!
  - We want better mechanisms to support demanding applications
- Issues:
  - Scheduling: which packet goes next?
  - Buffer management: which packets get dropped?
  - Congestion: how do hosts use the network yet avoid congestion?

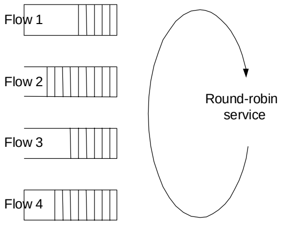
FIFO with Tail Drop



Fair Queuing (FQ)

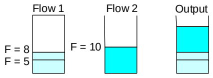
- FIFO is not guaranteed (or likely) to be fair
  - Flows jostle each other and hosts must play by the rules
  - Routers don't discriminate traffic from different sources
- Fair Queuing is an alternative scheduling algorithm
  - Maintain one queue per traffic source (flow) and send packets from each queue in turn
    - Actually, not quite, since packets are different sizes
  - Provides each flow with its "fair share" of the bandwidth
- Issues:
  - Implementation complexity, definition of flow

Fair Queuing



Fair Queuing

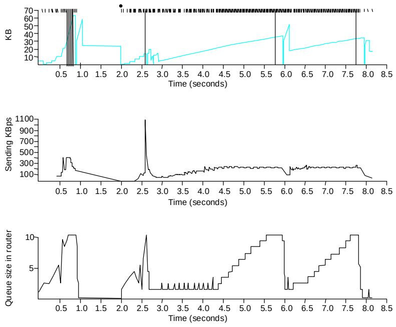
- Want to share bandwidth
  - At the "bit" level, but in reality must send whole packets
- Approximate with finish times for each packet
  - finish (F) = arrive + length*rate; rate depends on # of flows
  - Send in order of finish times, except don't preempt (stop) transmission if a new packet arrives that should go first



- More generally, assign weights to queues (WFQ)

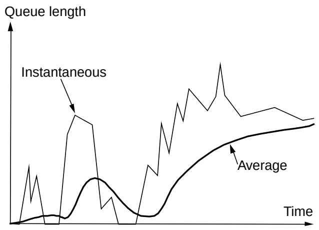
Congestion Avoidance

- TCP provides congestion control:
  - It recovers from congestion once it occurs
  - We would like to avoid congestion in the first place. Why?
- Congestion avoidance mechanisms
  - Aim to detect incipient congestion, before loss
  - Common approaches monitor queuing at routers
  - Queue only intended to absorb bursts, not build steadily



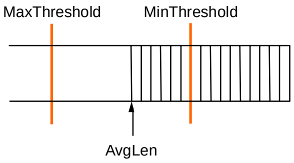
Incipient Congestion at a Router

- Sustained overload causes queue to build and overflow



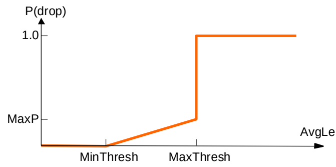
Random Early Detection (RED)

- Send "early" signal by probabilistically dropping a packet, allow source to respond before queue builds



Red Drop Curve

- Start dropping a fraction of the traffic as queue builds
- When queue is too high, revert to drop tail
- Nice theory, difficult to set parameters in practice

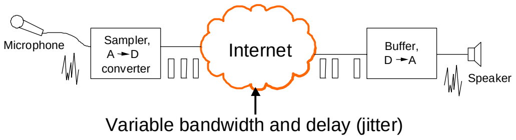


Explicit Congestion Notification (ECN)

- Why only drop packets to signal congestion?
  - Drops are a robust signal, but there are other means …
  - We need to be careful though: no extra packets
- ECN signals congestion by setting a bit in the IP header
- Receiver returns indication to the sender, who slows
- RED actually works by “marking” packets
  - Mark can be a drop or ECN signal if hosts understand ECN
  - Supports congestion avoidance without loss

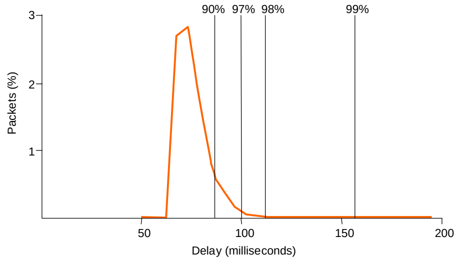
QOS – Application Needs

- Different applications have different network needs
  - Consider voice over IP as a real-time service

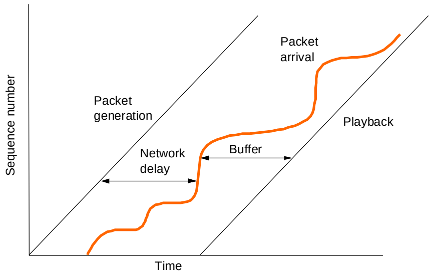


- Real-time apps need assurances from the network

Delay and Jitter



Playback with Buffering

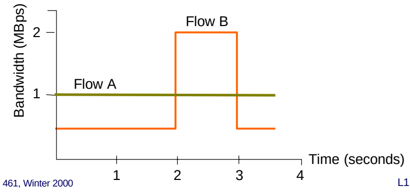


Approaches to QOS

- Fine-grained
  - Each application negotiates individual QOS guarantees
  - IETF Integrated services (Intserv)
- Coarse-grained
  - Several different QOS classes that apps can choose from
  - IETF Differentiated Services (Diffserv)
- To provide assurances we need to limit load
  - Admission control reserves network resources

Intserv

- Application reserves required resources
  - Send messages along a network path, e.g., with RSVP
  - Need to describe flow requirements to routers
  - Routers set aside resources, e.g., separate queues with priority



Diffserv

- Small number of different services: premium, regular
  - Packets marked for kind of service in IP header (TOS redefined)
- Routers understand different services but not flows
  - Might separate classes with WFQ
- Customers buy premium service from ISP ahead of time
  - Much less dynamic than Intserv
  - Marking policed at administrative boundaries

Key Concepts

- Congestion avoidance w/router support
- Different scheduling and buffer management algorithms can provide different kinds of service
- Real-time applications need service assurances (QOS)
- Assurances require admission control
- Two approaches being explored today:
  - Intserv: per flow reservations
  - Diffserv: small number of service classes