

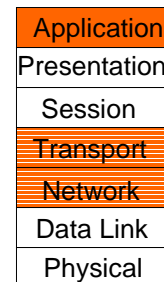
CSE/EE 461 – Lecture 20

Congestion Avoidance

David Wetherall
djw@cs.washington.edu

Last Time ...

- Introduction to Quality of Service
- Focus
 - What transports do applications need?
- Topics
 - Real-time versus Elastic applications
 - Adapting to variable delay
 - Token buckets as bandwidth descriptors



This Lecture

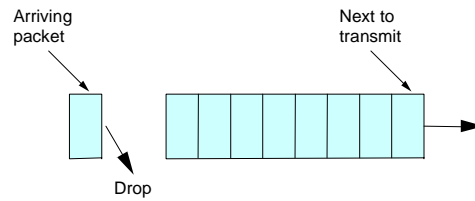
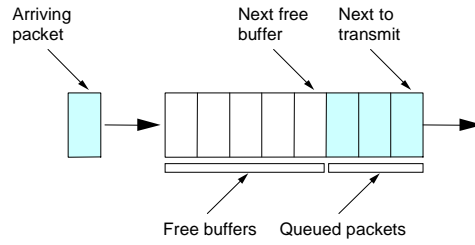
- Congestion Avoidance
- Focus
 - How to we avoid congestion?
- Topics
 - Random Early Detection (RED) gateways
 - Explicit Congestion Notification (ECN)

Application
Presentation
Session
Transport
Network
Data Link
Physical

Why Congestion Avoidance?

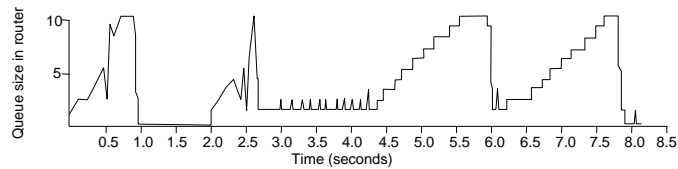
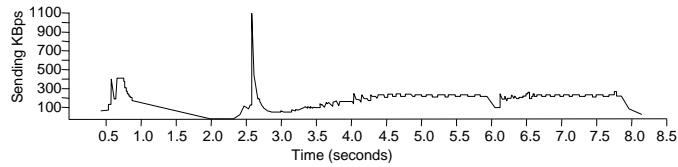
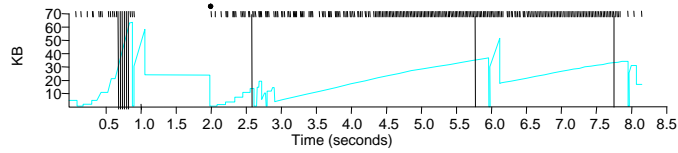
- TCP causes congestion as it probes for the available bandwidth and then recovers from it after the fact
 - Leads to loss, delay and bandwidth fluctuations (Yuck!)
 - We want congestion avoidance, not congestion control
- Congestion avoidance mechanisms
 - Aim to detect incipient congestion, before loss. So monitor queues to see that they absorb bursts, but not build steadily

FIFO with Tail Drop



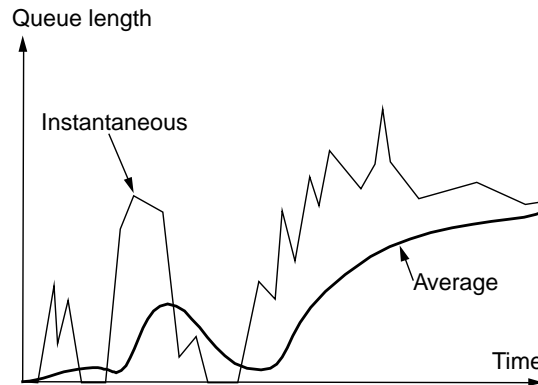
djw // CSE/EE 461, Autumn 2001

L20.5



Incipient Congestion at a Router

- Sustained overload causes queue to build and overflow

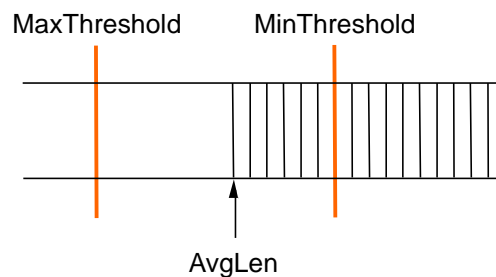


djw // CSE/EE 461, Autumn 2001

L20.7

Random Early Detection (RED)

- Common approach is to have routers monitor average queue and send “early” signal to source when it builds by probabilistically dropping a packet



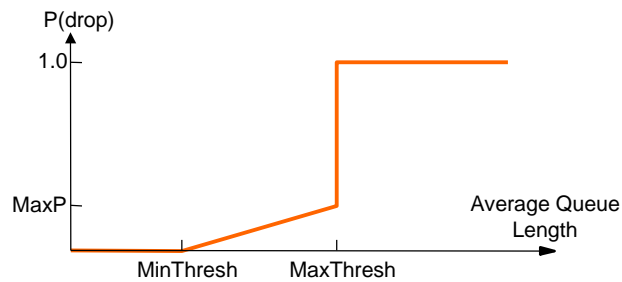
- Paradox: early loss can improve performance!

djw // CSE/EE 461, Autumn 2001

L20.8

Red Drop Curve

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



djw // CSE/EE 461, Autumn 2001

L20.9

Explicit Congestion Notification (ECN)

- Why 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 with a bit in the IP header
- Receiver returns indication to the sender, who slows
 - Need to signal this reliably or we risk instability
- RED actually works by “marking” packets
 - Mark can be a drop or ECN signal if hosts understand ECN
 - Supports congestion avoidance without loss

djw // CSE/EE 461, Autumn 2001

L20.10

Aside: TCP Vegas (Peterson '94)

- RED needs router upgrades but no host upgrades
- Instead, can we upgrade host but not router?
- TCP Vegas looks at the difference between cwnd (the amount of outstanding data in the network) and that acknowledged from the other side in the last interval
 - Excess must be buffered in the network at router queues
 - Vegas slows down when it believes there is a queue and otherwise increases to use the available bandwidth

Key Concepts

- We want to avoid congestion rather than control it after it has occurred
 - Think of in terms of the queues at routers
- Random early packet drops, rather than tail drop, can have unintuitive advantages
 - Signal congestion early, before we're forced to drop repeatedly
- ECN signals congestion using bit in the IP header
 - No loss and no extra packets at overloaded times