CSE/EE 461 – Lecture 20

Congestion Avoidance

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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)

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

Arriving packet

Next free buffer
Next to transmit

Free buffers Queued packets

Arriving packet

Next to transmit

Drop

Queue size in router

Sending KBps

KB

Time (seconds)

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720}

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Incipient Congestion at a Router

- Sustained overload causes queue to build and overflow

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!
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

![Red Drop Curve Graph]

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
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